

Prepared in cooperation with the
New York State Department of Environmental Conservation

Groundwater Quality in the Upper Hudson River Basin, New York, 2012



Open-File Report 2014–1084

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

Cover. (background) setting of a domestic well in Essex County (photograph by Tia-Marie Scott); (upper left) A U.S. Geological Survey scientist sampling a domestic well in Fulton County, New York (photograph by Paul M. Heisig); (lower right) a domestic well in Herkimer County, New York (photograph by Paul M. Heisig).

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By Tia-Marie Scott and Elizabeth A. Nystrom

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U.S. Department of the Interior
SALLY JEWELL, Secretary

U.S. Geological Survey
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U.S. Geological Survey, Reston, Virginia: 2014

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Conversion Factors and Datum

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)	259.0	hectare (ha)
square mile (mi ²)	2.590	square kilometer (km ²)
Volume		
gallon (gal)	3.785	liter (L)
Flow rate		
gallon per minute (gal/min)	0.06309	liter per second (L/s)
Pressure		
inch of mercury at 60°F (in Hg)	3.377	kilopascal (kPa)
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:

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$$

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

$$^{\circ}\text{C}=(^{\circ}\text{F}-32)/1.8$$

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

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

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 either in milligrams per liter (mg/L) or micrograms per liter (μg/L).

Abbreviations

AMCL	Alternative maximum contaminant level
CFCL	USGS Chlorofluorocarbon Laboratory
CFU	Colony-forming units
cICP-MS	Collision/reaction cell inductively coupled plasma-mass spectrometry
CIAT	2-Chloro-4-isopropylamino-6-amino- <i>s</i> -triazine
GC-MS	Gas chromatography-mass spectrometry
GPS	Global positioning system
HPLC-MS	High-performance liquid chromatography-mass spectrometry
ICP-AES	Inductively coupled plasma-atomic emission spectrometry
ICP-MS	Inductively coupled plasma-mass spectrometry
ICP-OES	Inductively coupled plasma-optical emission spectrometry
LRL	Laboratory reporting level
MCL	Maximum contaminant level
MTBE	Methyl <i>tert</i> -butyl ether
NAVD 88	North American Vertical Datum of 1988
NWIS	National Water Information System
NWQL	USGS National Water Quality Laboratory
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
PVC	Polyvinyl chloride
SDWS	Secondary drinking-water standards
THM	Trihalomethane
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile organic compound

Groundwater Quality in the Upper Hudson River Basin, New York, 2012

By Tia-Marie Scott and Elizabeth A. Nystrom

Abstract

Water samples were collected from 20 production and domestic wells in the Upper Hudson River Basin (north of the Federal Dam at Troy, N.Y.) in New York in August 2012 to characterize groundwater quality in the basin. The samples were collected and processed using standard U.S. Geological Survey procedures and were analyzed for 148 physiochemical properties and constituents, including dissolved gases, major ions, nutrients, trace elements, pesticides, volatile organic compounds (VOCs), radionuclides, and indicator bacteria.

The Upper Hudson River Basin covers 4,600 square miles in upstate New York, Vermont, and Massachusetts; the study area encompasses the 4,000 square miles that lie within New York. The basin is underlain by crystalline and sedimentary bedrock, including gneiss, shale, and slate; some sandstone and carbonate rocks are present locally. The bedrock in some areas is overlain by surficial deposits of saturated sand and gravel. Eleven of the wells sampled in the Upper Hudson River Basin are completed in sand and gravel deposits, and 9 are completed in bedrock. Groundwater in the Upper Hudson River Basin was typically neutral or slightly basic; the water typically was moderately hard. Bicarbonate, chloride, calcium, and sodium were the major ions with the greatest median concentrations; the dominant nutrient was nitrate. Methane was detected in 7 samples. Strontium, iron, barium, boron, and manganese were the trace elements with the highest median concentrations. Two pesticides, an herbicide degradate and an insecticide degradate, were detected in two samples at trace levels; seven VOCs, including chloroform, four solvents, and the gasoline additive MTBE were detected in four samples. The greatest radon-222 activity, 2,900 picocuries per liter, was measured in a sample from a bedrock well; the median radon activity was higher in samples from bedrock wells than in samples from sand and gravel wells. Coliform bacteria were detected in one sample with a maximum of 2 colony-forming units per 100 milliliters.

Water quality in the Upper Hudson River Basin is generally good, but concentrations of some constituents equaled or exceeded current or proposed Federal or New York State drinking-water standards. The standards exceeded are color (1 sample), pH (3 samples), sodium (3 samples), chloride (1 sample), dissolved solids (1 sample), arsenic (1 sample), iron (2 samples), manganese (2 samples), uranium (1 sample), radon-222 (12 samples), and gross beta activities (3 samples). Total coliform bacteria were each detected in one sample. Concentrations of fluoride, sulfate, nitrate, nitrite, aluminum, antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, zinc, and gross alpha activities did not exceed existing drinking-water standards in any of the samples collected. Methane concentration in one sample was greater than 28 milligrams per liter, with a concentration of 35.1 milligrams per liter.

Introduction

Groundwater is used as a source of drinking water by approximately one-quarter of the population of New York State (Kenny and others, 2009). In 2002, the U.S. Geological Survey (USGS), in cooperation with the New York State Department of Environmental Conservation (NYSDEC), developed a program to evaluate groundwater quality throughout the major river basins in New York on a rotating basis. The program parallels the NYSDEC Rotating Intensive Basin Study program (<http://www.dec.ny.gov/chemical/30951.html>), which evaluates surface-water quality on a 5-year cycle by sampling in 2 or 3 of the 14 major river basins in the State each year, and supports NYSDEC's responsibilities under Section 305(b) of the Clean Water Act Amendments of 1977 to report on the chemical quality of groundwater within New York (U.S. Environmental Protection Agency, 1997). The groundwater-quality program began with a pilot study in the Mohawk River Basin in 2002 and has continued throughout upstate New York since then (table 1); sampling completed in 2008 represented the conclusion of a

Table 1. Previous groundwater-quality studies and reports.

[**Bold** report listing indicates the previous groundwater quality study in the Upper Hudson River Basin]

Study area	Year	Report	Reference
Mohawk River Basin	2002	Water-Data Report NY-02-1	Butch and others, 2003
Chemung River Basin	2003	Open-File Report 2004-1329	Hetcher-Aguila, 2005
Lake Champlain Basin	2004	Open-File Report 2006-1088	Nystrom, 2006
Susquehanna River Basin	2004	Open-File Report 2006-1161	Hetcher-Aguila and Eckhardt, 2006
Delaware River Basin	2005	Open-File Report 2007-1098	Nystrom, 2007b
Genesee River Basin	2005	Open-File Report 2007-1093	Eckhardt and others, 2007
St. Lawrence River Basin	2005	Open-File Report 2007-1066	Nystrom, 2007a
Mohawk River Basin	2006	Open-File Report 2008-1086	Nystrom, 2008
Western New York	2006	Open-File Report 2008-1140	Eckhardt and others, 2008
Central New York	2007	Open-File Report 2009-1257	Eckhardt and others, 2009
Upper Hudson River Basin	2007	Open-File Report 2009-1240	Nystrom, 2009
Chemung River Basin	2008	Open-File Report 2011-1112	Risen and Reddy, 2011a
Eastern Lake Ontario Basin	2008	Open-File Report 2011-1074	Risen and Reddy, 2011b
Lower Hudson River Basin	2008	Open-File Report 2010- 1197	Nystrom, 2010
Lake Champlain Basin	2009	Open-File Report 2011- 1180	Nystrom, 2011
Susquehanna River Basin	2009	Open-File Report 2012- 1045	Reddy and Risen, 2012
Delaware River Basin	2010	Open-File Report 2011- 1320	Nystrom, 2012
Genesee River Basin	2010	Open-File Report 2012- 1135	Reddy, 2012
St. Lawrence River Basin	2010	Open-File Report 2011- 1320	Nystrom, 2012
Mohawk River Basin	2011	Open-File Report 2013-1021	Nystrom and Scott, 2013

first round of groundwater-quality sampling throughout New York State (excluding Long Island, which is monitored through local county programs). Groundwater-quality sampling was conducted in 2012 in the Upper Hudson River Basin and the Oswego, Seneca, and Oneida River Basins (the Finger Lakes area).

Objective and Approach

The objective of the groundwater-quality monitoring program is to quantify and report on ambient groundwater quality from bedrock and glacial-drift aquifers in upstate New York. Using consistent, standardized methods, groundwater-quality samples were collected from existing domestic and production wells using on-site, permanently installed pumps. Wells were selected to represent an approximately equal number of domestic and production wells, to represent an approximately equal number of bedrock and glacial-drift wells, and to provide a representative geographic distribution of samples with emphasis on areas of greatest groundwater use. As basins were sampled for the second time, approximately 20 percent of samples were collected from wells that previously have been sampled as part of the cycle of studies. Samples were analyzed for a broad suite of constituents, including physiochemical properties and concentrations of dissolved gases, major ions, nutrients, trace elements, pesticides, volatile organic compounds (VOCs), radionuclides, and indicator bacteria. The resulting data set will be used to establish a groundwater-quality baseline for New York State, characterizing naturally occurring and background conditions, and to identify long-term trends. The data are made available through the USGS National Water Information System (NWIS) (<http://nwis.waterdata.usgs.gov/ny/nwis/qw>) and project reports.

Groundwater-quality samples were collected in the Upper Hudson River Basin in 2007 and in 2012. In 2012, 20 environmental samples and 2 quality-assurance samples were collected during the month of August. Five of the wells sampled in 2012 were also sampled as part of this cycle of studies in 2007 (Nystrom, 2009).

Purpose and Scope

This report presents the findings of the 2012 study in the Upper Hudson River Basin, in which 20 groundwater-quality samples were collected during August 2012. The report (1) describes the hydrogeologic setting, sampled wells, and the methods of site selection, sample collection, and chemical analysis; (2) presents discussions of the analytical results; and (3) presents comparisons of the results of this study with results for selected wells in the Upper Hudson River Basin that were sampled in 2007 (Nystrom, 2009).

Hydrogeologic Setting

The Upper Hudson River Basin encompasses 4,600 mi² in upstate New York, Vermont, and Massachusetts and is defined as the part of the Hudson River Basin that lies above the Federal Lock and Dam at Troy, N.Y.; this study included only the 4,000-mi² part of the basin that lies within New York (fig. 1). The study area contains parts of eight counties (Albany, Essex, Fulton, Hamilton, Rensselaer, Saratoga, Warren, and Washington, fig. 1). Major tributaries to the Upper Hudson River include the Schroon River, Sacandaga River, Batten Kill, and Hoosic River. The Champlain Canal, which connects the Hudson River to Lake Champlain, exits the basin north of Glens Falls. A dam on the Sacandaga River, completed in 1930, created the Great Sacandaga Lake; the dam is used for flow regulation and for power generation. The highest elevations in the basin are more than 5,000 ft above NAVD 88 in the northern part of the basin (fig. 1). The largest urban centers in the basin are the outlying parts of the Albany-Schenectady-Troy area and the cities of Glens Falls and Saratoga Springs (fig. 1); the upland areas of the basin are predominantly forested (Vogelmann and others, 2001) with very little development.

The surficial material throughout the basin was deposited primarily during the Pleistocene epoch, when the Wisconsin glaciers covered most of the Northeast. Till was deposited by glaciers over most of the basin (fig. 2); sand and gravel deposits occur mainly in valleys. Till generally has low yields, whereas sand and gravel, including alluvium, outwash, and ice-contact deposits, form the most productive aquifers in the basin. Wells finished in these coarse deposits may yield as much as 1,000 gal/min (Phillips and Hanchar, 1996).

Bedrock in the Upper Hudson River Basin (fig. 3) consists of mostly crystalline and sedimentary rock (Isachsen and others, 2000). The northern part of the basin is underlain by crystalline metamorphic bedrock composed mainly of gneiss; the southern part is underlain mainly by metamorphosed clastic rocks, including shale and slate, although some sandstone and carbonate bedrock is present (fig. 3). The carbonate units are generally the bedrock aquifers with the highest yields in the basin; the sandstone and shale aquifers generally produce small to moderate yields, and the crystalline metamorphic bedrock generally produces the lowest yields (Hammond and others, 1978).

Methods of Investigation

The methods used in this study, including (1) well-selection criteria, (2) sampling methods, and (3) analytical methods, were designed to maximize data precision, accuracy, and comparability. Groundwater-sample collection and processing followed standard USGS procedures as documented in the National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, variously dated). Samples were analyzed by documented methods at the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado, and other laboratories.

Well Selection

The 20 wells selected for sampling (figs. 2 and 3) represent forested, developed, and agricultural areas (table 2). The final selection of each well was based on the availability of well-construction data and hydrogeologic information for the well and its surrounding area. The study did not target specific municipalities, industries, or agricultural practices.

The domestic wells were selected on the basis of information from the NYSDEC Water Well program, which began in 2000. The program requires that licensed well drillers file a report with NYSDEC containing basic information about each well drilled, such as well and casing depth, diameter, yield, and a hydrogeologic log. Inspection of well-completion report data identified several hundred wells as potential sampling sites; well owners were each sent a letter requesting permission to sample the well and a questionnaire about the well. Well owners who granted permission were contacted later by phone to verify well information and to arrange a convenient time for sampling.

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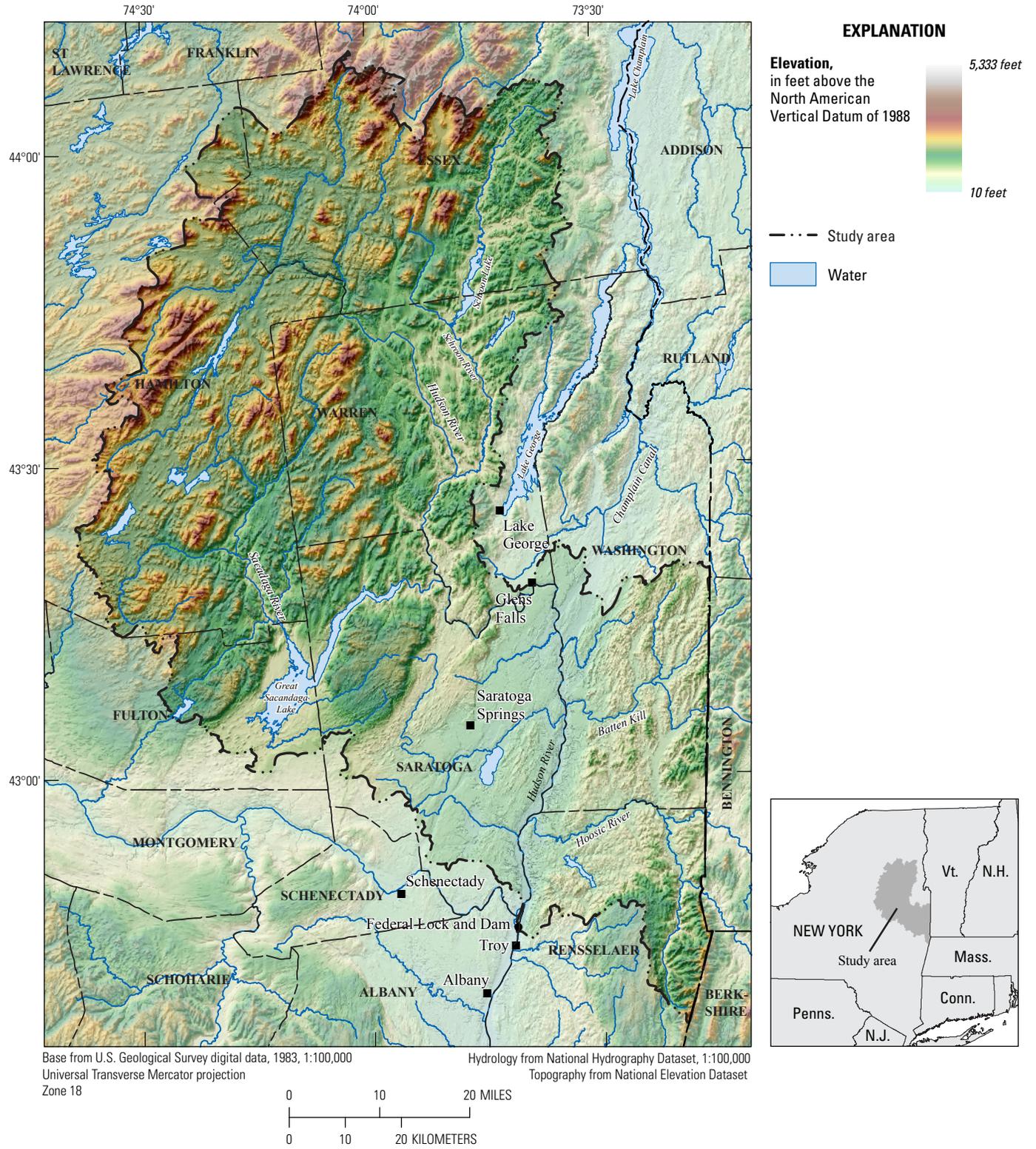


Figure 1. Topography and geography of the Upper Hudson River Basin, New York.

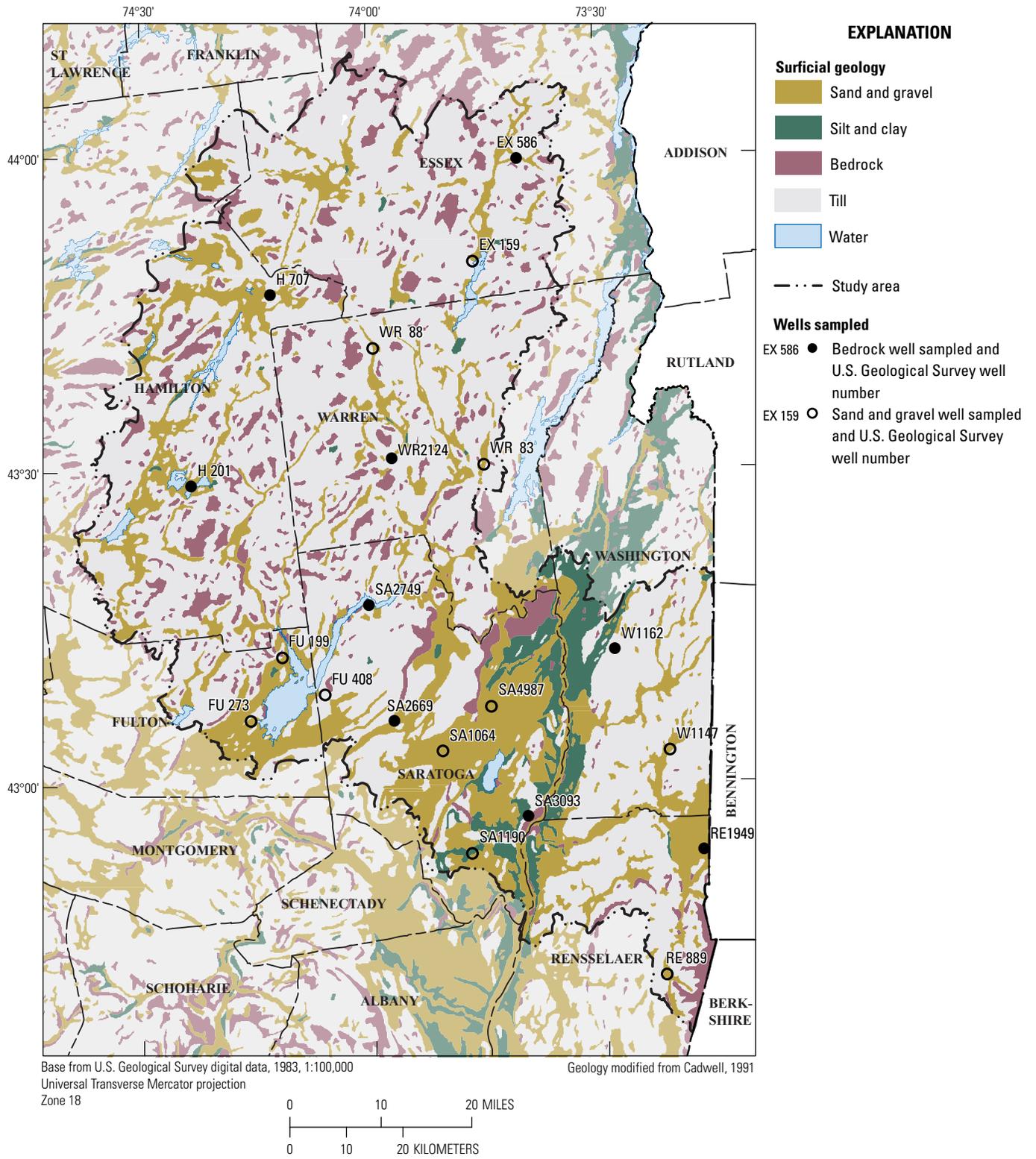


Figure 2 Generalized surficial geology of the Upper Hudson River Basin, New York, and locations of wells sampled in 2012.

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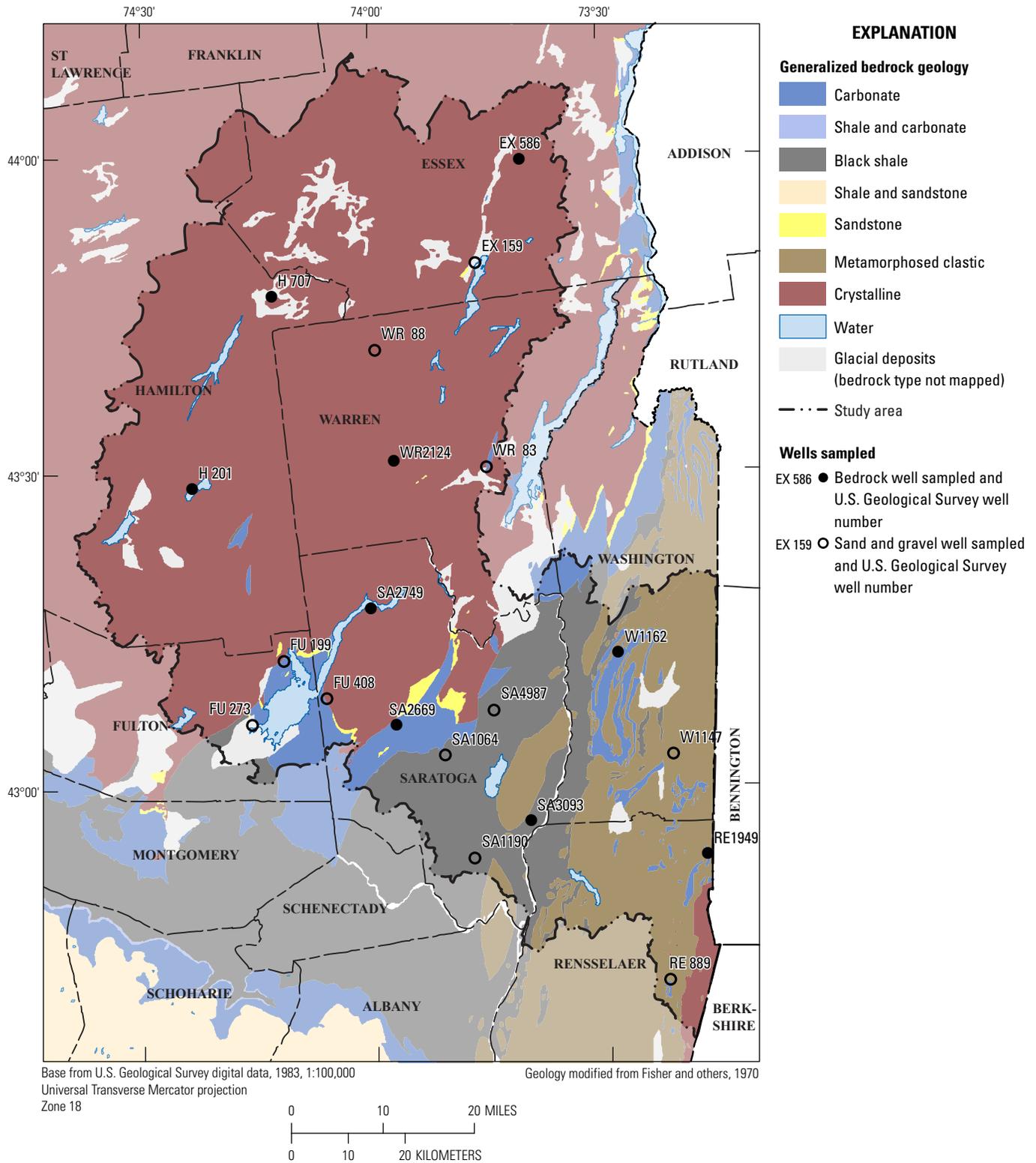


Figure 3. Generalized bedrock geology of the Upper Hudson River Basin, New York, and locations of wells sampled in 2012.

Table 2. Description of wells from which water samples were collected in the Upper Hudson River Basin, New York, 2012.

[--, unknown; well types: P, production; D, domestic. Land cover categories: D,  developed; F,  forested; A,  agricultural; W,  open water; WL,  wetlands. Well locations are shown in figures 2 and 3]

Well number ¹	U.S. Geological Survey station identifier	Date sampled	Well depth, feet below land surface	Casing depth, feet below land surface	Well type	Bedrock type	Land cover ² , percentage by category, within 0.5-mile radius surrounding the well							
							D	F	A	W	WL			
Sand and gravel wells														
EX 159	435000073461202	8/16/2012	196	184	P		34	21	6	21	18			
FU 199	431333074102001	8/23/2012	20	12	P		15	57	2	2	25			
FU 273	430616074155501	8/7/2012	42	--	P		43	29	12	5	11			
FU 408	430842074081101	8/7/2012	98	98	D			86			14			
RE 889	424135073222101	8/30/2012	80	60	P		29	57			14			
SA1064	430052073505501	8/22/2012	190	148	P		44	16			38			
SA1190	425325073471901	8/6/2012	107	92	P		40	20	2		38			
SA4987	430728073443401	8/16/2012	50	38	P		49	2	13		36			
W1147	430301073212601	8/8/2012	170	170	D		17	6		72			3	
WR 83	433035073450703	8/14/2012	33	33	P		15	46	11	6	22			
WR 88	434152073591001	8/14/2012	51	51	P		46	48				3	3	
Bedrock wells														
EX 586	435943073401401	8/15/2012	505	20	D	Crystalline		79		33	18			
H 201	432816074244501	8/21/2012	320	101	D	Crystalline	7	23	20	40	29			
H 707	434656074125801	8/13/2012	140	50	D	Crystalline	10	70			19			
RE1949	425330073171501	8/9/2012	580	84	D	Carbonate	8	23	67					
SA2669	430605073571001	8/20/2012	98	60	D	Carbonate		79		5	14			
SA2749	431620074000701	8/9/2012	338	20	D	Crystalline	14	62			22			
SA3093	425651073395801	8/6/2012	102	23	D	Shale	23	45		25	5			
W1162	431240073281701	8/8/2012	600	40	P	Shale	9	74		4	10		3	
WR2124	433104073572301	8/15/2012	409	101	D	Crystalline		95						

¹ EX, Essex County; FU, Fulton County; H, Hamilton County; RE, Rensselaer County; SA, Saratoga County; W, Washington County; WR, Warren County.

² Determined from the National Land Cover Data set (Vogelmann and others, 2001).

Production wells considered for sampling were identified through the U.S. Environmental Protection Agency (USEPA) Safe Drinking Water Information System, the New York State Department of Health (NYSDOH) Drinking Water Protection Program, and the NYSDEC Water Well program. Town officials and (or) water managers were sent letters requesting permission to sample a well, and follow-up phone calls were made to arrange a time for sampling. Well information, such as depth, was provided by water managers if a well-completion report was unavailable. The aquifer type indicated for sampled wells was assigned through inspection of hydrogeologic logs and published geologic maps, including Fisher and others (1970) and Cadwell (1991).

The characteristics of the wells sampled and the type of land cover surrounding each well are listed in table 2. The depths of the wells, the aquifer units from which samples were collected, and the numbers of production and domestic wells are summarized in table 3. Five wells sampled in 2012 (EX 159, FU 273, RE889, SA4987 and WR 83) were also sampled in 2007 (Nystrom, 2009).

Sampling Methods

Samples were collected and processed in accordance with documented USGS protocols (U.S. Geological Survey, variously dated). The samples were collected before any water-treatment system to be as representative of the aquifer water quality as possible. Most samples from domestic wells were collected from a spigot near the pressure tank; samples from production wells were collected at the spigot or faucet used for collection of raw-water samples by water managers.

At sites with garden-hose type spigots, samples were collected from one or more 10-ft lengths of Teflon tubing attached to the spigot. Domestic wells were purged after the tubing was connected by running to waste for at least 20 minutes at pumping rates ranging from about 2 to 5 gal/min or until at least one well-casing volume of water had passed the sampling point. Wells that had been used recently required removal of less than three well-casing volumes (U.S. Geological Survey, 2006). At least three well-casings of water were pumped from production wells before sampling; several were pumped for 1 hour or more prior to sampling, typically at rates of about 100 gal/min. During well purging, notes about the well and surrounding land and land use were recorded, including a global positioning system (GPS) measurement of latitude and longitude. After the well was purged, field measurements of water temperature, pH, specific conductance, and dissolved oxygen concentration were recorded at regular intervals until these values had stabilized, after which the sample was collected (U.S. Geological Survey, variously dated).

The flow rate for sample collection was adjusted to less than 0.5 gal/min when possible. The Teflon sampling tube was then connected to a sample-collection chamber constructed of a polyvinyl chloride (PVC) frame and a clear plastic chamber bag. The Teflon tubing and spigot-attachment equipment for each sample were pre-cleaned in the laboratory with a dilute phosphate-free detergent solution, followed by rinses with tap water and deionized water. Equipment for filtration of pesticide samples was rinsed with methanol as described in Wilde (2004).

Samples were collected and preserved in the sampling chamber according to standard USGS procedures. Samples for nutrient, major-ion, and some trace-element analyses were filtered through disposable (one-time use) 0.45-micrometer (μm) pore-size polyether sulfone capsule filters that were preconditioned in the laboratory with 3 liters (L) of deionized water the day of sample collection. Samples for pesticide analyses were filtered through baked 0.7- μm pore-size glass fiber filters. Ultra-pure nitric acid preservation was required for trace-element samples, except mercury, which was preserved with hydrochloric acid. Hydrochloric acid was added to VOC samples to kill bacteria that might degrade VOCs; samples for major-cation analysis

Table 3. Summary of information on wells from which water samples were collected in the Upper Hudson River Basin, New York, 2012.
[bls, below land surface]

Type of well	Number of wells		
	Production	Domestic	Total
Wells completed in sand and gravel (depth 20 to 196 feet bls)	9	2	11
Wells completed in bedrock (depth 98 to 600 feet bls)	1	8	9
Carbonate bedrock	0	2	2
Shale bedrock	1	1	2
Crystalline bedrock	0	5	5
Total number of wells	10	10	20

and some samples for radiochemical analysis were preserved with ultra-pure nitric acid. Acid preservative was added after the collection of other samples to avoid the possibility of cross contamination by the acid preservative; for example, samples preserved with nitric acid were acidified after the collection of samples for nutrient analysis. Samples for bacterial analysis were collected in accordance with NYSDEC and NYSDOH protocols, except that the tap from which each water sample was collected was not flame sterilized. Water samples for radon analysis were collected through a septum chamber with a glass syringe, according to standard USGS procedures. Water samples for the analysis of dissolved gases were filled and sealed while submerged in a beaker of water to prevent exposure to the atmosphere. Water samples analyzed by NYSDOH-certified laboratories were collected in bottles provided by the analyzing laboratory. After collection, all water samples except those for radiochemical analyses were chilled to 4 degrees Celsius (°C) or less and were kept chilled until delivery to the analyzing laboratory. Bacterial samples were hand delivered to the analyzing laboratory within 6 hours of collection; all other samples were shipped by overnight delivery to the designated laboratories.

Most sampling sites had easy access to a garden-hose type spigot; however, some supply wells did not. Wells FU 199 and FU 273 were sampled from a faucet using adapters to connect the Teflon tubing.

Analytical Methods

Samples were analyzed for 148 physiochemical properties and constituents, including dissolved gases, major ions, nutrients, trace elements, pesticides, pesticide degradates, VOCs, radionuclides, and bacteria. Physiochemical properties such as water temperature, pH, dissolved oxygen concentration, and specific conductance were measured at the sampling site. Major ions, nutrients, total organic carbon, trace elements, radon-222, pesticides, pesticide degradates, and VOCs were analyzed at the USGS NWQL in Denver, Colo. Selected dissolved gases were analyzed at the USGS Chlorofluorocarbon Laboratory (CFCL) in Reston, Virginia. Gross alpha and gross beta radioactivities were analyzed at Eberline Services in Richmond, California. Indicator bacteria were analyzed at the NYSDOH-certified St. Peter's Bender Laboratory in Albany, N.Y.

Anion concentrations were measured by ion-exchange chromatography, and cation concentrations were measured by inductively coupled plasma-atomic emission spectrometry (ICP-AES), as described in Fishman (1993). Nutrients were analyzed by colorimetry, as described by Fishman (1993), and Kjeldahl digestion with photometric finish, as described by Patton and Truitt (2000). Total organic carbon samples were analyzed by high temperature combustion and catalytic oxidation for measurement by infrared detection according to Standard Method 5310 (American Public Health Association, 1998). Mercury concentrations were measured through cold vapor-atomic fluorescence spectrometry according to methods described by Garbarino and Damrau (2001). Arsenic, chromium, and nickel samples were analyzed by use of collision/reaction cell inductively coupled plasma-mass spectrometry (cICP-MS), as described by Garbarino and others (2006). The remaining trace elements were analyzed by ICP-AES (Struzeski and others, 1996), inductively coupled plasma-optical emission spectrometry (ICP-OES), and inductively coupled plasma-mass spectrometry (ICP-MS) (Garbarino and Struzeski, 1998). Procedures for in-bottle digestions for trace-element analyses described by Hoffman and others (1996) were followed. Radon-222 activities were measured through liquid-scintillation counting (ASTM International, 2006). Samples for pesticide analyses were processed as described by Wilde and others (2004) and were analyzed using gas chromatography-mass spectrometry (GC-MS) and high-performance liquid chromatography-mass spectrometry (HPLC-MS), as described by Zaugg and others (1995), Sandstrom and others (2001), and Furlong and others (2001). VOCs were analyzed by GC-MS using methods described by Connor and others (1998).

Gross alpha and gross beta radioactivities were measured through gas flow proportional counting according to USEPA method 900.0 (U.S. Environmental Protection Agency, 1980). Carbon dioxide and methane concentrations were measured through gas chromatography with flame ionization detection; dissolved nitrogen gas and argon concentrations were measured through gas chromatography with thermal conductivity detection. Indicator bacteria samples were tested for total coliform, fecal coliform, and *Escherichia coli* (*E. coli*) using membrane filtration through Standard Method 9222 (American Public Health Association, 1998); a heterotrophic plate count test (SM 9215 B) also was done.

Quality-Control Samples

In addition to the 20 groundwater samples, 1 field blank sample and 1 replicate sample were collected for quality assurance. Constituents did not exceed laboratory reporting levels (LRLs) in the blank sample, except for chromium, which was measured at 0.33 micrograms per liter ($\mu\text{g/L}$) (LRL for chromium is 0.30 $\mu\text{g/L}$), and silica, which was measured at 0.075 milligrams per liter (mg/L) (LRL for silica is 0.036 mg/L). The minimum silica concentration detected in the environmental samples was 7.23 mg/L . The variability between replicate samples was less than 20 percent for all constituents with the exception of low level trace elements (iron and manganese in filtered water), heterotrophic plate count, and low level radon-222. No VOCs or pesticides were detected in the replicate samples.

Groundwater Quality

Many of the constituents for which the groundwater samples were analyzed were not detected in any sample. Some concentrations are reported as “estimated.” Estimated concentrations are typically reported when the detected value is less than the established LRL or when recovery of a compound has been shown to be highly variable (Childress and others, 1999). Concentrations of some constituents exceeded maximum contaminant levels (MCLs) or secondary drinking-water standards (SDWS) set by the USEPA (U.S. Environmental Protection Agency, 2009) or NYSDOH (New York State Department of Health, 2011). MCLs are enforceable standards for finished water in public water supplies; they are not enforceable for private homeowner wells but are presented here as a standard for evaluation of the water-quality results. SDWS are nonenforceable drinking-water standards that typically relate to aesthetic concerns such as taste, odor, or staining of plumbing fixtures.

The results of analyses of the 20 groundwater samples collected in the Upper Hudson River Basin during August 2012 are presented in tables 1-1 through 1-10 in *appendix 1*. Of the 148 constituents and physiochemical properties analyzed for, 83 were not detected at levels greater than the LRLs (*appendix table 1-1*). Results for the remaining 65 constituents and properties that were detected in the Upper Hudson River Basin are presented in *appendix 1*, tables 1-2 through 1-10.

Physiochemical Properties

Most (19) of the samples from the Upper Hudson River Basin had a color of less than (<) 1 platinum-cobalt (Pt-Co) unit (*table 4* and *appendix table 1-2*); one sample from a bedrock well had a color of 5 Pt-Co units. Sample pH was typically near neutral or slightly basic (median 7.8 for all wells) and ranged from 5.9 to 8.7. The pH of one sample from a bedrock well (8.7) was higher than the USEPA SDWS range for pH (6.5 to 8.5) and the pH of one sample from a sand and gravel well (5.9) was lower than the USEPA SDWS range for pH. Specific conductance ranged from 72 to 4,250 microsiemens per centimeter at 25 degrees Celsius ($\mu\text{S}/\text{cm}$ at 25°C); the median conductance was 308 $\mu\text{S}/\text{cm}$ at 25°C. Water temperature ranged from 7.8 to 13.0°C; the median temperature was 10.8°C. Hydrogen sulfide odor was detected at two sites, one was a sand and gravel well and one was a bedrock well.

Table 4. Drinking-water standards and summary statistics for physiochemical properties of groundwater samples from the Upper Hudson River Basin, New York, 2012.

[All concentrations in unfiltered water except as noted; Pt-Co units, platinum-cobalt units; $\mu\text{S}/\text{cm}$ at 25°C, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; --, not applicable; <, less than]

Constituent	Drinking-water standard	Number of samples exceeding standard	Median (all samples)	Summary statistics for physical properties					
				Sand and gravel aquifers (11 samples)			Bedrock aquifers (9 samples)		
				Minimum	Median	Maximum	Minimum	Median	Maximum
Color, filtered, Pt-Co units	¹ 15	0	<1	<1	<1	<1	<1	<1	5
pH	¹ 6.5-8.5	3	7.8	5.9	7.7	8.2	7.4	7.8	8.7
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	--	--	308	72	325	838	109	229	4,250
Temperature, °C	--	--	10.8	7.8	10.5	12.5	10.2	11.1	13.0

¹ U.S. Environmental Protection Agency Secondary Drinking Water Standard.

Dissolved Gases

Dissolved oxygen concentrations ranged from <0.3 to 10.8 mg/L (table 5 and appendix table 13) and typically were greater in samples from sand and gravel wells (median 4.4 mg/L) than in samples from bedrock wells (median 1.9 mg/L). The concentrations of carbon dioxide, argon, dissolved nitrogen gas, and methane were determined twice for each site (table 1–3). The median concentrations of these dissolved gases in the samples were 22.13 mg/L for nitrogen, 3.4 mg/L for carbon dioxide, 0.774 mg/L for argon, and <0.001 mg/L for methane. Methane was detected in 7 of the 20 samples, and most (4) of those detections were trace level. The maximum methane concentration measured was 35.1 mg/L in a sample from a well finished in sand and gravel. Although the USEPA and NYSDOH do not have MCLs for methane, dissolved methane concentrations greater than 28 mg/L (1 sample) can pose explosion hazards as a result of methane accumulation in confined spaces; in addition, the Office of Surface Mining recommends that methane concentrations ranging from 10 to 28 mg/L in water signify an action level where the situation should be closely monitored, and if the concentration increases, enclosed areas should be vented to prevent methane gas buildup (Eltzschlager and others, 2001).

Major Ions

The anions detected in the highest concentrations were bicarbonate (median concentration 89 mg/L) and chloride (median concentration 12.4 mg/L) (table 6 and appendix table 1–4). The cations detected in the highest concentrations were calcium (median concentration 29.1 mg/L) and sodium (median concentration 20.8 mg/L). The concentration of sodium in three samples exceeded the USEPA Drinking Water Advisory Taste Threshold of 60 mg/L; the maximum concentration of sodium detected was 122 mg/L. The concentration of chloride in one sample, 1,440 mg/L, exceeded the NYSDOH MCL and USEPA SDWS of 250 mg/L. The concentrations of fluoride and sulfate did not exceed established MCLs in any sample (table 6).

Most of the water samples (8 of 20) from the Upper Hudson River Basin were moderately hard (61 to 120 mg/L as calcium carbonate, CaCO₃; Hem, 1985). The median hardness of the samples was 97 mg/L as CaCO₃, and the maximum hardness was 1,860 mg/L as CaCO₃. Of the remaining twelve samples, five were soft (0 to 60 mg/L as CaCO₃), four were hard (121 to 180 mg/L as CaCO₃), and three were very hard (greater than 180 mg/L as CaCO₃). Alkalinity ranged from 20 to 251 mg/L as CaCO₃; the median was 74 mg/L of CaCO₃. Dissolved solids concentrations ranged from 53 to 2,770 mg/L with a median of 188 mg/L; dissolved solids concentration in one sample exceeded the USEPA SDWS for total dissolved solids of 500 mg/L.

The sample from one well, H 201, had very high concentrations of several ions including chloride, calcium, sodium, and magnesium, and had very high hardness and dissolved solids as a result. Concentrations of some trace elements in the sample from this well were also elevated. This well is one of several in the area affected by contamination from a former municipal stockpile of road salt; a reverse osmosis filtration system is used to treat the water produced from this well before household use.

Table 5. Summary statistics for concentrations of dissolved gases in groundwater samples from Upper Hudson River Basin, New York, 2012.

[All concentrations in unfiltered water; mg/L, milligrams per liter; <, less than]

Constituent	Summary statistics for concentrations of dissolved gases						
	Median (all samples)	Sand and gravel aquifers (11 samples)			Bedrock aquifers (9 samples)		
		Minimum	Median	Maximum	Minimum	Median	Maximum
Carbon dioxide, mg/L	3.4	0.7	4.3	30.9	1.3	1.9	15.4
Dissolved oxygen, mg/L	2.8	<0.3	4.4	10.8	<0.3	1.9	8.3
Argon, mg/L	0.774	0.163	0.758	0.846	0.714	0.808	0.875
Nitrogen gas, mg/L	22.13	2.58	21.84	24.34	19.78	23.03	27.72
Methane, mg/L	<0.001	<0.001	<0.001	35.1	<0.001	<0.001	7.16

Table 6. Drinking-water standards and summary statistics for concentrations of major ions in groundwater samples from the Upper Hudson River Basin, New York, 2012.

[All concentrations are in milligrams per liter in filtered water; --, not applicable; <, less than; °C, degrees Celsius; CaCO₃, calcium carbonate]

Constituent		Summary statistics for concentrations of major ions								
		Drinking-water standard	Number of samples exceeding standard	Median (all samples)	Sand and gravel aquifers (11 samples)			Bedrock aquifers (9 samples)		
					Minimum	Median	Maximum	Minimum	Median	Maximum
Cations	Calcium	--	--	29.1	0.046	31.4	105	9.68	27.4	611
	Magnesium	--	--	6.50	0.026	6.55	21.5	4.07	5.99	81.1
	Potassium	--	--	0.88	0.06	0.86	1.99	0.38	0.91	2.87
	Sodium	⁴ 60	3	20.8	5.07	40.0	80.7	3.21	5.25	122
Anions	Bicarbonate	--	--	89	25	124	305	44	77	263
	Chloride	^{2,3} 250	1	12.4	2.23	46.2	105	0.71	2.16	1,440
	Fluoride	¹ 4.0 ² 2.2 ³ 2	0	0.08	<0.04	0.05	0.44	<0.04	0.18	0.50
	Silica	--	--	10.8	7.23	10.8	13.6	9.08	10.8	16.6
	Sulfate	^{2,3} 250	0	12.7	<0.09	10.7	26.1	7.10	14.5	27.4
	Hardness as CaCO ₃	--	--	97	0.22	117	350	48.8	97.0	1,860
Alkalinity as CaCO ₃	--	--	74	20	102	251	39	64	217	
Dissolved solids, dried at 180°C	³ 500	1	188	53	209	471	64	136	2,770	

¹ U.S. Environmental Protection Agency Maximum Contaminant Level.

² New York State Department of Health Maximum Contaminant Level.

³ U.S. Environmental Protection Agency Secondary Drinking Water Standard.

⁴ U.S. Environmental Protection Agency Drinking Water Advisory Taste Threshold.

Nutrients and Total Organic Carbon

The dominant nutrient detected in the Upper Hudson River Basin was nitrate (table 7 and appendix table 1–5). The concentration of ammonia ranged from <0.07 to 1.3 mg/L as nitrogen (N) and was similar in samples from sand and gravel wells and from samples in bedrock wells. The concentration of nitrate ranged from <0.040 to 2.23 mg/L as N and was generally greater in samples from sand and gravel wells (median 0.218 mg/L as N) than in samples from bedrock wells (median 0.092 mg/L as N). The concentration of nitrate plus nitrite did not exceed the NYSDOH and USEPA MCL of 10 mg/L as N in any sample. Nitrite was detected in 5 of the 20 samples with a maximum concentration of 0.046 mg/L as N; the concentration of nitrite did not exceed the NYSDOH and USEPA MCL (1 mg/L as N) in any sample. Orthophosphate concentrations ranged from <0.004 to 0.891 mg/L as phosphorus (P). Total organic carbon was detected in 10 of the 20 samples; the maximum concentration was 1.8 mg/L.

Trace Elements

The trace elements present in the highest median concentrations in the samples were strontium, with a median of 192 micrograms per liter (µg/L), iron (median 9 µg/L in unfiltered water; 5 µg/L in filtered water), barium (median 14.4 µg/L), boron (median 9.6 µg/L in filtered water), and manganese (median 2.66 µg/L in unfiltered water; 1.16 µg/L in filtered water) (table 8 and appendix table 1–6). The highest detected concentration of a trace element was 3,550 µg/L of strontium in a sample from a bedrock well. The median concentrations of some trace elements were higher in samples from sand and gravel wells than in samples from bedrock wells, for example, barium, lead, and manganese; the median concentrations of other trace elements were greater in samples from bedrock wells than in samples from sand and gravel wells, including boron, copper, lithium, strontium, and uranium.

Table 7. Drinking-water standards and summary statistics for concentrations of nutrients in groundwater samples from the Upper Hudson River Basin, New York, 2012.

[All concentrations in milligrams per liter in filtered water except as noted. N, nitrogen; P, phosphorus; --, not applicable; <, less than]

Constituent	Summary statistics for concentrations of nutrients								
	Drinking-water standard	Number of samples exceeding standard	Median (all samples)	Sand and gravel aquifers (11 samples)			Bedrock aquifers (9 samples)		
				Minimum	Median	Maximum	Minimum	Median	Maximum
Ammonia plus organic N, as N	--	--	<0.07	<0.07	<0.07	1.3	<0.07	<0.07	0.83
Ammonia (NH ₃), as N	--	--	<0.010	<0.010	<0.010	1.07	<0.010	<0.010	0.787
Nitrate plus nitrite (NO ₂ + NO ₃), as N	^{1,2} 10	0	0.094	<0.040	0.218	2.23	<0.040	0.092	0.746
Nitrate (NO ₃), as N	^{1,2} 10	0	0.094	<0.040	0.218	2.23	<0.040	0.092	0.746
Nitrite (NO ₂), as N	^{1,2} 1	0	<0.001	<0.001	<0.001	0.046	<0.001	<0.001	0.001
Orthophosphate (PO ₄), as P	--	--	0.008	<0.004	0.008	0.891	<0.004	0.007	0.044
Total organic carbon, unfiltered	--	--	<0.5	<0.5	<0.5	1.8	<0.5	<0.5	1.2

¹ U.S. Environmental Protection Agency Maximum Contaminant Level.

² New York State Department of Health Maximum Contaminant Level.

The concentration of arsenic in one sample from a sand and gravel well exceeded the USEPA MCL and NYSDOH MCL of 10 µg/L. The concentration of iron in two unfiltered and one filtered samples exceeded the NYSDOH MCL and USEPA SDWS of 300 µg/L. One sample had an unfiltered iron concentration greater than 1,000 µg/L; the maximum iron concentration was 1,160 µg/L in an unfiltered sample from a sand and gravel well. The concentration of manganese in two unfiltered and two filtered samples exceeded the USEPA SDWS of 50 µg/L; the concentration of manganese in one unfiltered and one filtered samples exceeded the NYSDOH MCL of 300 µg/L. The maximum concentration of manganese, 678 µg/L, was in an unfiltered sample from a sand and gravel well. The concentration of uranium in one sample from a bedrock well exceeded the USEPA MCL and NYSDOH MCL of 30 µg/L. Drinking-water standards for aluminum, antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, and zinc were not exceeded; additionally, mercury, silver and thallium were not detected in any of the 20 samples collected (appendix table 1–1).

Pesticides

Two pesticide degradates were detected at trace concentrations in two samples from production wells – one finished in sand and gravel and one finished in bedrock (appendix table 1–7). The pesticide detected with the highest concentration (estimated 0.004 µg/L) was CIAT (2-chloro-4-isopropylamino-6-amino-*s*-triazine), a degradate of atrazine, which was detected in one sample from a bedrock well. *p,p'*-DDE, a degradate of DDT, was detected with a concentration of 0.001 µg/L in one sample from a sand and gravel well. No pesticide concentrations exceeded established drinking-water standards; pesticide degradates currently are not regulated.

Volatile Organic Compounds

VOCs were rarely detected in any of the 20 sampled wells. Seven VOCs were detected in samples from three sand and gravel wells and one bedrock well (appendix table 1–8). The VOCs detected are three trihalomethanes (THM), three solvents and the gasoline additive methyl *tert*-butyl ether (MTBE). THMs are byproducts that form when chlorine or bromine are used as disinfectants. Trichloromethane (chloroform) was the most frequently detected VOC, and was detected in three samples with a maximum concentration of 2.1 µg/L in a sample from a sand and gravel well. One sample from a sand and gravel well had detections of three THMs: bromodichloromethane (1.0 µg/L), dibromochloromethane (0.8 µg/L), and trichloromethane (2.1 µg/L). The concentration of total THMs did not exceed the NYSDOH and USEPA MCLs of 80 µg/L in any sample. One

Table 8. Drinking-water standards and summary statistics for concentrations of trace elements in groundwater samples from the Upper Hudson River Basin, New York, 2012.

[All concentrations in micrograms per liter in unfiltered water except as noted. <, less than; --, not applicable]

Constituent	Drinking-water standard	Number of samples exceeding standard	Median (all samples)	Summary statistics for concentrations of trace elements					
				Sand and gravel aquifers (11 samples)			Bedrock aquifers (9 samples)		
				Minimum	Median	Maximum	Minimum	Median	Maximum
Aluminum	³ 50-200	0	<3.8	<3.8	<3.8	9.0	<3.8	<3.8	7.5
Antimony	^{1,2} 6	0	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	.21
Arsenic	^{1,2} 10	1	<0.28	<0.28	<0.28	10.2	<0.28	<0.28	3.2
Barium	^{1,2} 2,000	0	14.4	0.14	20.4	482	1.41	12.8	767
Beryllium	^{1,2} 4	0	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	.05
Boron, filtered	--	--	9.6	2.3	8.8	103	1.9	10.0	264
Cadmium	^{1,2} 5	0	<0.016	<0.016	<0.016	0.016	<0.016	<0.016	0.017
Chromium	^{1,2} 100	0	<0.30	<0.30	<0.30	0.47	<0.30	<0.30	1.1
Cobalt	--	--	<0.02	<0.02	<0.02	0.14	<0.02	<0.02	0.19
Copper	³ 1,000	0	2	<0.70	1.9	26.3	<0.70	2.1	3.4
Iron, filtered	^{2,3} 300	1	5	<3.2	7.1	1,570	<3.2	4.6	41.9
Iron	^{2,3} 300	2	9	<4.6	7.9	1,610	<4.6	10.5	787
Lead	⁴ 15	0	0.24	<0.04	0.26	1.55	<0.04	0.15	2.68
Lithium	--	--	1.16	<0.15	0.72	68.8	0.17	1.42	236
Manganese, filtered	² 300 ³ 50	1 1	1.16	<0.16	2.54	672	<0.16	0.25	248
Manganese	² 300 ³ 50	1 1	2.66	<0.4	3.0	678	<0.4	2.3	280
Mercury	^{1,2} 2	1 1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Molybdenum	--	0	0.65	<0.05	0.15	4.21	<0.05	0.86	7.37
Nickel	--	--	<0.38	<0.19	0.27	3.1	<0.19	<0.38	0.31
Selenium	^{1,2} 50	--	<0.100	<0.050	<0.050	0.252	<0.050	0.067	0.415
Silver	^{2,3} 100	0	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.030
Strontium	--	0	192	<0.80	92.3	612	25.5	258	3,550
Thallium	^{1,2} 2	--	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.12
Zinc	^{2,3} 5,000	0	<3.0	<3.0	<3.0	119	<3.0	<3.0	193
Uranium	^{1,2} 30	0	0.256	<0.014	0.150	0.863	0.016	1.50	31.4

¹ U.S. Environmental Protection Agency Maximum Contaminant Level.² New York State Department of Health Maximum Contaminant Level.³ U.S. Environmental Protection Agency Secondary Drinking Water Standard.⁴ U.S. Environmental Protection Agency Treatment Technique.

sample from a bedrock well had detections of three solvents and MTBE: 1,1,1-trichloroethane was detected with a concentration of 0.2 µg/L (NYSDOH MCL of 200 µg/L and USEPA MCL of 5 µg/L), 1,1-dichloroethane was detected with a concentration of 0.1 µg/L (USEPA MCL of 5 µg/L), 1,2-dichlorobenzene was detected with a concentration of 0.1 µg/L (USEPA MCL of 5 µg/L and NYSDOH MCL of 600 µg/L), and MTBE was detected with a concentration of 0.7 µg/L (USEPA MCL of 10 µg/L).

Radionuclides

Gross alpha activity ranged from non-detectable levels to 13 picocuries per liter (pCi/L); the median activity was 0.55 pCi/L (table 9 and appendix table 1–9). The gross alpha activity did not exceed the NYSDOH and USEPA MCLs of 15 pCi/L in any sample. Gross beta activities ranged from non-detectable levels to 9.5 pCi/L. The USEPA and NYSDOH MCLs for gross beta are 4 millirem per year, a dosage determination that requires knowledge of the specific radionuclide sources. The activity units (picocuries per liter) that were used to measure gross beta radioactivity in this study are not comparable to dosage units (millirems per year) without determination of the nuclide sources, therefore, it is not possible to determine whether any of the samples exceeded the MCL for gross beta radioactivity. Radon-222 activities in the water samples ranged from <12.5 to 2,900 pCi/L; the median was 330 pCi/L. The highest radon activity was in a sample from a well finished crystalline bedrock; the median radon activity in samples from bedrock wells (520 pCi/L) was higher than the median activity in samples from sand and gravel wells (203 pCi/L). Radon is currently (2013) not regulated in drinking water; however, the USEPA has proposed a two-part standard for radon in drinking water: (1) a 300 pCi/L MCL for areas that do not implement an indoor-air radon mitigation program and (2) an alternative MCL (AMCL) of 4,000 pCi/L for areas that do (U.S. Environmental Protection Agency, 1999). Activities in 12 of the samples exceeded the proposed MCL, but none exceeded the proposed AMCL.

Bacteria

Coliform bacteria were detected in one sample from a sand and gravel production well (appendix table 1–10), with 2 colony-forming units (CFUs) per 100 mL. The NYSDOH and USEPA MCLs for total coliform bacteria are exceeded when 5 percent of samples of finished water collected in 1 month test positive for total coliform (if 40 or more samples are collected per month) or when two samples of finished water test positive for total coliform (if fewer than 40 samples are collected per month). Fecal coliform bacteria and *Escherichia coli* (*E. coli*) were not detected in any samples. The heterotrophic plate count ranged from <1 CFU per mL to 152 CFU per mL; the USEPA MCL for the heterotrophic plate count is 500 CFU/mL, which was not exceeded in any sample.

Table 9. Drinking-water standards and summary statistics for concentrations of radionuclides in groundwater samples from the Upper Hudson River Basin, New York, 2012.

[All activities in picocuries per liter in unfiltered water except as noted. mrem/yr, millirem per year; --, not applicable; <, less than]

Constituent	Summary statistics for radionuclide activities								
	Drinking-water standard	Number of samples exceeding standard	Median (all samples)	Sand and gravel aquifers (11 samples)			Bedrock aquifers (9 samples)		
				Minimum	Median	Maximum	Minimum	Median	Maximum
Gross alpha radioactivity	^{1,2} 15	0	0.55	<0.39	<1.9	<1.9	<0.45	1.9	13
Gross beta radioactivity	^{1,2} 4 mrem/yr	--	1.25	<0.64	<0.96	2.8	1.1	1.7	9.5
Radon-222	³ 300 ⁴ 4,000	12 0	330	< 12.5	203	880	35	520	2,900

¹ U.S. Environmental Protection Agency Maximum Contaminant Level.

² New York State Department of Health Maximum Contaminant Level.

³ U.S. Environmental Protection Agency Proposed Maximum Contaminant Level.

⁴ U.S. Environmental Protection Agency Proposed Alternative Maximum Contaminant Level.

Wells sampled in 2007 and 2012

Five of the wells sampled in 2012 (wells EX 159, FU 273, RE 889, SA4987 and WR 83) were sampled previously in 2007 as part of this study. Of the 148 constituents and physiochemical properties that samples were analyzed for in 2011, 140 were common to both 2007 and 2012 years of analyses; the values for the physiochemical properties of the samples and the concentrations of nutrients, major ions, trace elements, radon-222, detected pesticides, pesticide degradates, and VOCs are presented in appendix tables 2-1 through 2-5. Differences between wells were often greater than differences between samples at a single well; however, well SA4987, a sand and gravel well, showed more variability than other wells. One pesticide degradate was detected in the one of the wells sampled in both 2007 and 2012 (appendix table 2-14): p,p'-DDE was not detected ($<0.003 \mu\text{g/L}$) in 2007, but was detected in 2012 at a trace level ($0.001 \mu\text{g/L}$). Three VOCs, all THMs, were detected in four of the five wells sampled in 2007 and 2012; two of the wells had more detections of THMs in 2007 than in 2012, and two had more detections of THMs in 2012 than in 2007. Coliform bacteria were detected in one of the five resampled wells in 2012 (2 CFU per mL) but were not detected in 2007 (appendix table 1-15).

Summary

Groundwater samples were collected during August 2012 from 20 wells in the Upper Hudson River Basin to characterize the groundwater quality. Sample collection and analysis followed standard USGS procedures and other documented procedures. Samples were analyzed for physical properties and concentrations of dissolved gases, major ions, nutrients, trace elements, pesticides, volatile organic compounds (VOCs), radionuclides, and bacteria. Many of the 148 constituents analyzed for were not detected in any of the samples.

The depths of sand and gravel wells sampled in the Upper Hudson River Basin range from 20 to 196 ft below land surface; the bedrock wells are 98 to 600 ft deep and typically are completed in shale, carbonate, or crystalline bedrock. Half of the 20 wells sampled are production wells; half are domestic wells. The samples generally indicated good water quality, although properties and concentrations of some constituents—pH, sodium, chloride, dissolved solids, arsenic, iron, manganese, radon-222, and uranium—equaled or exceeded primary, secondary, or proposed drinking-water standards. The constituents most frequently detected in concentrations exceeding drinking-water standards were radon-222 (12 samples had concentrations equal to or greater than the U.S. Environmental Protection Agency (USEPA) proposed maximum contaminant level (MCL) of 300 picocuries per liter), sodium (3 samples had concentrations greater than the USEPA Drinking Water Taste Advisory of 60 milligrams per liter (mg/L)), and iron (2 unfiltered samples had concentrations greater than the New York State Department of Health MCL and USEPA secondary drinking-water standard (SDWS) of 300 micrograms per liter ($\mu\text{g/L}$)).

Sample pH was typically near neutral or slightly basic. Methane was detected in 7 of the 20 samples; 1 sample had a methane concentration greater than 28 mg/L. The water typically was moderately hard, and the median dissolved solids concentration was 188 mg/L. The ions detected in the highest median concentrations were bicarbonate, chloride, calcium, and sodium. The dominant nutrient was nitrate; concentrations of nitrate and nitrite did not exceed established drinking-water standards. Strontium and iron were the trace elements with the highest median concentrations. Two pesticide degradates were detected in two samples; both were trace-level detections and seven VOCs were detected in four samples. Radon-222 activities in 12 samples exceeded a proposed MCL, but none exceeded the proposed AMCL. Coliform bacteria were detected in one sample. Fecal coliform and *Escherichia coli* bacteria were not detected in any samples.

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Appendix 1. Results of Water-Sample Analyses, 2012.

(<http://pubs.usgs.gov/of/2014/1084/>)

Appendix 2. Results of Water-Sample Analyses, 2007 and 2012.

(<http://pubs.usgs.gov/of/2014/1084/>)

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