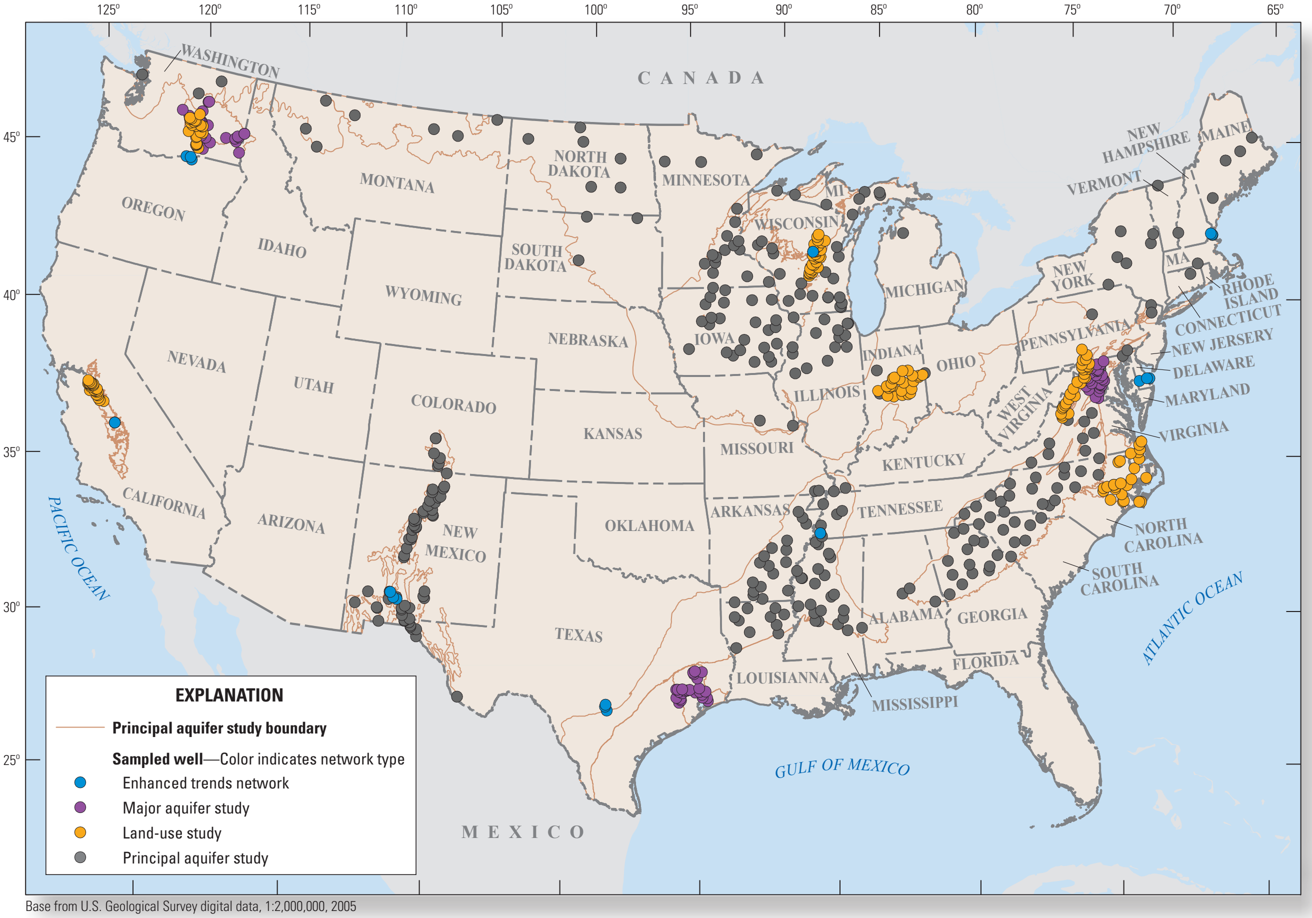
USGS
science for a changing world

National Water-Quality Assessment Project

Groundwater-Quality Data from the National Water-Quality Assessment Project, January through December 2014 and Select Quality-Control Data from May 2012 through December 2014



Base from U.S. Geological Survey digital data, 1:2,000,000, 2005

Data Series 1063

U.S. Department of the Interior
U.S. Geological Survey

Cover figure. Groundwater study networks and wells sampled as part of the U.S. Geological Survey National Water-Quality Assessment Project from January through December 2014 for which water-quality data are included in this report.

Groundwater-Quality Data from the National Water-Quality Assessment Project, January through December 2014 and Select Quality-Control Data from May 2012 through December 2014

By Terri L. Arnold, Laura M. Bexfield, MaryLynn Musgrove, Bruce D. Lindsey,
Paul E. Stackelberg, Jeanine R. Barlow, Leslie A. DeSimone, Justin T. Kulongoski,
James A. Kingsbury, Joseph D. Ayotte, Brandon J. Fleming, and Kenneth Belitz

National Water-Quality Assessment Project

Data Series 1063

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
RYAN K. ZINKE, Secretary

U.S. Geological Survey
William H. Werkheiser, Acting Director

U.S. Geological Survey, Reston, Virginia: 2017

Suggested citation:
Arnold, T.L., Bexfield, L.M., Musgrove, MaryLynn, Lindsey, B.D., Stackelberg, P.E., Barlow, J.R., DeSimone, L.A., Kulongoski, J.T., Kingsbury, J.A., Ayotte, J.D., Fleming, B.J., and Belitz, Kenneth, 2017, Groundwater-quality data from the National Water-Quality Assessment Project, January through December 2014 and select quality-control data from May 2012 through December 2014: U.S. Geological Survey Data Series 1063, 83 p., https://doi.org/10.3133/ds1063.

ISSN 2327-638X (online)

Foreword

Sustaining the quality of the Nation's water resources and the health of our diverse ecosystems depends on the availability of sound water-resources data and information to develop effective, science-based policies. Effective management of water resources also brings more certainty and efficiency to important economic sectors. Taken together, these actions lead to immediate and long-term economic, social, and environmental benefits that make a difference to the lives of the almost 400 million people projected to live in the United States by 2050.

In 1991, Congress established the National Water-Quality Assessment (NAWQA) to address where, when, why, and how the Nation's water quality has changed, or is likely to change in the future, in response to human activities and natural factors. Since then, NAWQA has been a leading source of scientific data and knowledge used by national, regional, state, and local agencies to develop science-based policies and management strategies to improve and protect water resources used for drinking water, recreation, irrigation, energy development, and ecosystem needs (https://water.usgs.gov/nawqa/applications/). Plans for the third decade of NAWQA (2013–23) address priority water-quality issues and science needs identified by NAWQA stakeholders, such as the Advisory Committee on Water Information and the National Research Council, and are designed to meet increasing challenges related to population growth, increasing needs for clean water, and changing land-use and weather patterns.

The NAWQA project is assessing the quality of groundwater used for public and domestic drinking-water supply. NAWQA obtains samples from public supply wells, domestic wells, and relatively shallow monitoring wells, and analyzes those samples for a large number of chemical constituents. These data are used to assess the suitability of the resource for human consumption, as well as to evaluate changes in groundwater quality over a variety of time scales. Groundwater quality is also assessed at multiple scales: locally, regionally, and nationally. Groundwater-quality data collected by the NAWQA Project during each year are published in annual data series reports. This report, the second in the series, combines groundwater-quality data collected at 559 sites to provide a summary of groundwater quality in selected aquifers across the Nation during 2014. All NAWQA reports are available online at https://water.usgs.gov/nawqa/bib/.

We hope this publication will provide you with insights and information to meet your water-resource needs and will foster increased citizen awareness and involvement in the protection and restoration of our Nation's waters. The information in this report is intended primarily for those interested or involved in resource management and protection, conservation, regulation, and policymaking at the regional and national levels.

Dr. Donald W. Cline
Associate Director for Water
U.S. Geological Survey

Contents

Figures

Figures—Continued

Tables

Conversion Factors

U.S. customary units to International System of Units (SI)

Multiply	**By**	**To obtain**
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
billion gallons per day (Bgal/d)	43.81	cubic meter per second (m^3/s)
	Radioactivity	
picocurie per liter (pCi/L)	0.037	becquerel per liter (Bq/L)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F=(1.8×°C)+32

Datum

Vertical coordinate information is referenced to either the North American Vertical Datum of 1988 (NAVD 88) or the National Geodetic Vertical Datum of 1929 (NGVD 29) and is specified in tables where vertical datum is reported.

Altitude, as used in this report, refers to distance above the vertical datum.

Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given in either milligrams per liter (mg/L), micrograms per liter (µg/L), or nanograms per liter (ng/L).

Activities for radioactive constituents in water are given in picocuries per liter (pCi/L).

This report contains Chemical Abstracts Service (CAS) Registry Numbers®, which are a Registered Trademark of the American Chemical Society. The CAS recommends the verification of the CAS Registry Numbers through CAS Client Services^{SM}.

Abbreviations

ASCII	American Standard Code for Information Interchange
EPA	U.S. Environmental Protection Agency
ETN	enhanced trends network
HHB	human-health benchmark
HHBP	human-health benchmark for pesticides
ID	identification
LRL	laboratory reporting level
LT–MDL	long-term method detection level
LUS	land-use study
MAR	Midwestern agricultural region
MAS	major aquifer study
MCL	maximum contaminant level
MDL	method detection level
NAWQA	National Water-Quality Assessment
PAS	principal aquifer study
QC	quality control
ssL_c	sample-specific critical level
ssMDC	sample-specific minimum detectable concentration
USGS	U.S. Geological Survey
VOC	volatile organic compound

Groundwater-Quality Data from the National Water-Quality Assessment Project, January through December 2014 and Select Quality-Control Data from May 2012 through December 2014

By Terri L. Arnold, Laura M. Bexfield, MaryLynn Musgrove, Bruce D. Lindsey, Paul E. Stackelberg, Jeanine R. Barlow, Leslie A. DeSimone, Justin T. Kulongoski, James A. Kingsbury, Joseph D. Ayotte, Brandon J. Fleming, and Kenneth Belitz

Abstract

Groundwater-quality data were collected from 559 wells as part of the National Water-Quality Assessment Project of the U.S. Geological Survey National Water-Quality Program from January through December 2014. The data were collected from four types of well networks: principal aquifer study networks, which are used to assess the quality of groundwater used for public water supply; land-use study networks, which are used to assess land-use effects on shallow groundwater quality; major aquifer study networks, which are used to assess the quality of groundwater used for domestic supply; and enhanced trends networks, which are used to evaluate the time scales during which groundwater quality changes. Groundwater samples were analyzed for a large number of water-quality indicators and constituents, including major ions, nutrients, trace elements, volatile organic compounds, pesticides, radionuclides, and some constituents of special interest (arsenic speciation, chromium [VI] and perchlorate). These groundwater-quality data, along with data from quality-control samples, are tabulated in this report and in an associated data release.

Introduction

The National Water-Quality Assessment (NAWQA) Project of the U.S. Geological Survey (USGS) National Water-Quality Program was fully implemented in 1991 and operates in about 10-year long cycles. The NAWQA Project began its third cycle of studies in 2013. The NAWQA Project is designed to describe current water-quality conditions of the Nation’s freshwater streams, rivers, and aquifers; describe how water quality is changing with time; improve understanding of the natural and human factors that affect water quality; forecast future water-quality conditions; and assess effects of water-quality stressors on aquatic ecosystems (Rowe and others, 2010, 2013). For the third cycle of studies, the NAWQA Project design was modified to include the last two goals listed above.

The NAWQA Project groundwater assessments focus on the quality of groundwater used for public and domestic drinking-water supply; groundwater susceptibility to degradation; effects of natural and human factors on source, transport, and flux of contaminants to and within aquifers; groundwater- quality contributions to surface-water quality; and current and historic management practices relative to groundwater quality. Groundwater quality is studied at multiple scales: locally, regionally, and nationally. The primary regional scale at which groundwater data are collected during the third cycle of the NAWQA Project is the scale of the principal aquifers (Burow and Belitz, 2014). A principal aquifer is defined as a regionally extensive aquifer or aquifer system that has the potential to be used as a source of potable water. Principal aquifers were selected for assessment based on their national ranking as sources of water used for public supply (Arnold and others, 2016a).

Groundwater-quality data collected by the NAWQA Project during each year will be published in annual data series reports. The first report and associated data release in this series published data collected between May 2012 and December 2013 (Arnold and others, 2016a, b).

Purpose and Scope

The purpose of this report is to present the analytical results of the groundwater-quality samples collected in 2014 as part of the third cycle of NAWQA Project studies and provide brief descriptions of the groundwater-quality study networks for use in subsequent publications. Types of analyses include the following: water-quality indicators, major and minor ions, nutrients, volatile organic compounds (VOCs), pesticides, radionuclides, and select constituents of special interest (arsenic speciation, chromium [V], and perchlorate). The water-quality data are presented in tables formatted as tab-delimited American Standard Code for Information Interchange (ASCII) text files, which may be imported into spreadsheet, database, or statistical software for manipulation and analysis. These water-quality data tables are available from Arnold and others (2017).

Groundwater Study Design

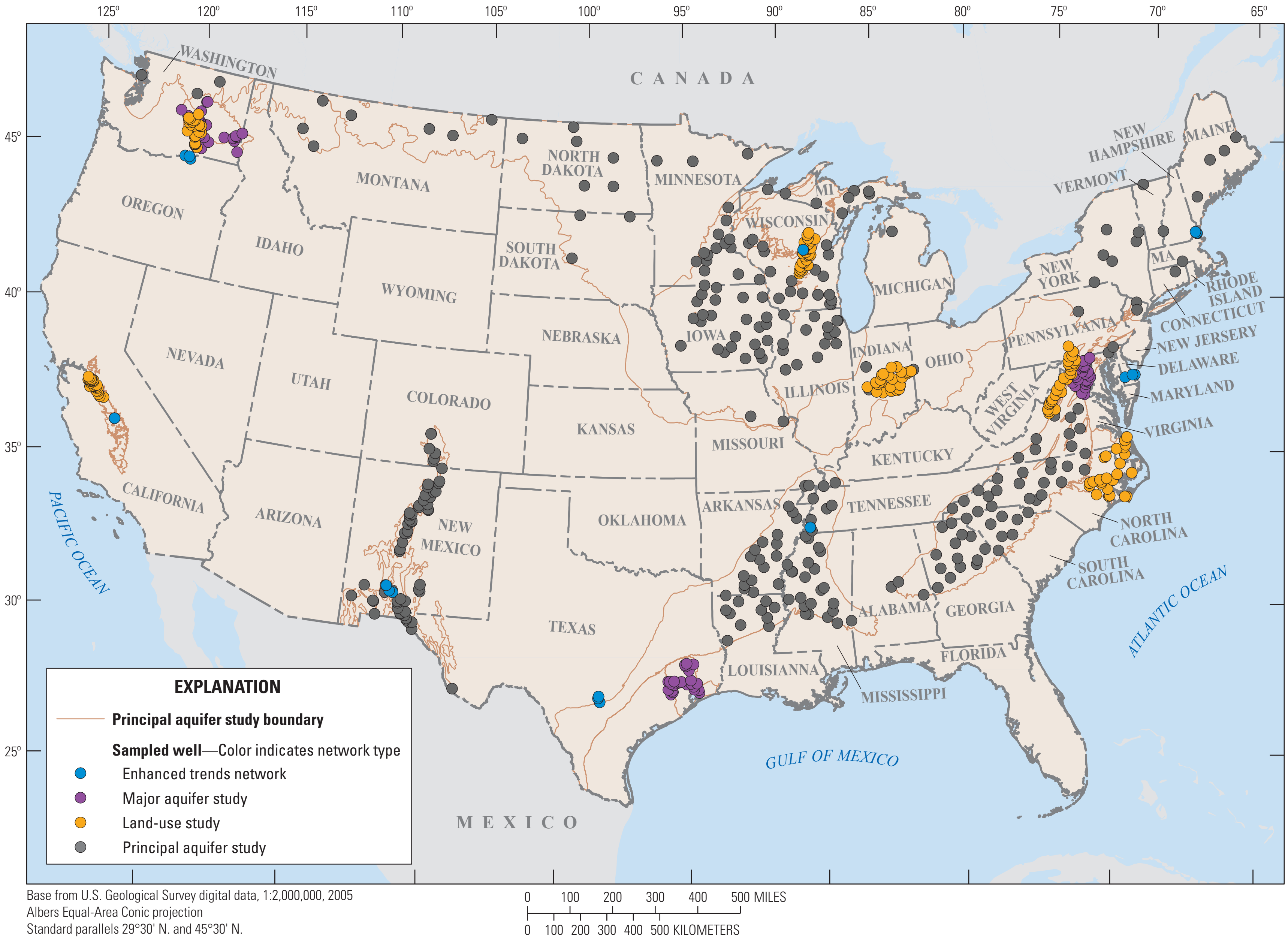
Groundwater-quality samples are collected from wells that are organized into networks (fig. 1) for study purposes. A network is a group of wells that have been selected for sampling based on specific hydrogeologic conditions, land use, or other design criteria. Many networks have wells that were sampled in multiple decadal sampling periods; however, if a network well was damaged or destroyed, had too little water, or the current owner would not permit sampling, then that well was not resampled. Maps and tables in this report and in Arnold and others (2017) have well identification (ID) numbers assigned by the NAWQA Project to identify the wells; because some wells could not be resampled, some networks do not have consecutively numbered NAWQA Project ID numbers. As used on maps showing network-specific information (figs. 2–17), the ID numbers are shown either as numbers only or a combination of numbers and letters that indicate a particular well within the network. The NAWQA well identification number listed in table 1 of this report and table 1 of Arnold and others (2017) is a combination of the network name and the NAWQA Project ID. Data from four primary types of groundwater study networks are presented in this report (fig. 1): principal aquifer study (PAS), land-use study (LUS), major aquifer study (MAS), and enhanced trends networks (ETN).

Wells in PAS, LUS, and MAS networks were randomly selected using an equal-area grid to divide the study area (Scott, 1990). The equal-area grid method allows for evaluation of constituent concentrations at a regional scale (Belitz and others, 2010). For LUS networks, random potential sampling locations in each grid cell were generated by a software program (Scott, 1990), and monitoring wells were subsequently installed as near to the randomly selected locations as possible. Study areas for LUS networks included the areal extents of the primary aquifer and a specific land use (for example, orchard) of interest. For MAS and PAS networks, one well per grid cell was randomly selected from a population of existing domestic or public-supply wells (Gilliom and others, 1995; Scott, 1990). For PAS networks, if no public-supply well was available within a grid cell (for example, because permission to sample could not be obtained), an additional well was selected within an adjacent grid cell, not to exceed four wells in two adjacent grid cells. Equal-area grids used for network design only are shown on figures relating to PAS networks because the grids are not available for LUS or MAS networks designed during the first two decades of sampling.

The ETN wells were selected from existing networks where possible. The wells are in hydrogeologic settings where changes in hydrologic conditions, land use, or contaminant inputs are expected to be quickly reflected in groundwater.

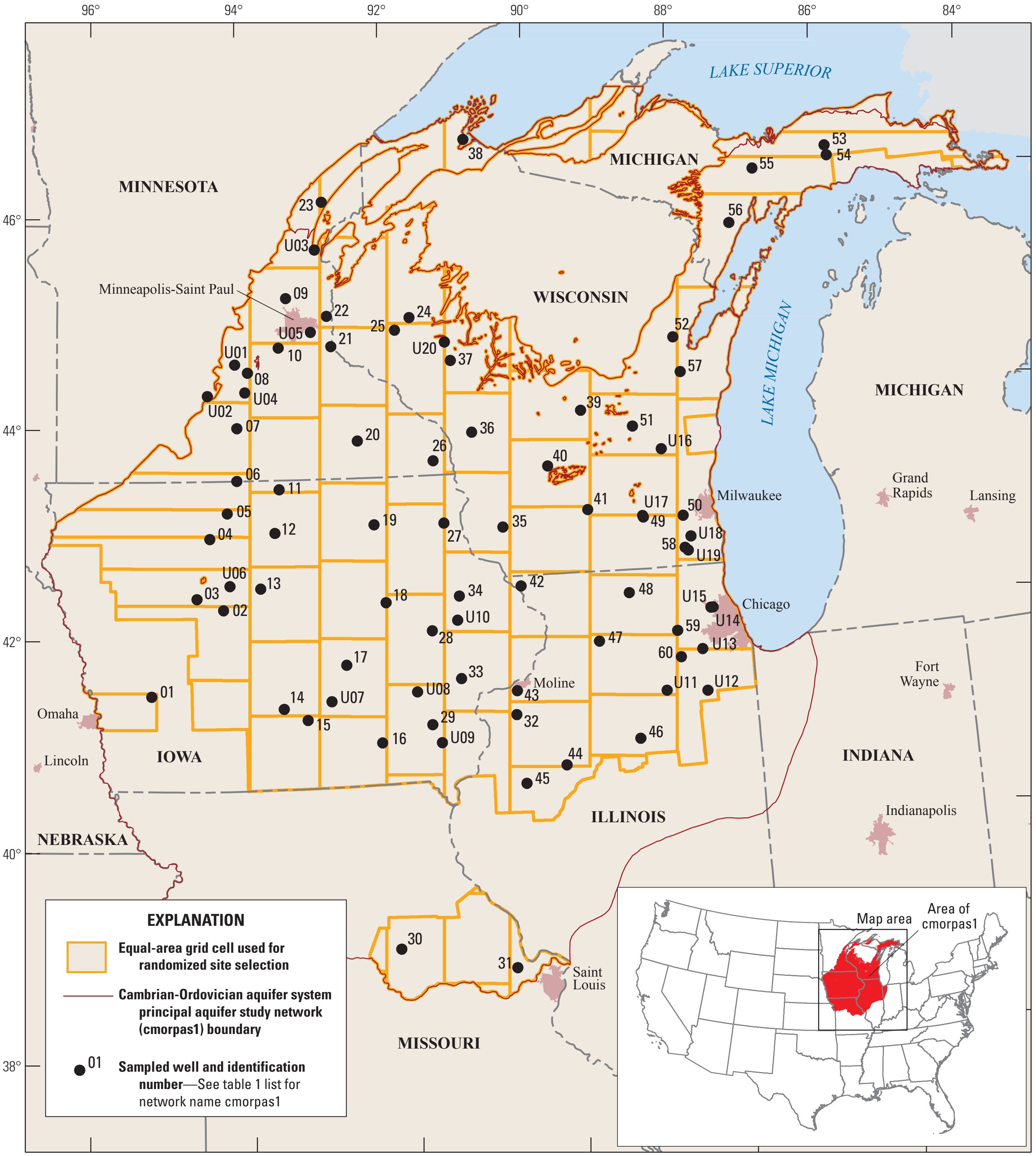
Principal Aquifer Study Networks

The PAS networks consist of public-supply wells, and water is sampled from the part of the aquifer used for the public drinking-water supply (Burow and Belitz, 2014). Public-supply wells are generally the deepest wells sampled. Wells in PAS networks are sampled once to assess groundwater-quality conditions in the study areas. The extents of PAS areas are based on the U.S. Geological Survey (2003) map of principal aquifers and may be modified in some areas, as described in this report. Data from the following PAS networks are included in this report: the Cambrian-Ordovician aquifer system (cmorpas1; fig. 2), glacial aquifer system (glacpas1; fig. 3), Mississippi Embayment-Texas Coastal Uplands aquifer system (metxpas1; fig. 4), Piedmont and Blue Ridge crystalline-rock aquifers (piedpas1; fig. 5), and Rio Grande aquifer system (rgaqpas1; fig. 6).



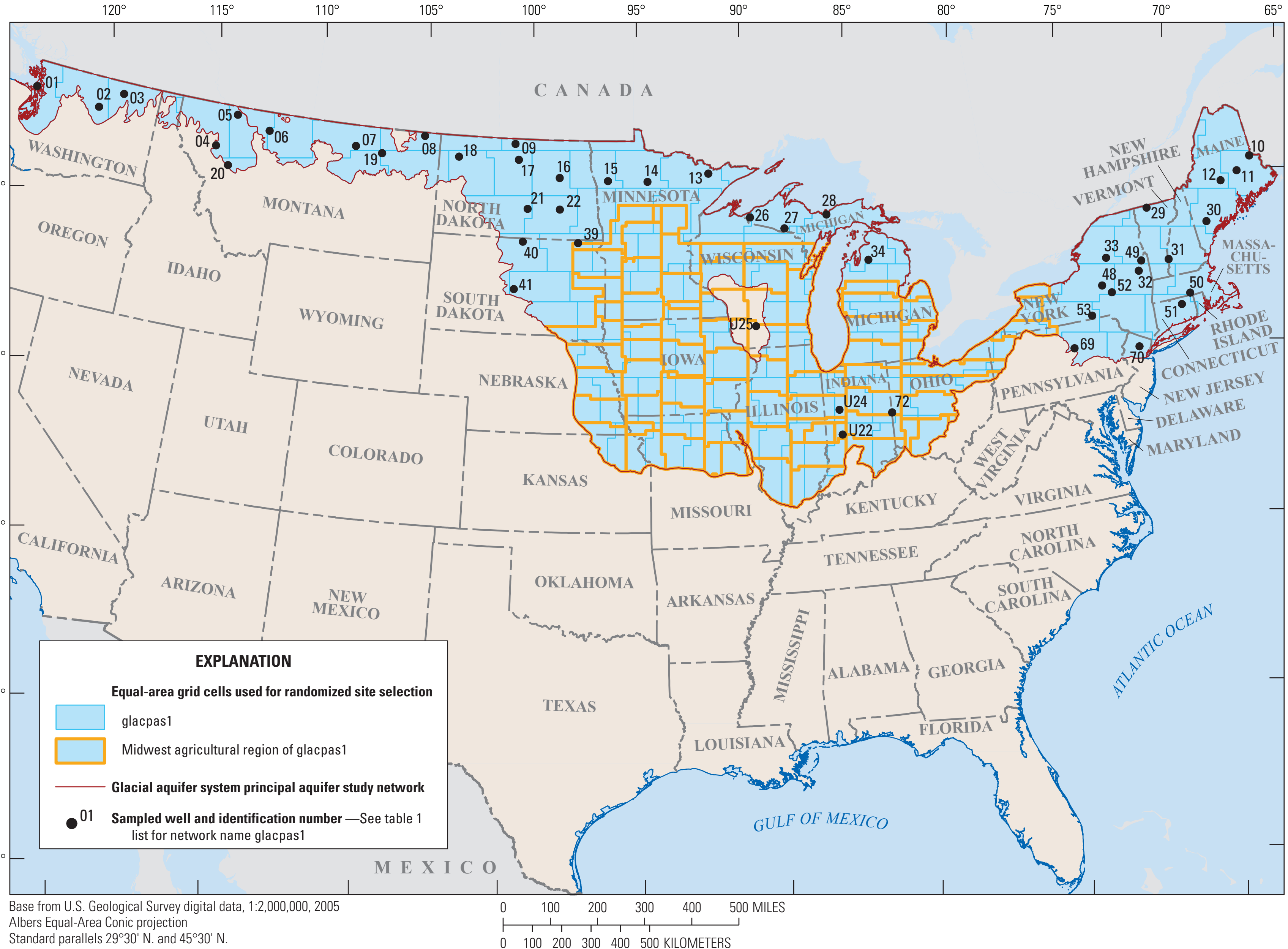
Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30' N. and 45°30' N.
Central meridian 96°00' W.
North American Datum of 1983

Figure 1. Groundwater study networks and wells sampled as part of the U.S. Geological Survey National Water-Quality Assessment Project from January through December 2014 for which water-quality data are included in this report.



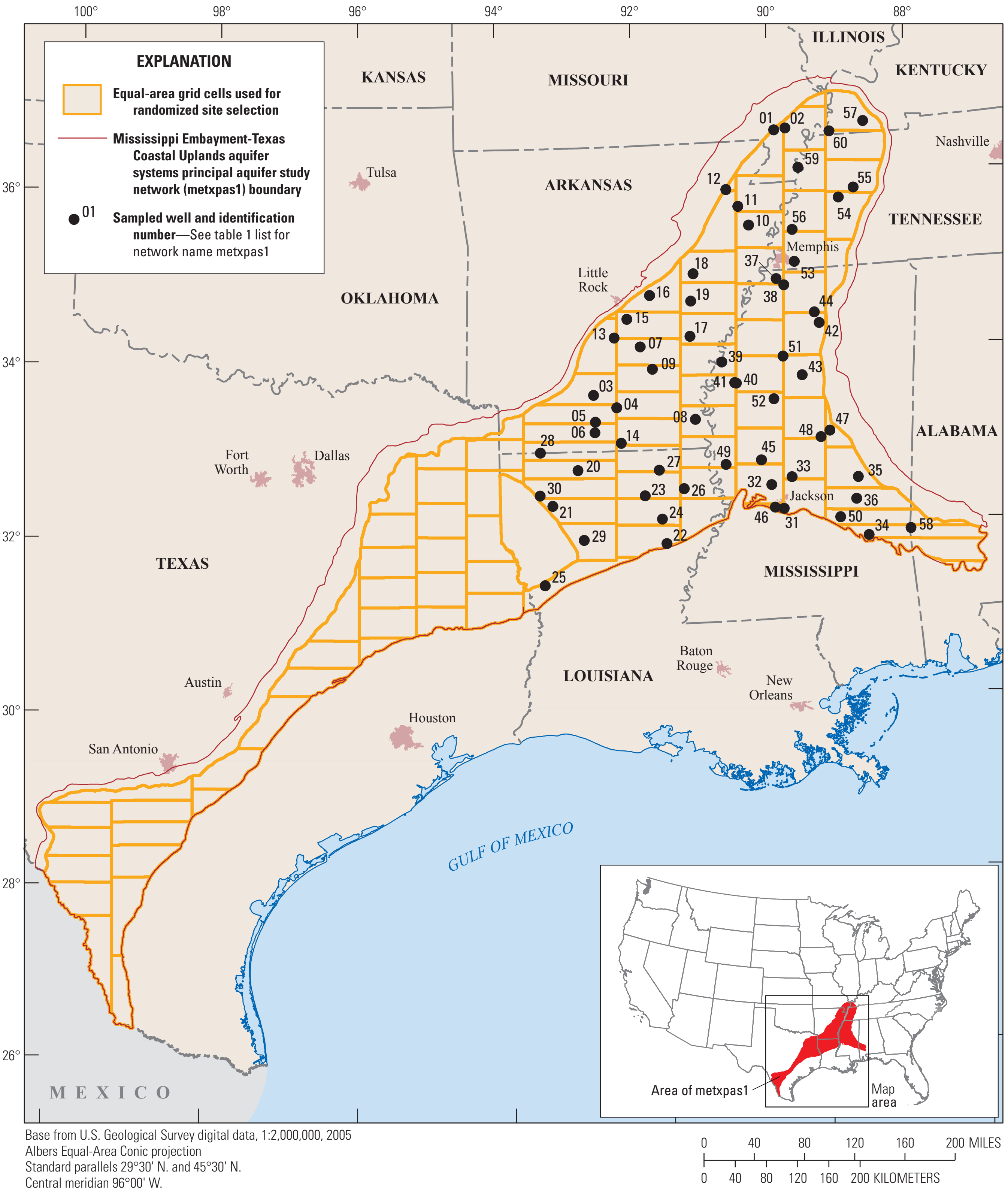
Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30′ N. and 45°30′ N.
Central meridian 96°00′ W.
North American Datum of 1983

Figure 2. Study area and wells sampled as part of the Cambrian-Ordovician aquifer system principal aquifer study network (cmorpas1) for the U.S. Geological Survey National Water-Quality Assessment Project, March through November 2014.



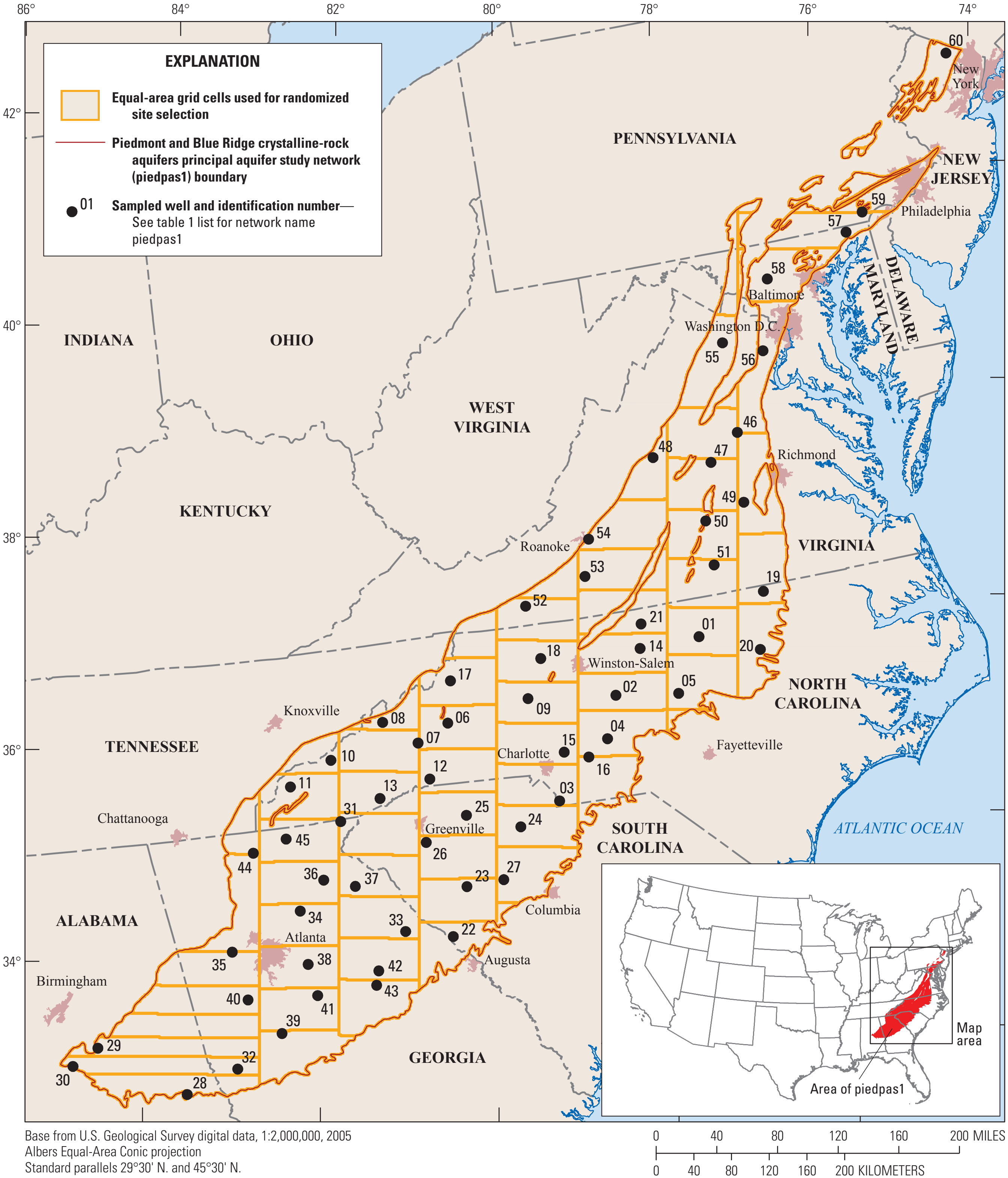
Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30' N. and 45°30' N.
Central meridian 96°00' W.
North American Datum of 1983

Figure 3. Study area and wells sampled as part of the glacial aquifer system principal aquifer study network (glacpas1) for the U.S. Geological Survey National Water-Quality Assessment Project, April through November 2014.



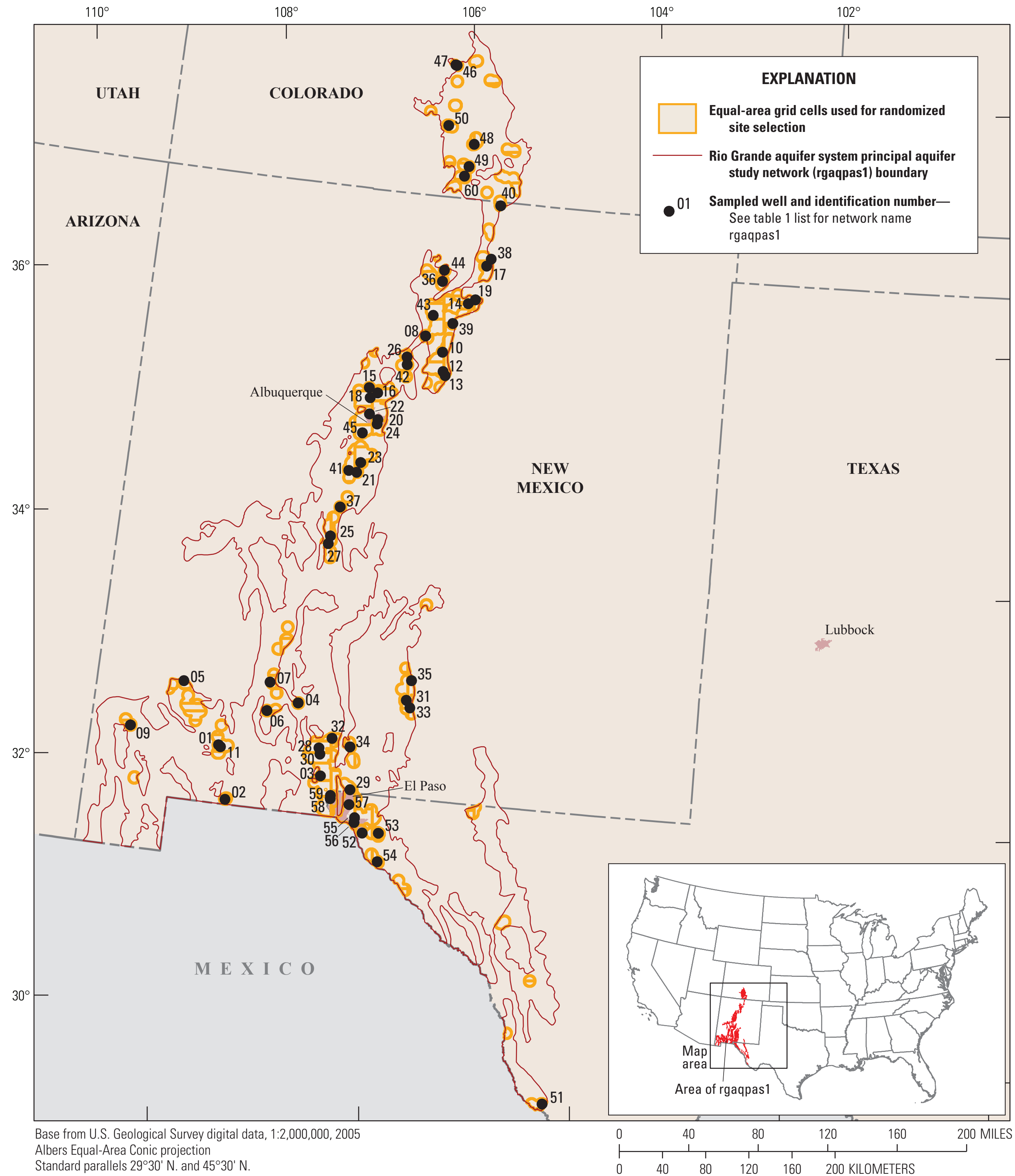
Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30′ N. and 45°30′ N.
Central meridian 96°00′ W.
North American Datum of 1983

Figure 4. Study area and wells sampled as part of the Mississippi Embayment-Texas Coastal Uplands aquifer systems principal aquifer study network (metxpas1) for the U.S. Geological Survey National Water-Quality Assessment Project, April through December 2014.



Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30' N. and 45°30' N.
Central meridian 96°00' W.
North American Datum of 1983

Figure 5. Study area and wells sampled as part of the Piedmont and Blue Ridge crystalline-rock aquifers principal aquifer study network (piedpas1) for the U.S. Geological Survey National Water-Quality Assessment Project, July through November 2014.



Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30′ N. and 45°30′ N.
Central meridian 96°00′ W.
North American Datum of 1983

Figure 6. Study area and wells sampled as part of the Rio Grande aquifer system principal aquifer study network (rgaqpas1) for the U.S. Geological Survey National Water-Quality Assessment Project, May through October 2014.

Cambrian-Ordovician Aquifer System Principal Aquifer Study Network (cmorpas1)

The Cambrian-Ordovician aquifer system underlies an area of about 184,000 square miles (mi^2), which includes about 26 million people in parts of 7 Midwestern States. The aquifer system is a major source of groundwater in the upper Midwest; however not all of the aquifer area is usable for drinking water (Wilson, 2012). Total withdrawals in 2000 were 932 million gallons per day (Mgal/d), including 590 Mgal/d for public supply and 41 Mgal/d for domestic supply, and the aquifer system ranks ninth in the Nation as a source of groundwater for public supply (Maupin and Barber, 2005; Maupin and Arnold, 2010; Arnold and others, 2016a). Agriculture is the dominant overlying land use (Homer and others, 2015), covering about 70 percent of the aquifer system's areal extent. Developed areas include the major metropolitan areas of Minneapolis-St. Paul, Minnesota, Milwaukee, Wisconsin, and Chicago, Illinois.

Rocks of the Cambrian-Ordovician aquifer system are mainly sandstones and carbonates of marine origin that form a complex, multilayered sequence. The aquifer rocks outcrop at land surface or subcrop beneath glacial deposits in southeastern Minnesota, northeastern Iowa, Wisconsin, northern Illinois, and extreme northwestern Indiana (Young, 1992; Wilson, 2012). The rock layers dip and thicken to the south and east from structural highs of the Precambrian crystalline basement near the outcrop or subcrop areas into structural lows in southwestern Iowa and in the Illinois and Michigan basins. In eastern Wisconsin, in most of Iowa, Illinois, and Indiana, and Missouri, rocks of the Cambrian-Ordovician aquifer system are buried and confined by younger rocks. The aquifer system is recharged primarily in the outcrop or subcrop areas through direct infiltration of precipitation or percolation through overlying unconsolidated deposits. Groundwater flows through local flow systems to streams or regionally along longer and deeper flow paths towards major river valleys, Lake Michigan, or the downdip structural basins (Wilson, 2012). Groundwater in large parts of the confined system, in far western Iowa, most of Missouri, south-central Illinois, and Indiana is too saline to use for drinking water. Areas of Precambrian-age sandstones in southeastern Minnesota and the Upper Peninsula of Michigan are hydraulically connected to and difficult to distinguish from the overlying Cambrian sandstones (Wilson, 2012).

The Cambrian-Ordovician aquifer system PAS network (cmorpas1; fig. 2) consists of 80 public-supply wells in total: 60 wells that were selected using an equal-area grid and an additional 20 wells that were selected to study radionuclides in the aquifer system. The 60-cell, equal-area grid extends across the areas of the Cambrian-Ordovician aquifer system and the hydraulically-connected Precambrian sandstones in Minnesota and Michigan, but excludes areas where groundwater in the aquifer system is too saline for drinking water use. The 20 additional supply wells were selected based on their history of producing water with elevated gross alpha radiation to improve understanding of the conditions and radionuclides that give rise to high gross alpha measurements in the aquifer system. The wells selected to study radionuclides are indicated by a "U" in NAWQA Project ID number. Wells in the cmorpas1 network were typically between 286 and 2,000 feet (ft) deep (table 1–1; appendix 1) and open to the aquifer across a wide range of lengths (table 1–2; appendix 1). All 80 wells were sampled between March and November 2014.

Glacial Aquifer System Principal Aquifer Study Network (glacpas1)

The glacial aquifer system underlies nearly one million square miles of the northern contiguous United States, across parts of 25 states from Maine to Washington. The area underlain by this aquifer has a population of about 99 million people. The aquifer system provides more groundwater for public supply and private domestic supply than any other aquifer in the Nation. In 2000, about 2.6 billion gallons were pumped per day for these uses (Maupin and Barber, 2005; Maupin and Arnold, 2010; Arnold and others, 2016a). Land use in the area underlain by the glacial aquifer system is mostly agricultural in the central and west-central regions and mostly natural in the east and west (Homer and others, 2015). Large urban areas also are underlain by the glacial aquifer system, and nearly one-third of the United States population lives in this area (Warner and Ayotte, 2015).

The glacial aquifer system consists of unconsolidated sediments left behind by the continental glaciers in the northern United States. The wide variety of glacial depositional processes and environments resulted in the accumulation of a heterogeneous mixture of sediments in a wide variety of hydrogeologic settings (Warner and Ayotte, 2015). Regionally, however, there are some general similarities in hydrogeologic setting and sediment type. In the east, glacial sediments fill crystalline bedrock valleys and cover broad, low-lying areas with outwash deposits, typically ranging in thickness from less than 50 to 200 ft (Olcott, 1995). Discontinuous layers of sand and gravel in these settings provide the most productive water supplies from the glacial aquifer system in the east. In the central and west-central regions, the glacial aquifer system consists of thick sequences of coarse- and fine-grained glacial sediments that fill and obscure previously formed bedrock valleys (as much as 400 ft in thickness; Whitehead, 1994). Unsorted, fine-grained till sediments overlie the buried valleys and contain discontinuous layers of more permeable sediments. Northern areas in the central region also contain thick sequences of glacial-lake deposits. The western region of the glacial aquifer system consists mostly of coarse-grained sediments in valleys and in thick layers in flatter topography. Recharge to the glacial system is from precipitation, inflow from adjacent aquifers, or through confining units; discharge is typically to streams and other surface waters (Olcott, 1992, 1995).

The glacial aquifer system PAS network (glacpas1; fig. 3) extends across the glaciated areas of the lower 48 states and includes a total of 115 public-supply wells. About three-fourths of the wells (90 wells) were spatially distributed throughout the aquifer area. These 90 wells were selected using an equal-area grid that divided the glacial region into 90 cells, each about 8,000 mi^2 in area. An additional 25 wells were spatially distributed in the Midwestern agricultural region (MAR) of the glacial aquifer using a second equal-area grid overlying the original 90-cell grid. The second grid had 60 cells, each about 6,000 mi^2. In the area where the two equal-area grids overlapped, a well was selected for sampling if a cell from the second grid did not already contain a well selected from the 90-cell grid. The result of the overlap was a grid with 72 cells (average size 5,000 mi^2) and a denser distribution of wells in the Midwestern agricultural region than in the rest of the aquifer area. The MAR was defined through analysis of groundwater-quality data as one of five areas with distinct water-quality characteristics in the glacial aquifer system (Arnold and others, 2008). The MAR was selected for additional assessment of the quality of public drinking-water supplies because it is an area with intensive agrichemical inputs and relatively high water use for public supply as compared with other parts of the glacial aquifer system (Arnold and others, 2008).

Wells in the glacpas1 were sampled in 2013 and 2014. Data from 69 wells sampled in 2013 were published in Arnold and others (2016a, b); these included 47 wells from the spatially distributed, 90-cell grid and 22 wells from the MAR. Data from 46 wells sampled between April and November 2014 are included in this report. The 46 wells sampled in 2014 include 43 from the spatially distributed 90-cell grid and 3 wells from the MAR; wells from the MAR are indicated by a “U” in NAWQA Project ID number. The wells for which data are included in this report were typically about 43 to 230 ft deep (table 1–1; appendix 1) and open to the aquifer across lengths of about 8 to 40 ft (table 1–2; appendix 1).

Mississippi Embayment-Texas Coastal Uplands Aquifer Systems Principal Aquifer Study Network (metxpas1)

The Mississippi Embayment-Texas Coastal Uplands aquifer systems underlie an area of 117,000 mi^2, which includes about 7 million people in Texas, Louisiana, Arkansas, Illinois, Kentucky, Tennessee, Mississippi, and Alabama. Together, withdrawals from these aquifer systems are among the 10th largest in the United States for both public and domestic supply, with combined withdrawals in 2000 of 724 Mgal/d for public supply and 100 Mgal/d for domestic supply (Maupin and Arnold, 2010; Arnold and others, 2016a). Land use in the area overlying the Mississippi Embayment-Texas Coastal Uplands aquifer systems is primarily agricultural (34 percent) and natural land cover (60 percent) with a small percentage (6.5 percent) of urban and other developed land (Homer and others, 2015). Metropolitan areas surrounding Memphis, Tennessee, and Jackson, Mississippi are included in the aquifer area.

The Mississippi Embayment-Texas Coastal Uplands aquifers consist of thick beds of primarily unconsolidated sand with interbedded layers of silt and clay (Kingsbury and others, 2014). A regional upper confining layer, present throughout much of the study area, separates Mississippi Embayment-Texas Coastal Uplands aquifers from the overlying Mississippi River Valley Alluvial aquifer and the Coastal Lowlands aquifer system to the south. In the northern part of the study area, the aquifers are part of a thick sequence of sediments that were deposited in a broad structural trough; the aquifers generally dip toward the Mississippi River and thicken in the down-dip direction. In the southern part of the study area, the aquifers dip and thicken toward the Gulf of Mexico.

The Mississippi Embayment-Texas Coastal Uplands aquifers are recharged predominantly by the infiltration of rainfall in areas where the aquifer sediments are exposed at land surface (Kingsbury and others, 2014). In areas where groundwater withdrawals have lowered water levels, the aquifers also may be recharged by streams or the downward movement of water from the overlying alluvial aquifer and other shallow aquifers. Groundwater flows from areas of recharge to points of discharge (primarily major rivers and pumped wells) along regional flow paths that tend to follow the slope of the geologic units. In some areas, groundwater flow is affected by geologic structures, such as faults and areas of uplift, and by salt domes, particularly in parts of Texas and Louisiana.

Five regional aquifers, separated in many places by regional confining units of silt and clay, make up the aquifer system (Kingsbury and others, 2014). Two of the aquifers, the Middle Claiborne aquifer and the Lower Claiborne-Upper Wilcox aquifer, are present throughout most of the aquifer system and are the primary aquifers used for public supply. These two aquifers were sampled to characterize groundwater used for public supply in the Mississippi Embayment-Texas Coastal Uplands aquifer system.

The Mississippi Embayment-Texas Coastal Uplands aquifer systems PAS network (metxpas1; fig. 4) includes 92 public-supply wells distributed across the extent of the Middle Claiborne and Lower Claiborne-Upper Wilcox aquifers. Wells were selected using an equal-area grid that extended across 97,500 mi^2 in parts of eight states. Samples from 60 wells were collected in the Mississippi Embayment aquifer system between April and December 2014, and 32 wells in the Texas Coastal Uplands were sampled between July and September 2015. Data from the 2014 sampling effort are presented in this report. Wells in the metxpas1 sampled in 2014 were typically about 143to 950 ft deep (table 1–1; appendix 1) and had a wide range of open interval lengths (table 1–2; appendix 1).

Piedmont and Blue Ridge Crystalline-Rock Aquifer Principal Aquifer Study Network (piedpas1)

The Piedmont and Blue Ridge crystalline-rock aquifers underlie about 87,000 mi^2, which includes about 25 million people in New Jersey, Pennsylvania, Delaware, Maryland, West Virginia, Virginia, Tennessee, North Carolina, South Carolina, Georgia, and Alabama. The crystalline-rock aquifers are a significant source of water for public and domestic supply locally, and, together with the other rock types of the Valley and Ridge and the Piedmont and Blue Ridge aquifers, rank second in the Nation as a source of groundwater for private domestic supply (Maupin and Arnold, 2010; Arnold and others, 2016a). A large percentage (70 percent) of the land overlying the Piedmont and Blue Ridge crystalline-rock aquifers is forested or other undeveloped land; agricultural (17 percent) and urban or other developed land uses (13 percent) cover the remaining land area (Homer and others, 2015).

The Piedmont and Blue Ridge crystalline-rock aquifers consist of a variety of rock types such as gneiss, schist, phyllite, granite, and basalt (Chapman and others, 2013). Rocks are overlain by unconsolidated deposits called regolith, which is more permeable than the underlying bedrock and is important for the storage and transmission of water. Most recharge to these aquifers is from local precipitation. Flow in the crystalline-rock aquifers is limited to fractures; thus, individual well yields are low in these aquifers relative to well yields in other bedrock types in the region (Trapp and Horn, 1997).

The Piedmont and Blue Ridge crystalline-rock aquifers PAS network (piedpas1; fig. 5) includes 60 public-supply wells. Wells were selected using an equal area grid with a cell size of about 1,500 mi^2. Data for all 60 wells in the piedpas1 network are included in this report. The wells were typically 178 to 550 ft deep (table 1–1; appendix 1) and had a wide range of open interval lengths (table 1–1 and appendix 1).All wells were sampled between July and November 2014.

Rio Grande Aquifer System Principal Aquifer Study Network (rgaqpas1)

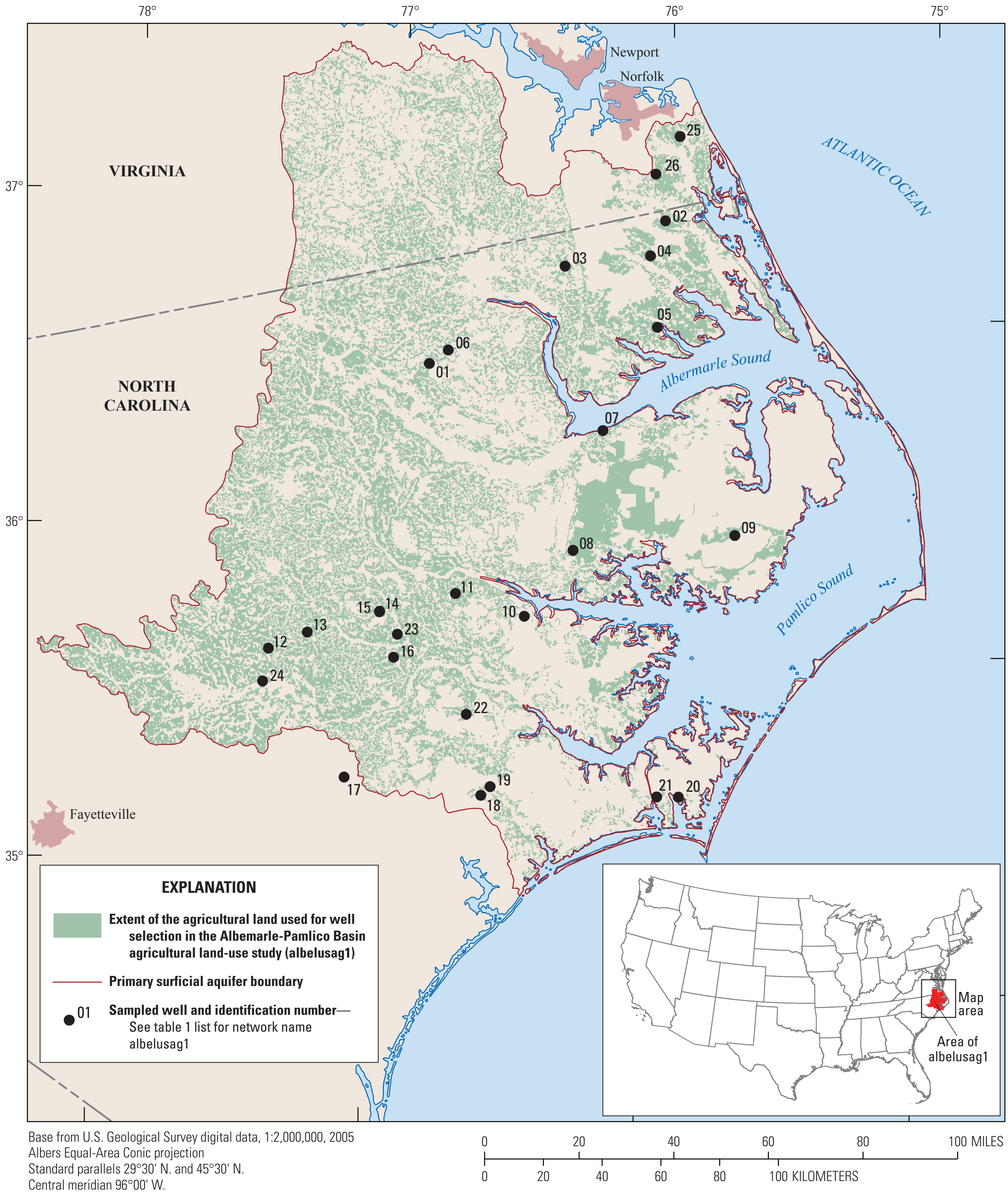
The Rio Grande aquifer system underlies an area of 29,000 square miles (mi^2), which includes about 2 million people in Colorado, New Mexico, and Texas. The aquifer system ranks eighteenth in the Nation as a source of groundwater for public supply, and about 240 Mgal/d were pumped for this use in 2000 (Maupin and Barber, 2005; Arnold and others, 2016a). Land use overlying the Rio Grande aquifer system is primarily natural land cover (93 percent), with relatively small areas of agriculture (4 percent) or urban and other developed land (3 percent) (Homer and others, 2015). The urban area of Albuquerque, New Mexico, lies within the aquifer system's overlying land.

The Rio Grande aquifer system consists of hydraulically connected basin-fill aquifers in about 20 alluvial basins that extend along the Rio Grande Valley and nearby valleys (Wilkins and others, 1980; Robson and Banta, 1995). Deposits forming the basin fill are primarily unconsolidated to moderately consolidated deposits of gravel, sand, silt, and clay of Tertiary to Quaternary age. Maximum thickness of the basin deposits within individual basins ranges widely, from as little as 2,000 ft near El Paso, Texas to as much as 30,000 ft in the San Luis Valley of southern Colorado (Robson and Banta, 1995). Groundwater in the basin-fill aquifers is generally unconfined, but confining units are present in some basins (Anning and others, 2007). As a result of the semiarid to arid climate, almost all of the precipitation that falls in the valleys is lost to evapotranspiration (Robson and Banta, 1995). Recharge is from infiltration of mountain runoff and inflow from fractured bedrock along mountain fronts and, in some basins, from stream loss from the Rio Grande and (or) crop irrigation (Robson and Banta, 1995; Bexfield and others, 2011; Thiros and others, 2014). Evapotranspiration typically is the largest natural component of discharge. Groundwater also discharges to the Rio Grande and to wells supplying water for irrigation and public supply.

The Rio Grande aquifer system PAS network (rgaqpas1; fig. 6) includes 79 public-supply wells. Sixty public-supply wells were selected using an equal-area grid of 60 cells. Parts of the region are sparsely populated, and public-supply wells are not evenly distributed across the aquifer area. Consequently, the equal-area grid was drawn within a 5,320-mi^2 area that was defined by placing 3.1-mi buffers around the existing public-supply wells. The area of each cell was about 89 mi^2. All 60 of the wells that were selected using the equal-area grid were sampled between May and October of 2014 and have data presented in this report. These wells were typically more than 500 ft deep, but most ranged in depth from 235 to 1099 ft (table 1–1; appendix 1) and were typically open to the aquifer across long intervals (table 1–2; appendix 1). An additional 16 wells and 3 springs were selected for sampling during 2015 to characterize geothermal waters and deep sedimentary brines that might contribute to—and affect the quality of—water withdrawn from public-supply wells in the Rio Grande aquifer system.

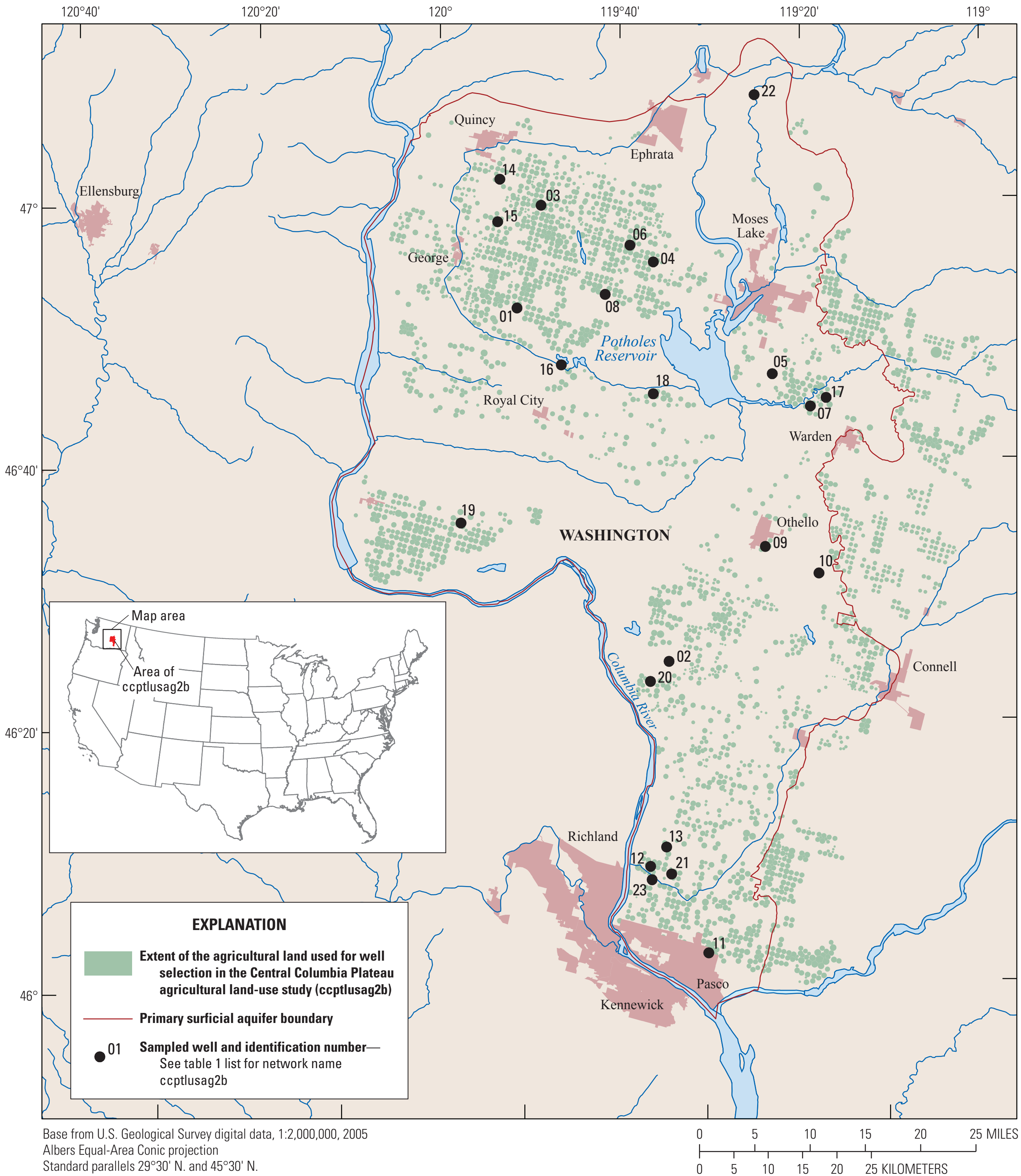
Decadal Trends Networks—Land-Use Study Networks

Land-use study (LUS) networks are designed to facilitate analysis of land-use effects on shallow groundwater quality. Wells in LUS networks are sampled once per decade to assess temporal trends in water quality. Wells in LUS networks typically are shallow and screened near the water table to allow sampling of recently recharged groundwater that may exhibit chemical characteristics indicative of the surrounding land use. The LUS areas are determined by the areal extents of the primary aquifer and a targeted overlying land use (Lapham and others, 1995). Data from the following LUS networks are included in this report: the Albemarle-Pamlico Drainage Basin agricultural LUS network (albelusag1; fig. 7); Columbia Plateau agricultural LUS network (ccptlusag2b; fig. 8); Potomac River Basin agricultural LUS network (potolusag1; fig. 9); San Joaquin Valley agricultural LUS network (sanjlusor2a; fig. 10); Western Lake Michigan Drainages agricultural LUS network (wmiclusag2; fig. 11); and White River Basin agricultural LUS network (whitluscr1; fig. 12).



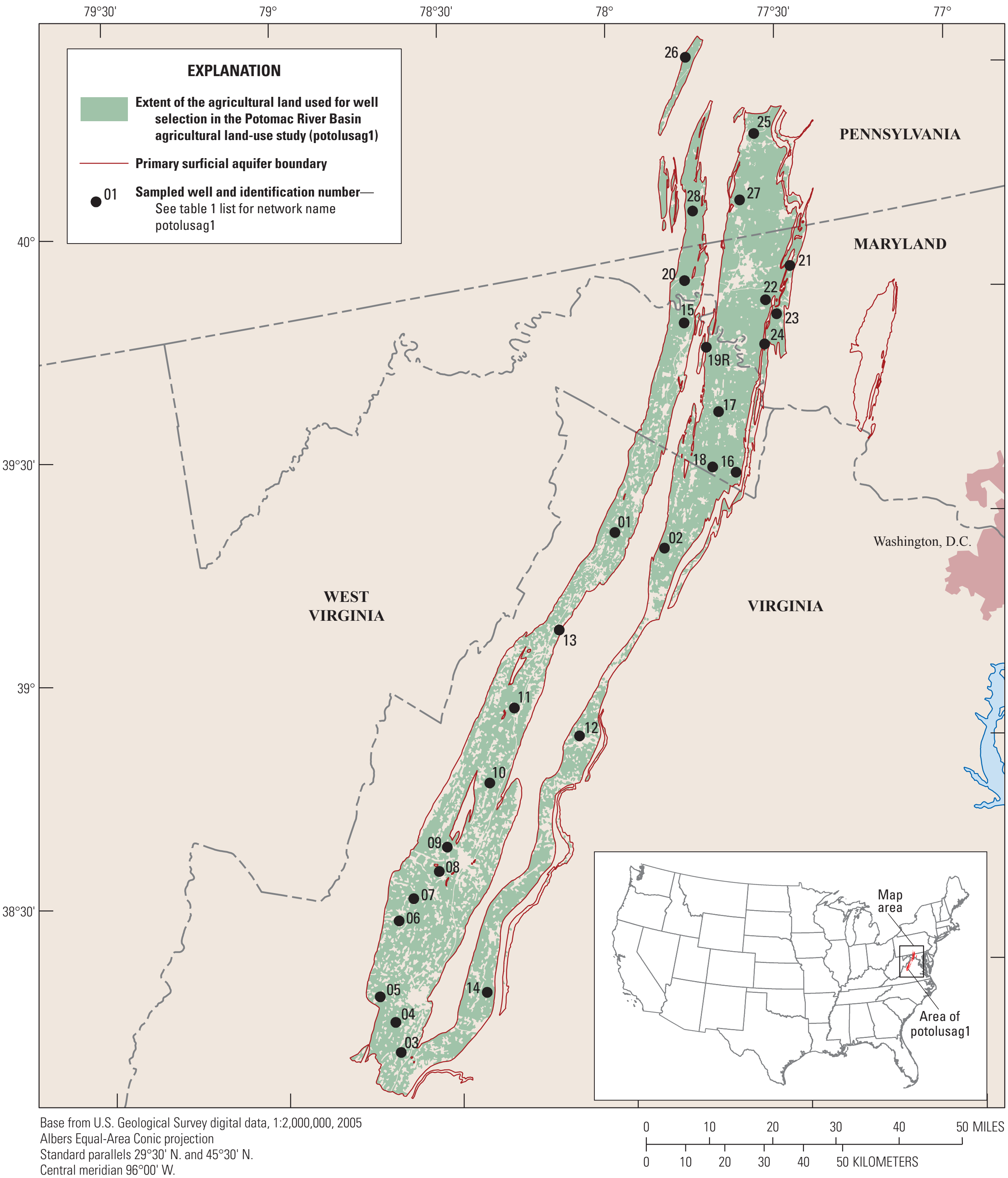
Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30′ N. and 45°30′ N.
Central meridian 96°00′ W.
North American Datum of 1983

Figure 7. Study area and wells sampled as part of the Albemarle-Pamlico Basin agricultural land-use study network (albelusag1) for the U.S. Geological Survey National Water-Quality Assessment Project, April through June 2014.



Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30' N. and 45°30' N.
Central meridian 96°00' W.
North American Datum of 1983

Figure 8. Study area and wells sampled as part of the Central Columbia Plateau agricultural land-use study network (ccptlusag2b) for the U.S. Geological Survey National Water-Quality Assessment Project, July through September 2014.



Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30' N. and 45°30' N.
Central meridian 96°00' W.
North American Datum of 1983

Figure 9. Study area and wells sampled as part of the Potomac River Basin agricultural land-use study network (potolusag1), for the U.S. Geological Survey National Water-Quality Assessment Project, June through August 2014.

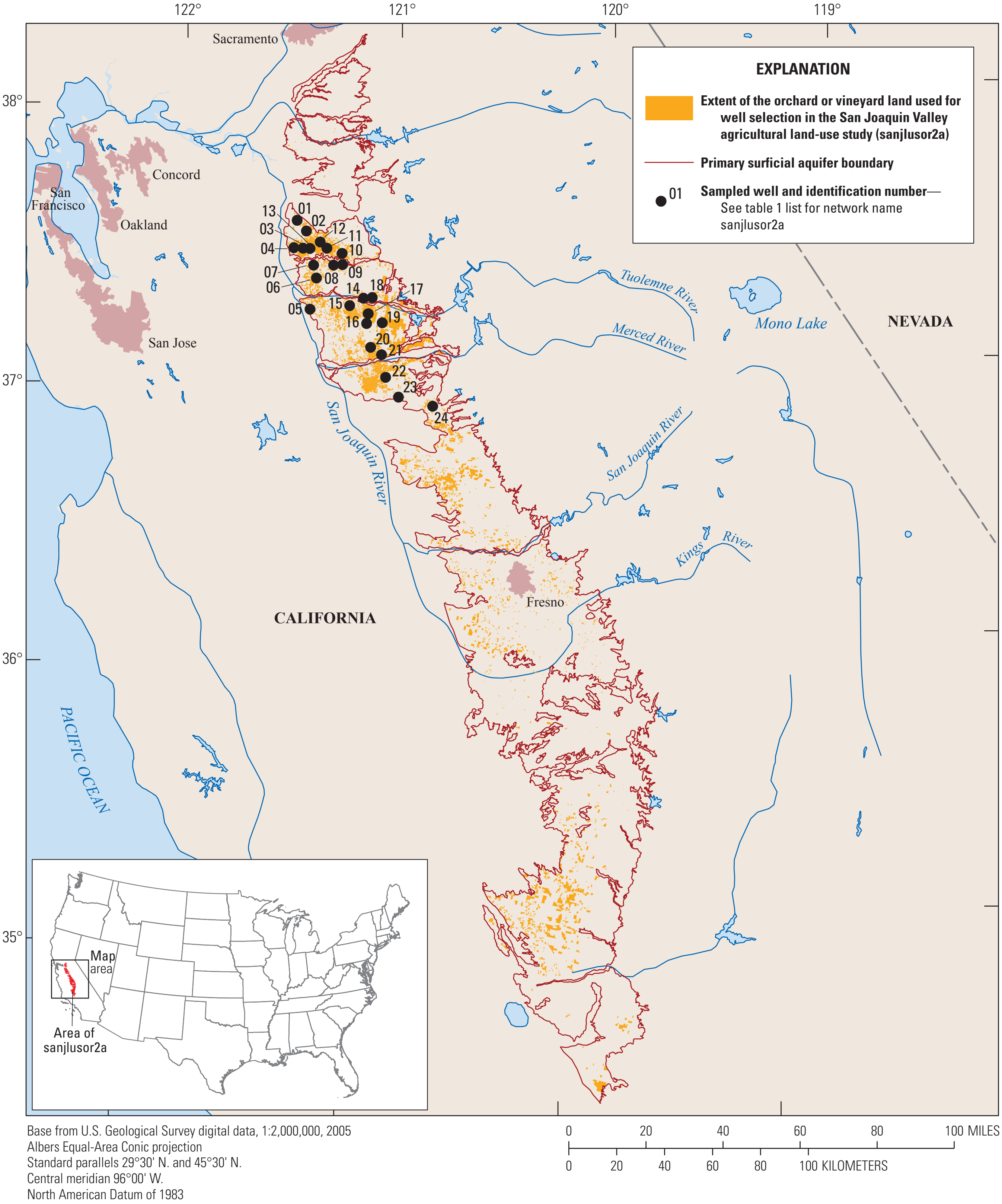
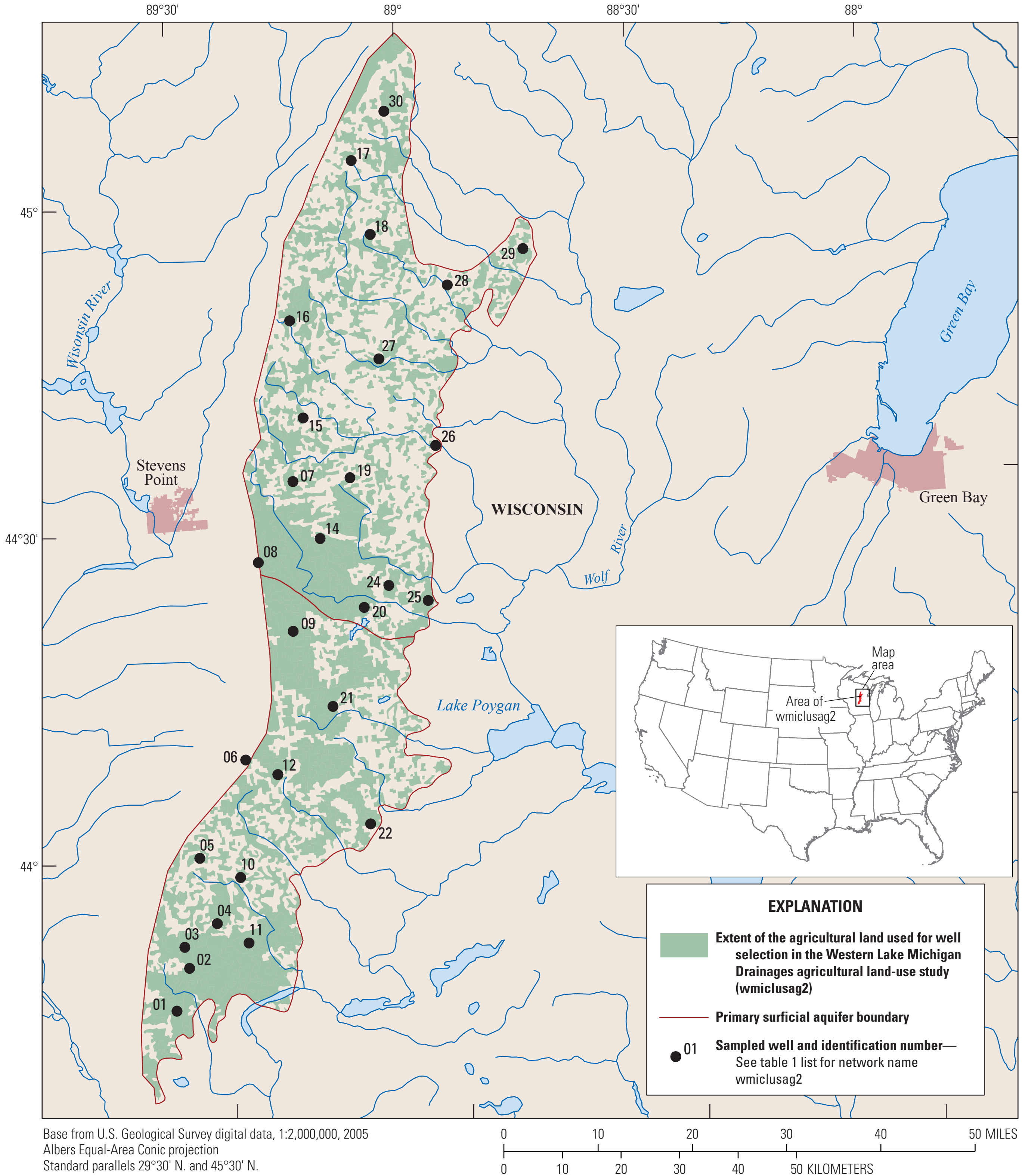


Figure 10. Study area and wells sampled as part of the San Joaquin Valley agricultural land-use study network (sanjlusor2a) for the U.S. Geological Survey National Water-Quality Assessment Project, June and July 2014.



EXPLANATION

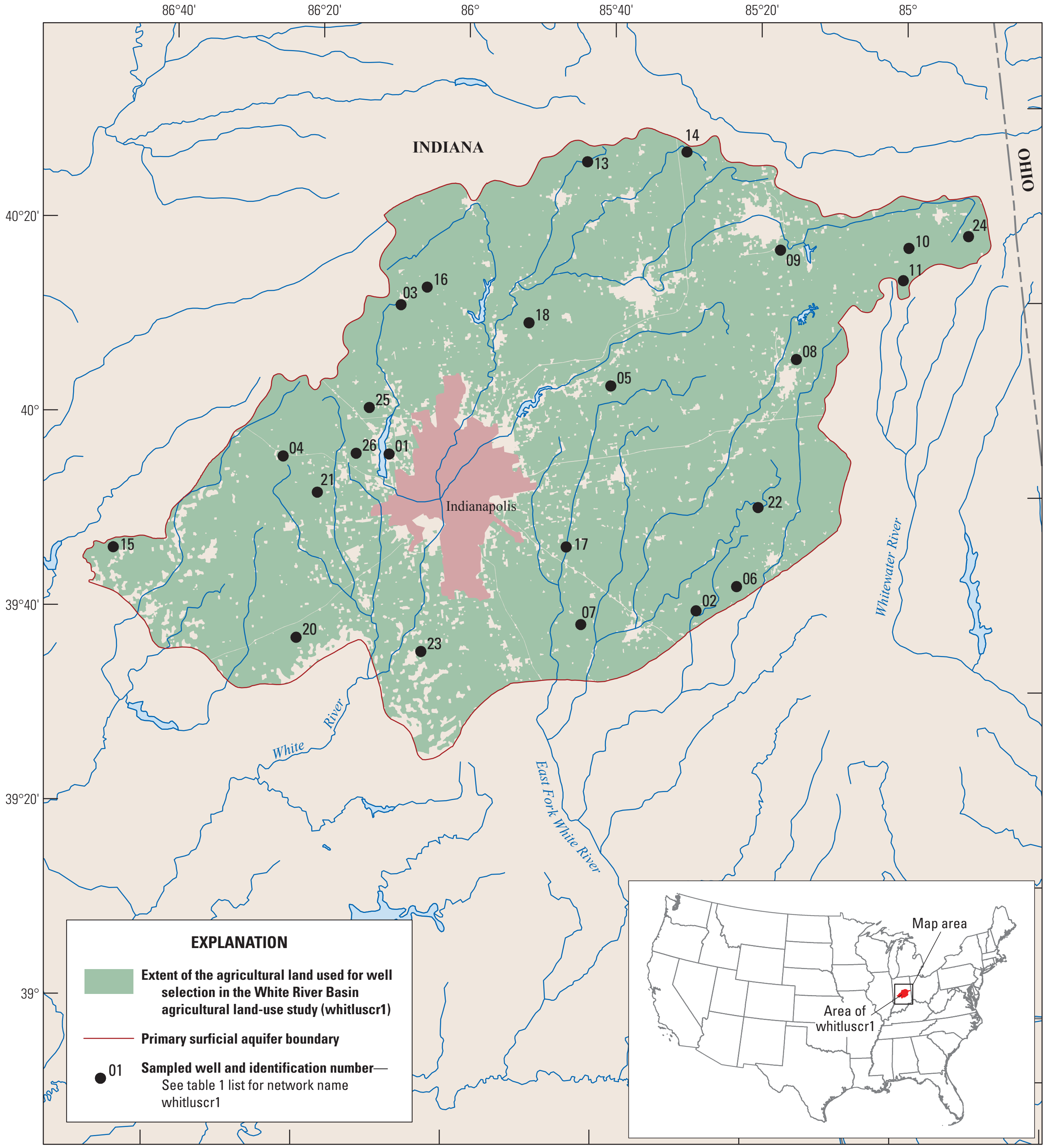
🟩 **Extent of the agricultural land used for well selection in the Western Lake Michigan Drainages agricultural land-use study (wmiclusag2)**

— **Primary surficial aquifer boundary**

● 01 **Sampled well and identification number**—See table 1 list for network name wmiclusag2

Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30' N. and 45°30' N.
Central meridian 96°00' W.
North American Datum of 1983

Figure 11. Study area and wells sampled as part of the Western Lake Michigan Drainages agricultural land-use study network (wmiclusag2) for the U.S. Geological Survey National Water-Quality Assessment Project, July 2014.



Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30' N. and 45°30' N.
Central meridian 96°00' W.
North American Datum of 1983

Figure 12. Study area and wells sampled as part of the White River Basin agricultural land-use study network (whitluscr1) for the U.S. Geological Survey National Water-Quality Assessment Project, August and September 2014.

Albemarle-Pamlico Drainage Basin Agricultural Land-Use Study Network (albelusag1)

The agricultural land-use study in the Albemarle-Pamlico Drainage Basin (albelusag1; fig. 7) was designed to characterize the effects of the intensive agriculture in this region on shallow groundwater quality. The study area of about 4,900 mi^2 includes the targeted agricultural areas in North Carolina and Virginia within the 15,000-mi^2 basin that are underlain by the surficial aquifer of the Northern Atlantic Coastal Plain aquifer system. The surficial aquifer in this area is subdivided into the Coastal Lowlands and the Middle Coastal Plain and has a mixed sediment texture (Ator and others, 2005). The Coastal Lowlands are predominantly poorly drained, shallow sediments; the Middle Coastal Plain has a mix of poorly drained, fine-grained sediments and well-drained, sandy sediments. The surficial aquifer is used for both public and private domestic supply. Crops are mainly corn, soybean, cotton, peanut, tobacco, grain, and potato. Animal agriculture includes poultry, hog, and cattle production (Spruill and others, 1998).

The albelusag1 includes 26 monitoring wells. The wells were typically about 11 to 33 ft deep (table 1–1; appendix 1), with most open intervals ranging from 3 to 9 ft (table 1–2; appendix 1). Twenty-two wells were sampled in this network in 1994 and 26 wells were sampled in 2002; however, only 15 of the wells sampled in 2014 had been sampled previously. Samples for the current phase of monitoring were collected in April through June of 2014.

Columbia Plateau Agricultural Land-Use Study Network (ccptlusag2b)

The agricultural land-use study in the central Columbia Plateau aquifer system (ccptlusag2b; fig. 8) was designed to characterize the effects of intensively irrigated row crop agricultural on shallow groundwater quality. The study area of 2,500 mi^2 is in south-central Washington and is contained within the Columbia Basin Irrigation Project area, a large-scale irrigation project through which a series of canals divert Columbia River water to a highly productive agricultural basin. The shallow aquifers in this area are unconsolidated basin-fill deposits; together with the underlying basaltic rocks, these aquifers make up the Columbia Plateau aquifer system (Whitehead, 1994).

The ccptlusag2b includes 23 monitoring wells, which were installed throughout the study area in a sand and gravel aquifer. The targeted area for well installation was the combined area (390 mi^2) served by existing (1980s) center-pivot irrigation sprinklers, buffered by 1,050 ft to include adjacent areas containing domestic-supply wells near the irrigated fields. The wells were originally installed in areas dominated by row crops such as potatoes and corn. However, the area has experienced rapid change in crop and irrigation types. Data for 23 wells are included in this report. The wells were typically 21 to 86 ft deep, with a median depth of 42 ft (table 1–1; appendix 1). The wells were typically open to the aquifer across 5- to 15-ft intervals (table 1–2; appendix 1). The ccptlusag2b network was previously sampled in 1994–95 and 2002. Samples for the current phase of monitoring were collected July through September 2014.

Potomac River Basin Agricultural Land-Use Study Network (potolusag1)

The agricultural land-use study in the Potomac River Basin (potolusag1; fig. 9) was designed to characterize shallow groundwater quality in agricultural settings overlying the Valley and Ridge carbonate-rock aquifers. The study area of about 1,600 mi^2 consists of the agricultural land overlying a 2,200-mi^2 area of these aquifers in Virginia, Maryland, West Virginia, and Pennsylvania (fig. 9). The Valley and Ridge carbonate-rock aquifers are mostly limestone and dolomite and contain solution features that allow for rapid infiltration and groundwater flow. Major agricultural land use in the area overlying the aquifers includes row crops, and dairy and poultry operations (Ferrari and Ator, 1995).

The potolusag1 includes 27 domestic-supply wells and 1 well used for irrigation. Most wells were between about 109 and 289 ft deep (table 1–1; appendix 1), and their open intervals were mostly between 26 and 281 ft (table 1–2; appendix 1). The potolusag1 network was previously sampled for the NAWQA program in 1993 and was resampled in 2002. Samples for the current phase of monitoring were collected June through August 2014.

San Joaquin Valley Agricultural Land-Use Study Network (sanjlusor2a)

The San Joaquin Valley agricultural land-use study (sanjlusor2a; fig. 10) was designed to characterize shallow groundwater quality in an almond-orchard setting of the eastern San Joaquin Valley, California. The eastern San Joaquin Valley is an area of intensive farming that also has a large urban population. The study area is located in the Eastern Alluvial Fans physiographic region, which is part of the Central Valley aquifer system and has extensive, widespread deposits of coarse-grained sediment (Burow and others, 1998; Thiros and others, 2010). The study area of about 520 mi^2 is limited to areas of almond agriculture, which is one of the major types of agriculture in the region.

The sanjlusor2a is made up of 24 domestic wells, which were mostly 116 to 224 ft deep (table 1–1; appendix 1) and generally open to the aquifer across intervals of 10 to 40 ft (table 1–2; appendix 1). The sanjlusor2a study network was previously sampled in 1994–95 and in 2001–2 (Burow and others, 1998; Thiros and others, 2014). Samples for the current phase of monitoring were collected in June and July of 2014.

Western Lake Michigan Drainages Agricultural Land-Use Study Network (wmiclusag2)

The agricultural land-use study in the western part of the Western Lake Michigan Drainages (wmiclusag2; fig. 11) was designed to characterize the effects of agricultural activities on shallow groundwater quality in the underlying coarse-grained deposits of the glacial aquifer system. The study area is about 810 mi^2 in central Wisconsin. Relatively thick (75–200 ft) glacial outwash and ice-contact deposits of mostly sand and gravel make up the aquifer in this area (Olcott, 1968; Richmond and Fullerton, 1983) and are a primary source for groundwater used in the study area. The glacial deposits are underlain by relatively impermeable Precambrian bedrock in the northern half of the study area and Cambrian-Ordovician sandstone in the southern half of the study area (Saad, 1997). The agricultural land use in the area is mostly cropland associated with dairy farming and vegetable production; however, the area also includes some Christmas tree farming, which is suited to the well-drained soils in the area (Saad, 1997).

The wmiclusag2 consists of 28 monitoring wells, which mostly ranged in depth from 22 to 85 ft with a median depth of 40 ft (table 1–1; appendix 1). The wells were open to the aquifer across 5-ft intervals with the exception of one well that was open to the aquifer across a 15-ft interval (table 1–2; appendix 1). The wmiclusag2 network was previously sampled in 1994 and 2002 (Saad, 1997; Saad, 2008). Samples for the current phase of monitoring were collected during July 2014.

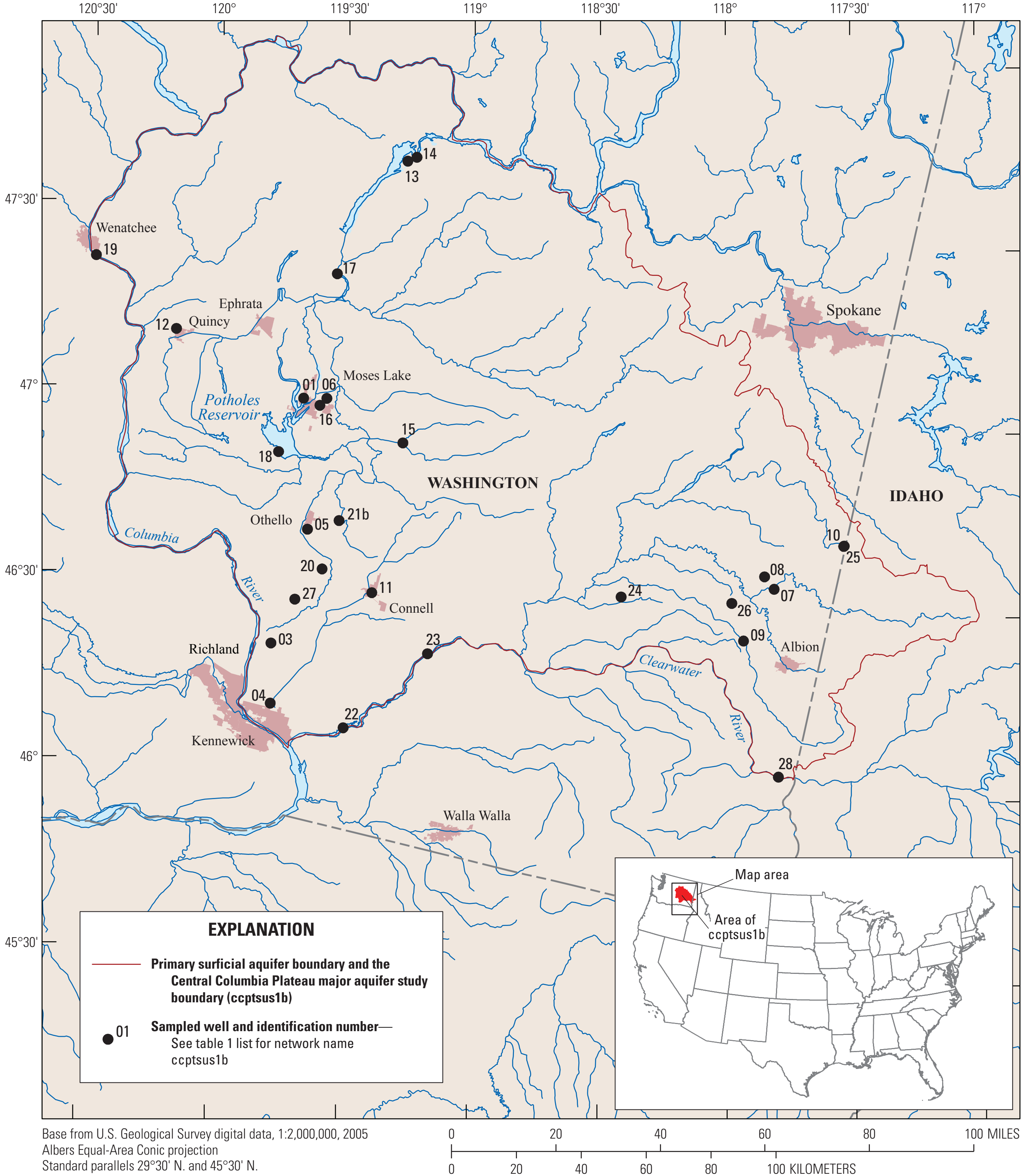
White River Basin Agricultural Land-Use Study Network (whitluscr1)

The White River Basin agricultural land-use study (whitluscr1; fig. 12) was designed to characterize the effects of agricultural activities on shallow groundwater in the till plain of the basin in central Indiana. The till plain, which covers the northern part of the basin, is generally underlain by 100 to 200 ft of silty-clay till interlayered with 5- to 10-ft-thick layers of sand and gravel. Water bearing units in the upper 50 ft of the till sequence consist of confined sand and gravel lenses that commonly do not provide sufficient yields for domestic use (Moore and Fenelon, 1996). Land use in the till plain is primarily (86 percent) corn and soybean row crop agriculture; however, the area also includes the metropolitan area of Indianapolis, Indiana (Fenelon, 1998). The study area of agricultural land use covers about 3,700 mi^2.

The whitluscr1 consists of 24 monitoring wells, which mostly ranged in depth from 19 to 42 ft with a median of 26 ft (table 1–1; appendix 1). Open intervals generally were between 5 to 7 ft (table 1–2; appendix 1). The whitluscr1 network was previously sampled in 1994 and 2002. Samples for the current phase of monitoring were collected during August and September 2014.

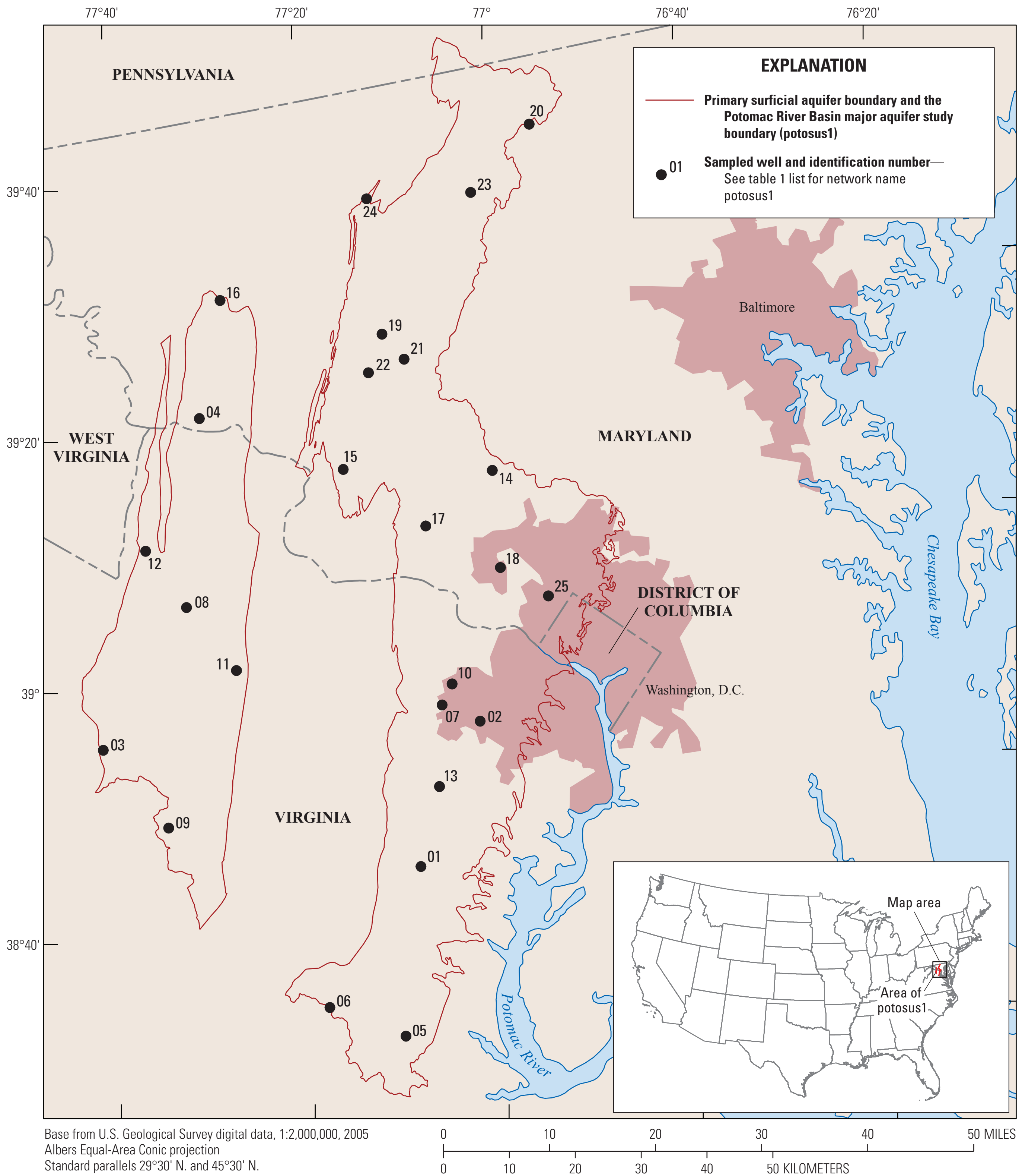
Decadal Trends Networks—Major Aquifer Study Networks

Major aquifer study (MAS) networks were designed to reflect the resource used for domestic supply. The MAS networks generally consist of domestic-supply wells but may include public-supply or other types of wells also. Domestic-supply wells typically draw groundwater from shallower depths of the aquifer than do public-supply wells. The MAS areas are determined by the areal extent of the primary aquifer and physiography and are designed to assess the condition of groundwater quality in the most heavily used aquifer in the area (Lapham and others, 1995, Koterba and others, 1995). Wells in MAS networks are sampled once per decade to assess temporal trends in water quality. Data from the following MAS networks are included in this report: the Columbia Plateau MAS (ccptsus1b; fig. 13), Potomac River Basin crystalline-rock MAS (potosus1; fig. 14), and Trinity River Basin MAS (trinsus3; fig. 15).



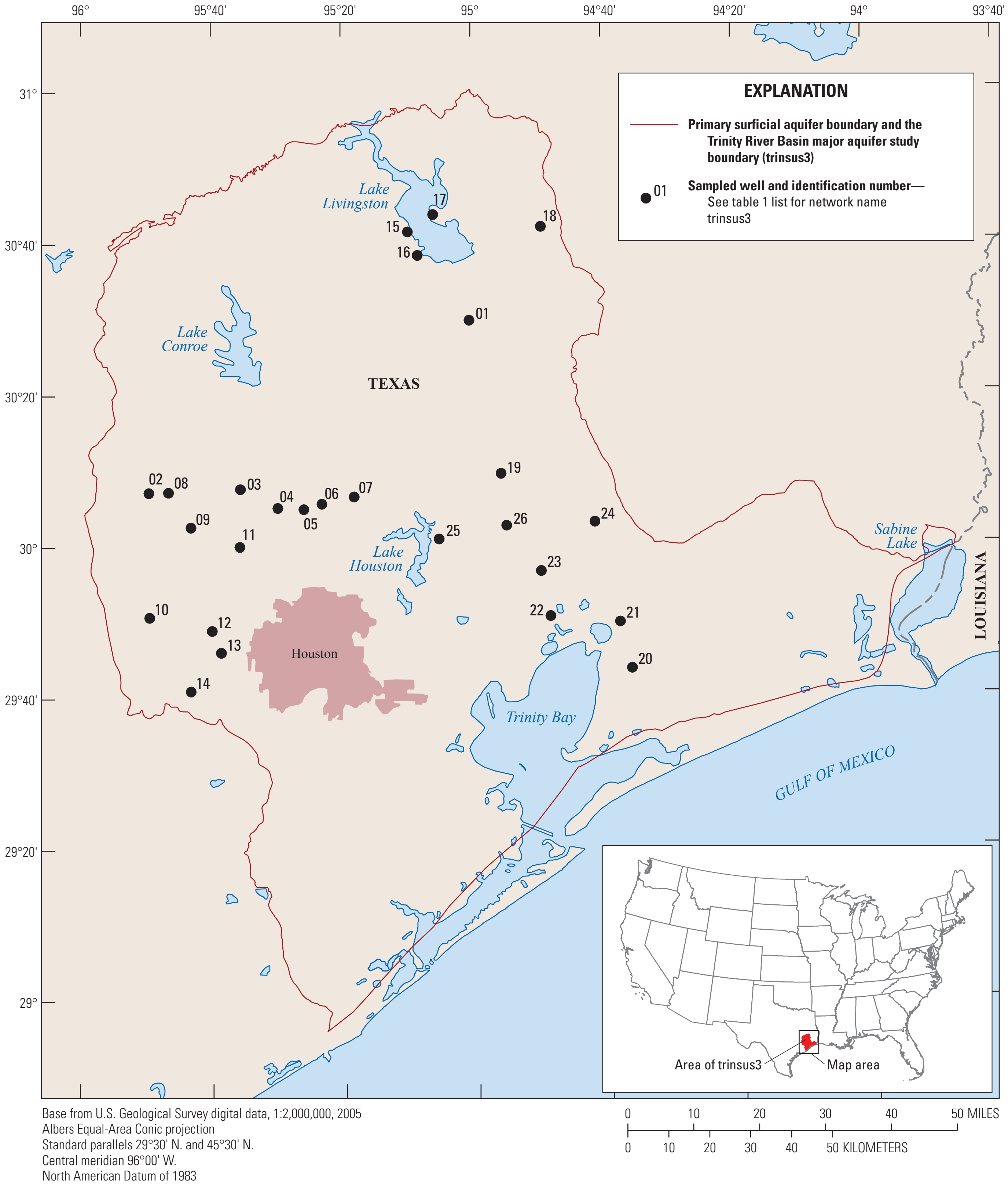
Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30' N. and 45°30' N.
Central meridian 96°00' W.
North American Datum of 1983

Figure 13. Study area and wells sampled as part of the Central Columbia Plateau major aquifer study network (ccptsus1b) for the U.S. Geological Survey National Water-Quality Assessment Project, July through September 2014.



Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30' N. and 45°30' N.
Central meridian 96°00' W.
North American Datum of 1983

Figure 14. Study area and wells sampled as part of the Potomac River Basin major aquifer study network (potosus1) for the U.S. Geological Survey National Water-Quality Assessment Project, June through November 2014.



Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30' N. and 45°30' N.
Central meridian 96°00' W.
North American Datum of 1983

Figure 15. Study area and wells sampled as part of the Trinity River Basin major aquifer study network (trinsus3) for the U.S. Geological Survey National Water-Quality Assessment Project, July through September 2014.

Columbia Plateau Major Aquifer Study Network (ccptsus1b)

The Columbia Plateau MAS (ccptsus1b; fig. 13) was designed to characterize the quality of groundwater in the basin-fill and the basaltic-rock aquifers underlying the Columbia Basin Irrigation Project area in south-central Washington. The study area of 13,000 mi^2 is located in a heavily irrigated and productive agricultural area. Agricultural activities are diverse and include numerous types of fruit orchards, row crops, and grasses (Jones and Wagner, 1995).

The ccptsus1b includes 30 wells throughout the study area in basin-fill and basaltic-rock aquifers. Data for 27 wells are included in this report (19 public-supply wells, 6 recreational-use wells, 1 industrial-supply well, and 1 unidentified well type). The wells were mostly 96 to 928 ft deep with a median depth of 220 ft (table 1–1; appendix 1). The wells have a wide range of open intervals ranging from 9 ft to more than 800 ft (table 1–2; appendix 1). The ccptsus1b network was previously sampled in 1994 and 2002. Samples for the current phase of monitoring were collected July through September 2014.

Potomac River Basin Crystalline-Rock Major Aquifer Study Network (potosus1)

The Potomac River Basin MAS network in the crystalline-rock aquifer (potosus1, fig. 14) was designed to characterize groundwater in the parts of the aquifer used for domestic supply. The potosus1 study area covers 1,800 mi^2 and is defined by the boundary intersections of the Potomac River basin and the Piedmont and Blue Ridge crystalline-rock aquifers. Aquifer characteristics are described in the Piedmont and Blue Ridge Crystalline-Rock Aquifers Principal Aquifers Study Network (piedpas1) section. The network is in suburban areas around Washington, D.C., and Baltimore, Maryland.

The potosus1 study network includes 25 wells, mostly used for domestic supply. The wells were typically about 89 to 233 ft deep (table 1–1; appendix 1), with open intervals typically ranging from about 51 to 192 ft (table 1–2; appendix 1). Twenty-five wells were sampled in this network in 1994; however, only 17 of these wells were the same as those sampled in 2014. Wells where the owners chose not to participate in 2014 were replaced with wells in the same vicinity. Samples for the current phase of monitoring were collected from June through November 2014.

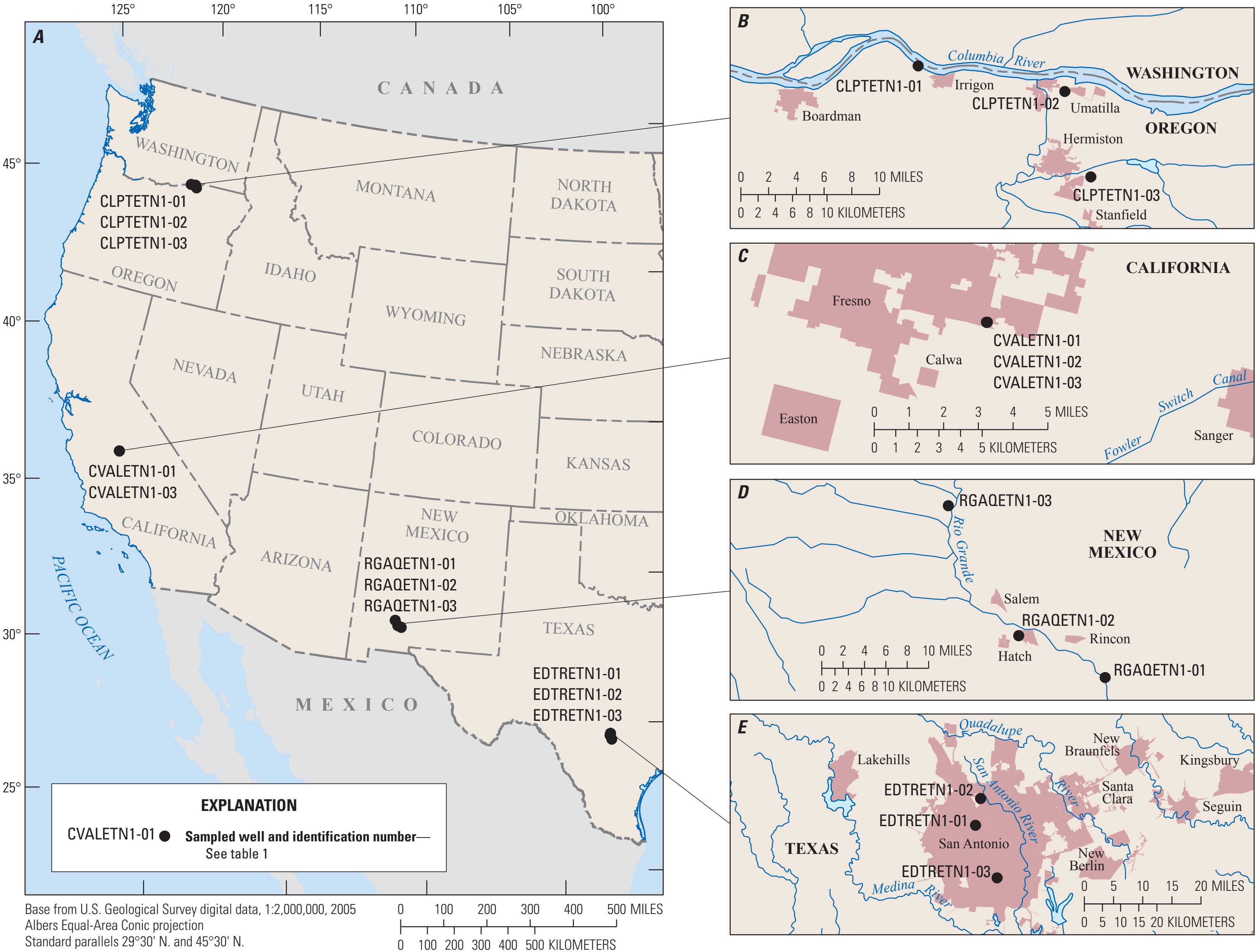
Trinity River Basin Major Aquifer Study Network (trinsus3)

The Trinity River Basin MAS network (trinsus3, fig. 15) was designed to characterize the quality of groundwater used for water supply in the outcrop area of the Chicot and Evangeline aquifers within the Coastal Lowlands aquifer system. The Coastal Lowlands aquifer system is made up of unconsolidated to partially consolidated sand, silt, and clay of Oligocene to Holocene age (Ryder, 1996; Renken, 1998). The study area for the trinsus3 network (about 9,100 mi^2) is located in the southern part of the Trinity River Basin and is constrained by the outcrop area of the Coastal Lowlands aquifer system (Reutter and Dunn, 1999).

The trinsus3 includes 30 wells. Data for 26 wells (20 domestic, 5 public supply, 1 recreational use) are included in this report. The wells typically were about 86 to 378 ft deep (table 1–1; appendix 1) and have a wide range of open intervals (table 1–2; appendix 1). The trinsus3 was previously sampled in 1994 (Reutter and Dunn, 1999) and 2002; samples for the current phase of monitoring were collected July through September 2014.

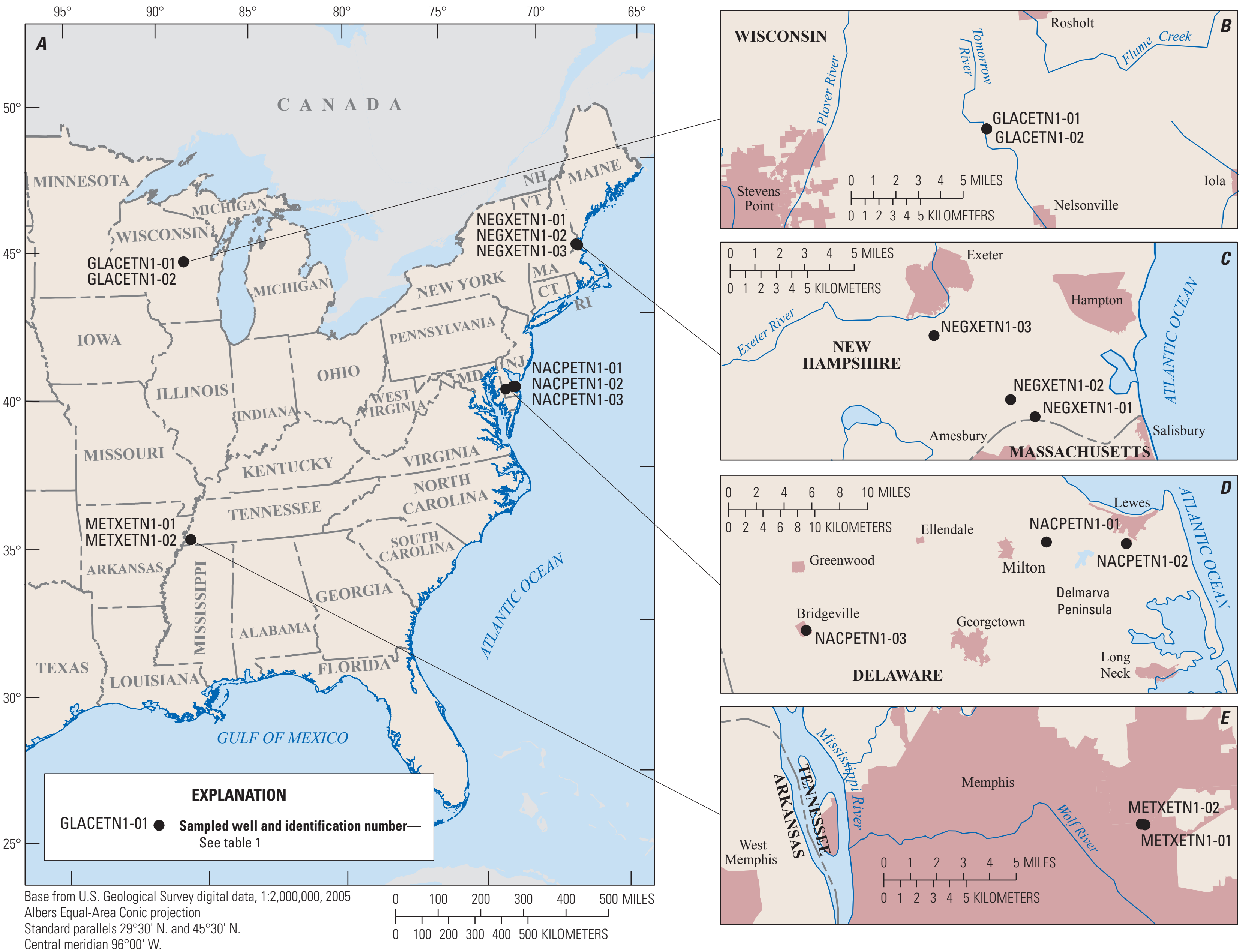
Enhanced Trends Networks

Enhanced trends networks (ETNs) consist of a small number of wells (typically two to four) that are sampled frequently to evaluate the time scales during which groundwater quality changes. Such changes might result from seasonal or annual variability in recharge, discharge, or contaminant loading (Rowe and others, 2013). Data from eight ETNs are included in this report (figs. 16-17): the Columbia Plateau ETN (clptetn1), Central Valley ETN (cvaletn1), Edwards-Trinity ETN (edtretn1), Glacial aquifer ETN (glacetn1), Mississippi Embayment ETN (metxent1), Northern Atlantic Coastal Plain ETN (nacpetn1), New England crystalline ETN (negxent1), and the Rio Grande ETN (rgaqetn1). Wells in ETNs are instrumented for high-frequency measurement of some parameters and they are periodically sampled for additional parameters. The ETN networks are divided into two groups of four networks that are sampled on a 4-yr alternating cycle. Four networks are sampled once every 2 months for 4 years, whereas the other four networks are sampled annually. After the first 4-yr period, the sampling frequency switches; the networks that were sampled every 2 months during the first period are sampled annually and the other four networks are sampled every 2 months. Data collected at a high frequency for wells in the ETNs are available on the Web; links to the data are provided in appendix 2.



Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30' N. and 45°30' N.
Central meridian 96°00' W.
North American Datum of 1983

Figure 16. *A*, Study areas and wells sampled in the western United States as part of the enhanced trends networks for the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014. *B–E*, Detail of well locations for: clptetn1 *B*, cvaletn1 *C*, rgaqetn1 *D*, and edtretn1 *E*.



Base from U.S. Geological Survey digital data, 1:2,000,000, 2005
Albers Equal-Area Conic projection
Standard parallels 29°30' N. and 45°30' N.
Central meridian 96°00' W.
North American Datum of 1983

Figure 17. *A,* Study areas and wells sampled in the eastern United States as part of the enhanced trends networks for the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014. *B–E,* Detail of well locations for: glacetn1 *B*, negxetn1 *C*, nacpetn1 *D*, and metxetn1 *E*.

Central Valley Enhanced Trends Network (cvaletn1)

The enhanced trends network in the Central Valley aquifer system (cvaletn1; fig. 16*A*, *C*) is intended to aid in the understanding of the subsurface movement of groundwater constituents (in some cases contaminants from land-use practices) between the shallow and deep parts of the aquifer system. The network is near Fresno, Calif., in the southeastern San Joaquin Valley. The site is on the Kings River alluvial fan, a topographically flat area just west of the foothills of the Sierra Nevada. The climate in the southeastern San Joaquin Valley is Mediterranean, characterized by hot, dry summers and cool, moist winters. Average annual rainfall in the city of Fresno is about 11 inches (in.), and more than 90 percent of the precipitation falls between October and April (Western Regional Climate Center, 2015). Historically, land use was predominantly agricultural but, during the last 30 years, has become increasingly urban.

The regional aquifer in the study area consists of three interconnected, unconfined alluvial layers: fluvial deposits of the Modesto and Riverbank Formations, coarse alluvium of the Turlock Lake Formations and North Merced Gravels, and finer grained continental sediments of the Laguna Formation (Marchand and Allwardt, 1981; Burow and others, 1997). The city of Fresno and its population of more than 500,000 rely almost exclusively on groundwater from this regional aquifer for water supply (City of Fresno, 2015). Groundwater flow and quality in the regional aquifer supplying Fresno are affected by human activities. Because of intensive well pumping and recharge from irrigation, groundwater flows downward rather than following the natural regional flow gradient southwest toward the axis of the San Joaquin Valley. Nitrate and the persistent soil fumigant 1,2-dibromo-3-chloropropane exceed U.S. Environmental Protection Agency (EPA) maximum contaminant levels (MCLs) in groundwater supplies in the area (Dubrovsky and others, 1998; Wright and others, 2004; Burow and others, 2007; Burton and Belitz, 2008; University of California, 2012; California State Water Resource Control Board, 2015).

The cvaletn1 is made up of three wells, two shallow and one deep, that represent different depths in the regional aquifer (table 1; table 1–1; appendix 1). Two wells (CVALETN1–03, 234 ft deep; and CVALETN1–02, 320 ft deep; table 1) are screened in the Turlock Lake Formations and the North Merced Gravels. These wells produce water that exceeds the MCLs for nitrate and 1,2-dibromo-3-chloropropane. The third deeper well (CVALETN1–01, 620 ft deep; table 1) is screened in the underlying Laguna Formation. The three wells are within about 50 ft of one another and are 3 mi west of NAWQA Project agricultural LUS wells (Burow and others, 1999). Wells CVALETN1–02 and CVALETN1–01 were sampled by the USGS Groundwater Ambient Monitoring and Assessment Program in 2005 (Burton and Belitz, 2008). All three wells in the cvaletn1 were initially sampled once or twice in 2013 as part of the cvaletn1. In 2014, for which data are included in this report, the wells were sampled bimonthly between January and December 2014, although not all three wells were sampled in all months.

Columbia Plateau Enhanced Trends Network (clptetn1)

The enhanced trends network in the Columbia Plateau aquifer system (clptetn1; fig. 16*A*, *B*) was designed to investigate questions about how groundwater quality differs between the shallow basin-fill (unconsolidated deposits) aquifers and the deeper, underlying basaltic-rock aquifers and how water quality varies along the flow paths. The network is located in the Columbia Plateau of north-central Oregon. The climate is arid to semiarid (Williamson and others, 1998). The topography reflects the gently folded and faulted volcanic terrain (Kahle and others, 2011). Agricultural land use is dominant in the area around the ETN wells; urban land use and natural land cover are subsidiary (Homer and others, 2015).

Basaltic rocks of the Columbia River Basalt Group form the primary aquifer. Overlying basin-fill deposits form a thinner, shallow aquifer that is less extensively developed than the underlying basalt aquifer. The Miocene basaltic-rock aquifers are as much as 15,000 ft thick near the center of the Columbia Plateau and are overlain by unconsolidated deposits of sand and gravel ranging from 0 to more than 300 ft thick (Kahle and others, 2011). The general movement of water in the aquifer systems is from recharge areas near the topographically high margins of the plateau toward regional drains, such as the Columbia River (Whitehead, 1994). Parts of the shallow aquifers have extensive nitrate contamination (Williamson and others, 1998; Grondin and others, 1995; Richerson, 2012).

The clptetn1 is made up of wells that represent different positions within the regional groundwater flow system at different depths (table 1–1; appendix 1). Well CLPTETN1–01 is a shallow (80 ft) domestic well in the sand and gravel aquifer. This well is adjacent to (about 300 ft from) the Columbia River and is at the distal end of the flow system in the unconsolidated basin-fill aquifer. Water quality in well CLPTETN1–01 may be affected by the Columbia River and (or) local agricultural practices. CLPTETN1–02 is a deep public-supply well (1,134 ft) with a long screened interval (500–1,134 ft), and CLPTETN1–03 is a shallow domestic well (54 ft). CLPTETN1–02 and CLPTETN1–03 were part of the clptetn1 network in 2014; however, because of issues with sample quality and sampling access these wells will no longer be included in the network after 2014

It is hypothesized that the temporal variability in chemistry of groundwater from the shallow wells in the clptetn1 network could be affected by their proximity to temporally varying boundary conditions, including river stage, irrigation, canal leakage, groundwater pumping, and recharge from aquifer storage and recovery projects. The location of one of the wells near a large river also provides an opportunity to compare and contrast the effect that a large-river boundary has on temporal variability of adjacent groundwater at different depths. The wells are located in an area similar to previously sampled wells in other parts of the Columbia Plateau aquifer system (Williamson and others, 1998). Wells CLPTETN1–01, CLPTETN1–02, and CLPTETN1–03 were sampled once in August 2014, and the data are included in this report.

Edwards-Trinity Aquifer System Enhanced Trends Network (edtretn1)

The enhanced trends network Edwards-Trinity aquifer system (edtretn1; fig. 16*A*, *E*) is designed to evaluate temporal variability in groundwater quality in a dynamic karst aquifer. The network is in the Edwards (Balcones Fault Zone) aquifer in south-central Texas. Central Texas is characterized as subhumid to semiarid, with hot summers and mild winters (Larkin and Bomar, 1983). Average annual rainfall in San Antonio is 29 in. but is highly variable (National Oceanic and Atmospheric Administration, 2014a). The aquifer is present in a narrow band along the Balcones Escarpment, below which the aquifer dips steeply to the south and southeast. Relief across the Balcones Escarpment ranges from about 100 to 500 ft. Land use is predominantly undeveloped rangeland with small amounts of agricultural and urban land. The region is prone to climatic and hydrologic extremes (Griffiths and Straus, 1985; Jones, 1991) and often cycles between very wet and very dry conditions that affect aquifer water levels, spring flow, water quality, and contaminant transport (Mahler and others, 2006; Musgrove and others, 2010, 2011; Wong and others, 2012).

The Edwards aquifer, which is the primary water supply for more than 2 million people in south-central Texas, is composed of Cretaceous-age carbonates that are extensively faulted, fractured, and karstified. The aquifer is divided into three zones: contributing, unconfined (recharge), and confined zones. Streams flowing south and east drain the contributing zone and recharge the Edwards aquifer by streamflow loss across the unconfined (recharge) zone. The confined zone is overlain by thick layers of clastic sediments. In addition to losing streams, other karst features, such as sinkholes and caves, supply recharge to the aquifer and provide direct interaction between surface water and groundwater (Sharp and Banner, 1997).

There are three wells in the edtretn1 (table 1). The wells are along an approximately north-to-south aquifer transect within the San Antonio metropolitan area (fig. 16*E*). One well is in the upgradient, unconfined recharge zone, and two wells are downgradient in the confined zone. The upgradient well (EDTRETN1–02) is 300 ft deep and open to the aquifer along the bottom 80 ft of its length (table 1–1; appendix 1). The downgradient wells are 550 ft (EDTRETN1–01) and 1,550 ft (EDTRETN1–03) deep and are open to the aquifer throughout their length below the confined zone (table 1). The furthest downgradient well (EDTRETN1–03) is close to the southern boundary of the aquifer. The wells are expected to represent a gradient of karst conditions, with greater temporal variability at the upgradient well and lower variability at the downgradient wells. The upgradient well has been sampled periodically as part of a study of groundwater quality in the urban San Antonio recharge zone of the Edwards aquifer, and data from that study are presented in Bush and others (2000). Wells in the edtretn1 were initially sampled as part of the edtretn1 in 2013 (Arnold and others, 2016a, b). In 2014, the wells were sampled approximately bimonthly from February to November 2014, and these data are included in this report.

Glacial Aquifer System Enhanced Trends Network (glacetn1)

The enhanced trends network in the glacial aquifer system (glacetn1; fig. 17*A*, *B*) was designed to identify the temporal variability and magnitude of observed changes in groundwater quality in agricultural areas of the glacial aquifer system. The glacetn1 network consists of five wells distributed in two locations: a location in central Wisconsin near the headwaters of the Tomorrow River has two wells (fig. 17*B*), and a location in southwestern Wisconsin near the community of Spring Green has three wells which were not sampled in 2014. Wisconsin has a temperate, continental climate characterized by a large annual range in air temperature and little monthly variation in precipitation. Annual precipitation, however, can vary considerably. From 1950 to 2003, annual precipitation ranged from 21 in. (1976) to 45 in. (1984), with a median and average of 32 in. (National Climatic Data Center, 2006). Spring Green, Wisconsin is a small community (population 1,628 in 2010) located in an agricultural area, predominantly dairy farms and row crops. Land use near the headwaters of the Tomorrow River is mainly forest, grassland, and row crops (Saad, 2008).

Surficial deposits in central and southwestern Wisconsin are remnants of glacial outwash and ice-contact deposits (Olcott, 1968) and are generally permeable sands or sand and gravel (Richmond and Fullerton, 1983). These deposits are typically 66 to 197 ft thick (Olcott, 1968), and, where saturated, constitute the glacial aquifer (Lapham and others, 2005). The concentration of nitrate in the glacial aquifer in agricultural areas of Wisconsin commonly exceeds the EPA MCL for drinking water (10 mg/L as N) due to applications of nitrogen for crops (Saad, 2008). Nitrate is the contaminant that most commonly causes public-water systems in Wisconsin to take corrective action to avoid exceeding drinking-water standards (Brian Austin, Wisconsin Department of Natural Resources, written commun., 2015).

The two wells in the glacetn1 near the headwaters of the Tomorrow River are a monitoring well, 34.5 ft deep (GLACETN1–02), that provides samples of recently recharged water and a second monitoring well, 83 ft deep (GLACETN1–01) (table 1–1; appendix 1), that provides samples of water that are about 36 years in age (Saad, 2008). The wells in the Tomorrow River location, GLACETN1–01 and GLACETN1–02, were sampled once in June, 2014, and these data are included in the present report. The three wells in the Spring Green location were not sampled in 2014, and data from those wells are not presented in this report.

Mississippi Embayment Aquifer System Enhanced Trends Network (metxetn1)

The enhanced trends network for the Mississippi Embayment aquifer system (metxetn1; fig. 17*A*, *E*) was designed to study how water quality in shallow and deep parts of the regional aquifer changes in response in changing hydrologic conditions and pumping. The network is at one of the water-supply facilities for the city of Memphis, Tennessee, in the north-central part of the Mississippi Embayment. Topography is gently rolling, and the climate is subtropical with an average annual precipitation of about 54 in. (National Oceanic and Atmospheric Administration, 2014b). Land use in the area is predominantly commercial and residential (Homer and others, 2015).

The Mississippi Embayment aquifer system consists of several thousand feet of sand, silt, and clay that fill a broad structural depression in the underlying bedrock (Cushing and others, 1964). The city of Memphis and surrounding municipalities rely on one of the regional aquifers in this system, the Memphis aquifer, as their primary source of water supply. The Memphis aquifer is about 500–900 ft thick and is composed primarily of sand. It is overlain by a shallow aquifer and by a confining unit, but the confining unit is thin or absent in some areas (Parks, 1990). Groundwater quality in the shallow aquifer has been affected by the overlying land use, as indicated by the presence of elevated nitrate, chloride, pesticides, and volatile organic compounds (Gonthier, 2002; Barlow and others, 2012). These contaminants have the potential to move down into the underlying Memphis aquifer (Graham and Parks, 1986; Parks, 1990; Parks and others, 1995; Clark and Hart, 2009).

The metxetn1 consists of one well in the shallow aquifer (METXETN1–02, 90 ft deep) and one well in the Memphis aquifer (METXETN1–01, 624 ft deep) (table 1–1; appendix 1). The wells are about 940 ft apart. Although groundwater does not follow a direct flow path from the shallow well to the deep well, water levels indicate that groundwater moves downward from the shallow aquifer to the Memphis aquifer through a window in the confining layer about 1.5 mi from the site (Welch and others, 2009). The shallow well produces groundwater that is typical of recent recharge to the shallow aquifer; groundwater from the deep well is currently unaffected by downward movement of shallow groundwater. The wells are within the area of a previously sampled study of the shallow aquifer underlying Memphis (miselusrc1; Kleiss and others, 2000; Gonthier, 2002), and METXETN1–02 was sampled as part of a flow path study in the Mississippi Embayment aquifer system in 2013. The wells were initially sampled as part of the metxetn1 in 2013 (Arnold and others, 2016a, b). Sampling in 2014 was approximately bimonthly between February and December 2014, and these data are included in this report.

Northern Atlantic Coastal Plain Enhanced Trends Network (nacpetn1)

The enhanced trends network in the Northern Atlantic Coastal Plain aquifer system (nacpetn1; fig. 17*A*, *D*) provides an opportunity to study the movement of contaminants downward into aquifers and the effects of recharge and pumping on the temporal variability of water quality. The network is located in the surficial aquifer of the coastal plain system in southern Delaware (fig. 17*D*). The climate is humid, with 44 in. average annual precipitation that is evenly distributed throughout the year (National Oceanic and Atmospheric Administration, 2014b). The topography in southern Delaware is flat. The primary land use in the area is agricultural, with lesser amounts of forest and urban land use (Homer and others, 2015).

The Northern Atlantic Coastal Plain aquifer system is a wedge of stacked aquifers and confining units dipping to the southeast with an extensive, unconfined surficial aquifer (Denver and others, 2014). The surficial aquifer in Delaware consists primarily of sandy and permeable Quaternary-age sediments (Ator and others, 2005). In southern Delaware, the surficial aquifer is the primary supply of drinking water for individual homes and many small towns (Maupin and Barber, 2005). Nitrate is the key contaminant of concern in these aquifers, and nitrate concentrations in groundwater and stream base flow (groundwater discharge) are among the highest in the Nation (Shedlock and others, 1999; Denver and others, 2014).

The nacpetn1 network has three wells that are located across southern Delaware in different parts of the flow system at different depths (table 1–1; appendix 1). Well NACPETN1–03 is a public-supply well, 119 ft deep, in southwestern Delaware near the center of the Delmarva Peninsula (fig. 17*D*). The well is screened in the transition zone between the surficial aquifer and the underlying Manokin aquifer, which becomes confined down-dip to the south and east. This well provides an opportunity to study the movement of contaminants between the unconfined and underlying confined aquifer. Well NACPETN1–02, 139 ft deep, also is a public-supply well, one of several supply wells for a coastal town. This well is open to the surficial aquifer and provides an opportunity to investigate the effects of nearby supply wells and seasonal pumping on the variability of water quality. Well NACPETN1–01 is a shallow monitoring well (22 ft) that is surrounded locally by agricultural land use. The effect of recharge on the variability of water quality is a question to be addressed with data from this well. Well NACPETN1–01 was previously sampled in 2002 and 2012 as part of the agricultural land-use study network (dlmvluscr1; Denver and others, 2014). All three wells in the nacpetn1 network were sampled once in 2014, in August, and these data are included in the present report.

New England Crystalline-Rock and Glacial Aquifer System Enhanced Trends Network (negxetn1)

The enhanced trends network in the New England crystalline-rock and glacial aquifer system (negxetn1, fig. 17*A*, *C*) provides the opportunity to study the temporal variability of contaminants in groundwater from geologic sources as well as contaminants from manmade sources with changing inputs. The network is located in southern coastal New Hampshire. The climate in southern New Hampshire is continental, with an average annual precipitation of about 43 in. (National Oceanic and Atmospheric Administration, 2014b). Land use in the southern part of the network area is predominantly commercial and residential; land use in the northern part of the area is more rural (Homer and others, 2015).

The crystalline-rock aquifer is hydraulically connected to the overlying glacial aquifer and both are heavily used for domestic and public supply (Stekl and Flanagan, 1992). The glacial aquifer is composed of till and stratified drift containing significant amounts of coarse-grained, ice contact and outwash deposits (Stekl and Flanagan, 1992; Flanagan and others, 1999). The underlying crystalline-bedrock aquifer is composed of metamorphosed marine sediments that are variably calcareous (Stekl and Flanagan, 1992; Ayotte and others, 2003). Concentrations of arsenic greater than the EPA MCL of 10 mg/L are known to occur in both the glacial and bedrock aquifers primarily as a result of geologic sources (Ayotte and others, 2003, 2006).

The negxetn1 network consists of three wells at different depths (table 1–1; appendix 1): two public-supply wells in the southern part of the network area (NEGXETN1–01 and NEGXETN1–02) and one domestic-supply well in the northern part (NEGXETN1–03). One public-supply well, NEGXETN1–01, is 83 ft deep and completed in glacial sediments overlying crystalline bedrock. The second public-supply well, NEGXETN1–02, is 492 ft deep and completed in the crystalline-rock aquifer. The domestic-supply well, NEGXETN1–03, is about 176 ft deep and has an open borehole in the crystalline-rock aquifer. Wells in the negxetn1 network were sampled bimonthly between March and November 2014, and these data are included in the present report.

Rio Grande Aquifer System Enhanced Trends Network (rgaqetn1)

The enhanced trends network in the Rio Grande aquifer system (rgaqetn1; fig. 16*A*, *D*) provides the opportunity to study temporal variability in the water quality of shallow groundwater affected by irrigation, river water infiltration, and variable hydrologic conditions in an arid climate. The network is in the arid Rincon Valley of south-central New Mexico. The narrow Rincon Valley is an entrenched valley of the Rio Grande that corresponds with the flood plain of the river (Anderholm, 2002; Hawley and others, 2005). Agricultural land use is dominant in the valley, although residential and urban land uses are present. A complex system of generally unlined canals delivers irrigation water diverted from the Rio Grande to agricultural fields. When drought conditions result in low surface-water allotments, groundwater commonly is pumped to supplement irrigation supplies (Moyer and others, 2013).

Most wells in the Rincon Valley are completed in the Quaternary valley fill, which generally is less than about 98 ft thick (Anderholm, 2002; Hawley and others, 2005). Shallow groundwater in parts of the valley-fill aquifer has been shown to have relatively large concentrations of total dissolved solids, nitrate, and (or) certain trace elements, including uranium (Anderholm, 2002). Total dissolved solids (salinity) is the key contaminant of concern in the area, and nitrate and certain trace elements, including uranium, also may be of concern (Anderholm, 2002; Moyer and others, 2013).

The rgaqetn1 network consists of three wells completed in the valley fill at different depths (table 1–1; appendix 1): two shallow wells that are screened across the water table (RGAQETN1–01 and RGAQETN1–03) and one deeper well (RGAQETN1–02). The wells, which are not located along a single groundwater-flow path, represent different crop types and different positions within the regional groundwater-flow system. The shallow wells yield groundwater typical of recent aquifer recharge in areas of intensive agricultural land use within the Rincon valley and likely reflect conditions in other areas of irrigated agriculture throughout the arid to semiarid Southwest. Well RGAQETN1–03 (22 ft deep), near the northern end of the valley, is in an area consisting mostly of flood-irrigated row crops including alfalfa, onions, peppers, corn, and cotton. This well is about 900 ft from the Rio Grande and may be affected by seepage from the river when surface-water flows are increased seasonally to meet demands for irrigation water. Well RGAQETN1–01 (about 23 ft deep), near the southern end of the valley, is in an area consisting largely of flood-irrigated pecan orchards. This well is immediately adjacent to a groundwater drain and about 0.5 mi from the Rio Grande, both of which likely gain water from the valley-fill aquifer throughout most or all of the year. The deep well RGAQETN1–02 (60 ft deep), used for irrigation, is in an area of transition between urban land use in the Village of Hatch and surrounding agricultural land use. All three wells are within the area of previous studies of shallow groundwater quality in agricultural areas and of groundwater used for drinking water in the Rio Grande aquifer system (Bexfield and Anderholm, 1997). The wells were sampled as part of the rgagetn1 network once in 2014, in June, and these data are included in the present report.

Sample Collection and Analysis

Data from analysis of samples collected January through December 2014 are available in Arnold and others (2017). During that time period, samples were collected for environmental assessment and quality assurance from 559 wells (fig. 1; table 1). Groundwater samples were collected and processed using methods designed to yield samples that were representative of environmental conditions, minimally affected by contamination, and consistent nationwide (Koterba and others, 1995; Lapham and others, 1995, U.S. Geological Survey, variously dated). All samples were collected at the wellhead (the point at which the groundwater exits the well near land surface) or as close to the wellhead as possible. This location is selected so that samples are collected before any treatment or blending potentially could alter constituent concentrations. Samples were collected and processed using prescribed protocols described in Koterba and others (1995), Lapham and others (1995), and the USGS National Field Manual (U.S. Geological Survey, variously dated). Samples were analyzed at the USGS National Water-Quality Laboratory in Denver, Colorado, for all constituents except four radionuclides and two constituents of special interest: perchlorate and hexavalent chromium. The radionuclide constituent concentrations (lead–210, polonium–210, radium–224, and radium–226) were analyzed by TestAmerica in Richlands, Washington. Perchlorate concentrations were analyzed by Weck Laboratories, Inc. in Industry, California. Hexavalent chromium (chromium (VI)) concentrations were analyzed by the USGS Trace Metal Laboratory in Boulder, Colo.

Groundwater samples were analyzed at the USGS National Water-Quality Laboratory for water-quality indicators, nutrients and dissolved organic carbon, major and minor ions, trace elements, VOCs, pesticides, and radiochemistry, and one item of special interest, arsenic speciation (Arnold and others, 2017). The constituents for which samples were collected are listed in table 2 of Arnold and others (2017) and are organized by constituent class; constituent primary uses and sources; analytical schedules and sampling period; analytical method references; USGS parameter codes; comparison thresholds; reporting levels; number of analyses, detections, and detections above the reporting level; and the table in which the data for the constituent class are shown. Analytical schedules are groups of constituents for which laboratory analysis is requested. The USGS parameter code identifies the constituents and indicates the laboratory method used to analyze the samples. The reported concentration of a constituent can be evaluated using the comparison threshold value. Of the comparison thresholds listed in table 2 of Arnold and others (2017), only the secondary maximum contaminant level is not health-based.

In addition to discrete water-quality samples that are collected periodically, the ETN wells also are instrumented to measure basic water-quality parameters at a high frequency during specific periods throughout each day. Each well is instrumented with a water-quality sonde that contains temperature, conductance, pH, and dissolved oxygen probes. Some wells also are instrumented to measure nitrate. The sonde sits in a flow-through chamber that receives groundwater flow from near the wellhead. Measurements of the basic water-quality parameters are made when the well is pumping and groundwater is flowing through the system, which may range from 1 to 24 hours per day. Water-quality data are recorded by the sonde at different intervals, from 2 minutes to 12 hours, depending on the network. The water-quality data are transmitted to a data collection platform where the data are stored and transmitted to the USGS National Water Information System Web (U.S. Geological Survey, 2016) database by the Geostationary Operational Environmental Satellite network. The high-frequency data are reviewed, corrected, and approved according to recommendations for publishing continuous water-quality records (Wagner and others, 2006).

Data Reporting

Several conventions are used for the constituent concentrations that are reported as not detected in water-quality samples (censored data or concentrations that are reported by the laboratory as “less than” a specified value). Inorganic constituents (major ions, nutrients, and trace elements) are reported using long-term method detection levels (LT–MDL) as the reporting levels. The LT–MDL is the smallest concentration that can be measured and reported with 99-percent confidence that the concentration is greater than zero (Childress and others, 1999). The LT–MDL is similar to a method detection level (MDL; U.S. Environmental Protection Agency, 2015), with the added characteristic that it is determined from statistical analysis of laboratory quality-control (QC) data during an extended period (Bonn, 2008). Organic constituents (VOCs and pesticides) are reported using laboratory reporting levels (LRLs). An LRL for a constituent is typically about twofold greater than the LT–MDL and is defined as the concentration at which the chance of a false negative error is 1 percent (Childress and others, 1999). In other words, there is 99-percent confidence at the LRL that a constituent has been correctly reported as absent.

The LRL is more protective than the LT–MDL against the chance of false negative errors—that is, the chance of incorrectly reporting that a constituent is absent in a water sample when it actually is present. The LT–MDL is defined in terms of false positive errors. For concentrations near the LT–MDL, the chance of incorrectly reporting that a constituent is present in a water sample when it is actually absent is 1 percent; however, the chance of a false negative error (incorrectly reporting that the constituent is absent when it actually is present) at the LT–MDL is 50 percent. In contrast, the LRL has a 1-percent chance of a false negative error. In other words, if a value is reported as less than an LRL, there is only a very small chance that it is present at a concentration greater than the LRL, whereas if a value is reported as less than an LT–MDL, there is a 50-percent chance that it is present at a concentration near but above the LT–MDL. The LRLs are used for reporting analytical results for VOCs and pesticides to allow for the robust analysis and interpretation of detection frequencies. The National Water-Quality Laboratory uses information-rich analytical methods such as gas chromatography or high-performance liquid chromatography for these constituents and often provides results that indicate the presence of these constituents at concentrations less than their LRLs.

A few constituents (for example, nitrate plus nitrite) are reported using MDLs or minimum reporting levels. The MDLs are calculated according to the EPA definition of an MDL, described previously, as the minimum concentration of a substance that can be measured and reported with 99-percent confidence that the value is above zero (Patton and Kryskalla, 2011; U.S. Environmental Protection Agency, 2015). A minimum reporting level is a reporting level that is chosen by the laboratory, but it is not necessarily associated with any specific method of determination or statistical certainty (Bonn, 2008).

Radionuclides are reported using units of radioactive activity (picocuries per liter) rather than concentration. Reporting levels for these constituents are based on the sample-specific critical level (ssL_c) or sample-specific minimum detectable concentrations (ssMDCs) (McCurdy and others, 2008). The ssL_c and ssMDC are calculated for each sample from parameter values used during the actual analysis of the sample. The ssL_c and ssMDC are analogous to the LT–MDL and LRL, respectively. The ssL_c is defined as the smallest measured activity that indicates detection of the radionuclide, with no more than a 5-percent chance of a false positive detection (U.S. Environmental Protection Agency, 2004). The specified probability associated with a critical level can vary, but it is typically 5 percent for radionuclides. Like the LT–MDL, the ssL_c is a reporting level that is based on a specified probability of false positive errors—that is, incorrectly reporting that the radionuclide is present when it is actually absent. The ssMDC, like the LRL, is a reporting level that is based on a specified probability of false negative errors—that is, failing to report that the radionuclide is present. The ssMDC is defined as the activity at which there is 5-percent chance of a false negative error and typically about twofold larger than the ssL_c (McCurdy and others, 2008).

The analytical methods for pesticides and VOCs in schedules 2437, 4436, and 4437 (table 2 of Arnold and others (2017)) are new methods that were still in the process of USGS approval when samples were analyzed. Results for laboratory methods that are unapproved generally are not made available to the public by the USGS, because the quality of the results could be affected by problems subsequently discovered during the process of method approval. For schedules 2437, 4436, and 4437, the method approval process revealed no substantial problems and resulted in no changes in the analytical process (Duane Wydoski, U.S. Geological Survey, written commun., 2015), thus indicating that the data reported before approval for these methods were of sufficient quality for public release. However, LRLs for individual compounds may be adjusted when additional QC data for the method are obtained and examined. The data from schedules 2437, 4436, and 4437 are reported relative to interim reporting levels, which are similar to LRLs. The analytical methods for pesticide schedule 2437 (Sandstrom and others, 2016), and VOC schedules 4436 and 4437 (Rose and others, 2016), were approved and published in 2016.

Concentration values below LT–MDLs, and concentration values between LT–MDLs and LRLs, are reported without any qualifiers in this report. Values below LT–MDLs or between LT–MDLs and LRLs can be identified by comparing the reported concentrations with the LT–MDLs and LRLs listed by compound in table 2 of Arnold and others (2017). It is important to note that there is greater uncertainly associated with values less than LT–MDLs (regarding risk of false positive errors or inaccurate detections) and with values less than LRLs (regarding risk of false negative values or inaccurate nondetections) than with values that are greater than LT–MDLs, LRLs, or both.

The data presented in this report and associated data release (Arnold and others, 2017) are current as of the date of retrieval (July 1, 2016) from the National Water Information System (NWIS; U.S. Geological Survey, 2016). However, results for individual constituents (also called parameters) may be changed at a later date to correct a previously undetected error or to reflect improved information about the performance of a laboratory method. For example, laboratory reporting limits may be adjusted when additional quality-control data for the method are examined. The well information and water-quality data presented in this report and the associated data release were reviewed by USGS Water Science Center personnel and subsequently verified by coauthors that are responsible for tracking the data.

Quality-Assurance and Quality-Control Methods

The quality-assurance plan for NAWQA Project groundwater samples was derived from previous NAWQA Project cycles of study (Koterba and others, 1995) and the USGS National Field Manual (U.S. Geological Survey, variously dated). About 14 percent of samples collected during any period are for data quality assurance and QC. Types of QC samples include equipment blanks, source solution blanks, field blanks, replicates, field spikes, and laboratory spikes.

Data and results from statistical analysis of blank, replicate, and spike (except pesticide spikes) QC samples are presented in appendix 4.

Blanks are used to test for bias from an unintentional introduction of contamination to environmental samples. Equipment blanks are used to test whether equipment is clean and free of contamination. Source solution blanks are used to test whether the water used for the blank sample is free of contamination. Field blanks are used to test for contamination that may be introduced during sample collection, processing, handling, and analysis. Field blanks also are used to test for contamination from the environment around where the sample was collected. Replicates are samples that are collected at the same time and using the same method as the environmental sample. Replicates measure the variability of determining a concentration in samples that should be essentially identical. Spiked samples are used to measure the performance of analytical methods on an environmental water sample. A sample can be spiked in the field or the laboratory.

The number and type of QC samples planned for each network study depend on the number of wells sampled, the number of sampling teams that are involved in the sampling, and the constituents for which samples will be analyzed as described in the following criteria:

- Equipment blanks are collected for nutrients, trace elements, and VOCs at the quantity of one blank for each team sampling the network.

- Source solution blanks are collected for nutrients, trace elements, and VOCs at the quantity of one blank for each team sampling the network. The VOCs have additional source solution blanks that are collected with each field blank.

- Field blanks are collected for major ions, nutrients, dissolved organic carbon, trace elements, and pesticides at the quantity of 1 blank for every 15 wells sampled or 1 blank for each team sampling the network (whichever results in a greater number of blanks). Field blanks are collected for VOCs at the quantity of 1 blank for every 10 wells sampled or 1 blank for each team sampling the network (whichever results in a greater number of blanks).

- Replicate samples are collected for major ions, nutrients, dissolved organic carbon, trace elements, VOCs, and radionuclides at the quantity of 1 replicate for every 30 wells sampled. Replicate samples are collected for pesticides at the quantity of 1 replicate for every 15 wells.

- Field spikes are collected for pesticides at the quantity of 1 spike sample for every 30 wells sampled.

- Laboratory spikes are collected for VOCs at the quantity of 1 spike sample for every 30 wells sampled.

Statistical analysis of QC sample data can be used to evaluate the variability or bias of the data, sampling and sample handling procedures, and laboratory and (or) field methods; and to ensure the environmental assessment samples represent true groundwater chemistry. The QC sample data provided in this report (appendix 4) and in Arnold and others (2017) include water quality for all blank and replicate QC samples collected between January and December 2014 in association with the environmental sample data. Data from the environmental and QC blank and replicate samples from the 2012–13 sampling period are presented in Arnold and others (2016a, b). Data from spike QC samples have not previously been published. Data from VOC spike QC data from May 2012 to December 2014 are published in this report (appendix 4) and in Arnold and others (2017) along with an analysis of QC data where detections in field blank samples, variability in replicate samples, and recoveries in VOC spike samples are described for the entire sampling period through the date covered in this report (May 2012–December 2014).

Groundwater-Quality Data

Groundwater samples were collected at 559 wells between January and December 2014 (table 1). Samples were analyzed for about 385 constituents (table 2 of Arnold and others, 2017); however, not all wells were sampled for all constituents. Results of analyses are presented in tables 3 through 12 of Arnold and others (2017), which are organized by constituent class: water-quality indicators (table 3); nutrients and dissolved organic carbon (table 4); major and minor ions (table 5); trace elements (table 6); VOCs (tables 7); pesticides (table 8); radiochemistry (table 9); and special-interest constituents, including arsenic speciation (table 10), chromium (VI) (table 11), and perchlorate (table 12). The constituents for which samples were analyzed and the table in which the data are presented are listed in table 2 of Arnold and others (2017). Comparative benchmarks (thresholds) listed in that table provide context for evaluating the constituent concentration data in terms of human health and other characteristics relevant for drinking-water use. Several types of thresholds are listed. The EPA MCLs are legally enforceable drinking-water standards that specify the maximum permissible level of a constituent that can be delivered to a user of a public water system. The EPA Human-Health Benchmarks for Pesticides (HHBPs) are nonenforceable screening levels for evaluating if a pesticide concentration in drinking-water sources may indicate a potential human-health risk (U.S. Environmental Protection Agency, 2012). The HHBPs include benchmarks for cancer and noncancer health effects (U.S. Environmental Protection Agency, 2013). The USGS Health-Based Screening Levels are nonenforceable benchmarks for constituents that do not have MCLs or HHBPs that can be used to evaluate if constituent concentrations may indicate a potential human-health concern (Toccalino, 2007; Toccalino and others, 2014). Like EPA

HHBPs, USGS health-based screening levels are categorized in terms of cancer and noncancer health effects.

The groundwater-quality data from January to December 2014 are presented in the format of tab-delimited ASCII text files and are available for download from Arnold and others (2017) along with complete metadata that describes the contents of each file. In addition to the complete metadata, each data file includes header lines that describe the source of the file. Header lines in the data files are indicated by the pound symbol (#), and the last line of the header is numbered. The first line after the header contains the column names for the tab-delimited data columns. The data may be imported into spreadsheet, database, or statistical software for manipulation and analysis. The data available from Arnold and others (2017) are referenced as tables 1 through 12 and appendix tables 4–7 through 4–27 in this report.

Water-Quality Indicators

Water-quality indicators include water temperature, dissolved oxygen, specific conductance, pH, alkalinity, carbonate and bicarbonate (calculated from alkalinity), and turbidity (table 3 of Arnold and others, 2017). Water-quality indicators are measured in the field when the other water samples are collected (U.S. Geological Survey, variously dated), and pH and specific conductance are sometimes also measured in the laboratory.

Water-quality indicators provide basic information about the general quality and geochemical conditions of the water. Dissolved oxygen is the concentration of oxygen dissolved in the water and is an indicator of reduction-oxidation (redox) conditions in the aquifer. Measurements of pH indicate the acidity or basicity of water. Dissolved oxygen and pH are important controls on the chemical reactions that can occur in water. Specific conductance is a measure of how well the water conducts electricity and indicates the relative amount of dissolved solids in the water. Alkalinity, carbonate, and bicarbonate indicate the hardness of water and are related to pH. Turbidity is a measure of the suspended solids in the water.

Inorganic Constituents

Inorganic constituents are most often naturally present in groundwater. Groundwater samples were analyzed for the following inorganic constituent classes: major and minor ions, nutrients and dissolved organic carbon, and trace elements (including metals; tables 4–6 of Arnold and others, 2017).

Nutrients include nitrogen and phosphorus compounds and dissolved organic carbon. Data for ammonia, nitrite plus nitrate, nitrite, total nitrogen, and phosphorus measured as orthophosphate are presented in table 4 of Arnold and others (2017). Nutrients are present naturally, but nutrient concentrations also are affected by human activities such as farming and wastewater disposal (Hem, 1992). Nitrogen was measured as total nitrogen and as the individual nitrogen species of nitrite, nitrate, and ammonia. Nutrient concentrations can affect the quality of groundwater for use as drinking water.

Major and minor ions are cations and anions that can be dissolved in water from geologic materials. Concentrations of major and minor ions can be used to classify water into different types (Hem, 1992; Hiscock, 2005). Waters with similar ion concentrations often have similar history, recharge areas, climate, mineralogy, and residence time (Güler and others, 2002). Some major ions can affect the quality of water for drinking and other uses. Groundwater samples were analyzed for 10 major and minor ions and total dissolved solids (table 5 of Arnold and others, 2017).

Trace elements consist of metals that are usually present in the environment in very small quantities (Hem, 1992). Trace elements often are dissolved in water from geologic materials, but concentrations of these elements also can be affected human activities such as mining. Many trace elements can affect the quality of groundwater for use as drinking water. Groundwater samples were analyzed for 22 trace elements (table 6 of Arnold and others, 2017).

Organic Compounds

Organic compounds are manmade chemicals and include VOCs and pesticides. VOCs are chemicals that tend to evaporate into the air and are found in a variety of substances including disinfectants, solvents, paint, fumigants, asphalt, and fuel additives (Zogorski and others, 2006). Pesticides are chemical compounds used to control plant or insect pests and include fungicides, herbicides, and insecticides (Gilliom and others, 2006). Many VOCs and pesticides, if present, can affect the quality of groundwater used for drinking water. Groundwater samples from 2014 were analyzed for 85 VOCs and 227 pesticides (tables 7 and 8 of Arnold and others, 2017).

Radiochemistry

Radiochemical constituents include radionuclides and measurements of radioactivity. Radionuclides are chemical constituents that are produced naturally by the decay of radioactive parent elements such as uranium and thorium. Sources of radionuclides in groundwater are geologic material such as rocks and soils (Hem, 1992). Radionuclides and measurements of radioactivity included in this report are alpha radioactivity, beta radioactivity, radon (a dissolved gas), several isotopes of radium (radium-224, radium-226, and radium-228), polonium-210, and lead-210 (table 9 of Arnold and others, 2017). Uranium also is a radionuclide, but it typically is measured in units of mass concentration rather than as units of radioactive activity. Therefore, uranium is included with trace elements (table 6 of Arnold and others, 2017). In total, groundwater samples were analyzed for eight radionuclides and measures of radioactivity.

Constituents of Special Interest

Several constituents of special interest were included for selected networks. Constituents of special interest were arsenic species (arsenate, arsenite, monomethylarsonate, and dimethylarsinate) which are derived from arsenic, hexavalent chromium (chromium (VI)), and perchlorate (tables 10–12 of Arnold and others, 2017). Arsenic and chromium are predominantly natural in origin but may have localized anthropogenic sources. Anthropogenic arsenic uses include metal and ore processing, glass production, fossil fuel combustion, wood preservatives, pesticides, semiconductor production, and pharmaceuticals (Garelick and others, 2008). Hexavalent chromium is chromium in the +6 oxidation state (six electrons lost from the atom) and is used in textile dyes, wood preservation, anticorrosive agents and other surface coatings (Nriagu and Niebor, 1988). Geochemical conditions such as redox and pH affect the speciation of chromium and arsenic in groundwater (Hem, 1992). Most arsenic and chromium in groundwater is from geologic sources in rocks and soils. Perchlorate is an inorganic constituent used in rocket fuels, fireworks, safety flares, and other products; it is present in some fertilizers and may occur naturally at low concentrations in groundwater (Srinivasan and Sorial, 2009; Jackson and others, 2015).

Summary

As part of the third decadal cycle of the U.S. Geological Survey National Water-Quality Assessment (NAWQA) Project, groundwater-quality data are being collected from well networks to assess water-quality conditions in the Nation’s principal aquifers and investigate changes in groundwater-quality conditions in selected land use and hydrogeologic settings. Groundwater-quality data are published in annual data series reports, of which this report is the second in the series.

During the period January through December 2014, 559 wells were sampled. Groundwater-quality data were collected from four types of well networks: principal aquifer study networks, land-use study networks, major aquifer study networks, and enhanced trends networks. Within principal aquifer, land-use, and major aquifer study networks, study areas were divided into equal-area grids and wells were selected for sampling using a stratified random sampling design. The number of wells in principal aquifer networks ranged from about 46 to 80 wells per network or aquifer for the studies included in this report. About 30 wells typically made up each land-use or major aquifer study network. Enhanced trends networks that were sampled in 2014 consisted of two to three wells that were selected at locations within aquifers where temporal changes in groundwater quality might be expected.

Groundwater samples were analyzed for water-quality indicators and constituents, including nutrients, major and minor ions, trace elements, volatile organic compounds, pesticides, radiochemistry, and select special-interest constituents such as arsenic speciation, hexavalent chromium, and perchlorate. These groundwater-quality data are tabulated in this report. Quality-control samples were collected along with environmental samples, and data from blank, replicate, and spike quality-control samples also are included in this report.

Acknowledgments

Many people in addition to the authors participated in providing information for this report. Bryant Jurgens and Tyler Johnson (both USGS) provided tools for data compilation. Personnel in U.S. Geological Survey Water Science Centers, too numerous to name individually, collected, packaged, and shipped water samples to the laboratories for analysis and ensured results were entered into the U.S. Geological Survey National Water Information System.

References Cited

Anderholm, S.K., 2002, Water-quality assessment of the Rio Grande Valley, Colorado, New Mexico, and Texas—Surface-water quality, shallow ground-water quality, and factors affecting water quality in the Rincon Valley, south-central New Mexico, 1994–95: U.S. Geological Survey Water-Resources Investigations Report 02–4188, 117 p, accessed March 15, 2017, at https://pubs.usgs.gov/wri/wri02-4188/.

Anning, D.W., Bauch, N.J., Gerner, S.J., Flynn, M.E., Hamlin, S.N., Moore, S.J., Schaefer, D.H., Anderholm, S.K., and Spangler, L.E., 2007, revised 2010, Dissolved solids in basin-fill aquifers and streams in the Southwestern United States: U.S. Geological Survey Scientific Investigations Report 2006–5315, v. 1.1, 168 p.

Arnold, T.L., Warner, K.L., Groschen, G.E., Caldwell, J.P., and Kalkoff, S.J., 2008, Hydrochemical regions of the glacial aquifer system, northern United States, and their environmental and water-quality characteristics: U.S. Geological Survey Scientific Investigations Report 2008–5015, 83 p., accessed January 4, 2016, at https://pubs.usgs.gov/sir/2008/5015/.

Arnold, T.L., DeSimone, L.A., Bexfield, L.M., Lindsey, B.D., Barlow, J.R., Kulongoski, J.T., Musgrove, MaryLynn, Kingsbury, J.A., and Belitz, Kenneth, 2016a, Groundwater quality data from the National Water-Quality Assessment Project, May 2012 through December 2013: U.S. Geological Survey Data Series 997, 56 p., https://doi.org/10.3133/ds997.

Arnold, T.L., DeSimone, L.A., Bexfield, L.M., Lindsey, B.D., Barlow, J.R., Kulongoski, J.T., Musgrove, MaryLynn, Kingsbury, J.A., and Belitz, Kenneth, 2016b, Groundwater quality data from the National Water Quality Assessment Project, May 2012 through December 2014 and select quality-control data from May 2012 through December 2013: U.S. Geological Survey Data Release, https://doi.org/10.5066/F7HQ3X18.

Arnold, T.L., Bexfield, L.M., Musgrove, MaryLynn, Lindsey, B.D., Stackelberg, P.E., Barlow, J.R., DeSimone, L.A., Kulongoski, J.T., Kingsbury, J.A., Ayotte, J.D., Fleming, B.J., and Belitz, Kenneth, 2017, Datasets from groundwater quality data from the National Water Quality Assessment Project, January through December 2014 and select quality-control data from May 2012 through December 2014: U.S. Geological Survey data release, https://doi.org/10.5066/F7W0942N.

Ator, S.W., Denver, J.M., Krantz, D.E., Newell, W.L., and Martucci, S.K., 2005, A surficial hydrogeologic framework for the Mid-Atlantic coastal plain: U.S. Geological Survey Professional Paper 1680, 44 p., and 4 maps.

Ayotte, J.D., Montgomery, D.L., Flanagan, S.M., and Robinson, K.W., 2003, Arsenic in groundwater in eastern New England: Occurrence, controls, and human health implications: Environmental Science & Technology, vol. 37, p. 2075–2083.

Ayotte, J.D., Nolan, B.T., Nuckols, J.R., Cantor, K.P., Robinson, G.R., Baris, Dalsu, Hayes, Laura, Karagas, Margaret, Bress, William, Silverman, D.T., and Lubin, J.H., 2006, Modeling the probability of arsenic in groundwater in New England as a tool for exposure assessment: Environmental Science & Technology, v. 40, no. 11, p. 3578–3585.

Barlow, J.R.B., Kingsbury, J.A., and Coupe, R.H., 2012, Changes in shallow groundwater quality beneath recently urbanized areas in the Memphis, Tennessee area: Journal of the American Water Resources Association, v. 48, no. 2, p. 336–354, accessed March 15, 2017 at http://onlinelibrary.wiley.com/doi/10.1111/j.1752-1688.2011.00616.x/pdf.

Belitz, Kenneth; Jurgens, Bryant; Landon, M. K., Fram, M. S., and Johnson, Tyler, 2010, Estimation of aquifer scale proportion using equal area grids—Assessment of regional scale groundwater quality: Water Resources Research, v. 46, no. 11, 14 p, accessed March 15, 2017 at http://onlinelibrary.wiley.com/doi/10.1029/2010WR009321/full.

Bexfield, L.M., and Anderholm, S.K., 1997, Water-quality assessment of the Rio Grande Valley, Colorado, New Mexico, and Texas—Ground-water quality in the Rio Grande flood plain, Cochiti Lake, New Mexico, to El Paso, Texas: U.S. Geological Survey Water-Resources Investigations Report 96–4249, 93 p.

Bexfield, L.M., Thiros, S.A., Anning, D.W., Huntington, J.M., and McKinney, T.S., 2011, Effects of natural and human factors on groundwater quality of basin-fill aquifers in the southwestern United States—conceptual models for selected contaminants: U.S. Geological Survey Scientific Investigations Report 2011–5020, 90 p.

Bonn, B.A., 2008, Using the U.S. Geological Survey National Water-Quality Laboratory LT–MDL to evaluate and analyze date: U.S. Geological Survey Open-File Report 2008–1227, 73 p., accessed January 4, 2016, at https://pubs.usgs.gov/of/2008/1227/.

Burow, K.R., and Belitz, Kenneth, 2014, Groundwater studies—Principal aquifer surveys: U.S. Geological Survey Fact Sheet 2014–3024, 2p., accessed January 4, 2016, at https://pubs.er.usgs.gov/publication/fs20143024.

Burow, K.R., Panshin, S.Y., Dubrovsky, N.M., VanBrocklin, David, and Fogg, G.E., 1999, Evaluation of processes affecting 1,2-dibromo-3-chloropropane (DBCP) concentrations in ground water in the eastern San Joaquin Valley, California—Analysis of chemical data and ground-water flow and transport simulations: U.S. Geological Survey Water-Resources Investigations Report 99–4059, 57 p., accessed January 4, 2016, at https://pubs.er.usgs.gov/publication/wri994059.

Burow, K.R., Shelton, J.L., and Dubrovsky, N.M., 1998, Occurrence of nitrate and pesticides in ground water beneath three agricultural land-use settings in the eastern San Joaquin Valley, California, 1993–1995: U.S. Geological Survey Water-Resources Investigations Reports 97–4284, 51 p, available from https://pubs.er.usgs.gov/publication/wri974284.

Burow, K.R., Weissmann, G.S., Miller, R.D., Placzek, Gary, 1997, Hydrogeologic facies characterization of an alluvial fan near Fresno, California, using geophysical techniques: U.S. Geological Survey Open-File Report 97–46, 15 p., accessed January 4, 2016, at https://pubs.usgs.gov/of/1997/0046/report.pdf.

Burow, K.R., Dubrovsky, N.M., and Shelton, J.L., 2007, Temporal trends in concentrations of DBCP and nitrate in groundwater in the eastern San Joaquin Valley, California, USA: Hydrogeology Journal, v. 15, no. 5, p. 991–1007, accessed January 4, 2016, at https//doi.org/10.1007/s10040-006-0148-7.

Burton, C.A., and Belitz, Kenneth, 2008, Ground-water quality data in the southeast San Joaquin Valley, 2005–2006—Results from the California GAMA Program: U.S. Geological Survey Data Series 351, 103 p., accessed January 4, 2016, at https://pubs.usgs.gov/ds/351/.

Bush, P.W., Ardis, A.F., Fahlquist, Lynne, Ging, P.B., Hornig, C.E., and Lanning-Rush, Jennifer, 2000, Water Quality in South-Central Texas, Texas, 1996–98: U.S. Geological Survey Circular 1212, 32 p., accessed October 31, 2016, http://pubs.water.usgs.gov/circ1212.

California State Water Resources Control Board, 2015, Geotracker GAMA: State of California, State Water Resources Control Board database, accessed February 10, 2015, at http://geotracker.waterboards.ca.gov/gama/.

Chapman, M.J., Cravotta, C.A., III, Szabo, Zoltan, and Lindsey, B.D., 2013, Naturally occurring contaminants in the Piedmont and Blue Ridge crystalline-rock aquifers and Piedmont Early Mesozoic basin siliciclastic-rock aquifers, eastern United States, 1994–2008: U.S. Geological Survey Scientific Investigations Report 2013–5072, 74 p.

Childress, C.J.O., Forman, W.T., Connor, B.F., and Maloney, T.J., 1999, New reporting procedures based on long-term method detection levels and some considerations for interpretations of water-quality data provided by the U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Open-File Report 99–193, 19 p., accessed January 4, 2016, at https://water.usgs.gov/owq/OFR_99-193/index.html.

City of Fresno, 2015, Groundwater + surface water: City of Fresno Water Division, accessed February 9, 2015, at http://www.fresno.gov/Government/DepartmentDirectory/PublicUtilities/Watermanagement/watersource/gwsw.htm.

Clark, B.R., and Hart, R.M., 2009, The Mississippi Embayment Regional Aquifer Study (MERAS)—Documentation of a groundwater-flow model constructed to assess water availability in the Mississippi embayment: U.S. Geological Survey Scientific Investigations Report 2009–5172, 62 p., accessed January 4, 2016, at https://pubs.usgs.gov/sir/2009/5172/.

Cushing, E.M., Boswell, E.H., and Hosman, R.L., 1964, General geology of the Mississippi embayment: U.S. Geological Survey Professional Paper 448–B, 28 p.

Denver, J.M., Ator, S.W., Fischer, J.M., Harned, D.C., Schubert, Christopher, and Szabo, Zoltan, 2014, The quality of our Nation's waters—Water quality in the Northern Atlantic Coastal Plain surficial aquifer system, Delaware, Maryland, New Jersey, New York, North Carolina, and Virginia, 1988–2009: U.S. Geological Survey Circular 1353, 88 p., accessed January 4, 2016, at https://pubs.usgs.gov/circ/1353/.

Dubrovsky, N.M., Kratzer, C.R., Brown, L.R., Gronberg, J.M., and Burow, K.R., 1998, Water quality in the San Joaquin-Tulare Basins, California, 1992–95: U.S. Geological Survey Circular 1159, 38 p., accessed January 4, 2016, at https://pubs.usgs.gov/circ/circ1159/.

Fenelon, J.M., 1998, Water quality in the White River Basin Indiana, 1992–96: U.S. Geological Survey Circular 1150, 31 p.

Ferrari, M.J, and Ator, S.W., 1995, Nitrate in groundwater in the Great Valley carbonate subunit of the Potomac River Basin: U.S. Geological Survey Water Resources Investigations Report 95–4099, 6 p.

Flanagan, S.M., Nielsen, M.G., Robinson, K.W., and Coles, J.F., 1999, Water quality assessment of the New England Coastal Basins in Maine, Massachusetts, New Hampshire, and Rhode Island—Environmental settings and implications for water quality and aquatic biota: U.S. Geological Survey Water-Resources Investigations Report 98–4249, 62 p.

Garelick, Hemda, Jones, Huw, Agnieszka, Dybowska, and Valsami-Jones, Eva, 2008, Arsenic pollution and remediation: An international perspective *in* Garelick, Hemda and Jones, Huw, (Eds.), Reviews of Environmental Contamination and Toxicology, v. 197, p. 17–60.

Gilliom, R.J., Barbash, J.E., Crawford, C.G., Hamilton, P.A., Martin, J.D., Nakagaki, Naomi, Nowell, L.H., Scott, J.C., Stackelberg, P.E., Thelin, G.P., and Wolock, D.M., 2006, The Quality of Our Nation's Waters – Pesticides in the Nation's Streams and Ground Water, 1992–2001, U.S. Geological Survey Circular 1291, 172 p. accessed August 9, 2017 at https://pubs.usgs.gov/circ/2005/1291/pdf/circ1291.pdf.

Gilliom, R.J., Alley, W.M. and Gurtz, M.E., 1995, Design of the National Water-Quality Assessment Program: occurrence and distribution of water-quality conditions, U.S. Geological Survey Circular 1112, 33 p. accessed March 1, 2016, at https://pubs.er.usgs.gov/publication/cir1112.

Graham, D.D., and Parks, W.S., 1986, Potential for leakage among principal aquifers in the Memphis area, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 85–4295, 46 p., accessed January 4, 2016, at https://pubs.usgs.gov/wri/wri85-4295/.

Griffiths, J.F., and Strauss, R.F., 1985, The variety of Texas weather: Weatherwise, v. 38, p. 137–141.

Grondin, G.H., Wozniak, K.C., Nelson, D.O., and Camacho, Ivan, 1995, Hydrogeology, groundwater chemistry and land uses in the Lower Umatilla basin Groundwater Management Area: Oregon Department of Environmental Quality unnumbered report, variously paged.

Gonthier, G.J., 2002, Quality of shallow ground water in recently developed residential and commercial areas, Memphis vicinity, Tennessee, 1997: U.S. Geological Survey Water-Resources Investigations Report 02–4294, 105 p., accessed January 4, 2016, at http://ms.water.usgs.gov/publications/WRIR_02_4294.html.

Güler, Cüneyt., Thyne, G.D., McCray, J.E., and Turner, A.K., 2002, Evaluation of graphical and multivariate statistical methods for classification of water chemistry data: Hydrogeology Journal, v. 10, no. 4, p. 455–474.

Hawley, J.W., Kennedy, J.F., Ortiz, M.A., and Carrasco, Sean, 2005, Digital hydrogeologic framework model of the Rincon Valley and adjacent areas of Dona Ana, Sierra and Luna Counties, NM, *addendum to* Hawley, J.W., and Kennedy, J.F., Creation of a digital hydrogeologic framework model of the Mesilla Basin and southern Jornada del Muerto Basin: New Mexico Water Resources Research Institute Technical Completion Report 332, 12 p.

Hem, J.D., 1992, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 2254, 264 p.

Hiscock, K.M., 2005, Hydrogeology—Principles and practice: United Kingdom, Blackwell Publishing, 389 p.

Homer, C., Dewitz, J., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N., Wickham, J., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States—Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345–354.

Jackson, W.A., Bohlke, J.K., Andraski, B.J., Fahlquist, Lynne, Bexfield, Laura, Eckardt, F.D., Gates, J.B., Davila, A.F., McKay, C.P., Rao, Balaji, Sevanthi, Ritesh, Rajagopalan, Srinath, Estrada, Nubia, Sturchio, Neil, Hatzinger, P.B., Anderson, T.A., Orris, G., Betahcourt, Julio, Stonestrom, David, Latorre, Claudio, Li, Yanhe, Harvey, G.J., 2015, Global patterns and environmental controls of perchlorate and nitrate co-occurrence in arid and semi-arid environments: Geochimica et Cosmochimica Acta, v. 164, p. 502–522.

Jones, B.D., 1991, Texas—Floods and droughts, *in* Paulson, R.W., Chase, E.B., Roberts, R.S., and Moody, D.W., comps., National water summary 1988–89—Hydrologic events and floods and droughts: U.S. Geological Survey Water-Supply Paper 2375, p. 513–520, accessed January 4, 2016, at https://pubs.er.usgs.gov/publication/wsp2375.

Jones, J.L. and Wagner, R.J. 1995, Water-quality assessment of the Central Columbia Plateau in Washington and Idaho-Analysis of available nutrient and pesticide data for ground water, 1942-92: U.S. Geological Survey Water-Resources Investigations Report 94-4258, 119 p.

Kahle, S.C., Morgan, D.S., Welch, W.B., Ely, D.M., Hinkle, S.R., Vaccaro, J.J., and Orzol, L.L., 2011, Hydrogeologic framework and hydrologic budget components of the Columbia Plateau Regional Aquifer System, Washington, Oregon, and Idaho: U.S. Geological Survey Scientific Investigations Report 2011–5124, 63 p., accessed May 11, 2017, at https://pubs.usgs.gov/sir/2011/5124/pdf/sir20115124.pdf.

Kingsbury, J.A., Barlow, J.R., Katz, B.G., Welch, H.L., Tollett, R.W., and Fahlquist, L.S., 2014, The quality of our Nation's waters—Water quality in the Mississippi embayment—Texas coastal uplands aquifer system and Mississippi River Valley alluvial aquifer, south-central United States, 1994–2008: U.S. Geological Survey Circular 1356, 72 p., https://doi.org/10.3133/cir1356.

Kleiss, B.A., Coupe, R.H., Gonthier, G.J., and Justus, B.J., 2000, Water quality in the Mississippi Embayment, Mississippi, Louisiana, Arkansas, Missouri, Tennessee, and Kentucky, 1995–98: U.S. Geological Survey Circular 1208, 36 p., accessed January 4, 2016, at https://pubs.usgs.gov/circ/circ1208/.

Koterba, M.T., Wilde, F.D., and Lapham, W.W., 1995, Groundwater data-collection protocols and procedures for the National Water-Quality Assessment Program—Collection and documentation of water-quality samples and related data: U.S. Geological Survey Open-File Report 95–399, 113 p., accessed January 4, 2016, at https://pubs.usgs.gov/of/1995/ofr-95-399/.

Lapham, W.W., Wilde, F.D., and Koterba, M.T., 1995, Ground-water data-collection protocols and procedures for the National Water-Quality Assessment Program—Selection, installation, and documentation of wells, and collection of related data: U.S. Geological Survey Open-File Report 95–398, 71 p., accessed January 4, 2016, at https://pubs.usgs.gov/of/1995/ofr-95-398/.

Lapham, W.W., Hamilton, P.A. and Myers, D.N., 2005, National Water-Quality Assessment Program—Cycle II, Regional assessments of aquifers: U.S. Geological Survey Fact Sheet 2005–3013, 4 p., accessed June 21, 2016, at https://pubs.usgs.gov/fs/2005/3013/.

Larkin, T.J., and Bomar, G.W., 1983, Climatic atlas of Texas: Texas Department of Water Resources, Limited Printing Report LP–192, 151 p.

Mahler, B.J., Garner, B.D., Musgrove, MaryLynn, Guilfoyle, A.L., and Rao, M.V., 2006, Recent (2003–05) water quality of Barton Springs, Austin, Texas, with emphasis on factors affecting variability: U.S. Geological Survey Scientific Investigations Report 2006–5299, 83 p., 5 appendixes, accessed January 4, 2016, at https://pubs.usgs.gov/sir/2006/5299/.

Marchand, D.E., and Allwardt, Alan, 1981, Late Cenozoic stratigraphic units, northeastern San Joaquin Valley, California: U.S. Geological Survey Bulletin 1470, 77 p., accessed January 4, 2016, at https://pubs.usgs.gov/bul/1470/report.pdf.

Maupin, M.A., and Arnold, T.L., 2010, Estimates for self-supplied domestic withdrawals and population served for selected principal aquifers, calendar year 2005: U.S. Geological Survey Open-File Report 2010–1223, 10 p., accessed January 4, 2016, at https://pubs.usgs.gov/of/2010/1223/.

Maupin, M.A., and Barber, N.L., 2005, Estimated withdrawals from principal aquifers in the United States, 2000: U.S. Geological Survey Circular 1279, 46 p., accessed January 4, 2016, at https://pubs.usgs.gov/circ/2005/1279/.

McCurdy, D.E., Garbarino, J.R., and Mullin, A.H., 2008, Interpreting and reporting radiological water-quality data: U.S. Geological Survey Techniques and Methods, book 5, chap. B6, 33 p., accessed January 4, 2016, at https://pubs.usgs.gov/tm/05b06/.

Moore, R.C., and Fenelon, J.M., 1996, Occurrence of nitrate in ground water in the White River Basin, Indiana, 1994–95: U.S. Geological Survey Fact Sheet 110–96, 4 p.

Moyer, D.L., Anderholm, S.K., Hogan, J.F., Phillips, F.M., Hibbs, B.J., Witcher, J.C., Matherne, A.M., and Falk, S.E., 2013, Knowledge and understanding of dissolved solids in the Rio Grande–San Acacia, New Mexico, to Fort Quitman, Texas, and plan for future studies and monitoring: U.S. Geological Survey Open–File Report 2013–1190, 55 p., available at https://pubs.usgs.gov/of/2013/1190/.

Musgrove, MaryLynn, Fahlquist, Lynne, Houston, N.A., Lindgren, R.J., and Ging, P.B., 2010, Geochemical evolution processes and water-quality observations based on results of the National Water-Quality Assessment Program in the San Antonio segment of the Edwards aquifer, Texas, 1996–2006: U.S. Geological Survey Scientific Investigations Report 2010−5129, 93 p., accessed January 4, 2016, at https://pubs.usgs.gov/sir/2010/5129/.

Musgrove, MaryLynn, Fahlquist, Lynne, Stanton, G.P., Houston, N.A., and Lindgren, R.J., 2011, Hydrogeology, chemical characteristics, and water sources and pathways in the zone of contribution of a public-supply well in San Antonio, Texas: U.S. Geological Survey Scientific Investigations Report 2011–5146, 194 p., accessed January 4, 2016, at https://pubs.usgs.gov/sir/2011/5146/.

National Climatic Data Center, Annual climatological summary, 2006 [Online] accessed June 11, 2007, at http://www.ncdc.noaa.gov.

National Oceanic and Atmospheric Administration, 2014a, National Weather Service forecast office—Austin/San Antonio, TX—Unique local climate data: National Weather Service, Austin/San Antonio, Texas, Weather Forecast Office Web site, accessed April 11, 2014, at http://www.nws.noaa.gov/climate/local_data.php?wfo=ewx.

National Oceanic and Atmospheric Administration, 2014b, Data tools—1981–2010 normals: National Oceanic and Atmospheric Administration, National Centers for Environmental Information Web site, accessed May 19, 2016, at http://www.ncdc.noaa.gov/cdo-web/datatools/normals.

Nriagu, J.O., and Niebor, E. (Eds.), 1988, Chromium in the natural and human environments: John Wiley & Sons, New York, 571 p

Olcott, P.G., 1968, Water resources of Wisconsin—Fox-Wolf River Basin: U.S. Geological Survey Hydrologic Investigations Atlas HA–321, 4 sheets.

Olcott, P.G., 1992, Ground water atlas of the United States—Iowa, Michigan, Minnesota, Wisconsin: U.S. Geological Survey Hydrologic Atlas 730–J, accessed January 4, 2016, at https://pubs.usgs.gov/ha/ha730/ch_j/index.html.

Olcott, P.G., 1995, Ground water atlas of the United States—Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont: U.S. Geological Survey Hydrologic Atlas 730–M, accessed January 4, 2016, at https://pubs.usgs.gov/ha/ha730/ch_m/index.html.

Parks, W.S., 1990, Hydrogeology and preliminary assessment of the potential for contamination of the Memphis aquifer in the Memphis area, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 90–4092, 39 p., accessed January 4, 2016, at https://pubs.usgs.gov/wri/wri904092/.

Parks, W.S., Mirecki, J.E., and Kingsbury, J.A., 1995, Hydrogeology, ground-water quality, and source of ground water causing water-quality changes in the Davis well field at Memphis, Tennessee: U.S. Geological Survey Water Resources Investigations Report 94–4212, 58 p.

Patton, C.J., and Kryskalla, J. R., 2011, Colorimetric determination of nitrate plus nitrite in water by enzymatic reduction, automated discrete analyzer methods: U.S. Geological Survey Techniques and Methods, book 5, chap. B8, 34 p., accessed January 4, 2016, at https://pubs.usgs.gov/tm/05b08/.

Renken, R.A., 1998, Ground water atlas of the United States—Arkansas, Louisiana, Mississippi: U.S. Geological Survey Hydrologic Atlas 730–F, accessed January 4, 2016, at https://pubs.usgs.gov/ha/ha730/ch_f/index.html.

Reutter, D.C. and Dunn, D.D., 1999, Water-quality assessment of the Trinity River basin, Texas: ground-water quality of the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers, February–August 1994: U.S. Geological Survey Water Resources Investigations Report 99–4233, 56 p.

Richerson, P., 2012, Analysis of groundwater nitrate concentrations in the Lower Umatilla Basin Groundwater Management Area: Oregon Department of Environmental Quality Report 12–WQ–019, variously paginated.

Richmond, G.M., and Fullerton, D.S., 1983, Quaternary geologic map of Lake Superior 4’ x 6’ quadrangle: U.S. Geological Survey, Miscellaneous Investigations Series I–1420 (NL16), Quaternary Atlas of the United States, scale 1:1,000,000.

Robson, S.G., and Banta, E.R., 1995, Ground water atlas of the United States—Arizona, Colorado, New Mexico, Utah: U.S. Geological Survey Hydrologic Atlas 730–C, accessed January 4, 2016, at https://pubs.usgs.gov/ha/ha730/ch_c/index.html.

Rose, D.L., Sandstrom, M.W., and Murtagh, L.K., 2016, Determination of heat purgeable and ambient purgeable volatile organic compounds in water by gas chromatography/mass spectrometry: U.S. Geological Survey Techniques and Methods, book 5, chap. B12, 62 p.

Rowe, G.L., Jr., Belitz, Kenneth, Essaid, H.I., Gilliom, R.J., Hamilton, P.A., Hoos, A.B., Lynch, D.D., Munn, M.D., and Wolock, D.W., 2010, Design of cycle 3 of the National Water-Quality Assessment Program, 2013–2023—Part 1—Framework of water-quality issues and potential approaches: U.S. Geological Survey Open-File Report 2009–1296, 54 p., accessed January 4, 2016, at https://pubs.usgs.gov/of/2009/1296/.

Rowe, G.L., Belitz, Kenneth, Demas, C.R., Essaid, H.I., Gilliom, R.J., Hamilton, P.A., Hoos, A.B., Lee, C.J., Munn, M.D., and Wolock, D.W., 2013, Design of cycle 3 of the National Water-Quality Assessment Program, 2013–23—Part 2—Science plan for improved water-quality information and management: U.S. Geological Survey Open File Report 2013–1160, accessed January 4, 2016, at https://pubs.usgs.gov/of/2013/1160/.

Ryder, P.D., 1996, Ground water atlas of the United States—Oklahoma, Texas: U.S. Geological Survey Hydrologic Atlas 730–E, accessed January 4, 2016, at https://pubs.usgs.gov/ha/ha730/ch_e/index.html.

Saad, D.A., 1997, Effects of land use and geohydrology on the quality of shallow groundwater in two agricultural areas in the Western Lake Michigan Drainages, Wisconsin: U.S. Geological Survey Water-Resources Investigations Report 96–4292, 69 p.

Saad, D.A., 2008, Agricultural-related trends in groundwater quality of the glacial deposits aquifer, central Wisconsin: Journal of Environmental Quality, v. 37, p. S–209 – S–225.

Sandstrom, M.W., Kanagy, L.K., Anderson, C.E., and Kanagy, C.J., 2016, Determination of pesticides and pesticide degradates in filtered water by direct aqueous injection liquid chromatography tandem mass spectrometry: U.S. Geological Survey Techniques and Methods, book 5, chap. B11, 54 p, https://doi.org/10.3133/tm5B11

Scott, J.C., 1990, Computerized stratified random site-selection approaches for design of a ground-water-quality sampling network: U.S. Geological Survey Water-Resources Investigations Report 90–4101, 109 p., accessed January 4, 2016, at https://pubs.er.usgs.gov/publication/wri904101.

Sharp, J.M., Jr., and Banner, J.L., 1997, The Edwards aquifer—A resource in conflict: Boulder, Colo., The Geological Society of America, Inc., GSA Today, v. 7, no. 8, p. 1–9.

Shedlock, R.J., Denver J.M., Hayes, M.A., Hamilton, P.A., Koterba, M.T., Bachman, L.J., Phillips P.J., and Banks, W.S.L., 1999, Water-quality assessment of the Delmarva Peninsula, Delaware, Maryland, and Virginia: Results of investigations, 1987–91: U.S. Geological Survey Water Supply Paper 2355–A, 41 p.

Spruill, Timothy B., Harned, Douglas A., Ruhl, Peter M., Eimers, Jo Leslie, McMahon, Gerard, Smith, Kelly E., Galeone, David R., and Woodside, Michael D., 1998, Water quality in the Albemarle-Pamlico Drainage Basin, North Carolina and Virginia, 1992–95: U.S. Geological Survey Circular 1157, 36 p.

Srinivasan, Rangesh, and Sorial, G.A., 2009, Treatment of perchlorate in drinking water: A critical review: Separation and Purification Technology, v. 69, p. 7-21.

Stekl, P.J., and Flanagan, S.M., 1992, Geohydrology and water quality of stratified-drift aquifers in the lower Merrimack and coastal river basins, southeastern New Hampshire: U.S. Geological Survey Water-Resources Investigations Report 91–4025, 93 p.

Thiros, S.A., Paul, A.P., Bexfield, L.M., and Anning, D.W., 2014, The quality of our Nation’s waters—Water quality in basin-fill aquifers of the southwestern United States: Arizona, California, Colorado, Nevada, New Mexico, and Utah, 1993–2009: U.S. Geological Survey Circular 1358, 113 p., https//doi.org/10.3133/cir1358.

Thiros, S.A., Bexfield, L.M., Anning, D.W., and Huntington, J.M., eds., 2010, Conceptual understanding and groundwater quality of selected basin-fill aquifers in the Southwestern United States: U.S. Geological Survey Professional Paper 1781, 288 p.

Toccalino, P.L., 2007, Development and application of health-based screening levels for use in water-quality assessments: U.S. Geological Survey Scientific Investigations Report 2007–5106, 12 p., accessed January 4, 2016, at https://pubs.usgs.gov/sir/2007/5106/.

Toccalino, P.L., Norman, J.E., and Schoephoester, K.M., 2014, Health-based screening levels for evaluating water-quality data: U.S. Geological Survey, http://.doi.org/10.5066/F71C1TWP.

Trapp, Henry, Jr., and Horn, M.A., 1997, Ground water atlas of the United States—Delaware, Maryland, New Jersey, North Carolina, Pennsylvania, Virginia, and West Virginia: U.S. Geological Survey Hydrologic Atlas 730–L, accessed January 4, 2016, at https://pubs.usgs.gov/ha/ha730/ch_l/index.html.

U.S. Environmental Protection Agency, 2004, Multi-agency radiological laboratory analytical protocols manual (MARLAP)—Part II—Chapters 18–20, appendix G (volume III): U.S. Environmental Protection Agency, EPA 402–B–04–001C, accessed May 19, 2015, at http://nepis.epa.gov/Exe/ZyPDF.cgi/P10094KI.PDF?Dockey=P10094KI.PDF.

U.S. Environmental Protection Agency, 2012, Human health benchmarks for pesticides: U.S. Environmental Protection Agency, EPA 822–F–12–001, accessed May 19, 2015, at http://nepis.epa.gov/Exe/ZyPDF.cgi/P100E60P.PDF?Dockey=P100E60P.PDF.

U.S. Environmental Protection Agency, 2013, Human health benchmarks for pesticides—Updated 2013 technical document: U.S. Environmental Protection Agency, EPA 820–R–13–010, accessed May 19, 2015, at http://nepis.epa.gov/Exe/ZyPDF.cgi/P100GRDJ.PDF?Dockey=P100GRDJ.PDF.

U.S. Environmental Protection Agency, 2015, Definition and procedure for the determination of the method detection limit—revision 1.11: U.S. Code of Federal Regulations, Title 40, v. 24, pt. 136, app. B, accessed May 14, 2015, at http://www.gpo.gov/fdsys/pkg/CFR-2012-title40-vol24/pdf/CFR-2012-title40-vol24-part136-appB.pdf.

U.S. Geological Survey, 2003, Principal aquifers of the 48 conterminous United States, Hawaii, Puerto Rico, and the U.S. Virgin Islands: U.S. Geological Survey, accessed January 4, 2016, at http://water.usgs.gov/GIS/metadata/usgswrd/XML/aquifers_us.xml.

U.S. Geological Survey, 2016, National Water Information System—Web interface, accessed July 1, 2016, at https://doi.org/10.5066/F7P55KJN

U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1–A9, accessed January 4, 2016, at https://pubs.water.usgs.gov/twri9A.

University of California, 2012, Addressing nitrate in California’s drinking water: Center for Watershed Sciences, University of California, Davis, Groundwater Nitrate Project, Implementation of Senate Bill X2 1, accessed February 9, 2015, at http://groundwaternitrate.ucdavis.edu/files/138956.pdf.

Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p., accessed January 4, 2016, at https://pubs.usgs.gov/tm/2006/tm1D3/.

Warner, K.L., and Ayotte, J.D., 2015, The quality of our Nation's waters—Water quality in the glacial aquifer system, northern United States, 1992–2009: U.S. Geological Survey Circular 1352, 133 p., https//doi.org/10.3133/cir1352.

Welch, H.L., Kingsbury, J.A., Tollett, R.W., and Seanor, R.C., 2009, Quality of shallow groundwater and drinking water in the Mississippi embayment-Texas coastal uplands aquifer system and the Mississippi River Valley alluvial aquifer, south-central United States, 1994–2004: U.S. Geological Survey Scientific Investigations Report 2009–5091, 51 p., accessed January 4, 2016, at https://pubs.usgs.gov/sir/2009/5091/.

Western Regional Climate Center, 2015, Fresno Yosemite International Airport, California (043257)—Period of record monthly climate summary: accessed February 5, 2015, at http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca3257

Whitehead, R.L., 1994, Ground water atlas of the United States—Idaho, Oregon, Washington: U.S. Geological Survey Hydrologic Atlas 730–H, accessed January 4, 2016, at https://pubs.usgs.gov/ha/ha730/ch_h/index.html

Williamson, A.D., A.K., Munn, M.D., Ryker, S.J., Wagner, R.J., Ebbert, J.C., and Vanderpool, A.M., 1998, Water quality in the Central Columbia Plateau, Washington and Idaho, 1992–95: U.S. Geological Survey Circular 1144, 35 p.

Wilkins, D.W., Scott, W.B., and Kaehler, C.A., 1980, Planning report for the southwest alluvial basins (east) regional aquifer-system analysis, parts of Colorado, New Mexico, and Texas: U.S. Geological Survey Open-File Report 80–564, 39 p.

Wilson, J.T., 2012, Water-quality assessment of the Cambrian-Ordovician aquifer system in the northern Midwest, United States: U.S. Geological Survey Scientific Investigations Report 2011–5229, 157 p.

Wong, C.I., Mahler, B.J., Musgrove, MaryLynn, and Banner, J.L., 2012, Changes in sources and storage in a karst aquifer during a transition from drought to wet conditions: Journal of Hydrology, v. 468–469, p. 159–172.

Wright, M.T., Belitz, Kenneth, and Johnson, Tyler, 2004, Assessing the susceptibility to contamination of two aquifer systems used for public water supply in the Modesto and Fresno metropolitan areas, California, 2001 and 2002: U.S. Geological Survey Scientific Investigations Report 2004–5149, 35 p., available at https://pubs.usgs.gov/sir/2004/5149/sir2004-5149.pdf.

Young, H.L., 1992, Summary of ground-water hydrology of the Cambrian-Ordovician aquifer system in the northern Midwest, United States: U.S. Geological Survey Professional Paper 1405–D, 55 p.

Zogorski, J.S., Carter, J.M., Ivahnenko, Tamara, Lapham, W.W., Moran, M.J., Rowe, B.L., Squillace, P.J., and Toccalino, P.L., 2006, The quality of our Nation's waters—Volatile organic compounds in the Nation's ground water and drinking-water supply wells: U.S. Geological Survey Circular 1292, 101 p.

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
clptetn1	CLPTETN1-01	01	ETN	Oreg.	Columbia Plateau basin-fill and basaltic-rock aquifers	80	79	80
clptetn1	CLPTETN1-02	02	ETN	Oreg.	Columbia Plateau basin-fill and basaltic-rock aquifers	1,134	500	1,134
clptetn1	CLPTETN1-03	03	ETN	Oreg.	Columbia Plateau basin-fill and basaltic-rock aquifers	54	47	54
cvaletn1	CVALETN1-01	01	ETN	Calif.	Central Valley aquifer system	620	410	610
cvaletn1	CVALETN1-02	02	ETN	Calif.	Central Valley aquifer system	320	160	310
cvaletn1	CVALETN1-03	03	ETN	Calif.	Central Valley aquifer system	234	214	224
edtretn1	EDTRETN1-01	01	ETN	Tex.	Edwards-Trinity aquifer system	550	317	550
edtretn1	EDTRETN1-02	02	ETN	Tex.	Edwards-Trinity aquifer system	300	220	300
edtretn1	EDTRETN1-03	03	ETN	Tex.	Edwards-Trinity aquifer system	1,550**	1,320	1,550
glacetn1	GLACETN1-01	01	ETN	Wis.	Glacial aquifer system	83	80	83
glacetn1	GLACETN1-02	02	ETN	Wis.	Glacial aquifer system	34.5	24.5	34.5
metxetn1	METXETN1-01	01	ETN	Tenn.	Mississippi Embayment-Texas Coastal Uplands aquifer system	624	520	624
metxetn1	METXETN1-02	02	ETN	Tenn.	Mississippi Embayment-Texas Coastal Uplands aquifer system	90	80	90
nacpetn1	NACPETN1-01	01	ETN	Del.	Northern Atlantic Coastal Plain aquifer system	22	19	22
nacpetn1	NACPETN1-02	02	ETN	Del.	Northern Atlantic Coastal Plain aquifer system	139	85	135
nacpetn1	NACPETN1-03	03	ETN	Del.	Northern Atlantic Coastal Plain aquifer system	119	100	119
negxetn1	NEGXETN1-01	01	ETN	N.H.	Glacial aquifer and New England crystalline-rock aquifers	83	73	83
negxetn1	NEGXETN1-02	02	ETN	N.H.	Glacial aquifer and New England crystalline-rock aquifers	492	88	492
negxetn1	NEGXETN1-03	03	ETN	N.H.	Glacial aquifer and New England crystalline-rock aquifers	176.3	na	176.3*
rgaqetn1	RGAQETN1-01	01	ETN	N. Mex.	Rio Grande aquifer system	22.6	7.5	17.5
rgaqetn1	RGAQETN1-02	02	ETN	N. Mex.	Rio Grande aquifer system	60	40	60
rgaqetn1	RGAQETN1-03	03	ETN	N. Mex.	Rio Grande aquifer system	22	11.5	21.5
albelusag1	ALBELUSAG1-01	01	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	12	7	12
albelusag1	ALBELUSAG1-02	02	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	20	10	15
albelusag1	ALBELUSAG1-03	03	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	31	20	30
albelusag1	ALBELUSAG1-04	04	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	10.7	6.7	10.7
albelusag1	ALBELUSAG1-05	05	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	15.5	10.5	15.5

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
albelusag1	ALBELUSAG1-06	06	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	33	28	33
albelusag1	ALBELUSAG1-07	07	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	23	13	18
albelusag1	ALBELUSAG1-08	08	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	25	15	20
albelusag1	ALBELUSAG1-09	09	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	31.7	21.7	26.7
albelusag1	ALBELUSAG1-10	10	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	28	24	28
albelusag1	ALBELUSAG1-11	11	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	10.9	5.9	10.9
albelusag1	ALBELUSAG1-12	12	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	34.8	29.8	34.8
albelusag1	ALBELUSAG1-13	13	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	19.2	5.2	10.2
albelusag1	ALBELUSAG1-14	14	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	36	34	36
albelusag1	ALBELUSAG1-15	15	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	8.5	3	8
albelusag1	ALBELUSAG1-16	16	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	15	10.4	15
albelusag1	ALBELUSAG1-17	17	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	25	15	25
albelusag1	ALBELUSAG1-18	18	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	16.9	13.9	16.9
albelusag1	ALBELUSAG1-19	19	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	23	13	18
albelusag1	ALBELUSAG1-20	20	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	14	9	14
albelusag1	ALBELUSAG1-21	21	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	19	9	14
albelusag1	ALBELUSAG1-22	22	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	13	8	13
albelusag1	ALBELUSAG1-23	23	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	19	9	14
albelusag1	ALBELUSAG1-24	24	LUS	N.C.	Northern Atlantic Coastal Plain aquifer system	12.3	10.3	12.3
albelusag1	ALBELUSAG1-25	25	LUS	Va.	Northern Atlantic Coastal Plain aquifer system	10	7	10
albelusag1	ALBELUSAG1-26	26	LUS	Va.	Northern Atlantic Coastal Plain aquifer system	24.5	14.5	19.5
ccptlusag2b	CCPTLUSAG2B-01	01	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	36	26	36
ccptlusag2b	CCPTLUSAG2B-02	02	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	19	14	19
ccptlusag2b	CCPTLUSAG2B-03	03	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	67	52	67
ccptlusag2b	CCPTLUSAG2B-04	04	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	112	107	112
ccptlusag2b	CCPTLUSAG2B-05	05	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	38.5	33.5	38.5

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
ccptlusag2b	CCPTLUSAG2B-06	06	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	79.5	74.5	79.5
ccptlusag2b	CCPTLUSAG2B-07	07	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	35	30	35
ccptlusag2b	CCPTLUSAG2B-08	08	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	54	49	54
ccptlusag2b	CCPTLUSAG2B-09	09	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	38	33	38
ccptlusag2b	CCPTLUSAG2B-10	10	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	34	29	34
ccptlusag2b	CCPTLUSAG2B-11	11	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	88	83	88
ccptlusag2b	CCPTLUSAG2B-12	12	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	72	67	72
ccptlusag2b	CCPTLUSAG2B-13	13	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	42.4	37	42
ccptlusag2b	CCPTLUSAG2B-14	14	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	21.5	18.5	21.5
ccptlusag2b	CCPTLUSAG2B-15	15	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	21	18	21
ccptlusag2b	CCPTLUSAG2B-16	16	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	45	30	44
ccptlusag2b	CCPTLUSAG2B-17	17	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	31	25	30
ccptlusag2b	CCPTLUSAG2B-18	18	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	29	24	29
ccptlusag2b	CCPTLUSAG2B-19	19	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	55	48.5	53.5
ccptlusag2b	CCPTLUSAG2B-20	20	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	16	11	16
ccptlusag2b	CCPTLUSAG2B-21	21	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	53	48	53
ccptlusag2b	CCPTLUSAG2B-22	22	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	98	83	98
ccptlusag2b	CCPTLUSAG2B-23	23	LUS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	64.5	59	64
potolusag1	POTOLUSAG1-01	01	LUS	Va.	Valley and Ridge aquifers	360	48	360
potolusag1	POTOLUSAG1-02	02	LUS	Va.	Valley and Ridge aquifers	290	93	290
potolusag1	POTOLUSAG1-03	03	LUS	Va.	Valley and Ridge aquifers	245	na	245*
potolusag1	POTOLUSAG1-04	04	LUS	Va.	Valley and Ridge aquifers	181	na	181*
potolusag1	POTOLUSAG1-05	05	LUS	Va.	Valley and Ridge aquifers	180	40	180
potolusag1	POTOLUSAG1-06	06	LUS	Va.	Valley and Ridge aquifers	117	70	117
potolusag1	POTOLUSAG1-07	07	LUS	Va.	Valley and Ridge aquifers	288	51	288
potolusag1	POTOLUSAG1-08	08	LUS	Va.	Valley and Ridge aquifers	170	21	170
potolusag1	POTOLUSAG1-09	09	LUS	Va.	Valley and Ridge aquifers	285	21	285

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
potolusag1	POTOLUSAG1-10	10	LUS	Va.	Valley and Ridge aquifers	na	na	na
potolusag1	POTOLUSAG1-11	11	LUS	Va.	Valley and Ridge aquifers	na	na	na
potolusag1	POTOLUSAG1-12	12	LUS	Va.	Valley and Ridge aquifers	146	na	146*
potolusag1	POTOLUSAG1-13	13	LUS	Va.	Valley and Ridge aquifers	164	na	164*
potolusag1	POTOLUSAG1-14	14	LUS	Va.	Valley and Ridge aquifers	131	na	131*
potolusag1	POTOLUSAG1-15	15	LUS	W. Va.	Valley and Ridge aquifers	123	42	123
potolusag1	POTOLUSAG1-16	16	LUS	W. Va.	Valley and Ridge aquifers	126	na	126*
potolusag1	POTOLUSAG1-17	17	LUS	W. Va.	Valley and Ridge aquifers	175	na	175*
potolusag1	POTOLUSAG1-18	18	LUS	W. Va.	Valley and Ridge aquifers	155	84	155
potolusag1	POTOLUSAG1-19R	19R	LUS	W. Va.	Valley and Ridge aquifers	205	na	205*
potolusag1	POTOLUSAG1-20	20	LUS	Md.	Valley and Ridge aquifers	250	235	250
potolusag1	POTOLUSAG1-21	21	LUS	Md.	Valley and Ridge aquifers	166	57	166
potolusag1	POTOLUSAG1-22	22	LUS	Md.	Valley and Ridge aquifers	225	21	225
potolusag1	POTOLUSAG1-23	23	LUS	Md.	Valley and Ridge aquifers	100	83	100
potolusag1	POTOLUSAG1-24	24	LUS	Md.	Valley and Ridge aquifers	300	na	300*
potolusag1	POTOLUSAG1-25	25	LUS	Pa.	Valley and Ridge aquifers	85	na	85*
potolusag1	POTOLUSAG1-26	26	LUS	Pa.	Valley and Ridge aquifers	90	na	90*
potolusag1	POTOLUSAG1-27	27	LUS	Pa.	Valley and Ridge aquifers	255	na	255*
potolusag1	POTOLUSAG1-28	28	LUS	Pa.	Valley and Ridge aquifers	240	104	240
sanjlusor2a	SANJLUSOR2A-01	01	LUS	Calif.	Central Valley aquifer system	108	98	108
sanjlusor2a	SANJLUSOR2A-02	02	LUS	Calif.	Central Valley aquifer system	122	112	122
sanjlusor2a	SANJLUSOR2A-03	03	LUS	Calif.	Central Valley aquifer system	200	180	200
sanjlusor2a	SANJLUSOR2A-04	04	LUS	Calif.	Central Valley aquifer system	175	155	175
sanjlusor2a	SANJLUSOR2A-05	05	LUS	Calif.	Central Valley aquifer system	120	100	120
sanjlusor2a	SANJLUSOR2A-06	06	LUS	Calif.	Central Valley aquifer system	117	97	117
sanjlusor2a	SANJLUSOR2A-07	07	LUS	Calif.	Central Valley aquifer system	120	100	120
sanjlusor2a	SANJLUSOR2A-08	08	LUS	Calif.	Central Valley aquifer system	160	150	160

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
sanjlusor2a	SANJLUSOR2A-09	09	LUS	Calif.	Central Valley aquifer system	165	145	165
sanjlusor2a	SANJLUSOR2A-10	10	LUS	Calif.	Central Valley aquifer system	120	100	120
sanjlusor2a	SANJLUSOR2A-11	11	LUS	Calif.	Central Valley aquifer system	160	120	160
sanjlusor2a	SANJLUSOR2A-12	12	LUS	Calif.	Central Valley aquifer system	250	85	105
sanjlusor2a	SANJLUSOR2A-13	13	LUS	Calif.	Central Valley aquifer system	115	85	115
sanjlusor2a	SANJLUSOR2A-14	14	LUS	Calif.	Central Valley aquifer system	127	107	127
sanjlusor2a	SANJLUSOR2A-15	15	LUS	Calif.	Central Valley aquifer system	150	130	150
sanjlusor2a	SANJLUSOR2A-16	16	LUS	Calif.	Central Valley aquifer system	195	175	195
sanjlusor2a	SANJLUSOR2A-17	17	LUS	Calif.	Central Valley aquifer system	190	170	190
sanjlusor2a	SANJLUSOR2A-18	18	LUS	Calif.	Central Valley aquifer system	135	115	135
sanjlusor2a	SANJLUSOR2A-19	19	LUS	Calif.	Central Valley aquifer system	168	na	168*
sanjlusor2a	SANJLUSOR2A-20	20	LUS	Calif.	Central Valley aquifer system	96	na	96*
sanjlusor2a	SANJLUSOR2A-21	21	LUS	Calif.	Central Valley aquifer system	211	130	211
sanjlusor2a	SANJLUSOR2A-22	22	LUS	Calif.	Central Valley aquifer system	230	220	230
sanjlusor2a	SANJLUSOR2A-23	23	LUS	Calif.	Central Valley aquifer system	180	170	180
sanjlusor2a	SANJLUSOR2A-24	24	LUS	Calif.	Central Valley aquifer system	230	220	230
whitluscr1	WHITLUSCR1-01	01	LUS	Ind.	Glacial aquifer system	19.8	17.4	19.4
whitluscr1	WHITLUSCR1-02	02	LUS	Ind.	Glacial aquifer system	38.6	33.2	38.2
whitluscr1	WHITLUSCR1-03	03	LUS	Ind.	Glacial aquifer system	24	19	24
whitluscr1	WHITLUSCR1-04	04	LUS	Ind.	Glacial aquifer system	28	22.9	27.9
whitluscr1	WHITLUSCR1-05	05	LUS	Ind.	Glacial aquifer system	17.5	12.5	17.5
whitluscr1	WHITLUSCR1-06	06	LUS	Ind.	Glacial aquifer system	42	37	42
whitluscr1	WHITLUSCR1-07	07	LUS	Ind.	Glacial aquifer system	25	19.4	24.4
whitluscr1	WHITLUSCR1-08	08	LUS	Ind.	Glacial aquifer system	41	35.5	40.5
whitluscr1	WHITLUSCR1-09	09	LUS	Ind.	Glacial aquifer system	27.9	20.5	27.5
whitluscr1	WHITLUSCR1-10	10	LUS	Ind.	Glacial aquifer system	18.5	13.1	18.1
whitluscr1	WHITLUSCR1-11	11	LUS	Ind.	Glacial aquifer system	30.4**	25.4	30.4

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
whitluscr1	WHITLUSCR1-13	13	LUS	Ind.	Glacial aquifer system	16	13.1	15.6
whitluscr1	WHITLUSCR1-14	14	LUS	Ind.	Glacial aquifer system	25	19.4	24.4
whitluscr1	WHITLUSCR1-15	15	LUS	Ind.	Glacial aquifer system	22	17.2	22
whitluscr1	WHITLUSCR1-16	16	LUS	Ind.	Glacial aquifer system	21	16.1	21
whitluscr1	WHITLUSCR1-17	17	LUS	Ind.	Glacial aquifer system	60	54.7	59.7
whitluscr1	WHITLUSCR1-18	18	LUS	Ind.	Glacial aquifer system	27	21.9	26.9
whitluscr1	WHITLUSCR1-20	20	LUS	Ind.	Glacial aquifer system	33	27.5	32.5
whitluscr1	WHITLUSCR1-21	21	LUS	Ind.	Glacial aquifer system	51	45.8	51*
whitluscr1	WHITLUSCR1-22	22	LUS	Ind.	Glacial aquifer system	26.5	21.3	26.3
whitluscr1	WHITLUSCR1-23	23	LUS	Ind.	Glacial aquifer system	32	22.4	29.9
whitluscr1	WHITLUSCR1-24	24	LUS	Ind.	Glacial aquifer system	25	20	25
whitluscr1	WHITLUSCR1-25	25	LUS	Ind.	Glacial aquifer system	21	15.2	20.2
whitluscr1	WHITLUSCR1-26	26	LUS	Ind.	Glacial aquifer system	25.5	20.5	25.5
wmiclusag2	WMICLUSAG2-01	01	LUS	Wis.	Glacial aquifer system	54	49	54
wmiclusag2	WMICLUSAG2-10	10	LUS	Wis.	Glacial aquifer system	60	na	60*
wmiclusag2	WMICLUSAG2-11	11	LUS	Wis.	Glacial aquifer system	32	27	32
wmiclusag2	WMICLUSAG2-12	12	LUS	Wis.	Glacial aquifer system	128	123	128
wmiclusag2	WMICLUSAG2-14	14	LUS	Wis.	Glacial aquifer system	94	89	94
wmiclusag2	WMICLUSAG2-15	15	LUS	Wis.	Glacial aquifer system	33	28	33
wmiclusag2	WMICLUSAG2-16	16	LUS	Wis.	Glacial aquifer system	16	1	16
wmiclusag2	WMICLUSAG2-17	17	LUS	Wis.	Glacial aquifer system	39	34	39
wmiclusag2	WMICLUSAG2-18	18	LUS	Wis.	Glacial aquifer system	10	5	10
wmiclusag2	WMICLUSAG2-19	19	LUS	Wis.	Glacial aquifer system	19	14	19
wmiclusag2	WMICLUSAG2-02	02	LUS	Wis.	Glacial aquifer system	73	68	73
wmiclusag2	WMICLUSAG2-20	20	LUS	Wis.	Glacial aquifer system	43	38	43
wmiclusag2	WMICLUSAG2-21	21	LUS	Wis.	Glacial aquifer system	81	76	81
wmiclusag2	WMICLUSAG2-22	22	LUS	Wis.	Glacial aquifer system	41	36	41

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
wmiclusag2	WMICLUSAG2-24	24	LUS	Wis.	Glacial aquifer system	29	24	29
wmiclusag2	WMICLUSAG2-25	25	LUS	Wis.	Glacial aquifer system	39	34	39
wmiclusag2	WMICLUSAG2-26	26	LUS	Wis.	Glacial aquifer system	29.5	24.5	29.5
wmiclusag2	WMICLUSAG2-27	27	LUS	Wis.	Glacial aquifer system	29	24	29
wmiclusag2	WMICLUSAG2-28	28	LUS	Wis.	Glacial aquifer system	28	23	28
wmiclusag2	WMICLUSAG2-29	29	LUS	Wis.	Glacial aquifer system	32	27	32
wmiclusag2	WMICLUSAG2-03	03	LUS	Wis.	Glacial aquifer system	23	18	23
wmiclusag2	WMICLUSAG2-30	30	LUS	Wis.	Glacial aquifer system	55	50	55
wmiclusag2	WMICLUSAG2-04	04	LUS	Wis.	Glacial aquifer system	44	39	44
wmiclusag2	WMICLUSAG2-05	05	LUS	Wis.	Glacial aquifer system	39	34	39
wmiclusag2	WMICLUSAG2-06	06	LUS	Wis.	Glacial aquifer system	94	89	94
wmiclusag2	WMICLUSAG2-07	07	LUS	Wis.	Glacial aquifer system	68	63	68
wmiclusag2	WMICLUSAG2-08	08	LUS	Wis.	Glacial aquifer system	59	54	59
wmiclusag2	WMICLUSAG2-09	09	LUS	Wis.	Glacial aquifer system	81	76	81
ccptsus1b	CCPTSUS1B-01	01	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	132	122	132
ccptsus1b	CCPTSUS1B-03	03	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	1,000	575	1,000
ccptsus1b	CCPTSUS1B-04	04	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	155	na	155*
ccptsus1b	CCPTSUS1B-05	05	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	450	190	450
ccptsus1b	CCPTSUS1B-06	06	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	170	19	170
ccptsus1b	CCPTSUS1B-07	07	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	105.5	80	105.5
ccptsus1b	CCPTSUS1B-08	08	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	100	59	100
ccptsus1b	CCPTSUS1B-09	09	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	150	130	150
ccptsus1b	CCPTSUS1B-10	10	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	255	57	255
ccptsus1b	CCPTSUS1B-11	11	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	1,000	192	1,000
ccptsus1b	CCPTSUS1B-12	12	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	370	60	370
ccptsus1b	CCPTSUS1B-13	13	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	82	64	81
ccptsus1b	CCPTSUS1B-14	14	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	154**	145	154

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
ccptsus1b	CCPTSUS1B-15	15	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	430	47	430
ccptsus1b	CCPTSUS1B-16	16	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	568	108	568
ccptsus1b	CCPTSUS1B-17	17	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	147	21	147
ccptsus1b	CCPTSUS1B-18	18	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	180	73	180
ccptsus1b	CCPTSUS1B-19	19	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	36	26	36
ccptsus1b	CCPTSUS1B-20	20	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	717	157	717
ccptsus1b	CCPTSUS1B-21b	21b	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	960**	767	960
ccptsus1b	CCPTSUS1B-22	22	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	220	na	220*
ccptsus1b	CCPTSUS1B-23	23	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	100	65	91.8
ccptsus1b	CCPTSUS1B-24	24	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	273	86	273
ccptsus1b	CCPTSUS1B-25	25	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	907	684	907
ccptsus1b	CCPTSUS1B-26	26	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	89.8	54	89.8
ccptsus1b	CCPTSUS1B-27	27	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	747	22	703
ccptsus1b	CCPTSUS1B-28	28	MAS	Wash.	Columbia Plateau basin-fill and basaltic-rock aquifers	530	415	530
potosus1	POTOSUS1-01	01	MAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	134	na	134*
potosus1	POTOSUS1-02	02	MAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	105	na	105*
potosus1	POTOSUS1-03	03	MAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	71	na	71*
potosus1	POTOSUS1-04	04	MAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	156	na	156*
potosus1	POTOSUS1-05	05	MAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	365	na	365*
potosus1	POTOSUS1-06	06	MAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	175	na	175*
potosus1	POTOSUS1-07	07	MAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	na	na	na
potosus1	POTOSUS1-08	08	MAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	124	na	124*
potosus1	POTOSUS1-09	09	MAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	222	na	222*
potosus1	POTOSUS1-10	10	MAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	na	na	na
potosus1	POTOSUS1-11	11	MAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	162	na	162*
potosus1	POTOSUS1-12	12	MAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	200	na	200*
potosus1	POTOSUS1-13	13	MAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	na	na	na

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
potosus1	POTOSUS1-14	14	MAS	Md.	Piedmont and Blue Ridge crystalline-rock aquifers	131	na	131*
potosus1	POTOSUS1-15	15	MAS	Md.	Piedmont and Blue Ridge crystalline-rock aquifers	85	48	85
potosus1	POTOSUS1-16	16	MAS	Md.	Piedmont and Blue Ridge crystalline-rock aquifers	150	40	150
potosus1	POTOSUS1-17	17	MAS	Md.	Piedmont and Blue Ridge crystalline-rock aquifers	90	na	90*
potosus1	POTOSUS1-18	18	MAS	Md.	Piedmont and Blue Ridge crystalline-rock aquifers	na	na	na
potosus1	POTOSUS1-19	19	MAS	Md.	Piedmont and Blue Ridge crystalline-rock aquifers	na	na	na
potosus1	POTOSUS1-20	20	MAS	Md.	Piedmont and Blue Ridge crystalline-rock aquifers	153	26	153
potosus1	POTOSUS1-21	21	MAS	Md.	Piedmont and Blue Ridge crystalline-rock aquifers	na	na	na
potosus1	POTOSUS1-22	22	MAS	Md.	Piedmont and Blue Ridge crystalline-rock aquifers	117	53	117
potosus1	POTOSUS1-23	23	MAS	Md.	Piedmont and Blue Ridge crystalline-rock aquifers	150	na	150*
potosus1	POTOSUS1-24	24	MAS	Md.	Piedmont and Blue Ridge crystalline-rock aquifers	275	61	275
potosus1	POTOSUS1-25	25	MAS	Md.	Piedmont and Blue Ridge crystalline-rock aquifers	155	30	123
trinsus3	TRINSUS3-01	01	MAS	Tex.	Coastal lowlands aquifer system	490	376	470
trinsus3	TRINSUS3-02	02	MAS	Tex.	Coastal lowlands aquifer system	180	170	180
trinsus3	TRINSUS3-03	03	MAS	Tex.	Coastal lowlands aquifer system	280	260	280
trinsus3	TRINSUS3-04	04	MAS	Tex.	Coastal lowlands aquifer system	180	170	180
trinsus3	TRINSUS3-05	05	MAS	Tex.	Coastal lowlands aquifer system	170	na	170*
trinsus3	TRINSUS3-06	06	MAS	Tex.	Coastal lowlands aquifer system	1,182	864	1,162
trinsus3	TRINSUS3-07	07	MAS	Tex.	Coastal lowlands aquifer system	300	225	265
trinsus3	TRINSUS3-08	08	MAS	Tex.	Coastal lowlands aquifer system	204	175	195
trinsus3	TRINSUS3-09	09	MAS	Tex.	Coastal lowlands aquifer system	250	na	250*
trinsus3	TRINSUS3-10	10	MAS	Tex.	Coastal lowlands aquifer system	200	na	200*
trinsus3	TRINSUS3-11	11	MAS	Tex.	Coastal lowlands aquifer system	305	295	305
trinsus3	TRINSUS3-12	12	MAS	Tex.	Coastal lowlands aquifer system	190	180	190
trinsus3	TRINSUS3-13	13	MAS	Tex.	Coastal lowlands aquifer system	400	280	400
trinsus3	TRINSUS3-14	14	MAS	Tex.	Coastal lowlands aquifer system	336	na	336*
trinsus3	TRINSUS3-15	15	MAS	Tex.	Coastal lowlands aquifer system	210	na	210*

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
trinsus3	TRINSUS3-16	16	MAS	Tex.	Coastal lowlands aquifer system	210	170	209
trinsus3	TRINSUS3-17	17	MAS	Tex.	Coastal lowlands aquifer system	190	na	190*
trinsus3	TRINSUS3-18	18	MAS	Tex.	Coastal lowlands aquifer system	356	232	258
trinsus3	TRINSUS3-19	19	MAS	Tex.	Coastal lowlands aquifer system	190	na	190*
trinsus3	TRINSUS3-20	20	MAS	Tex.	Coastal lowlands aquifer system	42	30	40
trinsus3	TRINSUS3-21	21	MAS	Tex.	Coastal lowlands aquifer system	138	118	138
trinsus3	TRINSUS3-22	22	MAS	Tex.	Coastal lowlands aquifer system	166	156	166
trinsus3	TRINSUS3-23	23	MAS	Tex.	Coastal lowlands aquifer system	240	na	240*
trinsus3	TRINSUS3-24	24	MAS	Tex.	Coastal lowlands aquifer system	100	na	100*
trinsus3	TRINSUS3-25	25	MAS	Tex.	Coastal lowlands aquifer system	71	61	71
trinsus3	TRINSUS3-26	26	MAS	Tex.	Coastal lowlands aquifer system	18.5	8	18
cmorpas1	CMORPAS1-01	01	PAS	Iowa	Cambrian-Ordovician aquifer system	2,635	2,250	2,635
cmorpas1	CMORPAS1-02	02	PAS	Iowa	Cambrian-Ordovician aquifer system	1,870	1,745	1,870
cmorpas1	CMORPAS1-03	03	PAS	Iowa	Cambrian-Ordovician aquifer system	1,970	na	1,970*
cmorpas1	CMORPAS1-04	04	PAS	Iowa	Cambrian-Ordovician aquifer system	1,362	1,006	1,362
cmorpas1	CMORPAS1-05	05	PAS	Iowa	Cambrian-Ordovician aquifer system	600	na	600*
cmorpas1	CMORPAS1-06	06	PAS	Minn.	Cambrian-Ordovician aquifer system	550	400	550
cmorpas1	CMORPAS1-07	07	PAS	Minn.	Cambrian-Ordovician aquifer system	470	319	470
cmorpas1	CMORPAS1-08	08	PAS	Minn.	Cambrian-Ordovician aquifer system	900	698	900
cmorpas1	CMORPAS1-09	09	PAS	Minn.	Cambrian-Ordovician aquifer system	425	218	425
cmorpas1	CMORPAS1-10	10	PAS	Minn.	Cambrian-Ordovician aquifer system	352	257.5	352
cmorpas1	CMORPAS1-11	11	PAS	Iowa	Cambrian-Ordovician aquifer system	460	na	460*
cmorpas1	CMORPAS1-12	12	PAS	Iowa	Cambrian-Ordovician aquifer system	1,512	251.5	1,512
cmorpas1	CMORPAS1-13	13	PAS	Iowa	Cambrian-Ordovician aquifer system	2,000	na	2,000*
cmorpas1	CMORPAS1-14	14	PAS	Iowa	Cambrian-Ordovician aquifer system	2,435	1,988.7	2,435
cmorpas1	CMORPAS1-15	15	PAS	Iowa	Cambrian-Ordovician aquifer system	2,439	na	2,439*
cmorpas1	CMORPAS1-16	16	PAS	Iowa	Cambrian-Ordovician aquifer system	2,108	1,695	2,108

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
cmorpas1	CMORPAS1-17	17	PAS	Iowa	Cambrian-Ordovician aquifer system	2,550	2,194	2,508
cmorpas1	CMORPAS1-18	18	PAS	Iowa	Cambrian-Ordovician aquifer system	1,400	na	1,400*
cmorpas1	CMORPAS1-19	19	PAS	Iowa	Cambrian-Ordovician aquifer system	1,300	835	1,300
cmorpas1	CMORPAS1-20	20	PAS	Minn.	Cambrian-Ordovician aquifer system	805	381	805
cmorpas1	CMORPAS1-21	21	PAS	Wis.	Cambrian-Ordovician aquifer system	286	214	286
cmorpas1	CMORPAS1-22	22	PAS	Minn.	Cambrian-Ordovician aquifer system	242	166	242
cmorpas1	CMORPAS1-23	23	PAS	Minn.	Cambrian-Ordovician aquifer system	392	66	392
cmorpas1	CMORPAS1-24	24	PAS	Wis.	Cambrian-Ordovician aquifer system	285	220	285
cmorpas1	CMORPAS1-25	25	PAS	Wis.	Cambrian-Ordovician aquifer system	394	166.1	394
cmorpas1	CMORPAS1-26	26	PAS	Minn.	Cambrian-Ordovician aquifer system	708	590	708
cmorpas1	CMORPAS1-27	27	PAS	Iowa	Cambrian-Ordovician aquifer system	850	na	850*
cmorpas1	CMORPAS1-28	28	PAS	Iowa	Cambrian-Ordovician aquifer system	1,566	1,077.5	1,566
cmorpas1	CMORPAS1-29	29	PAS	Iowa	Cambrian-Ordovician aquifer system	1,900	na	1,900*
cmorpas1	CMORPAS1-30	30	PAS	Mo.	Cambrian-Ordovician aquifer system	1,515	440	1,515
cmorpas1	CMORPAS1-31	31	PAS	Mo.	Cambrian-Ordovician aquifer system	1,680	970	1,680
cmorpas1	CMORPAS1-32	32	PAS	Ill.	Cambrian-Ordovician aquifer system	1,281	1,058	1,281
cmorpas1	CMORPAS1-33	33	PAS	Iowa	Cambrian-Ordovician aquifer system	1,655	1,088	1,655
cmorpas1	CMORPAS1-34	34	PAS	Iowa	Cambrian-Ordovician aquifer system	1,215	768	1,215
cmorpas1	CMORPAS1-35	35	PAS	Wis.	Cambrian-Ordovician aquifer system	994	310	994
cmorpas1	CMORPAS1-36	36	PAS	Wis.	Cambrian-Ordovician aquifer system	173	77.8	173
cmorpas1	CMORPAS1-37	37	PAS	Wis.	Cambrian-Ordovician aquifer system	170	71	170
cmorpas1	CMORPAS1-38	38	PAS	Wis.	Cambrian-Ordovician aquifer system	605	100	605
cmorpas1	CMORPAS1-39	39	PAS	Wis.	Cambrian-Ordovician aquifer system	380	170	380
cmorpas1	CMORPAS1-40	40	PAS	Wis.	Cambrian-Ordovician aquifer system	400	50	400
cmorpas1	CMORPAS1-41	41	PAS	Wis.	Cambrian-Ordovician aquifer system	330	130	330
cmorpas1	CMORPAS1-42	42	PAS	Ill.	Cambrian-Ordovician aquifer system	1,600	370	1,600
cmorpas1	CMORPAS1-43	43	PAS	Ill.	Cambrian-Ordovician aquifer system	1,739	1,161	1,739

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
cmorpas1	CMORPAS1-44	44	PAS	Ill.	Cambrian-Ordovician aquifer system	1,743	876	1,743
cmorpas1	CMORPAS1-45	45	PAS	Ill.	Cambrian-Ordovician aquifer system	1,509	1,061	1,509*
cmorpas1	CMORPAS1-46	46	PAS	Ill.	Cambrian-Ordovician aquifer system	2,005	665	2,005
cmorpas1	CMORPAS1-47	47	PAS	Ill.	Cambrian-Ordovician aquifer system	1,472	300	1,472*
cmorpas1	CMORPAS1-48	48	PAS	Ill.	Cambrian-Ordovician aquifer system	1,312	323	1,312*
cmorpas1	CMORPAS1-49	49	PAS	Wis.	Cambrian-Ordovician aquifer system	854	96.8	854
cmorpas1	CMORPAS1-50	50	PAS	Wis.	Cambrian-Ordovician aquifer system	2,028	500	2,028
cmorpas1	CMORPAS1-51	51	PAS	Wis.	Cambrian-Ordovician aquifer system	185	75	185
cmorpas1	CMORPAS1-52	52	PAS	Wis.	Cambrian-Ordovician aquifer system	708	120	708
cmorpas1	CMORPAS1-53	53	PAS	Mich.	Cambrian-Ordovician aquifer system	630	320	630
cmorpas1	CMORPAS1-54	54	PAS	Mich.	Cambrian-Ordovician aquifer system	815	180	815
cmorpas1	CMORPAS1-55	55	PAS	Mich.	Cambrian-Ordovician aquifer system	487	422	487
cmorpas1	CMORPAS1-56	56	PAS	Mich.	Cambrian-Ordovician aquifer system	354	310	354
cmorpas1	CMORPAS1-57	57	PAS	Wis.	Cambrian-Ordovician aquifer system	595	150	595
cmorpas1	CMORPAS1-58	58	PAS	Wis.	Cambrian-Ordovician aquifer system	1,474	355.5	1,474
cmorpas1	CMORPAS1-59	59	PAS	Ill.	Cambrian-Ordovician aquifer system	1,353	628	1,353
cmorpas1	CMORPAS1-60	60	PAS	Ill.	Cambrian-Ordovician aquifer system	1,335	808	1,335*
cmorpas1	CMORPAS1-U01	U01	PAS	Minn.	Cambrian-Ordovician aquifer system	690	560	690
cmorpas1	CMORPAS1-U02	U02	PAS	Minn.	Cambrian-Ordovician aquifer system	212	na	212*
cmorpas1	CMORPAS1-U03	U03	PAS	Minn.	Cambrian-Ordovician aquifer system	220	114	220
cmorpas1	CMORPAS1-U04	U04	PAS	Minn.	Cambrian-Ordovician aquifer system	798	510	798
cmorpas1	CMORPAS1-U05	U05	PAS	Minn.	Cambrian-Ordovician aquifer system	484	399	484
cmorpas1	CMORPAS1-U06	U06	PAS	Iowa	Cambrian-Ordovician aquifer system	1,830	454	1,830
cmorpas1	CMORPAS1-U07	U07	PAS	Iowa	Cambrian-Ordovician aquifer system	2,205	1,738	2,205
cmorpas1	CMORPAS1-U08	U08	PAS	Iowa	Cambrian-Ordovician aquifer system	1,715	1,463	1,715
cmorpas1	CMORPAS1-U09	U09	PAS	Iowa	Cambrian-Ordovician aquifer system	1,860	623	1,860
cmorpas1	CMORPAS1-U10	U10	PAS	Iowa	Cambrian-Ordovician aquifer system	1,640	1,176	1,640

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
cmorpas1	CMORPAS1-U11	U11	PAS	Ill.	Cambrian-Ordovician aquifer system	460	na	460*
cmorpas1	CMORPAS1-U12	U12	PAS	Ill.	Cambrian-Ordovician aquifer system	1,578	174	1,578
cmorpas1	CMORPAS1-U13	U13	PAS	Ill.	Cambrian-Ordovician aquifer system	1,441	320	1,441
cmorpas1	CMORPAS1-U14	U14	PAS	Ill.	Cambrian-Ordovician aquifer system	1,558	991	1,323
cmorpas1	CMORPAS1-U15	U15	PAS	Ill.	Cambrian-Ordovician aquifer system	1,536	440	1,536
cmorpas1	CMORPAS1-U16	U16	PAS	Wis.	Cambrian-Ordovician aquifer system	1,163	403	1,163
cmorpas1	CMORPAS1-U17	U17	PAS	Wis.	Cambrian-Ordovician aquifer system	838	200	838
cmorpas1	CMORPAS1-U18	U18	PAS	Wis.	Cambrian-Ordovician aquifer system	1,500	402	1,500
cmorpas1	CMORPAS1-U19	U19	PAS	Wis.	Cambrian-Ordovician aquifer system	1,550	360	1,550
cmorpas1	CMORPAS1-U20	U20	PAS	Wis.	Cambrian-Ordovician aquifer system	100	43	100
glacpas1	GLACPAS1-01	01	PAS	Wash.	Glacial aquifer system	200	184	200
glacpas1	GLACPAS1-02	02	PAS	Wash.	Glacial aquifer system	120	110	120
glacpas1	GLACPAS1-03	03	PAS	Wash.	Glacial aquifer system	100	56	68
glacpas1	GLACPAS1-04	04	PAS	Mont.	Glacial aquifer system	160.4	150.4	160.4
glacpas1	GLACPAS1-05	05	PAS	Mont.	Glacial aquifer system	58	46	56
glacpas1	GLACPAS1-06	06	PAS	Mont.	Glacial aquifer system	37	27	37
glacpas1	GLACPAS1-07	07	PAS	Mont.	Glacial aquifer system	90	84	90
glacpas1	GLACPAS1-08	08	PAS	Mont.	Glacial aquifer system	111	99	111
glacpas1	GLACPAS1-09	09	PAS	N. Dak.	Glacial aquifer system	57	49	57
glacpas1	GLACPAS1-10	10	PAS	Maine	Glacial aquifer system	45	35	45
glacpas1	GLACPAS1-11	11	PAS	Maine	Glacial aquifer system	88	na	88*
glacpas1	GLACPAS1-12	12	PAS	Maine	Glacial aquifer system	70	55	70
glacpas1	GLACPAS1-13	13	PAS	Minn.	Glacial aquifer system	40	32	40
glacpas1	GLACPAS1-14	14	PAS	Minn.	Glacial aquifer system	191	161	191
glacpas1	GLACPAS1-15	15	PAS	Minn.	Glacial aquifer system	56	41	56
glacpas1	GLACPAS1-16	16	PAS	N. Dak.	Glacial aquifer system	250	200	250
glacpas1	GLACPAS1-17	17	PAS	N. Dak.	Glacial aquifer system	41	25	40

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
glacpas1	GLACPAS1-18	18	PAS	N. Dak.	Glacial aquifer system	156	133	153
glacpas1	GLACPAS1-19	19	PAS	Mont.	Glacial aquifer system	72	53	63
glacpas1	GLACPAS1-20	20	PAS	Mont.	Glacial aquifer system	100	93	100
glacpas1	GLACPAS1-21	21	PAS	N. Dak.	Glacial aquifer system	124	84	124
glacpas1	GLACPAS1-22	22	PAS	N. Dak.	Glacial aquifer system	220	199.5	220
glacpas1	GLACPAS1-26	26	PAS	Mich.	Glacial aquifer system	157	130	157
glacpas1	GLACPAS1-27	27	PAS	Mich.	Glacial aquifer system	130	114	130
glacpas1	GLACPAS1-28	28	PAS	Mich.	Glacial aquifer system	174	153.6	174
glacpas1	GLACPAS1-29	29	PAS	Vt.	Glacial aquifer system	na	na	na
glacpas1	GLACPAS1-30	30	PAS	Maine	Glacial aquifer system	75	65	75
glacpas1	GLACPAS1-31	31	PAS	N.H.	Glacial aquifer system	30	na	30*
glacpas1	GLACPAS1-32	32	PAS	N.Y.	Glacial aquifer system	140	na	140*
glacpas1	GLACPAS1-33	33	PAS	N.Y.	Glacial aquifer system	236.3	196.3	236.3
glacpas1	GLACPAS1-34	34	PAS	Mich.	Glacial aquifer system	300	280	300
glacpas1	GLACPAS1-39	39	PAS	S. Dak.	Glacial aquifer system	299	275	299
glacpas1	GLACPAS1-40	40	PAS	S. Dak.	Glacial aquifer system	260	na	260*
glacpas1	GLACPAS1-41	41	PAS	S. Dak.	Glacial aquifer system	63	49	63
glacpas1	GLACPAS1-48	48	PAS	N.Y.	Glacial aquifer system	49	na	49*
glacpas1	GLACPAS1-49	49	PAS	N.Y.	Glacial aquifer system	50	38	50
glacpas1	GLACPAS1-50	50	PAS	Mass.	Glacial aquifer system	69	54	69
glacpas1	GLACPAS1-51	51	PAS	Conn.	Glacial aquifer system	70	60.3	70
glacpas1	GLACPAS1-52	52	PAS	N.Y.	Glacial aquifer system	43.6	33.6	43.6
glacpas1	GLACPAS1-53	53	PAS	N.Y.	Glacial aquifer system	160	na	160*
glacpas1	GLACPAS1-69	69	PAS	Pa.	Glacial aquifer system	43	33	43
glacpas1	GLACPAS1-70	70	PAS	N.J.	Glacial aquifer system	136.3	116.3	136.3
glacpas1	GLACPAS1-72	72	PAS	Ind.	Glacial aquifer system	95	75	95
glacpas1	GLACPAS1-U22	U22	PAS	Ind.	Glacial aquifer system	55	50	55

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
glacpas1	GLACPAS1-U24	U24	PAS	Ind.	Glacial aquifer system	104	74	104
glacpas1	GLACPAS1-U25	U25	PAS	Wis.	Glacial aquifer system	125	na	125*
metxpas1	METXPAS1-01	01	PAS	Mo.	Mississippi Embayment-Texas Coastal Uplands aquifer system	860	na	860*
metxpas1	METXPAS1-02	02	PAS	Mo.	Mississippi Embayment-Texas Coastal Uplands aquifer system	460	na	460*
metxpas1	METXPAS1-03	03	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	221	174	221
metxpas1	METXPAS1-04	04	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	613	560	610
metxpas1	METXPAS1-05	05	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	470	430	470
metxpas1	METXPAS1-06	06	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	615	493	615
metxpas1	METXPAS1-07	07	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	863	783	863
metxpas1	METXPAS1-08	08	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	330	na	330*
metxpas1	METXPAS1-09	09	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	887	na	887*
metxpas1	METXPAS1-10	10	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	1,288.5	1,205	1,285
metxpas1	METXPAS1-11	11	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	485	96.7	126.7
metxpas1	METXPAS1-12	12	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	129	97	127
metxpas1	METXPAS1-13	13	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	569	509	569
metxpas1	METXPAS1-14	14	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	290	250	290
metxpas1	METXPAS1-15	15	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	255	215	255*
metxpas1	METXPAS1-16	16	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	437	na	437*
metxpas1	METXPAS1-17	17	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	768	na	768*
metxpas1	METXPAS1-18	18	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	259	199	259
metxpas1	METXPAS1-19	19	PAS	Ark.	Mississippi Embayment-Texas Coastal Uplands aquifer system	595	na	595*
metxpas1	METXPAS1-20	20	PAS	La.	Mississippi Embayment-Texas Coastal Uplands aquifer system	555	525	555
metxpas1	METXPAS1-21	21	PAS	La.	Mississippi Embayment-Texas Coastal Uplands aquifer system	270	240	270
metxpas1	METXPAS1-22	22	PAS	La.	Mississippi Embayment-Texas Coastal Uplands aquifer system	80	na	80*
metxpas1	METXPAS1-23	23	PAS	La.	Mississippi Embayment-Texas Coastal Uplands aquifer system	340	300	340
metxpas1	METXPAS1-24	24	PAS	La.	Mississippi Embayment-Texas Coastal Uplands aquifer system	110	60	90
metxpas1	METXPAS1-25	25	PAS	La.	Mississippi Embayment-Texas Coastal Uplands aquifer system	145	115	145

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
metxpas1	METXPAS1-26	26	PAS	La.	Mississippi Embayment-Texas Coastal Uplands aquifer system	443	362	437
metxpas1	METXPAS1-27	27	PAS	La.	Mississippi Embayment-Texas Coastal Uplands aquifer system	109	89	109
metxpas1	METXPAS1-28	28	PAS	La.	Mississippi Embayment-Texas Coastal Uplands aquifer system	491	384	491
metxpas1	METXPAS1-29	29	PAS	La.	Mississippi Embayment-Texas Coastal Uplands aquifer system	110	80	110
metxpas1	METXPAS1-30	30	PAS	La.	Mississippi Embayment-Texas Coastal Uplands aquifer system	527	496	527
metxpas1	METXPAS1-31	31	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	829	749	829
metxpas1	METXPAS1-32	32	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	1,325	1,245	1,325
metxpas1	METXPAS1-33	33	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	995	935	995
metxpas1	METXPAS1-34	34	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	541	495	541
metxpas1	METXPAS1-35	35	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	252	160	252
metxpas1	METXPAS1-36	36	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	305	255	305
metxpas1	METXPAS1-37	37	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	424	404	424
metxpas1	METXPAS1-38	38	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	371	301	371
metxpas1	METXPAS1-39	39	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	814	755	814
metxpas1	METXPAS1-40	40	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	744	683	744
metxpas1	METXPAS1-41	41	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	785	705	785
metxpas1	METXPAS1-42	42	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	96	71	96
metxpas1	METXPAS1-43	43	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	175	135	175
metxpas1	METXPAS1-44	44	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	337	317	337
metxpas1	METXPAS1-45	45	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	990	910	990
metxpas1	METXPAS1-46	46	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	1,120	1,055	1,120
metxpas1	METXPAS1-47	47	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	204	174	204
metxpas1	METXPAS1-48	48	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	450	345	450
metxpas1	METXPAS1-49	49	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	800	700	800
metxpas1	METXPAS1-50	50	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	946	886	946
metxpas1	METXPAS1-51	51	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	529	489	529
metxpas1	METXPAS1-52	52	PAS	Miss.	Mississippi Embayment-Texas Coastal Uplands aquifer system	780	710	780

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
metxpas1	METXPAS1-53	53	PAS	Tenn.	Mississippi Embayment-Texas Coastal Uplands aquifer system	622	516	616
metxpas1	METXPAS1-54	54	PAS	Tenn.	Mississippi Embayment-Texas Coastal Uplands aquifer system	213	168	213
metxpas1	METXPAS1-55	55	PAS	Tenn.	Mississippi Embayment-Texas Coastal Uplands aquifer system	450	355	445
metxpas1	METXPAS1-56	56	PAS	Tenn.	Mississippi Embayment-Texas Coastal Uplands aquifer system	565	495	565
metxpas1	METXPAS1-57	57	PAS	Ky.	Mississippi Embayment-Texas Coastal Uplands aquifer system	280	na	280*
metxpas1	METXPAS1-58	58	PAS	Ala.	Mississippi Embayment-Texas Coastal Uplands aquifer system	382	322	382
metxpas1	METXPAS1-59	59	PAS	Mo.	Mississippi Embayment-Texas Coastal Uplands aquifer system	1,390	1,300	1,390
metxpas1	METXPAS1-60	60	PAS	Ky.	Mississippi Embayment-Texas Coastal Uplands aquifer system	672	na	672*
piedpas1	PIEDPAS1-01	01	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	300	54	300
piedpas1	PIEDPAS1-02	02	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	550	98	550
piedpas1	PIEDPAS1-03	03	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	380	na	380*
piedpas1	PIEDPAS1-04	04	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	130	80	130
piedpas1	PIEDPAS1-05	05	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	500	42	500
piedpas1	PIEDPAS1-06	06	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	860	159	860
piedpas1	PIEDPAS1-07	07	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	405	80	405
piedpas1	PIEDPAS1-08	08	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	440	52	440
piedpas1	PIEDPAS1-09	09	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	547	68	547
piedpas1	PIEDPAS1-10	10	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	148	64	148
piedpas1	PIEDPAS1-11	11	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	307	52	307
piedpas1	PIEDPAS1-12	12	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	405	50	405
piedpas1	PIEDPAS1-13	13	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	280	na	280*
piedpas1	PIEDPAS1-14	14	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	345	39	345
piedpas1	PIEDPAS1-15	15	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	390	116	390
piedpas1	PIEDPAS1-16	16	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	260	na	260*
piedpas1	PIEDPAS1-17	17	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	500	76	500
piedpas1	PIEDPAS1-18	18	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	504	21	504
piedpas1	PIEDPAS1-19	19	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	325	na	325*
piedpas1	PIEDPAS1-20	20	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	500	na	500*

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
piedpas1	PIEDPAS1-21	21	PAS	N.C.	Piedmont and Blue Ridge crystalline-rock aquifers	160	na	160*
piedpas1	PIEDPAS1-22	22	PAS	S.C.	Piedmont and Blue Ridge crystalline-rock aquifers	155	na	155*
piedpas1	PIEDPAS1-23	23	PAS	S.C.	Piedmont and Blue Ridge crystalline-rock aquifers	na	na	na
piedpas1	PIEDPAS1-24	24	PAS	S.C.	Piedmont and Blue Ridge crystalline-rock aquifers	320	na	320*
piedpas1	PIEDPAS1-25	25	PAS	S.C.	Piedmont and Blue Ridge crystalline-rock aquifers	225	na	225*
piedpas1	PIEDPAS1-26	26	PAS	S.C.	Piedmont and Blue Ridge crystalline-rock aquifers	283	50	283
piedpas1	PIEDPAS1-27	27	PAS	S.C.	Piedmont and Blue Ridge crystalline-rock aquifers	305	132	305
piedpas1	PIEDPAS1-28	28	PAS	Ala.	Piedmont and Blue Ridge crystalline-rock aquifers	140	na	140*
piedpas1	PIEDPAS1-29	29	PAS	Ala.	Piedmont and Blue Ridge crystalline-rock aquifers	250	na	250*
piedpas1	PIEDPAS1-30	30	PAS	Ala.	Piedmont and Blue Ridge crystalline-rock aquifers	na	na	na
piedpas1	PIEDPAS1-31	31	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	204	83	204
piedpas1	PIEDPAS1-32	32	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	585	78	585
piedpas1	PIEDPAS1-33	33	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	550	92	550
piedpas1	PIEDPAS1-34	34	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	195	166	195
piedpas1	PIEDPAS1-35	35	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	445	33	445
piedpas1	PIEDPAS1-36	36	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	605	112	605
piedpas1	PIEDPAS1-37	37	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	650	126	650
piedpas1	PIEDPAS1-38	38	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	525	58	525
piedpas1	PIEDPAS1-39	39	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	505	105	505
piedpas1	PIEDPAS1-40	40	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	375	57	375
piedpas1	PIEDPAS1-41	41	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	450	na	450*
piedpas1	PIEDPAS1-42	42	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	405	63	405
piedpas1	PIEDPAS1-43	43	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	380	40	380
piedpas1	PIEDPAS1-44	44	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	280	60	280
piedpas1	PIEDPAS1-45	45	PAS	Ga.	Piedmont and Blue Ridge crystalline-rock aquifers	496	60	496
piedpas1	PIEDPAS1-46	46	PAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	211	na	211*
piedpas1	PIEDPAS1-47	47	PAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	na	na	na

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
piedpas1	PIEDPAS1-48	48	PAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	335	68	268
piedpas1	PIEDPAS1-49	49	PAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	400	100	400
piedpas1	PIEDPAS1-50	50	PAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	528	na	528*
piedpas1	PIEDPAS1-51	51	PAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	385	na	385*
piedpas1	PIEDPAS1-52	52	PAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	550	50	550
piedpas1	PIEDPAS1-53	53	PAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	330	85	330
piedpas1	PIEDPAS1-54	54	PAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	na	na	na
piedpas1	PIEDPAS1-55	55	PAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	418	198	418
piedpas1	PIEDPAS1-56	56	PAS	Va.	Piedmont and Blue Ridge crystalline-rock aquifers	400	150	400
piedpas1	PIEDPAS1-57	57	PAS	Md.	Piedmont and Blue Ridge crystalline-rock aquifers	200	na	200*
piedpas1	PIEDPAS1-58	58	PAS	Md.	Piedmont and Blue Ridge crystalline-rock aquifers	260	na	260*
piedpas1	PIEDPAS1-59	59	PAS	Pa.	Piedmont and Blue Ridge crystalline-rock aquifers	92	65	92
piedpas1	PIEDPAS1-60	60	PAS	N.J.	Piedmont and Blue Ridge crystalline-rock aquifers	705	57	705
rgaqpas1	RGAQPAS1-01	01	PAS	N. Mex.	Rio Grande aquifer system	567.5	225	550
rgaqpas1	RGAQPAS1-02	02	PAS	N. Mex.	Rio Grande aquifer system	605	280	550
rgaqpas1	RGAQPAS1-03	03	PAS	N. Mex.	Rio Grande aquifer system	590	340	590
rgaqpas1	RGAQPAS1-04	04	PAS	N. Mex.	Rio Grande aquifer system	251	151	251
rgaqpas1	RGAQPAS1-05	05	PAS	N. Mex.	Rio Grande aquifer system	107	40	100
rgaqpas1	RGAQPAS1-06	06	PAS	N. Mex.	Rio Grande aquifer system	700	540	700
rgaqpas1	RGAQPAS1-07	07	PAS	N. Mex.	Rio Grande aquifer system	210	138	198
rgaqpas1	RGAQPAS1-08	08	PAS	N. Mex.	Rio Grande aquifer system	910	380	900
rgaqpas1	RGAQPAS1-09	09	PAS	N. Mex.	Rio Grande aquifer system	500	130	500
rgaqpas1	RGAQPAS1-10	10	PAS	N. Mex.	Rio Grande aquifer system	2,000	na	2,000*
rgaqpas1	RGAQPAS1-11	11	PAS	N. Mex.	Rio Grande aquifer system	484	240	484
rgaqpas1	RGAQPAS1-12	12	PAS	N. Mex.	Rio Grande aquifer system	250	120	209
rgaqpas1	RGAQPAS1-13	13	PAS	N. Mex.	Rio Grande aquifer system	268	185	250
rgaqpas1	RGAQPAS1-14	14	PAS	N. Mex.	Rio Grande aquifer system	250	na	250*

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
rgaqpas1	RGAQPAS1-15	15	PAS	N. Mex.	Rio Grande aquifer system	1,310	820	1,290
rgaqpas1	RGAQPAS1-16	16	PAS	N. Mex.	Rio Grande aquifer system	1,487	800	1,435
rgaqpas1	RGAQPAS1-17	17	PAS	N. Mex.	Rio Grande aquifer system	204	na	204*
rgaqpas1	RGAQPAS1-18	18	PAS	N. Mex.	Rio Grande aquifer system	1,470	825	1,450
rgaqpas1	RGAQPAS1-19	19	PAS	N. Mex.	Rio Grande aquifer system	255	na	255*
rgaqpas1	RGAQPAS1-20	20	PAS	N. Mex.	Rio Grande aquifer system	1,056	456	1,032
rgaqpas1	RGAQPAS1-21	21	PAS	N. Mex.	Rio Grande aquifer system	602	330	590
rgaqpas1	RGAQPAS1-22	22	PAS	N. Mex.	Rio Grande aquifer system	804	216	804
rgaqpas1	RGAQPAS1-23	23	PAS	N. Mex.	Rio Grande aquifer system	492	239	479
rgaqpas1	RGAQPAS1-24	24	PAS	N. Mex.	Rio Grande aquifer system	900	452	900
rgaqpas1	RGAQPAS1-25	25	PAS	N. Mex.	Rio Grande aquifer system	225	180	220
rgaqpas1	RGAQPAS1-26	26	PAS	N. Mex.	Rio Grande aquifer system	300	250	300
rgaqpas1	RGAQPAS1-27	27	PAS	N. Mex.	Rio Grande aquifer system	505	388	491
rgaqpas1	RGAQPAS1-28	28	PAS	N. Mex.	Rio Grande aquifer system	600	280	580
rgaqpas1	RGAQPAS1-29	29	PAS	N. Mex.	Rio Grande aquifer system	737	430	730
rgaqpas1	RGAQPAS1-30	30	PAS	N. Mex.	Rio Grande aquifer system	685	320	685
rgaqpas1	RGAQPAS1-31	31	PAS	N. Mex.	Rio Grande aquifer system	236**	60	236
rgaqpas1	RGAQPAS1-32	32	PAS	N. Mex.	Rio Grande aquifer system	1,175	700	1,150
rgaqpas1	RGAQPAS1-33	33	PAS	N. Mex.	Rio Grande aquifer system	1,003	320	980
rgaqpas1	RGAQPAS1-34	34	PAS	N. Mex.	Rio Grande aquifer system	700	455	690
rgaqpas1	RGAQPAS1-35	35	PAS	N. Mex.	Rio Grande aquifer system	640	440	620
rgaqpas1	RGAQPAS1-36	36	PAS	N. Mex.	Rio Grande aquifer system	80	na	80*
rgaqpas1	RGAQPAS1-37	37	PAS	N. Mex.	Rio Grande aquifer system	370	320	359
rgaqpas1	RGAQPAS1-38	38	PAS	N. Mex.	Rio Grande aquifer system	500	na	500*
rgaqpas1	RGAQPAS1-39	39	PAS	N. Mex.	Rio Grande aquifer system	496	na	496*
rgaqpas1	RGAQPAS1-40	40	PAS	N. Mex.	Rio Grande aquifer system	250	na	250*
rgaqpas1	RGAQPAS1-41	41	PAS	N. Mex.	Rio Grande aquifer system	504	150	504

Table 1. Network name, well identification number, identification number shown on figures, network type, state, aquifer, well depth, and depth to top and bottom of perforated interval for wells sampled by the U.S. Geological Survey National Water-Quality Assessment Project, January through December 2014.—Continued

[ETN, Enhanced trends network; **, the recorded well depth was less than the recorded depth to the bottom of the perforated interval but is assumed to be the depth to the bottom of the perforated interval if the recorded hole depth was greater than or equal to the depth to the bottom of the perforated interval; na, information is not available and cannot be assumed; *, information is unavailable about the bottom of perforation, but it is assumed to be bottom of well (Well_depth); LUS, Land-use study; MAS, Major aquifer study; PAS, Principal aquifer study]

Network name	Well identification number	Identification number shown on figures 2-17	Network type	State	Aquifer	Well depth, in feet below land surface	Depth to perforation top, in feet below land surface	Depth to perforation bottom, in feet below land surface
rgaqpas1	RGAQPAS1-42	42	PAS	N. Mex.	Rio Grande aquifer system	460	370	450
rgaqpas1	RGAQPAS1-43	43	PAS	N. Mex.	Rio Grande aquifer system	750	450	740
rgaqpas1	RGAQPAS1-44	44	PAS	N. Mex.	Rio Grande aquifer system	25	na	25*
rgaqpas1	RGAQPAS1-45	45	PAS	N. Mex.	Rio Grande aquifer system	502	442	482
rgaqpas1	RGAQPAS1-46	46	PAS	Colo.	Rio Grande aquifer system	714	190	714
rgaqpas1	RGAQPAS1-47	47	PAS	Colo.	Rio Grande aquifer system	714	650	700
rgaqpas1	RGAQPAS1-48	48	PAS	Colo.	Rio Grande aquifer system	1,635	868	1,635
rgaqpas1	RGAQPAS1-49	49	PAS	Colo.	Rio Grande aquifer system	908	550	908
rgaqpas1	RGAQPAS1-50	50	PAS	Colo.	Rio Grande aquifer system	881	340	875
rgaqpas1	RGAQPAS1-51	51	PAS	Tex.	Rio Grande aquifer system	530	310	520
rgaqpas1	RGAQPAS1-52	52	PAS	Tex.	Rio Grande aquifer system	390	250	380
rgaqpas1	RGAQPAS1-53	53	PAS	Tex.	Rio Grande aquifer system	650	448	640
rgaqpas1	RGAQPAS1-54	54	PAS	Tex.	Rio Grande aquifer system	512	260	430
rgaqpas1	RGAQPAS1-55	55	PAS	Tex.	Rio Grande aquifer system	620	400	600
rgaqpas1	RGAQPAS1-56	56	PAS	Tex.	Rio Grande aquifer system	746	556	746
rgaqpas1	RGAQPAS1-57	57	PAS	Tex.	Rio Grande aquifer system	820	600	800
rgaqpas1	RGAQPAS1-58	58	PAS	Tex.	Rio Grande aquifer system	462	258	452
rgaqpas1	RGAQPAS1-59	59	PAS	Tex.	Rio Grande aquifer system	1,090	544	1,090
rgaqpas1	RGAQPAS1-60	60	PAS	Colo.	Rio Grande aquifer system	929	368	929

Appendixes

Appendix 1. Well Depth and Open Interval by Study Network

Table 1–1. Well depth by study network.

[ETN, enhanced trends network; nc, not calculated;LUS, land-use study; MAS, major aquifer study; PAS, principal aquifer study]

Network type	Network name	Number of wells in network with data presented in this report	Number of wells with well depth data	Well depth, in feet below land surface							
				Minimum	10th percentile	25th percentile	Median	75th percentile	90th percentile	Maximum	Mean
ETN	clptetn1	3	3	54	nc	nc	80	nc	nc	1,134	nc
ETN	cvaletn1	3	3	234	nc	nc	320	nc	nc	620	nc
ETN	edtretn1	3	3	300	nc	nc	550	nc	nc	1,550	nc
ETN	glacetn1	2	2	34.5	nc	nc	58.8	nc	nc	83	nc
ETN	metxetn1	2	2	90	nc	nc	357	nc	nc	624	nc
ETN	nacpetn1	3	3	22	nc	nc	119	nc	nc	139	nc
ETN	negxetn1	3	3	83	nc	nc	176.3	nc	nc	492	nc
ETN	rgaqetn1	3	3	22	nc	nc	22.6	nc	nc	60	nc
LUS	albelusag1	26	26	8.5	10.8	13.3	19.1	25	32.45	36	20
LUS	ccptlusag2b	23	23	16	21.1	32.5	42.4	65.8	86.3	112	50
LUS	potolusag1	28	26	85	108.5	134.8	177.5	248.8	289	360	194
LUS	sanjlusor2a	24	24	96	115.6	120	160	191.3	224.3	250	160
LUS	whitluscr1	24	24	16	18.9	21.8	26	32.3	41.7	60	29
LUS	wmiclusag2	28	28	10	21.8	29.4	40	62	84.9	128	49
MAS	ccptsus1b	27	27	36	95.9	139.5	220	549	928.2	1,000	371
MAS	potosus1	25	19	71	89	120.5	150	168.5	232.6	365	159
MAS	trinsus3	26	26	18.5	85.5	172.5	202	295	378	1,182	254
PAS	cmorpas1	80	80	100	285.9	480.5	1,248	1,610	2,000.5	2,635	1,134
PAS	glacpas1	46	45	30	43.2	57	100	157	229.8	300	117
PAS	metxpas1	60	60	80	143.4	277.5	477.5	771	950.4	1,390	533
PAS	piedpas1	60	56	92	177.5	275	382.5	500	550	860	382
PAS	rgaqpas1	60	60	25	234.9	385	595	808	1,098.5	2,000	644

Table 1–2. Length of open interval by study network.

[ETN, enhanced trends network; nc, not calculated; LUS, land-use study; MAS, major aquifer study; PAS, principal aquifer study]

Network type	Network name	Number of wells in network with data presented in this report	Number of wells with well depth data	Length of open interval, in feet							
				Minimum	10th percentile	25th percentile	Median	75th percentile	90th percentile	Maximum	Mean
ETN	clptetn1	3	3	1	nc	nc	7	nc	nc	634	nc
ETN	cvaletn1	3	3	10	nc	nc	150	nc	nc	200	nc
ETN	edtretn1	3	3	80	nc	nc	230	nc	nc	233	nc
ETN	glacetn1	2	2	3	nc	nc	6.5	nc	nc	10	nc
ETN	metxetn1	2	2	10	nc	nc	57	nc	nc	104	nc
ETN	nacpetn1	3	3	3	nc	nc	19	nc	nc	50	nc
ETN	negxetn1	3	2	10	nc	nc	207	nc	nc	404	nc
ETN	rgaqetn1	3	3	10	nc	nc	10	nc	nc	20	nc
LUS	albelusag1	26	26	2	3	4.7	5	5	8.8	10	5
LUS	ccptlusag2b	23	23	3	5	5	5	5	14.9	15	6
LUS	potolusag1	28	14	15	26	73.5	138	202.3	280.8	312	141
LUS	sanjlusor2a	24	22	10	10	12.5	20	20	39.5	81	21
LUS	whitluscr1	24	24	2	4.8	5	5	5	6.7	7.5	5
LUS	wmiclusag2	28	27	5	5	5	5	5	5	15	5
MAS	ccptsus1b	27	25	9	12.8	26.8	151	310	656.8	808	215
MAS	potosus1	25	6	37	50.5	71.3	101.5	122.8	192.3	214	108
MAS	trinsus3	26	17	10	10	10	20	39.0	155.6	298	45
PAS	cmorpas1	80	70	44	93.6	200.5	445.7	749.2	1,304.2	1,528	530
PAS	glacpas1	46	38	5	8	10	14.5	20	40	50	17
PAS	metxpas1	60	50	20	30	33.3	59.5	80	102.8	122	58
PAS	piedpas1	60	39	27	113.6	239	340	458	536.4	701	337
PAS	rgaqpas1	60	51	39	60	145	244	449	630	767	291

Appendix 2. High-Frequency Data from Enhanced Trends Networks

High-frequency data collected at enhanced trends network sites are available from the National Water Information System (U.S. Geological Survey, 2016) online database (table 2–1). The links in table 2–1 below provide access to the high-frequency data on the Web. To access the data for the time period covered by this report, the user should open the National Water Information System Web page at https://doi.org/10.5066/F7P55KJN. The user should then change the begin and end dates to retrieve the data for the time period January 1, 2014, to December 31, 2014.

Some of the enhanced trends network sites may have different equipment installed and may collect different parameters than others. Additionally, some sites have missing record for various parameters because of equipment failures at various times during the data collection period.

Table 2–1. Web links to data collected at a high frequency from enhanced trends networks.

[See figure 16 of this report for locations of enhanced trends networks. NAWQA, National Water-Quality Assessment]

Network name	NAWQA Project well identification number	Link to data collected at a high frequency
clptetn1	CLPTETN1–01	https://waterdata.usgs.gov/nwis/uv?site_no=455415119314601
clptetn1	CLPTETN1–02	No high frequency data are available for 2014.
clptetn1	CLPTETN1–03	https://waterdata.usgs.gov/nwis/uv?site_no=455009119142301
cvaletn1	CVALETN1–01	https://waterdata.usgs.gov/nwis/uv?site_no=364200119420001
cvaletn1	CVALETN1–02	https://waterdata.usgs.gov/nwis/uv?site_no=364200119420002
cvaletn1	CVALETN1–03	https://waterdata.usgs.gov/nwis/uv?site_no=364200119420003
edtretn1	EDTRETN1–01	https://waterdata.usgs.gov/nwis/uv?site_no=293116098334101
edtretn1	EDTRETN1–02	https://waterdata.usgs.gov/nwis/uv?site_no=293516098325501
edtretn1	EDTRETN1–03	https://waterdata.usgs.gov/nwis/uv?site_no=292331098294501
glacetn1	GLACETN1–01	https://waterdata.usgs.gov/nwis/uv?site_no=443320089212303
glacetn1	GLACETN1–02	https://waterdata.usgs.gov/nwis/uv?site_no=443320089212304
metxetn1	METXETN1-01	https://waterdata.usgs.gov/nwis/uv?site_no=351113089513401
metxetn1	METXETN1–02	https://waterdata.usgs.gov/nwis/uv?site_no=351111089512501
nacpetn1	NACPETN1–01	https://waterdata.usgs.gov/nwis/uv?site_no=384637075153201
nacpetn1	NACPETN1–02	https://waterdata.usgs.gov/nwis/uv?site_no=384526075091601
nacpetn1	NACPETN1–03	https://waterdata.usgs.gov/nwis/uv?site_no=384428075355701
negxetn1	NEGXETN1–01	https://waterdata.usgs.gov/nwis/uv?site_no=425311070535801
negxetn1	NEGXETN1–02	https://waterdata.usgs.gov/nwis/uv?site_no=425400070545401
negxetn1	NEGXETN1–03	https://waterdata.usgs.gov/nwis/uv?site_no=425651070573701
rgaqetn1	RGAQETN1–01	https://waterdata.usgs.gov/nwis/uv?site_no=323733107011002
rgaqetn1	RGAQETN1–02	https://waterdata.usgs.gov/nwis/uv?site_no=324007107095501
rgaqetn1	RGAQETN1-03	https://waterdata.usgs.gov/nwis/uv?site_no=324955107180902

Appendix 3. Analysis of Blank Samples for Possible Contamination Bias of Manganese and Cobalt

The U.S. Geological Survey Office of Water Quality determined that from October 1, 2008, to September 30, 2014, water samples for cobalt and manganese were potentially affected by contamination bias from high-capacity capsule filters (Office of Water Quality Technical Memorandum 2016.05 (http://water.usgs.gov/admin/memo/QW/qw2016.05.pdf, accessed July 1, 2016). Groundwater-quality data from blank samples for cobalt and manganese that were collected for the third cycle of the National Water Quality Assessment Project between May 2012 and December 2014 were evaluated to determine the possible effects of this contamination on environmental samples. Cobalt was detected in 86 of 279 blank samples (31 percent) and the concentration in the 95th percentile of blanks was 0.17 µg/L. Manganese was detected in 54 of 282 blank samples (19 percent) and the concentration in the 95th percentile of blanks was 0.5 µg/L.

Interpretations of environmental data in the lower range of detections may be affected by contamination bias for cobalt and manganese. Non-detections are not considered to be affected by contamination because the contaminant is absent. Also, values from environmental samples that are greater than 10 times the 90 percent upper confidence limit for the 95th percentile of field blanks (1.7 µg/L for Co and 5.0 µg/L for Mn) are not likely to be affected by contamination bias. Results between the reporting limit and the upper confidence level for the 95th percentile of blanks may be influenced by contamination bias and would warrant annotation that contamination due to the contaminated filters may cause the measured values to be in excess of the actual amount of the constituent present in the sample (Muller and others, 2015). Subsequent retrievals of these data from the U.S. Geological Survey National Water Information System (NWIS) database (U.S. Geological Survey, 2016) may include raised reporting levels or additional value qualifier codes because of this bias. For this report, raw cobalt and manganese results as stored in the NWIS database on July 1, 2016, have been reported in the data tables. However, for data analysis, users might decide that application of a raised reporting level is appropriate. Based on results of the blank samples discussed in the previous paragraph, data users might select raised reporting levels of 0.17 µg/L for cobalt and 0.5 µg/L for manganese, but different reporting levels could be selected based on the particular objectives of data analysis.

References Cited

Mueller, D.K., Schertz, T.L., Martin, J.D., and Sandstrom, M.W., 2015, Design, analysis, and interpretation of field quality-control data for water-sampling projects: U.S. Geological Survey Techniques and Methods, book 4, chap. C4, 54 p., https://pubs.usgs.gov/tm/04/c04/.

U.S. Geological Survey, 2016, National Water Information System—Web interface, accessed September 28, 2016, at https://doi.org/10.5066/F7P55KJN.

Appendix 4. Quality-Control Data and Analysis

Samples

Quality-control (QC) samples are routinely collected along with the environmental groundwater samples. The third cycle of the U.S. Geological Survey National Water-Quality Assessment (NAWQA) Project groundwater studies began in 2013, although there was a small pilot study in 2012. Data from the environmental and QC blank and replicate samples from the 2012–13 sampling period were presented in Arnold and others (2016a, b). This report presents a summary of QC samples from the entire sampling period (May 2012–December 2014) and the January–December 2014 sampling period covered by this report. A summary of results from blank samples collected during the sampling period January–December 2014 is shown in table 4–1, and a summary for the sampling period May 2012–December 2014 is shown in table 4–2. A summary of replicate samples, an analysis of the variability in detections and concentrations of selected analytes from replicate samples, and a summary of spike samples for the entire sampling period May 2012–December 2014 are shown in tables 4–3 through 4–6. Data from the environmental and QC samples from the January to December 2014 sampling period are presented in tables 4–7 through 4–27 of Arnold and others (2017). Data and summaries for pesticide spike samples are not included in this report.

Blank Sample Approach

Blank samples are QC samples that are used to determine if water samples might become contaminated during sample collection, field processing, transport, or laboratory analysis (Mueller and others, 2015). Blank samples are collected using blank water that has been prepared to be free of detectable concentrations of the constituents of interest. An equipment blank generally is collected in a controlled environment (such as a laboratory) before field sampling begins and is intended to evaluate the suitability of the equipment and equipment cleaning protocols for the established data-quality requirements. A field blank is subjected to all the same aspects of sample collection, field processing, preservation, transportation, and laboratory handling as an environmental sample and is intended to evaluate the potential for these procedures to be sources of contamination. A source solution blank is a sample of the water used to collect the equipment and field blanks and is intended to verify that the blank water itself has no detectable concentrations of the constituents of interest. Because field blanks are collected under conditions most comparable to conditions affecting environmental samples, these blanks are most directly representative of potential sources of contamination to environmental samples and were the focus of this initial evaluation of blank-sample results.

Results of the initial evaluation of data from field blanks for major and trace elements, nutrients, volatile organic compounds (VOCs), and pesticide compounds collected during the 2014 sampling period of January 2014 through December 2014 and the entire Cycle 3 sampling period of May 2012 through December 2014 are presented in this report. Data from 2014 are published in this report and in Arnold and others (2017), and data from 2013 are published in Arnold and others (2016a, b). About 75–80 percent of the field blanks collected for each of these constituents during the Cycle 3 sampling period have been associated with groundwater sites that are sampled using a dedicated pump (primarily public-supply and domestic wells), and the rest have been associated with groundwater sites that are sampled using a portable sampling pump (monitoring wells). The objective of this initial evaluation of field blanks was to determine if environmental concentrations of these constituents as reported by the National Water-Quality Laboratory are suitable for comparison to their corresponding human-health benchmarks (HHBs) or, if HHBs have not been established, to U.S. Environmental Protection Agency secondary maximum contaminant levels (SMCLs). The HHBs are a set of health-based comparison thresholds that include EPA maximum contaminant levels, Health-Based Screening Levels, and Human Health Benchmarks for pesticides. Further evaluation of results for blank samples, such as through methods used by Olsen and others (2010), Bender and others (2011), Fram and others (2012), or Davis and others (2014), would be needed to determine if inadvertent contamination of samples with certain constituents would affect the interpretation of environmental concentrations of those constituents for objectives other than those presented in this report.

Blank Sample Counts

The total number of blank samples and the number of field blanks collected for groundwater sites vary by constituent group during the 2014 sampling period (table 4–1) and the Cycle 3 sampling period (table 4–2). Data for all blank samples from the 2014 sampling period are presented in tables 4–7 through 4–14 of Arnold and others (2017). All Cycle 3 blank samples were analyzed using the corresponding laboratory methods listed in table 2 of Arnold and others (2017). Of the 350 Cycle 3 VOC blank samples, 28 were collected in 2012 or early 2013 and analyzed for an older analytical schedule using purge and trap gas chromatography/mass spectrometry (Gilliom and others, 2006; Zogorski and others, 2006); 322 were collected in 2013–14 and analyzed using the most recent analytical schedule and laboratory methods (purge and trap gas chromatography/mass spectrometry and heated purge and trap gas chromatography/mass spectrometry). Of the 106 Cycle 3 pesticide blank samples, 8 were collected in 2012 and analyzed for an older analytical schedule using gas chromatography/mass spectrometry; 98 were collected in 2013–14 and analyzed using the most recent analytical schedule and laboratory method (direct aqueous injection liquid chromatography tandem mass spectrometry). One blank sample collected in 2014 was analyzed using both an older and the most recent analytical schedule. Not included in table 4–1 are sample counts for special-interest constituents that were collected only in selected well networks: arsenic species, perchlorate, and hexavalent chromium. Only four to seven field blanks were collected for each of these special-interest constituents through December 2014.

Table 4–1. Summary of results for field blanks collected by the National Water-Quality Assessment Project from January 2014 to December 2014.

[VOCs, volatile organic compounds; HHB, human-health benchmark; SMCL, secondary maximum contaminant level]

Type of summary	Major and minor elements	Trace elements	Nutrients	VOCs	Pesticide compounds
Total number of blank samples	123	123	124	156	45
Number of field blanks	56	56	54	48	41
Number of constituents analyzed	10	22	5	85	225
Number of constituents detected in field blanks	8	16	3	14	8
Number of constituents detected in field blanks that have an HHB	1	13	1	7	5
Number of constituents detected in field blanks that have an SMCL	4	5	0	0	0
Largest ratio of the maximum concentration in a field blank to the corresponding HHB, in percent	0.25	3.7	0.53	0.55	0.25
Largest ratio of the maximum concentration in a field blank to the corresponding SMCL, in percent	14	199	Not applicable	Not applicable	Not applicable

Table 4–2. Summary of results for field blanks collected by the National Water-Quality Assessment Project from May 2012 to December 2014.

[VOCs, volatile organic compounds; HHB, human-health benchmark; SMCL, secondary maximum contaminant level]

Type of summary	Major and minor elements	Trace elements	Nutrients	VOCs	Pesticide compounds
Total number of blank samples	255	253	250	350	106
Number of field blanks	113	111	112	115	100
Number of constituents analyzed	10	22	5	129	272
Number of constituents detected in field blanks	8	17	4	22	19
Number of constituents detected in field blanks that have an HHB	1	14	2	11	14
Number of constituents detected in field blanks that have an SMCL	4	5	0	0	0
Largest ratio of the maximum concentration in a field blank to the corresponding HHB, in percent	0.40	3.7	0.67	2.0	0.25
Largest ratio of the maximum concentration in a field blank to the corresponding SMCL, in percent	14	199	Not applicable	Not applicable	Not applicable

Constituent Concentrations in Blank Samples

Of the 10 major or minor elements included in laboratory analysis (not including analysis for dissolved-solids concentration), 8 were detected in at least 1 field blank collected during 2014 (table 4–1); the same elements were detected in at least one Cycle 3 field blank (table 4–2). Only one of the detected major or minor elements (fluoride) has an HHB (table 2 of Arnold and others, 2017); four (chloride, fluoride, sulfate, and iron) have SMCLs. The maximum concentration for fluoride in any Cycle 3 field blank was 0.4 percent of its corresponding HHB. For chloride, fluoride, and sulfate, the maximum concentration in any Cycle 3 field blank was less than 1 percent of the corresponding SMCL; for iron, the maximum concentration was 14 percent of its corresponding SMCL.

Of the 22 trace elements included in laboratory analysis, 16 were detected in at least 1 field blank collected during 2014 (table 4–1), and 17 were detected in at least 1 Cycle 3 field blank (table 4–2). Of the 17 trace elements detected in Cycle 3 field blanks, 14 (antimony, barium, boron, cadmium, chromium, copper, lead, manganese, molybdenum, nickel, silver, strontium, uranium, and zinc) have HHBs (table 2 of Arnold and others, 2017); five (aluminum, copper, manganese, silver, and zinc) have SMCLs. For 11 of the 14 detected trace elements with HHBs, the maximum concentration measured in a Cycle 3 field blank was less than 1 percent of the corresponding HHB. For the remaining three trace elements (antimony, copper, and lead), the maximum concentration was less than 4 percent of the HHB. For silver and zinc, the maximum concentration measured in a Cycle 3 field blank was less than 1 percent of the corresponding SMCL. For copper and manganese, the maximum concentration was less than 4 percent of the corresponding SMCL. However, for aluminum the maximum concentration was nearly 200 percent of the corresponding SMCL. Results for blind blanks submitted to the National Water Quality Lab (NWQL) to evaluate laboratory data quality indicate false positive detections of aluminum in blank samples submitted to the laboratory during July and August of 2014 (U.S. Geological Survey Inorganic Blind Sample Project, https://bqs.usgs.gov/ibsp/). Investigation of this issue by the NWQL indicated the occurrence of sporadic contamination at concentrations up to at least 63 micrograms per liter (µg/L) from at least July 2014 through December 2015, although the source of contamination and, therefore, the exact magnitude of contamination and the time period(s) affected, have not been established (Tedmund Struzeski, U.S. Geological Survey Inorganic Blind Sample Project, written commun., 2015). For NAWQA field blanks collected through the end of December 2014, detections of aluminum above the laboratory reporting limit were reported in blank samples collected primarily between May 29, 2014, and July 16, 2014.

Random low-level contamination of water samples with manganese and cobalt from certain capsule filters used by NAWQA and across the USGS from about October 1, 2008 to about September 30, 2014 was documented in the U.S. Geological Survey Office of Water Quality Technical Memorandum 2016.05 (http://water.usgs.gov/admin/memo/QW/qw2016.05.pdf, accessed July 1, 2016). The maximum concentration of the trace element manganese reported in a Cycle 3 NAWQA field blank (1.83 µg/L) was less than 1 percent of the corresponding HHB of 300 µg/L. Cobalt has no corresponding HHB for comparison. Blank samples for cobalt and manganese collected for NAWQA during this time period were evaluated to determine the possible effects of this contamination on environmental samples and evaluation results are described in Appendix 3.

Of the five nutrients or groups of nutrients that the laboratory analyzes directly (as opposed to the nutrients with calculated results), three were detected in at least one 2014 field blank (table 4–1) and four were detected in at least one Cycle 3 field blank (table 4–2). Two of the nutrients detected in Cycle 3 field blanks (nitrite and nitrate) have HHBs (table 2 of Arnold and others, 2017); none have SMCLs. For each of the two nutrients with HHBs, the maximum concentration measured in a Cycle 3 field blank was less than 1 percent of the corresponding threshold. Dissolved organic carbon (DOC) does not have an HHB, but was detected in 18 of 54 field blanks collected during 2014, and in 33 of 96 field blanks collected during Cycle 3. Concentrations during Cycle 3 ranged from 0.24 to 180 mg/L, and included multiple values above 1 mg/L. However, concentrations of this magnitude probably reflect inadequate rinsing of sampling equipment with blank water between use of methanol during the cleaning process and subsequent collection of the blank sample. Therefore, these results likely are not representative of the actual potential for contamination of environmental samples, which are collected only after flushing of sampling equipment with copious quantities of native groundwater.

Blank samples collected in 2012 were analyzed for 85 VOCs, and blank samples collected in 2013 and 2014 were analyzed for a different (but partially overlapping) list of 85 VOCs. The change in laboratory methods and constituent lists resulted in a total of 129 different VOCs in the overall dataset of blank results. Fourteen VOCs were detected in at least one 2014 field blank (table 4–1), and a total of 22 VOCs were detected in at least one Cycle 3 field blank (table 4–2). Eleven of the compounds detected in Cycle 3 field blanks (1,1-dichloroethene, 1,4-dichlorobenzene, benzene, carbon disulfide, dichloromethane, ethylbenzene, m-xylene plus p-xylene, o-xylene, styrene, toluene, and trichloromethane) have HHBs (table 2 in Arnold and others, 2017); none have SMCLs. For 9 of the 11 VOCs with HHBs, the maximum concentration measured in a blank was less than 1 percent of the corresponding HHB threshold; for the remaining 2 VOCs (1,1-dichloroethene and dichloromethane), the maximum concentration was 2 percent or less of the corresponding HHB threshold.

Blank samples collected in 2012 were analyzed for 137 pesticide compounds, and blank samples collected in 2013 and 2014 were analyzed for 227 pesticide compounds. The change in laboratory methods and constituents resulted in a total of 272 different pesticide compounds in the overall dataset of blank results. Eight pesticide compounds were detected in at least 1 field blank from 2014 (table 4–1), and a total of 19 pesticide compounds were detected in at least one Cycle 3 field blank (table 4–2). Fourteen of the compounds detected in Cycle 3 field blanks (atrazine, metolachlor, nicosulfuron, piperonyl butoxide, aldicarb sulfone, bromacil, cis-permethrin, desulfinylfipronil, diflubenzuron, metribuzin, oxamyl, propiconazole, tebuthiuron, and trans-permethrin) have HHBs; none have SMCLs. For all of the pesticide compounds with HHBs, the maximum concentration measured in a field blank was about 0.25 percent or less of the corresponding HHB threshold.

A few of the special-interest constituents collected in only selected well networks were detected in one or more field blanks, and these results are not included in table 4–2. Three arsenic species (arsenite, dimethylarsinate, and monomethylarsonate) were not detected in the four available field blanks, but arsenate was detected in one field blank at a concentration of 1.51 µg/L, which is about 15 percent of the HHB of 10 µg/L for total arsenic. Therefore, it is possible that contamination could limit the suitability of arsenate results for comparison with the arsenic HHB. Perchlorate was not detected in any of the five available field blanks. Hexavalent chromium was detected in one of the seven available field blanks at a concentration of 0.3 µg/L, which is 7.5 percent of the upper cancer Health-Based Screening Levels. Corresponding total chromium values are reported by the same laboratory that analyzes for hexavalent chromium; two of seven available field blanks had a detection of total chromium at concentrations up to 0.6 µg/L, which is 0.6 percent of the HHB. Therefore, it appears that there is minimal potential for contamination of hexavalent chromium or total chromium from the Boulder, Colorado laboratory to affect comparison of these values to HHBs.

The maximum concentrations of major and minor ions, nutrients, VOCs, and pesticide compounds in Cycle 3 field blanks are all substantially less than the thresholds used by the NAWQA Project to distinguish between low and moderate concentrations (50 percent of the HHB or SMCL for inorganic constituents, and 10 percent of the HHB for organic constituents). Therefore, results of the field blank samples for these constituent groups indicate minimal potential for effects of contamination on the number of groundwater samples that would be classified as having moderate or high concentrations relative to current HHBs or SMCLs. For trace elements, the maximum concentrations in Cycle 3 field blanks are also substantially less than the relevant thresholds with the exception of aluminum. Because data from laboratory blind blanks and from NAWQA field blanks indicate that laboratory contamination might have substantially affected aluminum results for some environmental samples from late May 2014 through at least December 2014, aluminum results from this time period cannot confidently be classified as moderate or high relative to the SMCL of 50 µg/L.

Replicate Sample Approach

Replicate samples are QC samples that are used to estimate variability of analytical results caused by random measurement error (Mueller and others, 2015). Replicate samples are two or more water samples that are collected, processed, and analyzed in a manner that allows them to be considered essentially identical in composition and analysis (Mueller and others, 2015). Replicate groundwater samples for NAWQA consist of two samples collected one after the other in the field (sequential field replicates).

Replicate samples typically are used to evaluate variability in analyte concentration by estimating standard deviation (SD) as a function of concentration (Mueller and others, 2015). The presence of censored values affects the calculation of these estimates and generally necessitates estimation of the variability in analyte detection, as well. One measure of the variability in analyte detection is the mean detection rate for all replicate pairs having at least one detection (Martin, 2002; Mueller and others, 2015). Another measure is the percentage of replicate sets with inconsistent detections, which is calculated as the number of replicate sets with inconsistent detections divided by the total number of replicate sets minus the number of sets with consistent non-detections (Martin, 2002; Mueller and others, 2015). A one-sided upper confidence limit for the percentage of inconsistent replicate sets can be calculated as described by Mueller and others (2015, p. 32). Multiple approaches are available to estimate the variability of analyte concentrations as a function of concentration. Three of these approaches and the requirements to apply them are described by Mueller and others (2015, p. 32).

Data and results of the initial evaluation of data from replicate samples for a variety of constituents collected during the entire Cycle 3 sampling period of May 2012 through December 2014 are presented in this report. The objective of this initial evaluation of replicate samples was to broadly characterize variability in analyte detection and concentration to explore implications for comparisons of environmental concentrations of analytes as reported by the NWQL with their corresponding HHBs or SMCLs. For example, large variability in analyte detection and (or) concentration near an HHB could reduce confidence in whether or not the reported concentration represents a true exceedance of an HHB in the environment. As part of this evaluation, for analytes that include censored values and have at least 10 replicate pairs not composed of consistent nondetections, the mean detection rate (for all replicate pairs having at least one detection) and the percentage of replicate sets with inconsistent detections were calculated. A piecewise-linear model used by Mueller and Titus (2005) and described by Mueller and others (2015) was used to estimate variability in analyte concentrations for constituents having at least 10 replicate pairs with consistent detections. This two-range model divides concentrations into: (1) a low range for which the SD of replicates generally is uniform and the average SD is used to estimate variability; and (2) a high range for which the relative standard deviation (RSD; the ratio, in percent, of SD to mean concentration) generally is uniform and the average RSD is used to estimate variability. Graphs of SD and RSD against mean concentration are used to select an appropriate boundary concentration between the low and high ranges (Mueller and others, 2015). In some cases, either SD or RSD is fairly uniform throughout the range of available concentrations and, therefore, no boundary is needed.

Replicate Sample Counts

The total number of replicate samples collected for groundwater sites during Cycle 3 varies by constituent group (table 4–3). Data for all replicate samples from the 2014 sampling period are presented in tables 4–15 through 4–22 of Arnold and others (2017). All Cycle 3 replicate samples were analyzed using the corresponding laboratory methods listed in table 2 of Arnold and others (2017). Of the 58 Cycle 3 VOC replicate samples, 5 were collected in 2012 and analyzed for an older analytical schedule using purge and trap gas chromatography/mass spectrometry (Gilliom and others, 2006; Zogorski and others, 2006). The remaining 53 were collected in 2013–14 and analyzed using the most recent analytical schedule and laboratory methods (purge and trap gas chromatography/mass spectrometry and heated purge and trap gas chromatography/mass spectrometry). Of the 73 Cycle 3 pesticide replicate samples, 4 were collected in 2012 and analyzed for an older analytical schedule using gas chromatography/mass spectrometry. The remaining 69 were collected in 2013–14 and analyzed using the most recent analytical schedule and laboratory method (direct aqueous injection liquid chromatography tandem mass spectrometry). Not included in table 4–3 are sample counts or results for special-interest constituents collected only in selected well networks; only 2 to 5 replicate samples were collected for each of these constituents through December 2014.

Table 4–3. Summary of results for replicate samples collected by the National Water-Quality Assessment Project from May 2012 to December 2014.

[VOCs, volatile organic compounds; mg/L, milligrams per liter; µg/L, micrograms per liter; ng/L, nanograms per liter]

Type of summary	Major and minor elements and physical parameters	Trace elements	Nutrients	VOCs	Pesticide compounds
Total number of replicate samples	65	63	59	58	73
Number of samples included in analysis of replicate results (2013–14 samples for VOCs and pesticide compounds)	65	63	59	53	69
Total number of constituents included in analysis of replicate results	13	22	5	83	227
Number of constituents that include censored values and have at least 10 replicate pairs without consistent nondetections	4	20	5	1	6
Range in mean detection rate for replicate pairs having at least 1 detection (in percent)	89.7–100	89.3–100	86.4–100	100	80–100
Number of constituents with mean detection rate less than 75 percent	0	0	0	0	0
Range in percentage of replicate pairs with inconsistent detections	0–20.5	0–21.4	0–27.3	0	0–40.0
Number of constituents with percentage of replicate pairs with inconsistent detections greater than 50 percent	0	0	0	0	0
Number of constituents that have at least 10 replicate pairs with consistent detections	13	20	4	1	5
Range in standard deviation for lower concentration range of two-range model	0.0016–8.6 mg/L	0.0014–1.3 µg/L	0.0010–0.013 mg/L	0.0060	0.84–20 ng/L
Range in relative standard deviation for higher concentration range of two-range model	0.29–8.0 percent	1.1–2.5 percent	0.91–2.1 percent	Not applicable	14 percent

Replicate Sample Results

Analysis of variability in analyte detection and (or) analyte concentration was performed for only the subset of constituents that met certain requirements. Analysis of replicate results was not performed for constituent/method combinations for which fewer than 10 replicate pairs had been analyzed. Therefore, VOCs and pesticide compounds determined with older laboratory methods used for analysis of replicates collected in 2012 were not evaluated for variability. In addition, analysis of variability in analyte detection was performed only for constituents that included censored values and had at least 10 replicate pairs without consistent non-detections (table 4–4). Analysis of analyte concentrations was performed only for constituents that had at least 10 replicate pairs with consistent detections (table 4–5).

Table 4–4. Estimated variability in detection of selected analytes based on field replicate samples collected by the U.S. Geological Survey National Water-Quality Assessment Project, May 2012 through December 2014.

[Variability was evaluated only for constituents having censored values and at least 10 replicate pairs without consistent non-detections. *N*, number of pairs with at least one detection; CEAT, 2-chloro-6-ethylamino-4-amino-s-triazine; CAAT, chlorodiamino-*s*-triazine; SA, sulfonic acid]

Constituent	*N*	Mean detection rate (percent)	Pairs with inconsistent detections (percent)
Major and minor elements			
Bromide	46	95.7	8.7
Fluoride	54	100	0
Sulfate	53	100	0
Iron	39	89.7	20.5
Trace elements			
Aluminum	27	92.6	14.8
Arsenic	19	92.1	15.8
Antimony	47	97.9	4.3
Barium	58	100	0
Beryllium	19	100	0
Boron	53	100	0
Cadmium	14	89.3	21.4
Chromium	24	100	0
Cobalt	40	97.5	5.0
Copper	20	90.0	20.0
Lead	41	92.7	14.6
Lithium	56	100	0
Manganese	44	98.9	2.3
Molybdenum	51	100	0
Nickel	47	100	0
Selenium	39	96.2	7.7
Strontium	61	100	0
Uranium	47	98.9	2.1
Vanadium	43	97.7	4.7
Zinc	33	93.9	12.1
Nutrients			
Ammonia	24	97.9	4.2
Nitrite plus nitrate	35	97.1	5.7
Nitrite	11	86.4	27.3
Total nitrogen	53	99.1	1.9
Orthophosphate	51	100	0

Table 4–4. Estimated variability in detection of selected analytes based on field replicate samples collected by the U.S. Geological Survey National Water-Quality Assessment Project, May 2012 through December 2014.—Continued

[Variability was evaluated only for constituents having censored values and at least 10 replicate pairs without consistent non-detections. *N*, number of pairs with at least one detection; CEAT, 2-chloro-6-ethylamino-4-amino-s-triazine; CAAT, chlorodiamino-*s*-triazine; SA, sulfonic acid]

Constituent	*N*	Mean detection rate (percent)	Pairs with inconsistent detections (percent)
Volatile organic compounds			
Trichloromethane	19	100	0
Pesticide compounds			
Atrazine	19	84.2	31.6
Metolachlor	10	80.0	40.0
Deethylatrazine (CIAT)	20	82.5	35.0
CEAT	13	96.2	7.7
CAAT	18	100	0
Metolachlor SA	22	93.2	13.6

Table 4–5. Estimated variability in concentrations of selected analytes based on field replicate samples collected by the U.S. Geological Survey National Water-Quality Assessment Project, May 2012 through December 2014.

[Variability was evaluated only for constituents having at least 10 replicate pairs with consistent detections. *N*, number of values in that category; mg/L, milligrams per liter; SD, standard deviation; µS/cm, microsiemens per centimeter at 25 degrees Celsius; RSD, relative standard deviation; µg/L, micrograms per liter; ng/L, nanograms per liter; CAAT, chlorodiamino-s-triazine; CEAT, 2-chloro-6-ethylamino-4-amino-s-triazine; SA, sulfonic acid]

Constituent	Concentration range (units)	*N*	Variability		
			Statistic	Value	Units
Major and minor elements and physical parameters (units mg/L unless otherwise noted)					
pH	All available values (standard units)	62	Mean SD	0.032	standard units
Specific conductance	All available values (µS/cm)	61	Mean RSD	0.29	µS/cm
Calcium	<10	15	Mean SD	0.061	mg/L
	>10	42	Mean RSD	1.0	percent
Magnesium	<10	31	Mean SD	0.035	mg/L
	>10	26	Mean RSD	0.64	percent
Potassium	<2	28	Mean SD	0.019	mg/L
	>2	29	Mean RSD	1.9	percent
Sodium	<40	31	Mean SD	0.12	mg/L
	>40	26	Mean RSD	1.4	percent
Bromide	All available concentrations	42	Mean SD	0.0037	mg/L
Chloride	<10	19	Mean SD	0.0048	mg/L
	>10	39	Mean RSD	0.57	percent
Fluoride	<0.2	29	Mean SD	0.0016	mg/L
	>0.2	25	Mean RSD	2.6	percent
Silica	All available concentrations	57	Mean SD	0.13	mg/L
Sulfate	<40	34	Mean SD	0.034	mg/L
	>40	19	Mean RSD	0.90	percent
Residue on evaporation	All available concentrations	56	Mean SD	8.6	mg/L
Iron	<100	18	Mean SD	2.6	µg/L
	>100	13	Mean RSD	8.0	percent
Trace elements (units µg/L)					
Aluminum	All available concentrations	23	Mean SD	0.25	µg/L
Arsenic	<0.8	23	Mean SD	0.0080	µg/L
	>0.8	22	Mean RSD	1.2	percent
Antimony	<0.2	15	Mean SD	0.0014	µg/L
	>0.2	1	Mean RSD	Insufficient data	percent
Barium	<20	20	Mean SD	0.077	µg/L
	>20	38	Mean RSD	1.1	percent
Beryllium	<0.06	13	Mean SD	0.0014	µg/L
	>0.06	6	Mean RSD	Insufficient data	percent
Boron	<70	33	Mean SD	0.41	µg/L
	>70	20	Mean RSD	2.0	percent
Cadmium	All available concentrations	11	Mean SD	0.0040	µg/L
Chromium	<2	20	Mean SD	0.017	µg/L
	>2	4	Mean RSD	Insufficient data	percent
Cobalt	<0.4	30	Mean SD	0.0059	µg/L
	>0.4	8	Mean RSD	Insufficient data	percent
Copper	All available concentrations	16	Mean SD	0.20	µg/L

Table 4–5. Estimated variability in concentrations of selected analytes based on field replicate samples collected by the U.S. Geological Survey National Water-Quality Assessment Project, May 2012 through December 2014.—Continued

[Variability was evaluated only for constituents having at least 10 replicate pairs with consistent detections. *N*, number of values in that category; mg/L, milligrams per liter; SD, standard deviation; µS/cm, microsiemens per centimeter at 25 degrees Celsius; RSD, relative standard deviation; µg/L, micrograms per liter; ng/L, nanograms per liter; CEAT, 2-chloro-6-ethylamino-4-amino-*s*-triazine; CAAT, chlorodiamino-*s*-triazine; SA, sulfonic acid]

Constituent	Concentration range (units)	*N*	Variability		
			Statistic	Value	Units
Trace elements (units µg/L)—Continued					
Lead	<0.4	26	Mean SD	0.011	µg/L
	>0.4	9	Mean RSD	Insufficient data	percent
Lithium	<10	35	Mean SD	0.044	µg/L
	>10	21	Mean RSD	1.5	percent
Manganese	<10	23	Mean SD	0.021	µg/L
	>10	20	Mean RSD	2.3	percent
Molybdenum	<2	34	Mean SD	0.008	µg/L
	>2	17	Mean RSD	2.0	percent
Nickel	<1	31	Mean SD	0.025	µg/L
	>1	16	Mean RSD	1.2	percent
Selenium	<0.4	25	Mean SD	0.0054	µg/L
	>0.4	11	Mean RSD	2.5	percent
Strontium	<200	33	Mean SD	0.87	µg/L
	>200	28	Mean RSD	1.2	percent
Uranium	<5	37	Mean SD	0.011	µg/L
	>5	9	Mean RSD	Insufficient data	percent
Vanadium	<1	27	Mean SD	0.012	µg/L
	>1	14	Mean RSD	1.1	percent
Zinc	All available concentrations	29	Mean SD	1.3	µg/L
Nutrients (units mg/L)					
Ammonia	<0.5	16	Mean SD	0.0060	mg/L
	>0.5	7	Mean RSD	Insufficient data	percent
Nitrite plus nitrate	<3	16	Mean SD	0.013	mg/L
	>3	17	Mean RSD	0.91	percent
Total nitrogen	<2	30	Mean SD	0.071	mg/L
	>2	22	Mean RSD	0.94	percent
Orthophosphate	<0.05	32	Mean SD	0.0010	mg/L
	>0.05	19	Mean RSD	2.1	percent
Volatile organic compounds (units µg/L)					
Trichloromethane	All available concentrations	19	Mean SD	0.0060	µg/L
Pesticide compounds (units ng/L)					
Atrazine	<50	10	Mean SD	0.84	ng/L
	>50	3	Mean RSD	Insufficient data	percent
Deethylatrazine (CIAT)	<200	10	Mean SD	4.9	ng/L
	>200	3	Mean RSD	Insufficient data	percent
CEAT	All available concentrations	12	Mean SD	9.4	ng/L
CAAT	<60	4	Mean SD	Insufficient data	ng/L
	>60	14	Mean RSD	14	percent
Metolachlor SA	<1,000	14	Mean SD	20	ng/L
	>1,000	5	Mean RSD	Insufficient data	percent

Among all constituents for which variability in detection was estimated, the mean detection rate ranged from 80.0 to 100 percent and the percentage of pairs with inconsistent detections ranged from 0.0 to 40.0 percent (table 4–4). In his assessment of pesticides, Martin (2002) used a mean detection rate of 75 percent or less or a percentage of inconsistent replicate sets of 50 percent or more to indicate high variability of detection. Using those same criteria, none of the constituents analyzed for this study would be considered to have high variability of detection. Martin (2002) also used a mean detection rate of 90 percent or more or a percentage of inconsistent replicate sets of 25 percent or less to indicate low variability of detection. Under these criteria, the following constituents do not have low variability of detection but rather would be considered to have moderate variability: iron, cadmium, nitrite, atrazine, metolachlor, and deethylatrazine. The initial analysis of variability of detection presented here did not include calculation of an upper confidence bound on percentages of inconsistent replicate sets to quantify uncertainty and did not account for changes in variability across concentration ranges. In general, variability of detection is higher at low concentrations and decreases with increasing concentrations (Martin, 2002). More detailed analysis of this type might be needed for the interpretation of environmental concentrations for objectives other than those presented in this report

For all constituents for which variability in concentration was estimated, the mean SD and (or) RSD determined for specified concentration ranges by means of the two-range model are presented in table 4–5. For major and minor elements, the SD at lower or all concentrations was typically less than 0.15 mg/L, with the exception of residue on evaporation (dissolved solids), and the RSD at higher concentrations was typically less than 3 percent, with the exception of iron. For trace elements, the SD at lower or all concentrations was typically 0.25 µg/L or less, with the exception of boron, strontium, and zinc, and the RSD at higher concentrations was uniformly less than 3 percent, where sufficient data were available to reasonably estimate the RSD. For nutrients, the SD at lower concentrations was uniformly less than 0.015 mg/L, and the RSD at higher concentrations was less than 2 percent, with the exception of orthophosphate. For VOCs, only trichloromethane had at least 10 replicate pairs with consistent detections; the mean SD for all available concentrations was 0.0060 µg/L. For pesticide compounds, only 5 analytes had at least 10 replicate pairs with consistent detections. The mean SD at lower or all concentrations was less than 10 ng/L, with the exception of metolachlor sulfonic acid. Data generally were insufficient to reasonably estimate the RSD at higher concentrations.

None of the special-interest constituents collected in only selected well networks had 10 or more samples available for a rigorous evaluation of variability. However, the two available replicate pairs for the four arsenic species indicated no inconsistent detections; only one analyte (arsenate) was detected, and in only one pair. Perchlorate was not detected in either sample of one pair, was detected in one sample of another pair (at a concentration nearly equivalent to the laboratory reporting level), and was detected in both samples of two pairs. Hexavalent chromium was not detected in either sample of two pairs, and had inconsistent detections in one of the three other pairs; concentrations within the two pairs with consistent detections were similar. The five replicate samples for total chromium from the Boulder, Colo. laboratory showed higher variability in both detections and concentrations.

Overall, the available results indicate generally low variability in analyte detection and concentration, meaning that random measurement error has minimal potential to affect the number of groundwater samples that would be classified as having moderate or high concentrations relative to current HHBs or SMCLs. However, further analysis beyond the scope of this initial evaluation of replicate results, such as the calculation of confidence intervals, would be needed to quantify the likely effects of variability for use of the environmental data for specific purposes.

Spike Sample Approach

Spike samples are QC samples that are used to estimate any positive or negative bias that might result from method performance, effects of the sample matrix, and (or) analyte degradation during sample shipment and storage (Mueller and others, 2015). Spike samples are collected by fortifying (spiking) a water sample with known concentrations of analytes. For pesticide compounds and arsenic species (arsenate and arsenite), NAWQA collects field matrix spikes, meaning that the spike solution is added to an environmental sample in the field. For VOCs, NAWQA collects laboratory matrix spikes, meaning that the spike solution is added to an environmental sample at the laboratory. Both types of spikes estimate recovery bias in an environmental water sample that could be caused by a problem with performance of the laboratory method and (or) by the chemical, physical, or biological characteristics of the water (Mueller and others, 2015). Field spikes also reflect any degradation that might have occurred in an analyte during the time period between sample collection and laboratory analysis. Laboratory spikes for VOCs and field spikes for arsenic species are included in this report, but field spikes for pesticides are not included in this report.

The percent recovery of an analyte in an individual spike sample is calculated by subtracting the concentration of the paired unspiked sample (collected closely in time) from the concentration of the spiked sample, then dividing by the expected concentration and multiplying by 100. The expected concentration is equal to the concentration of the spike solution times the amount of spike solution added to the sample, divided by the volume of the spiked sample. When the NWQL reported that an analyte was not detected in the paired unspiked sample, a concentration of zero was assumed for the purposes of the calculating the percent recovery. Spike solutions were obtained through the NWQL, which provides the concentration of each analyte included in an individual spike lot. Analytes included in spike solutions were assumed not to have degraded prior to use of the spike solution, although it is possible that future evaluation of spike sample results might indicate that the assumption is violated for certain spike lots and (or) compounds. For VOCs, the NWQL was assumed to have added 20 microliters of spike solution to a 43-milliliter sample. For arsenic species, field crews were assumed to have added 100 microliters of spike solution to an 11.5-milliliter sample.

Data and results of the initial evaluation of recovery data from laboratory spikes for VOCs and field spikes for arsenic species collected during the entire Cycle 3 sampling period of May 2012 through December 2014 are presented in this report. The objective of this initial evaluation of spike samples was to determine if substantial positive or negative recovery bias exists for any analytes. Substantial positive or negative bias could have implications for comparisons of environmental concentrations of these analytes as reported by the NWQL with their corresponding HHBs. For example, a large negative recovery bias could result in the laboratory reporting a concentration that is substantially less than the concentration actually present in the environment, leading to an incorrect conclusion that the concentration in the environment does not exceed an HHB when it actually does. Further evaluation of results for spike samples would be needed to determine if recovery bias for certain analytes would affect the interpretation of environmental concentrations of those analytes for objectives other than those presented in this report.

Spike Sample Counts

Between July 2012 and September 2014, a total of 113 laboratory spikes for VOCs (table 4–6) and 3 field spikes for arsenic species were collected for the NAWQA Project. Data for all VOC and arsenic species spike samples from Cycle 3 are presented in tables 4–23 through 4–25 of Arnold and others (2017). All Cycle 3 spike samples were analyzed using the corresponding laboratory methods listed in table 2 of Arnold and others (2017). Of the 113 VOC laboratory spikes, 4 were collected in 2012 and analyzed for one of two older analytical schedules (S2020 or S4024) using purge and trap gas chromatography/mass spectrometry (Gilliom and others, 2006; Zogorski and others, 2006). The remaining 99 were collected in 2013–14 and analyzed using one of the two most recent analytical schedules (S4436 or S4437) and laboratory methods (purge and trap gas chromatography/mass spectrometry and heated purge and trap gas chromatography/mass spectrometry, respectively).

Spike Sample Results

For VOC laboratory spikes collected during Cycle 3 for analysis by laboratory schedule 4436 or 4437, the median recovery for individual compounds ranged from 62.8 percent to 118.0 percent (table 4–6; tables 4–26 and 4–27 of Arnold and others (2017); figs. 4–1 and 4–2). The numbers of laboratory spikes available during Cycle 3 for laboratory schedules 2020 (two spikes) and 4024 (two spikes) were insufficient to confidently characterize recoveries for those laboratory schedules. Two VOCs on laboratory schedule 4436 had median recoveries less than 70 percent: butane (62.8 percent) and hexane (67.6 percent). No VOCs had median recoveries greater than 130 percent (tables 4–26 and 4–27 of Arnold and others, 2017). Neither of the two VOCs with relatively low recoveries has an HHB. Therefore, laboratory spike recovery results do not indicate any issues with comparing reported VOC concentrations to their corresponding HHBs.

For the three arsenic speciation field spikes collected during Cycle 3 for analysis by laboratory code 3142, recoveries ranged from 86.4 to 124.7 percent for arsenate, 97.4 to 111.2 percent for arsenite, 63.6 to 100.0 percent for dimethylarsinate, and 83.1 to 85.3 percent for monomethylarsonate. These results indicate generally little bias from method performance, effects of the sample matrix, and (or) analyte degradation. No HHBs exist that are specific to individual arsenic species, although there is an HHB for total arsenic.

Table 4–6. Summary of results for spike samples collected by the National Water-Quality Assessment Project from May 2012 to December 2014.

[VOCs, volatile organic compounds; HHB, human-health benchmark]

Type of summary	VOCs (laboratory schedules 4436 and 4437)
Total number of field spikes	0
Total number of laboratory spikes	113
Number of constituents analyzed	86
Range of median spike recoveries (in percent)	62.8–118.0
Number of compounds with median spike recovery less than 70 percent	2
Number of compounds with median spike recovery less than 70 percent with a corresponding HHB	0
Number of compounds with median spike recovery greater than 130 percent	0
Number of compounds with median spike recovery greater than 120 percent with a corresponding HHB	Not applicable

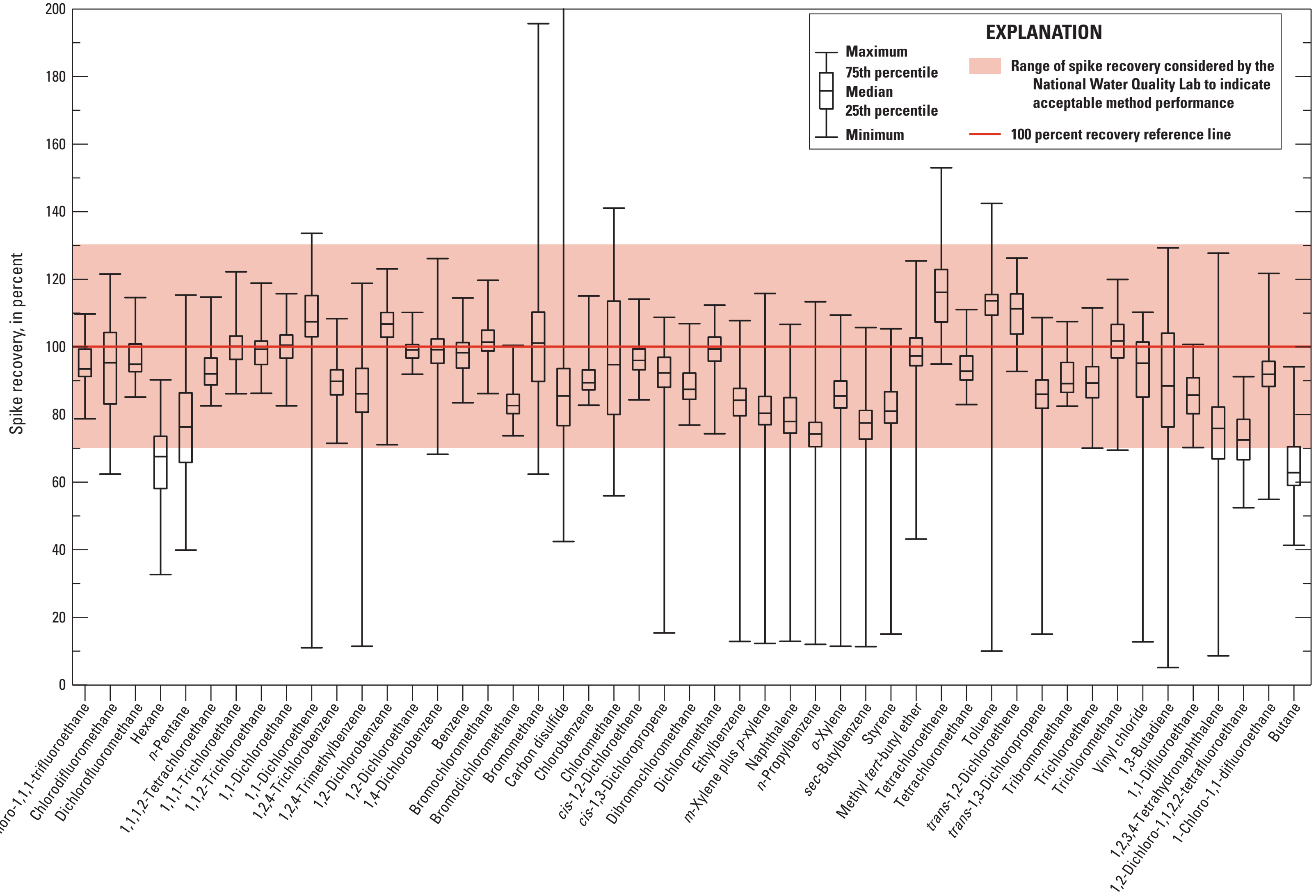


Figure 4–1. Boxplots of laboratory spike recovery results for volatile organic compounds included in laboratory schedule 4436.

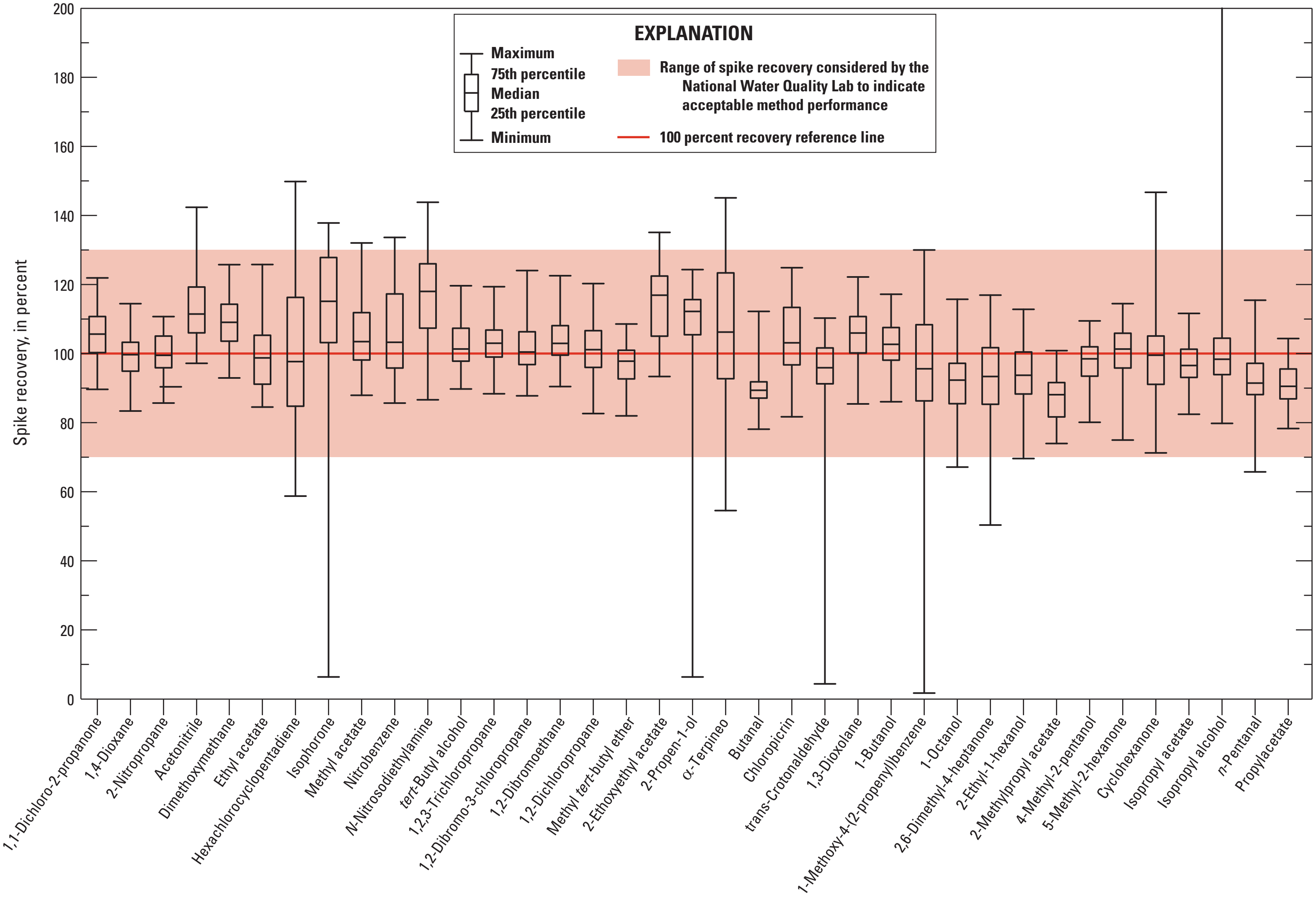


Figure 4–2. Boxplots of laboratory spike recovery results for volatile organic compounds included in laboratory schedule 4437.

References Cited

Arnold, T.L., Bexfield, L.M., Musgrove, MaryLynn, Lindsey, B.D., Stackelberg, P.E., Barlow, J.R., DeSimone, L.A., Kulongoski, J.T., Kingsbury, J.A., Ayotte, J.D., Fleming, B.J., and Belitz, Kenneth, 2017, Groundwater quality data from the National Water Quality Assessment Project, January through December 2014 and select quality-control data from May 2012 through December 2014: U.S. Geological Survey data release, https//doi.org/10.5066/F7HQ3X18.

Bender, D.A., Zogorski, J.S., Mueller, D.K., Rose, D.L., Martin, J.D., and Brenner, C.K., 2011, Quality of volatile organic compound data from groundwater and surface water for the National Water-Quality Assessment Program, October 1996–December 2008: U.S. Geological Survey Scientific Investigations Report 2011–5204, 128 p., accessed January 4, 2016, at https://pubs.usgs.gov/sir/2011/5204/.

Davis, T.A., Olsen, L.D., Fram, M.S., and Belitz, Kenneth, 2014, Updated study reporting levels (SRLs) for trace-element data collected for the California Groundwater Ambient Monitoring and Assessment (GAMA) Priority Basin Project, October 2009–March 2013: U.S. Geological Survey Scientific Investigations Report 2014–5105, 52 p., accessed January 4, 2016, at https://doi.org/10.3133/sir20145105.

Fram, M.S., Olsen, L.D., and Belitz, Kenneth, 2012, Evaluation of volatile organic compound (VOC) blank data and application of study reporting levels to groundwater data collected for the California GAMA Priority Basin Project, May 2004 through September 2010: U.S. Geological Survey Scientific Investigations Report 2012–5139, 94 p., accessed January 4, 2016, at https://pubs.usgs.gov/sir/2012/5139/.

Gilliom, R.J., Alley, W.M. and Gurtz, M.E., 1995, Design of the National Water-Quality Assessment Program: occurrence and distribution of water-quality conditions: U.S. Geological Survey Circular 1112, 33 p. accessed March 1, 2016, at https://pubs.er.usgs.gov/publication/cir1112.

Gilliom, R.J., Barbash, J.E., Crawford, C.G., Hamilton, P.A., Martin, J.D., Nakagaki, Naomi, Nowell, L.H., Scott, J.C., Stackelberg, P.E., Thelin, G.P., and Wolock, D.M., 2006, The quality of our Nation's waters—Pesticides in the Nation's streams and ground water, 1992–2001: U.S. Geological Survey Circular 1291, accessed January 4, 2016, at https://pubs.usgs.gov/circ/2005/1291/.

Martin, J.D., 2002, Variability of pesticide detections and concentrations in field replicate water samples collected for the National Water-Quality Assessment Program, 1992-97: U.S. Geological Survey Water-Resources Investigations Report 01–-4178, 84 p., accessed June 30, 2016, at https://pubs.usgs.gov/wri/2001/wri01_4178/.

Mueller, D.K., Schertz, T.L., Martin, J.D., and Sandstrom, M.W., 2015, Design, analysis, and interpretation of field quality-control data for water-sampling projects: U.S. Geological Survey Techniques and Methods, book 4, chap. C4, 54 p., https://doi.org/10.3133/tm4C4.

Mueller, David K. and Titus, Cindy J., 2005, Quality of nutrient data from streams and ground water sampled during water years 1992-2001: U.S. Geological Survey Scientific Investigations Report 2005–5106, 27 p.

Olsen, L.D., Fram, M.S., and Belitz, Kenneth, 2010, Review of trace-element field-blank data collected for the California Groundwater Ambient Monitoring and Assessment (GAMA) Program, May 2004–January 2008: U.S. Geological Survey Scientific Investigations Report 2009–5220, 47 p., accessed January 4, 2016, at https://pubs.usgs.gov/sir/2009/5220/.

Zogorski, J.S., Carter, J.M., Ivahnenko, Tamara, Lapham, W.W., Moran, M.J., Rowe, B.L., Squillace, P.J., and Toccalino, P.L., 2006, The quality of our Nation's waters—Volatile organic compounds in the Nation's groundwater and drinking-water supply wells: U.S. Geological Survey Circular 1292, 101 p., accessed January 4, 2016, at https://pubs.usgs.gov/circ/circ1292/.

For additional information contact:

Director, Illinois Water Science Center
U.S. Geological Survey
405 North Goodwin Avenue
Urbana, IL 61801-2347

Publishing support provided by the
Madison and Rolla Publishing Service Centers.

Arnold and others—**Groundwater-Quality Data from the National Water-Quality Assessment Project, January through December 2014**—Data Series 1063

ISSN 2327-638X (online)
https://doi.org/10.3133/ds1063