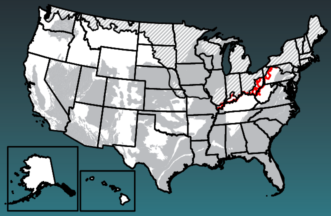
science for a changing world

National Water Quality Program—
National Water-Quality Assessment Project

Groundwater Quality in Selected Stream-Valley Aquifers, Eastern United States



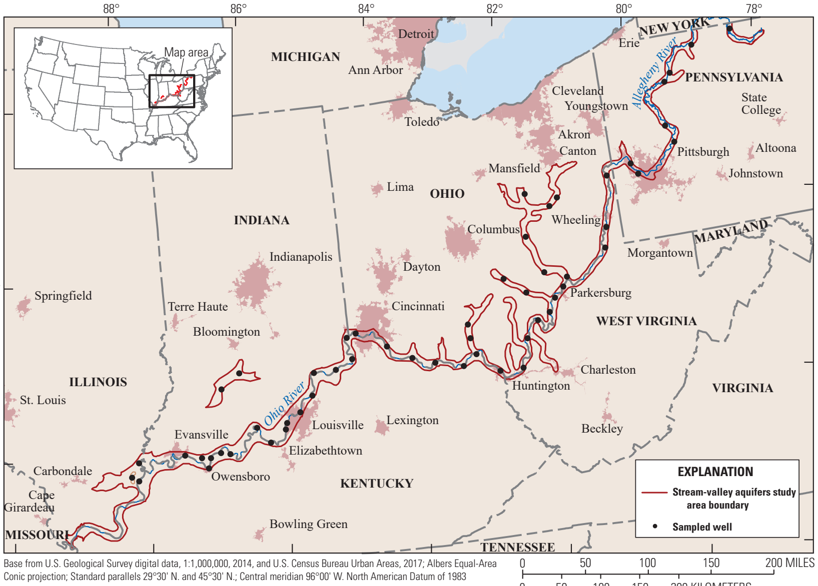
Groundwater provides nearly 50 percent of the Nation's drinking water. To help protect this vital resource, the U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Project assesses groundwater quality in aquifers that are important sources of drinking water (Burow and Belitz, 2014). The stream-valley aquifers constitute one of the important aquifer systems being evaluated.

Background

The stream-valley aquifers sampled for this study underlie an area of about 9,600 square miles, in the sedimentary deposits of the Ohio and Allegheny River drainages and parts of a few large tributaries. The study area includes parts of Pennsylvania, West Virginia, Ohio, Kentucky, Indiana, and Illinois. About 2.8 million people live in the area overlying these aquifers and about 200 million gallons of water per day were withdrawn for public supply in these states from stream-valley aquifers in 2000 (Sargent and others, 2008; Kingsbury and others, 2021). Most of the area overlying the aquifer is undeveloped (60 percent). Agricultural land use makes up about 27 percent and urban land use makes up about 13 percent of the study area. Major cities in the study area include Pittsburgh, Pennsylvania; Cincinnati, Ohio; Louisville, Kentucky; and Evansville, Indiana.

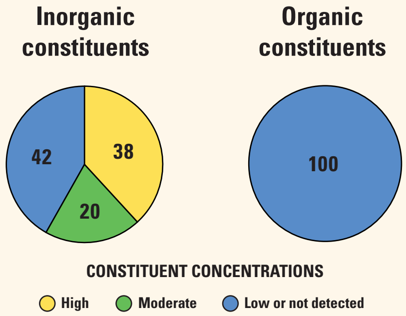
The stream-valley aquifers are within the Holocene-age sand and gravel deposited as alluvium along the valleys of major streams. Some of these sediments are reworked glacial deposits that were eroded and transported downstream, and they are associated with rivers such as the Allegheny and Ohio Rivers that have their headwaters in glaciated areas (Trapp and Horn, 1997). The stream-valley aquifers are associated with the sand and gravel deposits in the valleys of the stream or river that typically is hydraulically connected to the aquifers (Trapp and Horn, 1997). Groundwater in the stream-valley aquifers commonly is under water-table conditions, or unconfined conditions, but confined conditions are in places where clay or silt make up local confining units (Lloyd and Lyke, 1995). Recharge to the aquifer is from infiltration of precipitation and drainage of surface water from the streams and rivers adjacent to these aquifers (Lloyd and Lyke, 1995; Trapp and Horn, 1997). The rivers throughout much of the study area are regulated by lock and dam systems that may affect the movement of surface water into the aquifer (Maharjan and Donovan, 2016).

Groundwater quality in the stream-valley aquifers was evaluated by sampling 55 public-supply wells that were randomly distributed in an equal-area grid. Water-quality data collected from wells in a network designed in this way are representative of the spatial distribution of the water quality in the study area (Belitz and others, 2010). Groundwater-quality data from these wells were used to estimate the percentage of the study area with concentrations that are high, moderate, and low, with respect to constituent benchmarks. The accuracy of the estimates depends on the distribution and number of wells, not on the size of the area (Belitz and others, 2010). Wells ranged from about 45 to 135 feet (ft) deep with an average depth of about 86 ft. Samples were collected between June and September of 2019, and the samples were analyzed for a large number of natural and man-made constituents.



Base from U.S. Geological Survey digital data, 1:1,000,000, 2014, and U.S. Census Bureau Urban Areas, 2017; Albers Equal-Area Conic projection; Standard parallels 29°30' N. and 45°30' N.; Central meridian 96°00' W. North American Datum of 1983

Overview of Water Quality



Values are a percentage of the study area with concentrations in the three specified categories. Percentages might not sum to 100 because of rounding.

Principal Aquifer Studies are designed to evaluate untreated groundwater used for public supply. Groundwater quality is assessed by comparing concentrations to benchmarks established for drinking-water quality. Benchmarks and definitions of high, moderate, and low relative concentrations are discussed in the inset box on page 3.

Many inorganic constituents are present naturally in groundwater; however, their concentrations can be affected by human activities. One or more inorganic constituents with human-health benchmarks were present at high concentrations in about 38 percent of the study area and at moderate concentrations in about 20 percent.

Man-made organic constituents are found in products used in the home, business, industry, and agriculture. Organic constituents can enter the environment through normal use, spills, or improper disposal. Organic constituents were detected infrequently, and when detected, concentrations typically were low. No organic constituents with human-health benchmarks were detected at moderate or high concentrations in the study area.

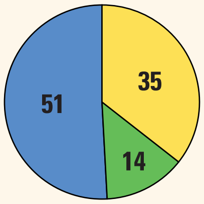
U.S. Department of the Interior
U.S. Geological Survey

Fact Sheet 2022–3037
June 2022

Results: Groundwater Quality at the Depth Zone Used for Public Supply in Stream-Valley Aquifers

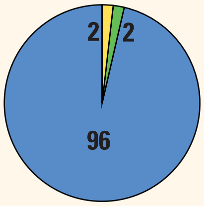
INORGANIC CONSTITUENTS

Inorganic Constituents with Human-Health Benchmarks



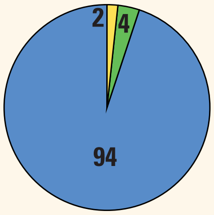
Trace elements and major and minor ions

Trace elements and major and minor ions are naturally present in the minerals of rocks, soils and sediments, and in the water that comes into contact with those materials. Samples were analyzed for 34 trace elements and major and minor ions, of which 22 have human-health benchmarks (health-based screening level [HBSL] benchmarks were updated in 2018 to include aluminum, cobalt, and iron; Norman and others, 2018). High and moderate concentrations of these constituents were measured in 49 percent of the study area with a total of five constituents present at elevated concentrations. Manganese was the trace element present at high and moderate concentrations most frequently, in 33 and 14 percent of the study area, respectively. Arsenic was present at moderate concentrations in 2 percent of the study area.



Radioactive constituents

Radioactivity is the release of energy or energetic particles during the spontaneous decay of unstable atoms, and humans are continuously exposed to small amounts of natural radioactivity. Most of the radioactivity in groundwater comes from the decay of naturally occurring uranium and thorium isotopes. Samples were analyzed for eight radioactive constituents, of which four have human-health benchmarks. Radioactive constituents were present at high and moderate concentrations in about 4 percent of the study area. Gross-beta radioactivity was the radiochemical constituent detected at high concentrations and radon was detected at moderate concentrations (one sample).

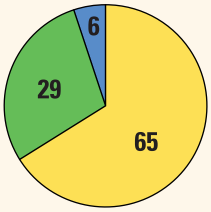


Nutrients

Nutrients are naturally present at low concentrations in groundwater; high and moderate concentrations (relative to human-health benchmarks) generally are a result of human activities. Samples were analyzed for five nutrients, of which two (nitrate and nitrite) have human-health benchmarks. Common sources of nutrients, aside from those naturally occurring in soils, include fertilizer applied to crops and landscaping, seepage from septic systems, and human and animal waste. Nitrate was the only nutrient present at elevated concentrations and was at high and moderate concentrations in 2 and 4 percent of the study area, respectively.

Inorganic Constituents and Field Measurements with Non-Health Benchmarks

(*Not included in water-quality overview charts shown on the front page*)



Constituents with non-health benchmarks

Some constituents affect the aesthetic properties of water, such as taste, color, and odor or can create nuisance problems, such as staining and scaling. The benchmarks used for these constituents, referred to as non-health benchmarks, are non-regulatory secondary maximum contaminant level (SMCL) benchmarks established for public drinking water. Some constituents such as manganese have human-health benchmarks and SMCLs. Samples were analyzed for 11 constituents that have SMCLs. One or more of these constituents were present at high concentrations in about 65 percent of the study area and at moderate concentrations in about 29 percent.

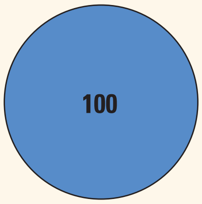
Total dissolved solids (TDS) concentration is a measure of the salinity of the groundwater based primarily on the concentrations of ions, and all water naturally contains TDS because of the weathering and dissolution of minerals in rocks and sediments. Total dissolved solids concentrations can be high as a result of natural factors or human activities such as road salting and some agricultural activities. Total dissolved solids were present at high and moderate concentrations relative to the SMCL in about 6 and 84 percent the study area, respectively.

Anoxic conditions (low concentrations of dissolved oxygen) in groundwater can result in the release of naturally occurring iron and manganese from minerals into groundwater. Iron and manganese were present at high concentrations relative to the SMCL in about 27 and 66 percent of the study area, respectively.

Groundwater pH has an SMCL range of 6.5–8.5. In the stream-valley aquifers, pH was less than or greater than the SMCL in about 5 percent of the study area.

Results: Groundwater Quality at the Depth Zone Used for Public Supply in Stream-Valley Aquifers

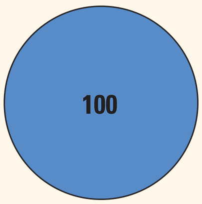
ORGANIC CONSTITUENTS



VOCs

Volatile Organic Compounds with Human-Health Benchmarks

Volatile organic compounds (VOCs) are present in many household, commercial, industrial, and agricultural products and are characterized by their tendency to volatilize (evaporate) into the air. Samples were analyzed for 85 VOCs, of which 51 have human-health benchmarks. Volatile organic compounds were not detected at high or moderate concentrations in the study area.



Pesticides

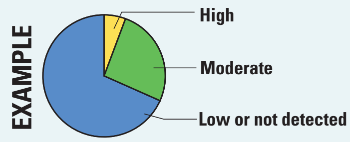
Pesticides with Human-Health Benchmarks

Pesticides, including herbicides, insecticides, and fumigants, are applied to crops, gardens and lawns, around buildings, and along roads to help control unwanted vegetation (weeds), insects, fungi, and other pests. Samples were analyzed for 225 pesticide compounds (pesticides and their breakdown products), of which 119 have human-health benchmarks. Pesticide compounds were detected at low concentrations throughout much of the study area, however, no pesticide compounds were detected at moderate or high concentrations in the study area.

BENCHMARKS FOR EVALUATING GROUNDWATER QUALITY

The USGS NAWQA Project uses benchmarks established for drinking water to provide context for evaluating the quality of untreated groundwater. The quality of water received by customers likely is different because after withdrawal, groundwater usually is treated prior to delivery. Federal regulatory benchmarks for protecting human health are used for this evaluation of water quality when available. Otherwise, non-regulatory human-health benchmarks and non-regulatory aesthetic benchmarks are used. Not all analyzed constituents have associated benchmarks and thus are not considered in this context. Out of 55 inorganic constituents and properties and 317 organic constituents analyzed, 24 and 157, respectively, have human-health benchmarks.

PERCENTAGE OF STUDY AREA



Values are a percentage of the study area with concentrations in the three specified categories. Percentages might not sum to 100 because of rounding.

Concentrations are considered high if they are greater than a human-health benchmark (Norman and others, 2018) or SMCL. For inorganic constituents, concentrations are moderate if they are greater than one-half of a benchmark. For organic constituents, concentrations are moderate if they are greater than one-tenth of a benchmark; this lower threshold was used because organic constituents are generally less prevalent and have smaller concentrations relative to benchmarks than inorganic constituents (Toccalino and others, 2004).

Benchmark Type and Value for Selected Constituents

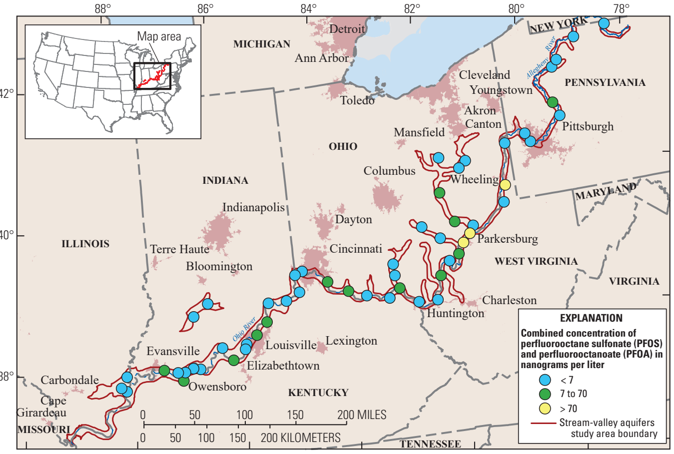
This table presents benchmarks for those constituents detected at high concentrations in the stream-valley aquifers. Benchmark types are regulatory U.S. Environmental Protection Agency (EPA) maximum contaminant levels (MCLs; U.S. Environmental Protection Agency, 2020a), non-regulatory health-based screening levels (HBSLs; Norman and others, 2018), and non-regulatory EPA secondary maximum contaminant levels (SMCLs; U.S. Environmental Protection Agency, 2020b).

[mg/L, milligram per liter; µg/L, microgram per liter; pCi/L, picocurie per liter]

Constituent	Benchmark		Constituent	Benchmark	
	Type	Value		Type	Value
Nitrate as nitrogen	MCL	10 mg/L	Iron	SMCL	300 µg/L
Cadmium	MCL	5 µg/L	Total dissolved solids (TDS)	SMCL	500 mg/L
Gross-beta activity	Screening level	50 pCi/L	Manganese	SMCL	50 µg/L
Iron	HBSL	4,000 µg/L	pH	SMCL	6.5–8.5
Manganese	HBSL	300 µg/L			

Per- and Polyfluoroalkyl Substances Were Detected Frequently

In addition to the constituents typically sampled for Principal Aquifer Studies, samples for the analysis of 24 per- and polyfluoroalkyl substances (PFAS) were collected from the wells in this network (McMahon and others, 2022a). These organic compounds have widespread use in household products, such as water repellent fabrics, nonstick products, food packaging, cleaning products and paints. PFAS also have been used extensively in fire-fighting foams (Glüge and others, 2020). Of the 24 PFAS analyzed, half were detected in samples (McMahon and others, 2022a). Perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) were among the most commonly detected PFAS in this assessment (McMahon and others, 2022a); about 50 percent of the study area had moderate concentrations, and about 5 percent of the study area had concentrations greater than the drinking water advisory level of 70 nanograms per liter for the combined concentrations (U.S. Environmental Protection Agency, 2016). Per- and polyfluoroalkyl substances were detected throughout the extent of the study area. The occurrence of PFAS in the study area was related to the distance of the wells from potential sources, such as fire training areas, landfills, chemical manufacturing plants, and airports (McMahon and others, 2022b).



Base from U.S. Geological Survey digital data, 1:1,000,000, 2014, and U.S. Census Bureau Urban Areas, 2017; Albers Equal-Area Conic projection; Standard parallels are 29°30' N. and 45°30' N.; Central meridian 96°00'W.; North American Datum of 1983

By James A. Kingsbury

Principal Aquifer Studies

The USGS NAWQA Project has been assessing the quality of groundwater since 1991. The NAWQA studies include Land Use Studies (LUS), Major Aquifer Studies (MAS), and Principal Aquifer Studies (PAS). These three study types are based on the sampling of networks of wells distributed across an area of interest. The LUS networks typically consist of observation wells that are relatively shallow (typically less than 100 feet deep); MAS networks typically consist of domestic-supply wells that are intermediate in depth (typically 50 to 150 feet); and PAS networks typically consist of public-supply wells that are relatively deep (typically 150 to 750 feet). A national synthesis of shallow and intermediate depth groundwater quality was reported by DeSimone and others (2015). This fact sheet provides a summary of PAS data for 55 public-supply wells sampled in 2019 in the stream-valley aquifers principal aquifer (data available in Gill and others, 2021).

The PAS assessments like this one allow for the comparison of constituent concentrations in untreated groundwater with benchmarks established for the protection of human health and for aesthetic qualities for drinking water and provide a basis for comparison of groundwater quality among principal aquifers.

The data collected by the NAWQA Project include chemical analyses generally not available as part of regulatory compliance monitoring, including measurements at concentrations much lower than human-health benchmarks and measurement of constituents that can be used to trace the sources and movement of groundwater.

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For More Information

Technical reports and hydrologic data collected for the USGS NAWQA Project may be obtained from

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U.S. Geological Survey
Water Availability and Use Science Program
Email: wausp-info@usgs.gov
WEB: https://water.usgs.gov/nawqa/

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