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

Groundwater Quality in the Chemung River, Eastern Lake Ontario, and Lower Hudson River Basins, New York, 2013

Open-File Report 2015–1168

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

Cover. Background photograph—Setting of a domestic well in Ulster County. Upper photograph—Setting of a production well in Putnam County. Lower photograph—Sampling at a domestic well in Rockland County.

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U.S. Geological Survey
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The authors extend thanks and appreciation to all well owners who took the time to fill out well surveys and to those who gave permission and facilitated sampling of their wells. Thanks are also extended to our contacts at the New York State Department of Environmental Conservation, the New York State Department of Health, county departments of health, and all of the public water supply personnel who provided information and help with this study. Additionally, the authors would like to extend thanks and appreciation to Paul Heisig, Richard Reynolds, and Brett Hayhurst of the U.S. Geological Survey for their work collecting the samples.

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Conversion Factors

Inch/Pound to International System of Units

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)
	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
°F = (1.8 × °C) + 32.

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as
°C = (°F – 32) / 1.8.

Datum

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.

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) 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-s-triazine
EPA	U.S. Environmental Protection Agency
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 *tert*-butyl ether
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
PERC	tetrachloroethene
SDWS	secondary drinking-water standards
TCE	trichloroethene
THM	trihalomethane
USGS	U.S. Geological Survey
VOC	volatile organic compound

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Abstract

In a study conducted by the U.S. Geological Survey (USGS) in cooperation with the New York State Department of Environmental Conservation, water samples were collected from 4 production wells and 4 domestic wells in the Chemung River Basin, 8 production wells and 7 domestic wells in the Eastern Lake Ontario Basin, and 12 production wells and 13 domestic wells in the Lower Hudson River Basin (south of the Federal Lock and Dam at Troy) in New York. All samples were collected in June, July, and August 2013 to characterize groundwater quality in these basins. The samples were collected and processed using standard USGS procedures and were analyzed for 148 physiochemical properties and constituents, including dissolved gases, major ions, nutrients, trace elements, pesticides, volatile organic compounds, radionuclides, and indicator bacteria.

The Chemung River Basin study area covers 1,744 square miles in south-central New York and encompasses the part of the Chemung River Basin that lies within New York. Two of the wells sampled in the Chemung River Basin are completed in sand and gravel, and 6 are completed in bedrock. Groundwater in the Chemung River Basin was generally of good quality, although properties and concentrations of some constituents—sodium, arsenic, aluminum, iron, manganese, radon-222, total coliform bacteria, and *Escherichia coli* bacteria—equaled or exceeded primary, secondary, or proposed drinking-water standards. The constituent most frequently detected in concentrations exceeding drinking-water standards (six of eight samples) was radon-222.

The Eastern Lake Ontario Basin study area covers 3,225 square miles in north-central New York. The Eastern Lake Ontario Basin (between the Oswego River Basin and the St. Lawrence River Basin) includes the Mid-Northern Lake Ontario Basin, the Black River Basin, and the Chaumont River-Perch River Basin. Five of the wells sampled in the Eastern Lake Ontario Basin are completed in sand and gravel, and 10 are completed in bedrock. Groundwater in the Eastern Lake Ontario Basin was generally of good quality, although properties and concentrations of some constituents—color, pH, sodium, dissolved solids, fluoride, iron, manganese, uranium, gross-α radioactivity, radon-222, total coliform bacteria, and fecal coliform bacteria—equaled or exceeded primary, secondary, or proposed drinking-water standards. The constituent most frequently detected in concentrations exceeding drinking-water standards (10 of 15 samples) was radon-222.

The Lower Hudson River Basin study area covers 5,607 square miles and encompasses the part of the Lower Hudson River Basin that lies within New York plus the parts of the Housatonic, Hackensack, Bronx, and Saugatuck River Basins that are in New York. Twelve of the wells sampled in the Lower Hudson River Basin are completed in sand-and-gravel deposits, and 13 are completed in bedrock. Groundwater in the Lower Hudson River Basin was generally of good quality, although properties and concentrations of some constituents—pH, sodium, chloride, dissolved solids, arsenic, aluminum, iron, manganese, radon-222, total coliform bacteria, fecal coliform bacteria, *Escherichia coli* bacteria, and heterotrophic plate count—equaled or exceeded primary, secondary, or proposed drinking-water standards. The constituent most frequently detected in concentrations exceeding drinking-water standards (20 of 25 samples) was radon-222.

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. This program also 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 (upstate is New York

State north of New York City) since then (table 1); sampling completed in 2008 represents the conclusion of a first round of groundwater-quality sampling throughout New York State (excluding Long Island and New York City). Groundwater-quality sampling was conducted in 2013 in the Chemung River Basin, the Eastern Lake Ontario Basin, and the Lower Hudson River Basin.

Objective and Approach

The objective of the groundwater-quality monitoring program is to quantify and report on ambient groundwater quality in 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 the 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 that characterizes naturally occurring and background conditions and to identify long-term trends. The data are made available on-line 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 Chemung River Basin in 2003, 2008, and 2013, and in the Eastern Lake Ontario Basin and Lower Hudson River Basin in 2008 and 2013. In 2013, during the months of June, July, and August, 8 environmental samples and 2 quality-assurance

Table 1. Previous groundwater-quality studies and reports.

[**Bold** report listing indicates the previous groundwater-quality studies in the Chemung River Basin, the Eastern Lake Ontario Basin, and the Lower 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
Western New York	2011	Open-File Report 2013–1095	Reddy, 2013
Central New York	2012	Open-File Report 2014–1226	Reddy, 2014
Upper Hudson River Basin	2012	Open-File Report 2014–1084	Scott and Nystrom, 2014

samples were collected in the Chemung River Basin. Fifteen environmental samples and 1 quality-assurance sample were collected in the Eastern Lake Ontario Basin, and 25 environmental samples and 2 quality-assurance samples were collected in the Lower Hudson River Basin. One of the Chemung River Basin wells sampled in 2013 was also sampled as part of this cycle of studies in 2008 (Risen and Reddy, 2011a). Three of the Eastern Lake Ontario Basin wells were also sampled as part of this cycle of studies in 2008 (Risen and Reddy, 2011b). Six of the Lower Hudson River Basin wells sampled in 2013 were also sampled as part of this cycle of studies in 2008 (Nystrom, 2010).

Purpose and Scope

This report presents the findings of the 2013 groundwater-quality study in the Chemung River Basin, Eastern Lake Ontario Basin, and Lower Hudson River Basin. Eight samples from the Chemung River Basin, 15 samples from the Eastern Lake Ontario Basin, and 25 samples from the Lower Hudson River Basin were collected during June, July, and August 2013. The report (1) describes the hydrogeologic setting, wells that were sampled, and the methods of site selection, sample collection, and chemical analysis; (2) presents discussions of the analytical results; (3) presents comparisons of analytical results to drinking-water-quality guidelines, and (4) presents comparisons of the results of this study with results for selected wells in the study areas that were sampled in 2008 (Risen and Reddy, 2011a and 2011b; Nystrom, 2010).

Hydrogeologic Setting

The study areas discussed in this report cover almost 10,000 square miles (mi^2), or 18 percent of New York State, and represent a wide range of geologic, hydrologic, and topographic settings, and land uses. Bedrock geology ranges from fairly uniform sedimentary rock in the Chemung River Basin to complex mixtures of sedimentary and metamorphic rock in the Eastern Lake Ontario and Lower Hudson River Basins. Surficial material throughout all three study areas consists of glacially and alluvially derived deposits.

Chemung River Basin

The Chemung River Basin encompasses 2,570 mi^2 in New York and Pennsylvania and includes both the Chemung River Basin and the Tioga River Basin; the study area includes only the 1,744 mi^2 of the basin that lies within New York (fig. 1). The study area includes parts of seven counties including Livingston, Allegany, Ontario, Steuben, Yates, Schuyler, and Chemung Counties (fig. 1). Major tributaries to the Chemung River include the Cohocton River, Mud Creek, Meads Creek, and Seeley Creek. Major tributaries to the Tioga River include the Canisteo River, Canacadea Creek, Bennetts Creek, and Tuscarora Creek. The Tioga River drains into the Chemung River, which then drains into the Susquehanna River in Pennsylvania south of Waverly, New York. The highest elevations in the Chemung River Basin study area are more than 2,000 feet (ft) above the North American Vertical Datum of 1988 (NAVD 88) in the southwestern part of the basin, south of Hornell (fig. 1). The lowest elevations are about 750 ft above NAVD 88 along the Chemung River at Waverly, New York. Precipitation in the Chemung River Basin study area varies minimally across the area from 32 to 36 inches per year (in/yr) (Randall, 1996). Urban centers in the Chemung River Basin study area include Waverly, Elmira, Corning, Bath, Cohocton, and Hornell. Land use in the basin is primarily forest and agriculture (pasture and crops). Pasture is concentrated in the uplands of the northern part of the study area; most cropland is located along the Cohocton River and its tributary valleys.

Bedrock in the Chemung River Basin study area consists of nearly flat-lying layers of sedimentary rock. Interbedded shales, siltstones, and fine-grained sandstones of Devonian age underlie almost all of the study area (fig. 2; Isachsen and others, 2000). Glacial till mantles the bedrock in the uplands. The valleys are filled with alluvium, outwash, lacustrine sediments, and ice-contact deposits, which can be up to 500 ft thick in the major valleys (Miller, 1982). Saturated sand-and-gravel deposits in the valley fill form unconfined and confined aquifers that supply water to the municipalities throughout the basin, including the cities of Elmira, Corning, and Bath (figs. 1 and 3).

Eastern Lake Ontario Basin

The Eastern Lake Ontario Basin study area encompasses 3,225 mi^2 and includes the area east of Lake Ontario between the Oswego River Basin and the St. Lawrence River Basin. This area includes the Black River, Chaumont River, and Perch River (fig. 4). The study area includes parts of six counties in north-central New York: Jefferson, Oswego, Lewis, Oneida, Herkimer, and Hamilton Counties (fig. 4). Major tributaries to the Black River include the Beaver River (including the Stillwater Reservoir), Otter Creek, Moose River (including Big Moose Lake and the Fulton Chain Lakes), Woodhull Creek (including Woodhull Lake), North Lake, and Kayuta Lake. Additional major tributaries to the Eastern Lake Ontario Basin include Sandy Creek, South Sandy Creek, and Salmon River (including the Salmon River Reservoir). The highest elevations in the Eastern Lake Ontario Basin study area are more than 3,000 ft above NAVD 88 in the Adirondack Uplands (fig. 4). The lowest elevations are about 250 ft above NAVD 88 along the shoreline of Lake Ontario. The climate is humid, and air temperature in the lowlands is moderated by Lake Ontario. The Tug Hill Uplands and the Adirondack Mountains receive substantially more precipitation than the Lake Ontario lowlands, primarily because of lake-effect snow in the winter months. Precipitation ranges from around an average of 42 in/yr in the western areas to about 48 in/yr in the

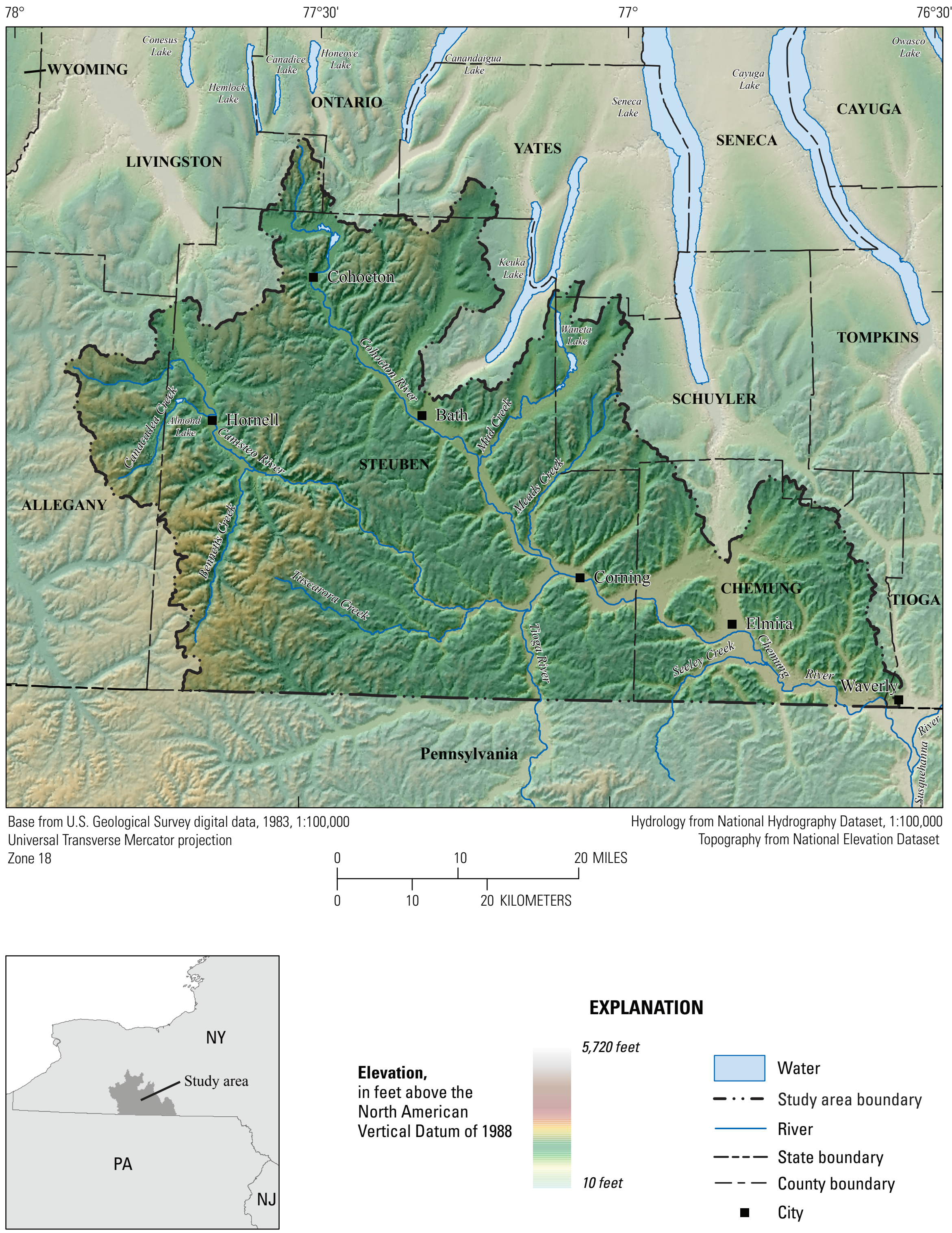

Figure 1. Topography and geography of the Chemung River Basin, New York.

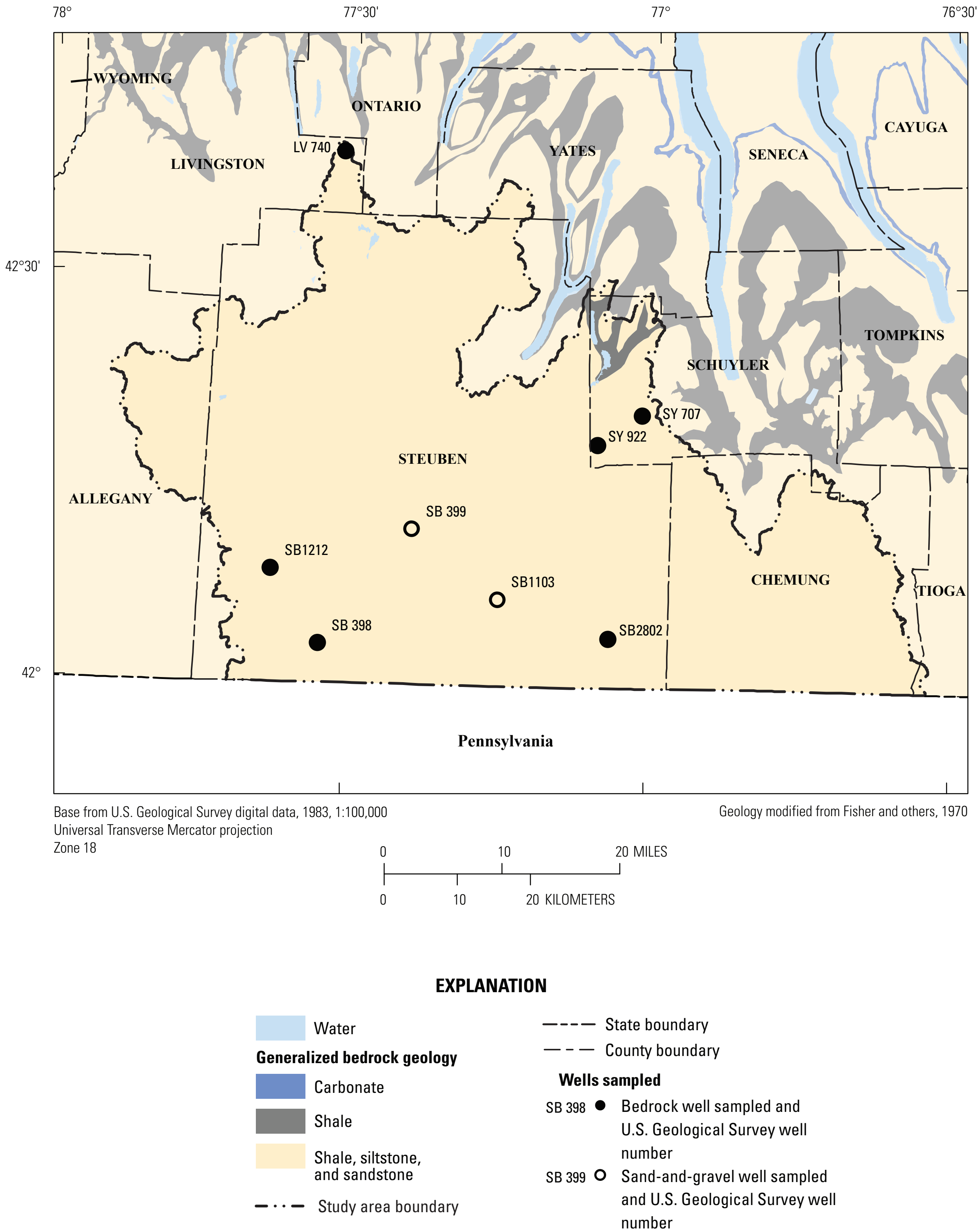

Figure 2. Generalized bedrock geology of the Chemung River Basin, New York, and locations of wells sampled in 2013.

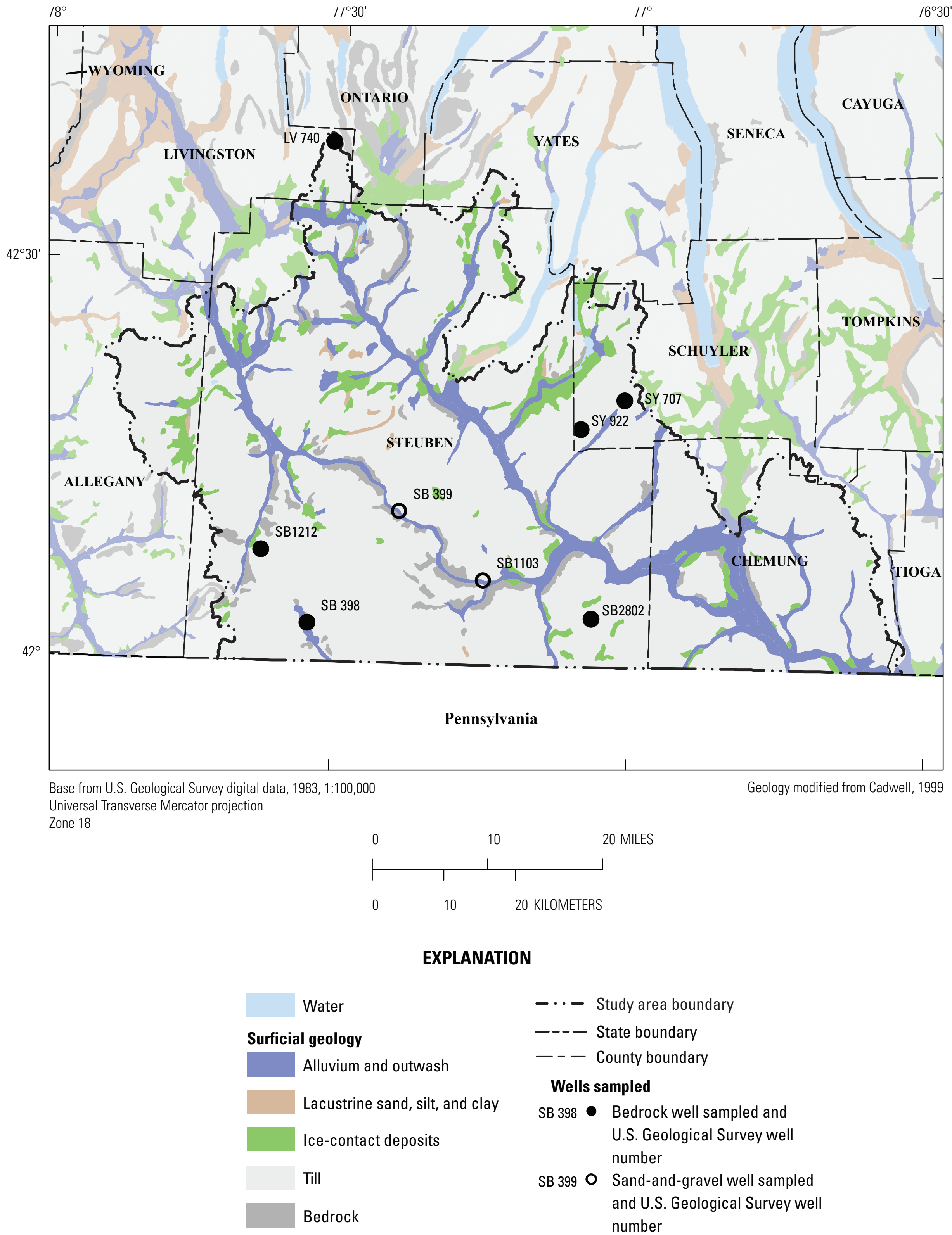

Figure 3. Generalized surficial geology of the Chemung River Basin, New York, and locations of wells sampled in 2013.

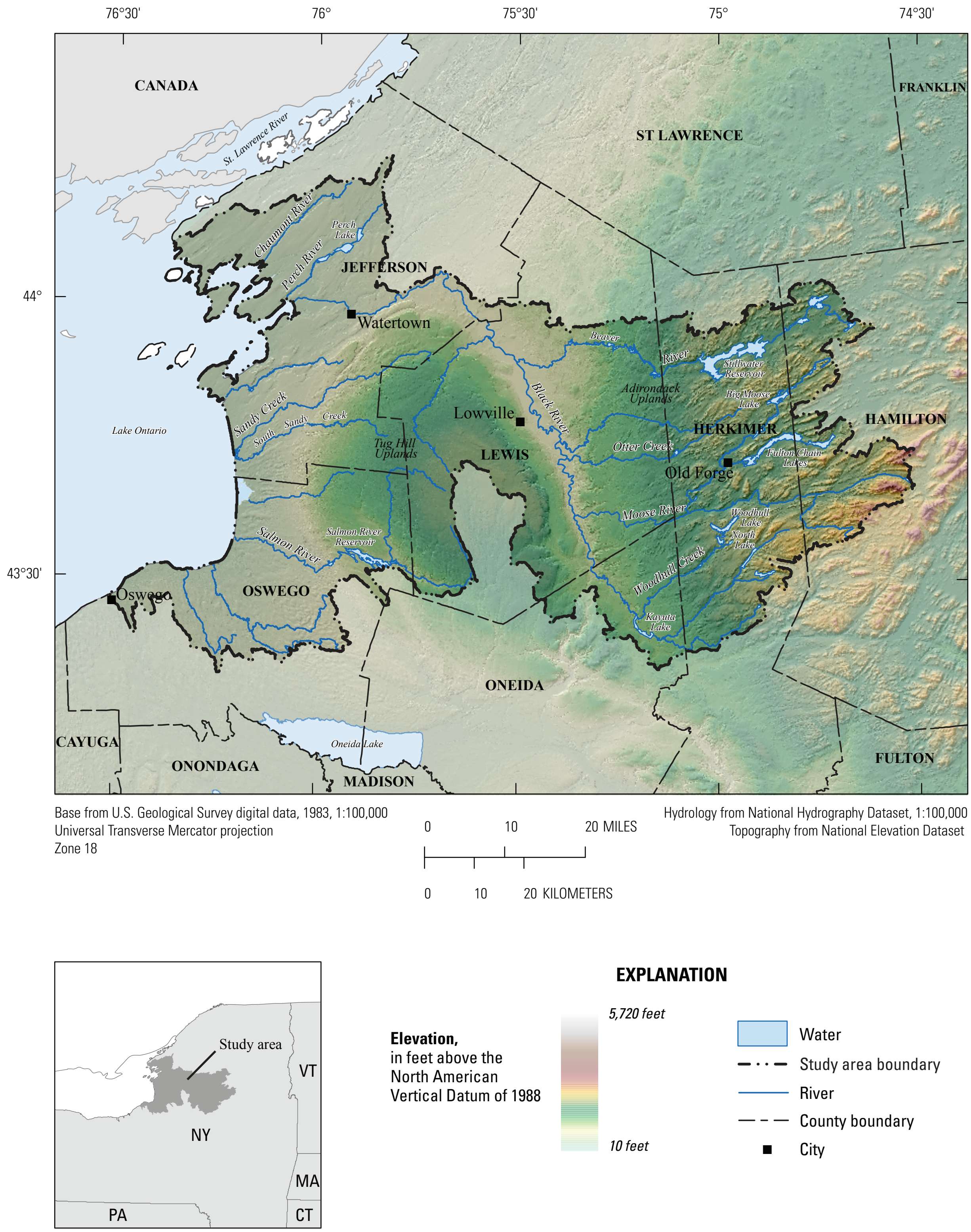

Figure 4. Topography and geography of the Eastern Lake Ontario Basin, New York.

central and eastern areas; the Tug Hill Uplands may receive up to 60 in/yr (Randall, 1996). About 30 percent of the annual precipitation infiltrates the land surface and recharges the sand-and-gravel and bedrock aquifers (Randall, 2001). Urban centers in the Eastern Lake Ontario Basin include Watertown, Oswego, Lowville, and Old Forge (fig. 4). The Watertown and Oswego metropolitan areas are in the western part of the study area. Forest and pasture dominate the lowland western parts of the study area where most of the population is located. The Tug Hill region is mostly undeveloped forest and wetland. The Adirondack Uplands area is predominantly steep gradient forest land and has numerous lakes.

Bedrock in the western and central parts of the Eastern Lake Ontario Basin study area (fig. 5) consists of gently dipping and interbedded shale, siltstone, sandstone, limestone, and dolostone of Ordovician and Silurian age (Broughton and others, 1962; Isachsen and others, 2000). A band of carbonate-rock aquifers—mostly limestone with some interbedded shale and dolostone—extends south-eastward from Watertown around the Tug Hill area to Forestport. The bedrock east of Oswego, including the Tug Hill Uplands, is mostly sandstone and siltstone. Bedrock in the Adirondack Uplands is a complex mixture of metamorphosed igneous and sedimentary rock. The surficial material throughout the Eastern Lake Ontario Basin study area consists of glacially derived deposits (fig. 6). A thin mantle of till on top of the bedrock in upland areas and morainal deposits of fine-grained, poorly sorted material formed valley plugs and low ridges (Cadwell, 1999). Meltwater streams deposited layers of stratified drift (fluvial sands and gravels) in front, on top, beneath, and alongside glaciers to form deposits. In some areas near Lake Ontario, sequences of beach sands were deposited along the shores of glacial lakes. These water-borne deposits of sand and gravel, where saturated with groundwater, now form important aquifers in the Lake Ontario Lowlands and in an area on the western side of the Adirondacks near Forestport. Glacial meltwaters also deposited fine-grained sediments in proglacial lakes resulting in limited permeability. The glacial deposits in the study area are described in detail by Fairchild (1928), Coates (1966), Waller and Ayer (1975), Miller (1982, 1988, 1990), Miller and others (1989), Zarriello (1993), Randall (2001), and Kontis and others (2004).

Lower Hudson River Basin

The Lower Hudson River Basin encompasses 5,313 mi^2 in New York, Massachusetts, Connecticut, and New Jersey, and is defined as that part of the Hudson River Basin that lies south of the Federal Lock and Dam at Troy, New York. This study area includes only the 5,001 mi^2 part of the Lower Hudson River Basin that lies within New York as well as 606 mi^2 of the Housatonic, Hackensack, Bronx, and Saugatuck River Basins that lie within New York along the southern and eastern borders of New York State (hereafter referred to as the “Lower Hudson River Basin study area,” fig. 7). The study area contains all or part of 16 counties, including all of Columbia, Dutchess, Putnam, Westchester, Bronx, New York, and Rockland Counties; much of Albany, Ulster, Orange, Greene, and Rensselaer Counties; and parts of Schenectady, Schoharie, Sullivan, and Delaware Counties (fig. 7). Major tributaries to the Lower Hudson River include the Wallkill River, Rondout Creek, Esopus Creek, Croton River, Catskill Creek, Kinderhook Creek, Normans Kill, Roeliff Jansen Kill, and Wappinger Creek. New York City maintains a system of reservoirs for drinking-water supply; several of these reservoirs are in the Delaware River Basin (not labeled, but west of the Lower Hudson River Basin, in fig. 7), but three are in the Lower Hudson River Basin, including the Ashokan Reservoir, Rondout Reservoir, and the Croton Reservoir system. Aqueducts bring water from these reservoirs to New York City for use. The highest elevations in the Lower Hudson River Basin study area are more than 4,000 ft above NAVD 88 along the western edge of the Hudson River Basin in the Catskill Mountains (fig. 7). The lowest elevations in the study area are along the Hudson River, which is tidal for more than 150 mi from its mouth at New York City to the Federal Lock and Dam at Troy, New York (fig. 7). The greatest precipitation in the study area is in the Catskill Mountains, where more than 60 in of precipitation can fall per year; the lowest amount of precipitation in the study area occurs along the Hudson Valley, where approximately 40 in. of precipitation falls per year (Randall, 1996). The largest urban center in the study area is New York City (fig. 7); other urban centers in the study area include Albany, Poughkeepsie, and Newburgh. Land use in the study area reflects these urban areas and the terrain of the land. The upland areas of the study area are predominantly forested (Vogelmann and others, 2001); urban development and agriculture occur mainly along the Hudson River Valley and other low-lying areas. Many fruit orchards are found in the Hudson River Valley, and numerous vegetable farms, especially onions, are present in the organic-rich “black dirt” region of Orange County.

Bedrock in the Lower Hudson River Basin (fig. 8) mainly consists of sedimentary and metamorphic clastic rock (Isachsen and others, 2000). The western part of the study area is underlain by shale and sandstone, with a band of carbonate rock running from north to south. The southeastern part of the study area is predominantly underlain by crystalline rock. The eastern part of the study area is underlain by a mix of clastic bedrock, including shale and graywacke, with some carbonate and crystalline rock. Yields of groundwater from bedrock wells in the study area vary greatly, but the carbonate units produce the highest average yields (Hammond and others, 1978). The surficial material throughout the Lower Hudson River Basin was deposited primarily during the Pleistocene epoch when the Wisconsinan glaciers covered most of the Northeast. Till was directly deposited by the glaciers and mantles bedrock in the uplands (fig. 9). Ice-contact and lacustrine sediments, outwash, and alluvium were deposited mainly in valleys during and following glacial retreat and form the most productive aquifers in the basin (Bugliosi and Trudell, 1988; Bugliosi and others, 1988).

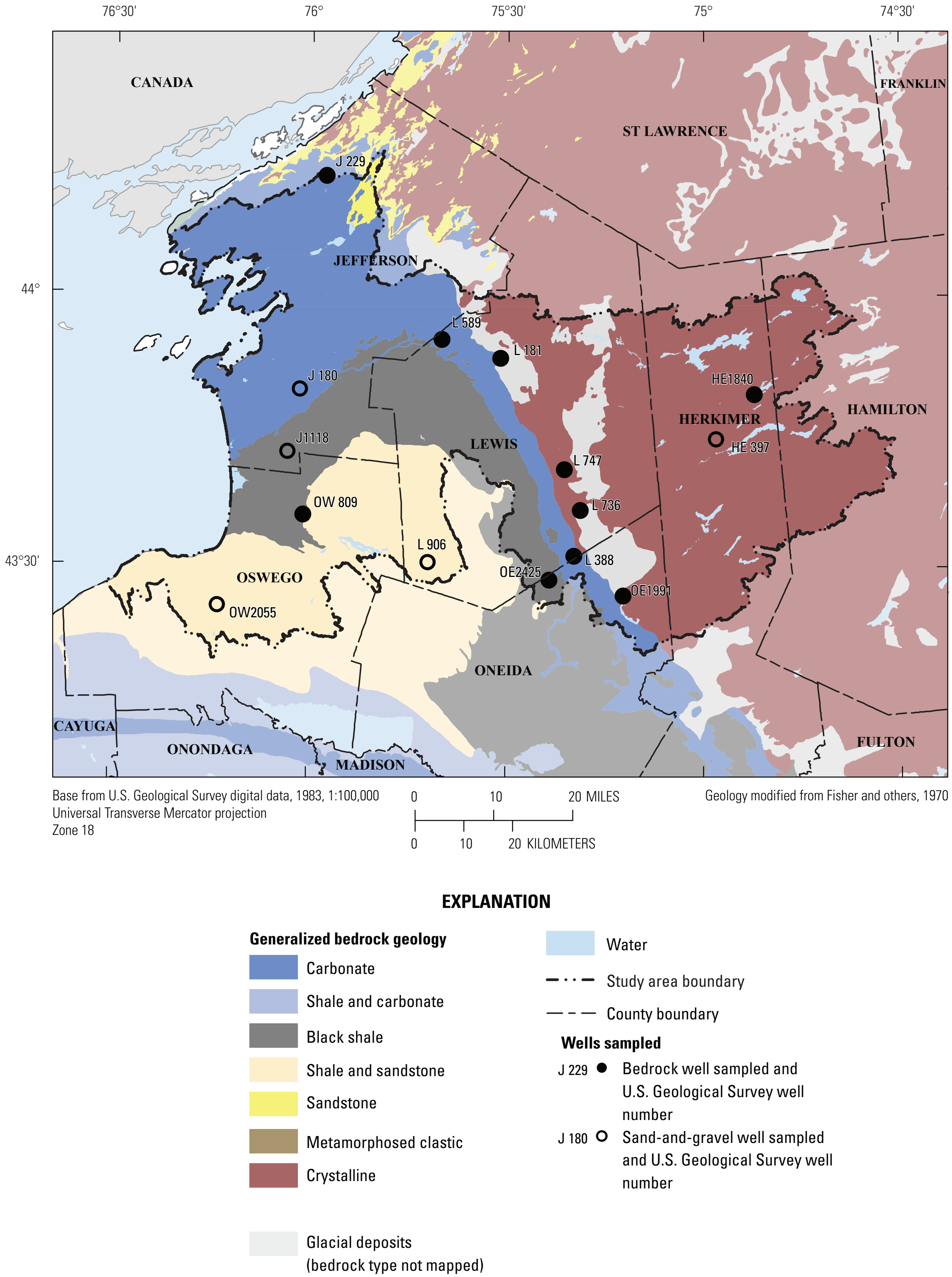

Figure 5. Generalized bedrock geology of the Eastern Lake Ontario Basin, New York, and locations of wells sampled in 2013.

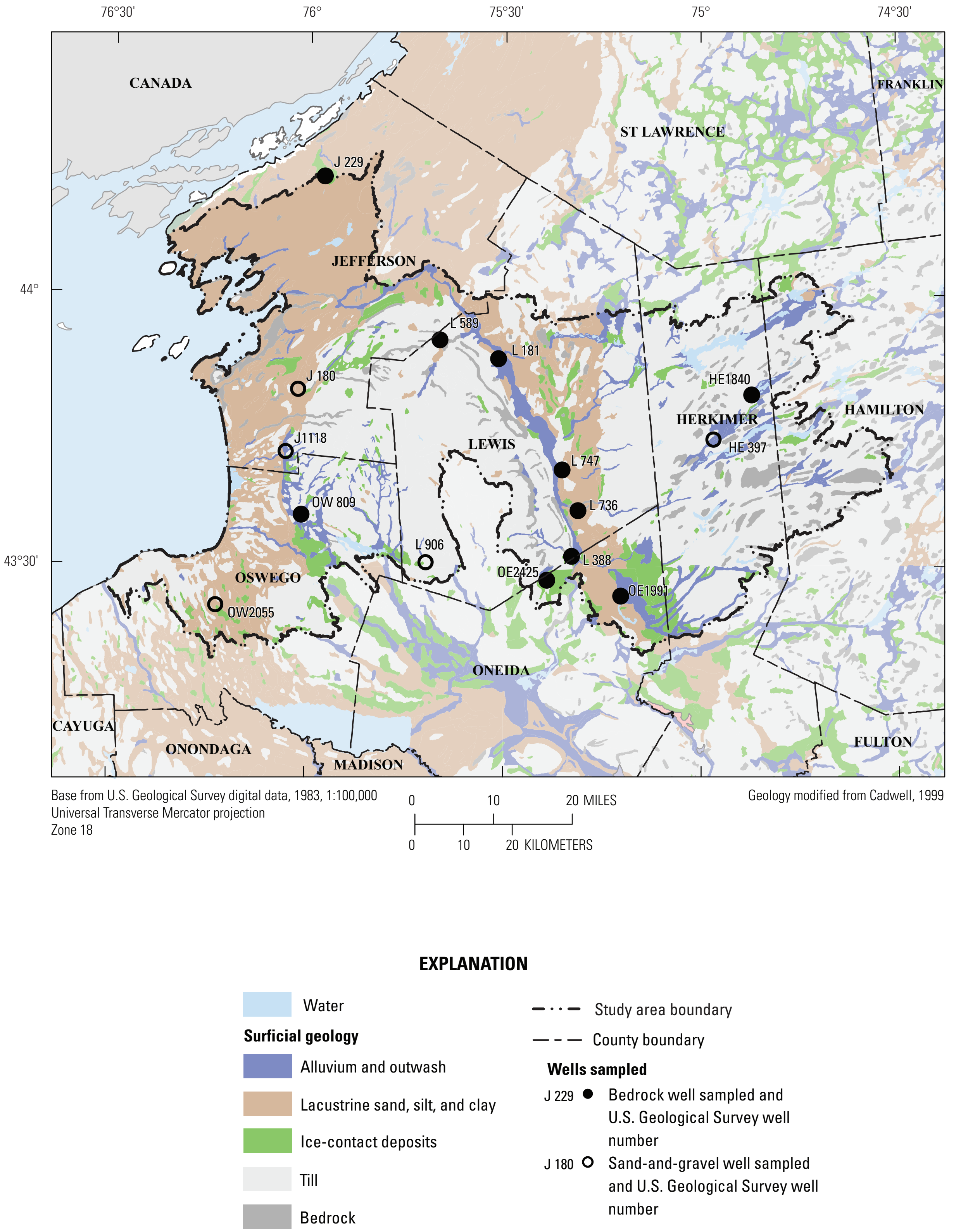

Figure 6. Generalized surficial geology of the Eastern Lake Ontario Basin, New York, and locations of wells sampled in 2013.

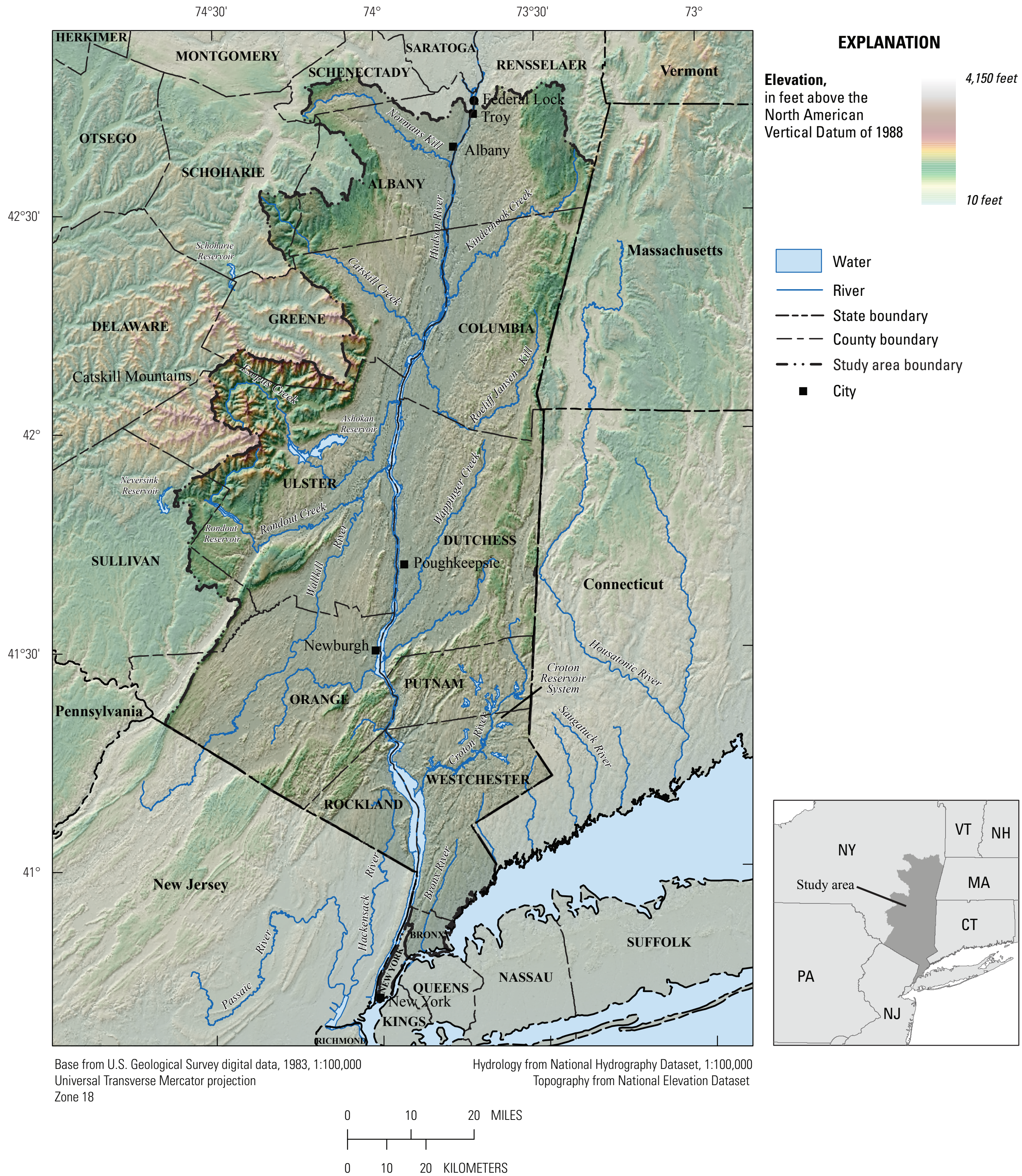

Figure 7. Topography and geography of the Lower Hudson River Basin, New York.

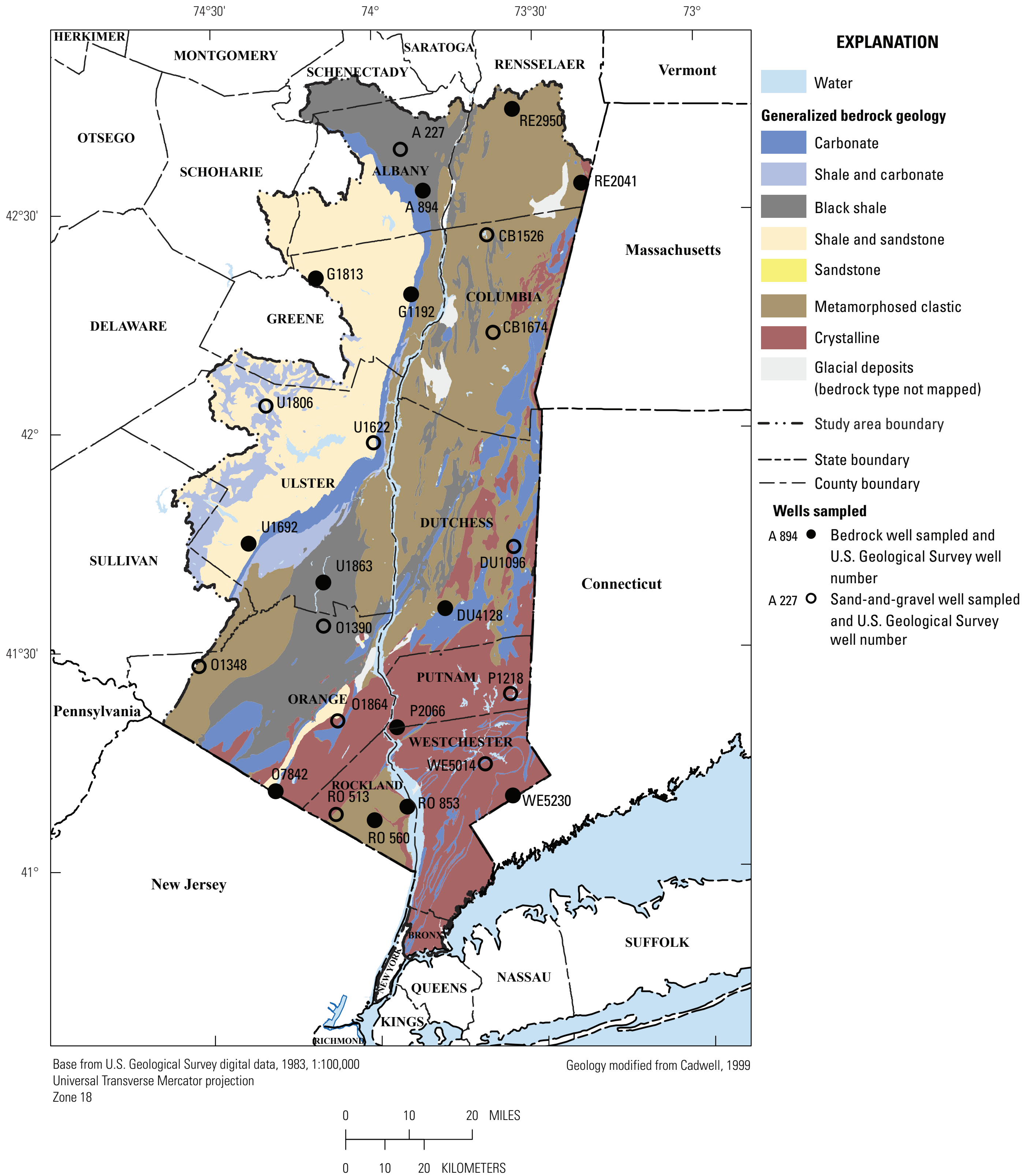

Figure 8. Generalized bedrock geology of the Lower Hudson River Basin, New York, and locations of wells sampled in 2013.

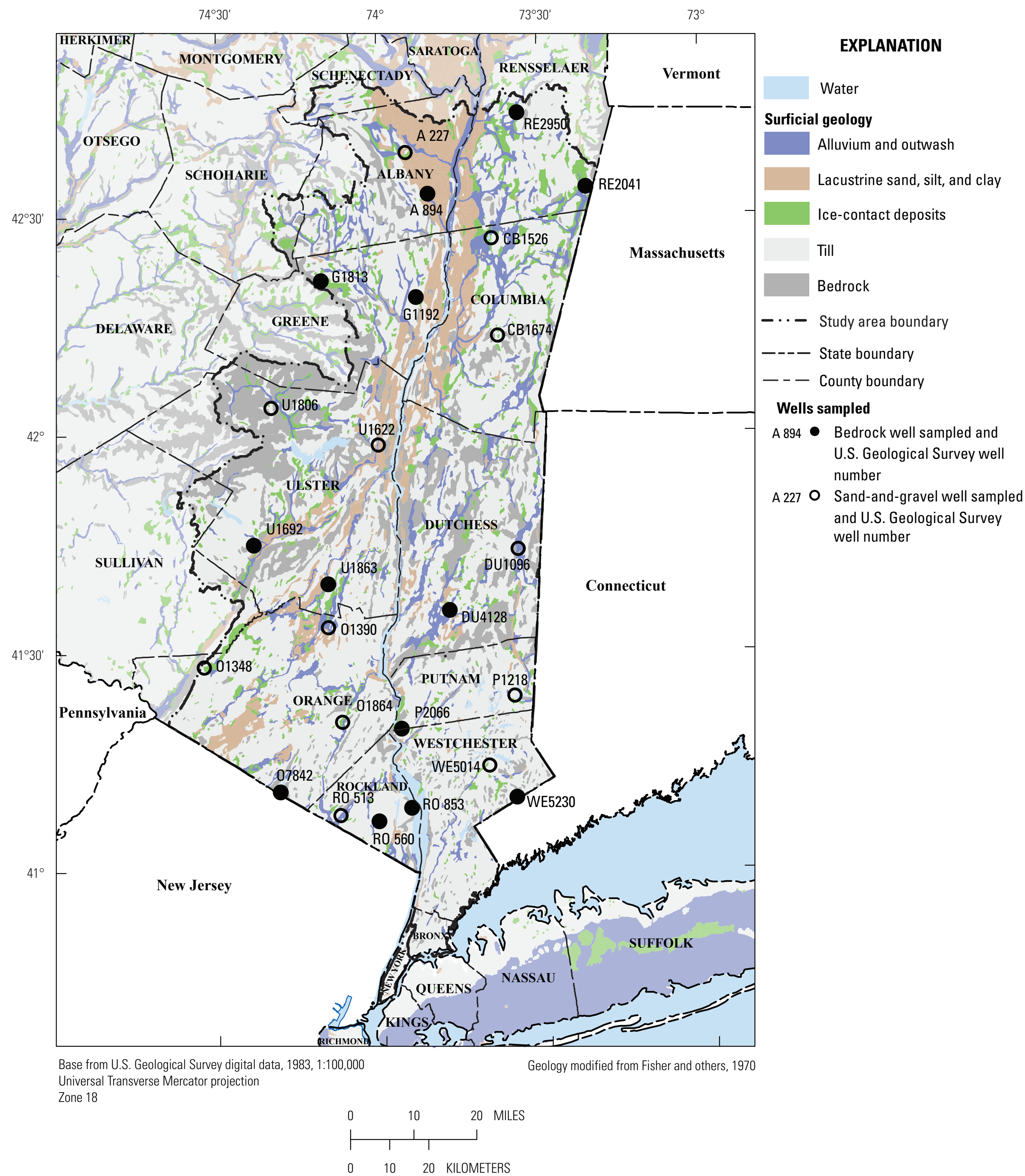

Figure 9. Generalized surficial geology of the Lower Hudson River Basin, New York, and locations of wells sampled in 2013.

Methods of Investigation

Well-selection criteria, sampling methods, and 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 published methods at the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado, and other laboratories.

Well Selection

The 48 wells selected for sampling (figs. 2, 3, 5, 6, 8 and 9) 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 New York State Department of Environmental Conservation (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 driller's log. Evaluation of well-completion report data identified several hundred wells as potential sampling sites; well owners were 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.

Production wells considered for sampling were identified through the U.S. Environmental Protection Agency (EPA) 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 evaluation of driller's logs and published geologic maps, including Fisher and others (1970) and Cadwell (1999).

The characteristics of the wells sampled, the USGS-assigned county well numbers of production and domestic wells, and the type of land cover surrounding each well are listed in table 2. The depths of the wells and the aquifer units from which samples were collected are summarized in table 3. One Chemung River Basin well sampled in 2013 (SB1103) was also sampled in 2008 (Risen and Reddy, 2011a). Three Eastern Lake Ontario Basin wells sampled in 2013 (J180, J1118, and OE1991) were also sampled in 2008 (Risen and Reddy, 2011b). Six Lower Hudson River Basin wells sampled in 2013 (CB1674, DU1096, P1218, RO560, RO853, and U1622) were also sampled in 2008 (Nystrom, 2010). Domestic wells that are completed in sand-and-gravel aquifers are generally finished with open-ended casing so that groundwater enters the well only through the end of the casing (thus, the casing depth and well depth for domestic sand-and-gravel wells listed in table 2 are the same). Production wells, however, are typically completed with a well screen to maximize the well yield; the difference between the casing depth and the well depth in table 2 is the approximate screened interval for these wells. In some cases, however, smaller yielding production wells are completed open-ended in sand-and-gravel aquifers with no screen (HE 397, OW2055). Bedrock wells, both domestic and production, are completed with a surface casing cemented several feet into competent bedrock, and the balance of the well is completed as an open hole in bedrock. In bedrock wells, groundwater moves mainly through joints and fractures in the rock towards the wellbore under pumping conditions.

Sampling Methods

Water-quality samples were collected and processed in accordance with documented USGS protocols. The samples were collected before any water-treatment system to be representative of the native aquifer water. 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.

Samples were collected from garden-hose spigots at all sites where possible. Domestic wells were purged by pumping groundwater to waste for at least 20 minutes at pumping rates ranging from about 2 to 5 gallons per minute (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. Field measurements of water temperature, pH, specific conductance, and dissolved oxygen concentration were recorded at the site using portable instruments (U.S. Geological Survey, variously dated).

The flow rate for sample collection was adjusted to less than 0.5 gal/min when possible. The sampling tube was then connected to a sample-collection chamber constructed of a polyvinyl chloride frame and a clear plastic chamber bag, the purpose of which is to minimize the possibility of any airborne contaminants getting into the water samples. The tubing and spigot-attachment equipment for each sample were pre-cleaned (U.S. Geological Survey, 2006).

Table 2. Description of wells from which water samples were collected in New York, 2013.

[--, 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 (Chemung River Basin), figures 5 and 6 (Eastern Lake Ontario Basin), and figures 8 and 9 (Lower Hudson River Basin). ID, identification]

Well number[1]	Station ID number	Date sampled (mm/dd/yyyy)	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
Chemung River Basin											
Sand-and-gravel wells											
SB 399	421130077233601	07/10/2013	80	--	P	--	5	66	24	3	2
SB1103	420630077145001	06/27/2013	76	63	P	--	13	53	29	4	1
Bedrock wells											
LV 740	423913077311101	07/23/2013	80	--	D	Clastic (shale)	3	91	4		2
SB 398	420247077323901	06/26/2013	105	41	P	Clastic (shale and sandstone)	9	48	43		
SB1212	420814077373001	07/11/2013	204	89	D	Clastic (shale)	2	83	15		
SB2802	420340077035001	08/06/2013	178	152	D	Clastic (shale)	3	43	5	3	1
SY 707	422017077005801	07/09/2013	80	55	P	Clastic (shale and sandstone)	3	88			9
SY 922	421800077051901	07/25/2013	70	20	D	Clastic (shale)	2	94	1		3
Eastern Lake Ontario Basin											
Sand-and-gravel wells											
HE 397	434414074580201	08/07/2013	236.3	236.3	P	--		47		11	42
J 180	434840076014001	08/27/2013	20	24	P	--	32	27	11		3
J1118	434239076032202	08/27/2013	30	22	P	--	1	25	56	1	8
L 906	433050075423501	08/08/2013	59	59	D	--	1	91	2		6
OW2055	432536076134601	08/27/2013	42	42	P	--	2	63	9		26
Bedrock wells											
HE1840	434904074521901	08/21/2013	340	19	D	Crystalline	5	37		36	22
J 229	441256075575501	08/26/2013	450	--	P	Carbonate	1	84	1		5
L 181	435303075305901	08/15/2013	210	--	P	Carbonate	11	26	52		11
L 388	433114075194101	07/29/2013	196	21	D	Carbonate	7	48	34	4	7
L 589	435313075402301	08/15/2013	275	33	P	Carbonate	3	37	57		3
L 736	433616075184601	07/29/2013	160	23	D	Crystalline		96	1		3
L 747	434048075211301	08/22/2013	165	58	D	Carbonate	2	67	17	2	12
OE1991	432652075121601	08/14/2013	700	63	P	Crystalline	6	8	5		9
OE2425	432836075232701	07/31/2013	184	18	D	Clastic (black shale)		63	34		3
OW 809	433539076005201	08/28/2013	62	20	D	Clastic (shale and sandstone)	1	64	29		6

Table 2. Description of wells from which water samples were collected in New York, 2013.—Continued

[--, 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 (Chemung River Basin), figures 5 and 6 (Eastern Lake Ontario Basin), and figures 8 and 9 (Lower Hudson River Basin). ID, identification]

Well number[1]	Station ID number	Date sampled (mm/dd/yyyy)	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
Lower Hudson River Basin											
Sand-and-gravel wells											
A 227	423855073544601	07/10/2013	80	64	P	--	37	26	13		24
CB1526	422660073385401	07/08/2013	40	38	D	--	25	27	1	38	
CB1674	421338073380901	07/25/2013	58	43	P	--	27	65	2		6
DU1096	414411073345302	07/25/2013	50	--	P	--	28	49	22		1
O1348	412824074321901	07/23/2013	70	35	P	--	33	56	2		9
O1390	413340074111801	07/15/2013	40	32	P	--	18	13	41		28
O1864	412039074072001	07/18/2013	134	--	P	--	49	26			25
P1218	412410073360105	07/30/2013	50	--	P	--	55	37		2	6
RO 513	410744074074901	08/01/2013	93	72	P	--	49	36			15
U1622	415846074002401	07/22/2013	62	50	P	--	52	21	2	4	21
U1806	420351074200001	07/22/2013	165	163	D	--	6	92	1		1
WE5014	411410073420301	07/30/2013	71.5	54	P	--	67	3	2		
Bedrock wells											
A 894	423308073503801	07/09/2013	522	357	D	Clastic (shale)	4	18	21		21
DU4128	413551073473601	07/16/2013	205	72	D	Carbonate and clastic (shale)	36	41	22	1	
G1192	421857073530301	07/11/2013	220	72.5	D	Carbonate	17	57	1	4	12
G1813	422118074103801	07/09/2013	285	48	D	Clastic (sandstone and shale)	2	84	13		1
O7842	411102074184901	07/18/2013	300	--	D	Crystalline	16	53		28	3
P2066	411940073564401	07/24/2013	205	32	D	Crystalline	6	93	1		1
RE2041	423355073211301	07/08/2013	462	40	D	Carbonate	3	77	18		2
RE2950	424409073334801	07/10/2013	220	42	D	Clastic (shale)	11	36	51		2
RO 560	410654074005401	08/01/2013	363	65	P	Clastic (sandstone)	89	5			6
RO 853	410840073545201	07/24/2013	575	80	D	Crystalline	21	4	7	28	5
U1692	414438074221701	07/15/2013	300	40	P	Clastic (sandstone)	5	85	3	1	6
U1863	413934074094701	07/16/2013	100	50	D	Clastic (shale)	3	25	57	4	11
WE5230	411008073354401	07/17/2013	455	--	D	Carbonate	3	59	2	1	8

[1]Prefix denotes county: A, Albany; CB, Columbia; DU, Dutchess; G, Greene; HE, Herkimer; J, Jefferson; L, Lewis; LV, Livingston; O, Orange; OE, Oneida; OW, Oswego; P, Putnam; RE, Rensselaer; RO, Rockland; SB, Steuben; SY, Schuyler; U, Ulster; WE, Westchester. Number is local well-identification number assigned by U.S. Geological Survey.

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

Table 3. Summary of 48 wells in New York with water samples collected in 2013.

[bls, below land surface]

Basin and type of well	Number of wells		
	Production	Domestic	Total
Chemung River Basin			
Wells completed in sand and gravel (depth 76 to 80 feet bls)	2	0	**2**
Wells completed in bedrock (depth 70 to 204 feet bls)	2	4	**6**
All well types	4	4	**8**
Eastern Lake Ontario Basin			
Wells completed in sand and gravel (depth 20 to 236.3 feet bls)	4	1	**5**
Wells completed in bedrock (depth 62 to 700 feet bls)	4	6	**10**
All well types	8	7	**15**
Lower Hudson River Basin			
Wells completed in sand and gravel (depth 40 to 165 feet bls)	10	2	**12**
Wells completed in bedrock (depth 100 to 575 feet bls)	2	11	**13**
All well types	12	13	**25**
ALL BASINS	**24**	**24**	**48**

Samples were collected and preserved in the sampling chamber according to standard USGS procedures (U.S. Geological Survey, 2006). 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 on the day of sample collection and stored on ice until use in the field. 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 ultra-pure hydrochloric acid. Hydrochloric acid was added to samples analyzed for volatile organic compounds (VOCs) to reduce the sample pH below 2.0 and kill bacteria that might degrade VOCs. Samples for major-cation analysis 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. Water samples for radon analysis were collected through a septum chamber with a glass syringe, according to standard USGS procedures (U.S. Geological Survey, 2006). Bottles containing 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. Samples for bacterial analysis were collected in accordance with NYSDEC and NYSDOH protocols (American Public Health Association, 1998), except that the tap from which each water sample was collected was not flame sterilized. Water samples for bacterial analysis were collected in sterilized bottles provided by the NYSDOH-certified 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.

Analytical Methods

Samples were measured for 148 physiochemical properties and constituents, including dissolved gases, major ions, nutrients, trace elements, pesticides, pesticide degradates, VOCs, radionuclides, and bacteria. 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, Colorado. Selected dissolved gases were analyzed at the USGS Chlorofluorocarbon Laboratory (CFCL) in Reston, Virginia. Gross-α and gross-β radioactivities were analyzed at Eberline Services in Richmond, California. Samples were analyzed for indicator bacteria at one of the following NYSDOH-certified laboratories: Community Science Institute in Ithaca, New York, analyzed Chemung River Basin samples; Converse Laboratories in Watertown, New York, analyzed Eastern Lake Ontario Basin samples; and St. Peter's Bender Laboratory in Albany, New York, analyzed Lower Hudson River Basin samples.

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). Color was determined by visual comparison using method I-1250-85 (Fishman 1989). 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 5310B (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 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-α and gross-β radioactivities were measured through gas flow proportional counting according to EPA 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 using gas chromatography with thermal conductivity detection (Busenberg and others, 1998). Indicator bacteria samples were tested for total coliform, fecal coliform, and *Escherichia coli (E. coli)* using membrane filtration and Standard Method 9222; a heterotrophic plate count test (SM 9215 B) also was done (American Public Health Association, 1998).

Quality-Control Samples

In addition to the 48 groundwater samples, 2 field blank samples and 2 replicate samples were collected for quality assurance. In one field blank, collected in the Lower Hudson River Basin, no constituents were detected at greater than the laboratory reporting levels (LRLs). In a second field blank, collected in the Chemung River Basin, three constituents exceeded LRLs. Silica was measured at 0.159 milligrams per liter (mg/L) (LRL for silica is 0.036 mg/L). The minimum silica concentration detected in the environmental samples was 3.26 mg/L. Ammonia plus organic nitrogen was measured at 0.29 mg/L as nitrogen (N) (LRL for ammonia plus organic nitrogen as N is 0.14 mg/L). Ten environmental samples had ammonia plus organic nitrogen detections less than 0.29 mg/L as N. These 10 samples were given “V” remark codes in associated tables and discussion within the text. “V” remark codes indicate that a value may be affected by contamination; the analyte was detected in environmental samples and the associated blanks. Toluene was measured at 0.4 micrograms per liter (µg/L) (LRL for toluene is 0.1 µg/L). Two environmental samples had toluene detections. Both of these detections were given “V” remark codes in associated tables and discussion within the text. The variability between replicate samples was less than 20 percent for all constituents with the exception of iron (in filtered water), nickel, molybdenum, color, and low level gross-β activity. No 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 “E” for 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 EPA (U.S. Environmental Protection Agency, 2009b) or NYSDOH (New York State Department of Health, 2011) (table 4), or proposed alternative MCLs set by the EPA (U.S. Environmental Protection Agency, 1999). 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 non-enforceable drinking-water standards that typically relate to aesthetic concerns such as taste, odor, or staining of plumbing fixtures. Well owners were notified promptly if any constituent exceeded EPA or NYSDOH MCLs. Copies of the complete analytical results were mailed to each well owner.

The results of analyses of the 48 groundwater samples collected in the Chemung River Basin, Eastern Lake Ontario Basin, and Lower Hudson River Basin during June, July, and August 2013 are presented in appendices 1–1 through 1–9. Of the 148 constituents and physiochemical properties analyzed for, 67 were not detected at levels greater than the LRLs (appendix 1–1). Results for the remaining 81 constituents and properties that were detected in the Chemung Basin, Eastern Lake Ontario Basin, and Lower Hudson River Basin are presented in appendices 1–2 through 1–9.

Table 4. Constituents that exceeded primary and (or) secondary drinking-water standards in groundwater samples collected in New York, 2013.

[Well types: P, production; D, domestic; --, not applicable; pAMCL, proposed alternative maximum contaminant level; pMCL, proposed maximum contaminant level; f, in filtered water; u, in unfiltered water. Well locations are shown in figures 2 and 3 (Chemung River Basin), figures 5 and 6 (Eastern Lake Ontario Basin), and figures 8 and 9 (Lower Hudson River Basin)]

Well number[1]	Well type	Bedrock type	Constituents that exceeded drinking-water standards
			Chemung River Basin
			Sand-and-gravel wells
SB 399	P	--	Iron (f, u)[3,4], manganese (f, u)[3,4], radon[7] (pAMCL)
SB1103	P	--	Iron (f, u)[3,4], manganese (f, u)[4], radon[7] (pAMCL)
			Bedrock wells
LV 740	D	Clastic (shale)	Radon[7] (pAMCL)
SB 398	P	Clastic (shale and sandstone)	Radon[7] (pAMCL)
SB1212	D	Clastic (shale)	Manganese (f, u)[3,4], radon[7] (pAMCL)
SB2802	D	Clastic (shale)	Aluminum[4], iron (f, u)[3,4], manganese (f, u)[3,4], radon[7] (pAMCL)
SY 707	P	Clastic (shale and sandstone)	Manganese (f,u)[4]
SY 922	D	Clastic (shale)	Sodium[5], manganese (f, u)[4], *E. Coli*[2,3,*], total coliform[2,3,*]
			Eastern Lake Ontario Basin
			Sand-and-gravel wells
HE 397	P	--	Radon[7] (pAMCL)
J 180	P	--	Radon[7] (pAMCL)
J1118	P	--	Radon[7] (pAMCL), fecal coliform[2,3,*], total coliform[2,3,*]
L 906	D	--	Iron (u)[3,4]
OW2055	P	--	Radon7 (pAMCL)
			Bedrock wells
HE1840	D	Crystalline	Color[4], pH[4], iron (f, u)[3,4], manganese (f, u)[3,4], uranium[2,3], gross-α radioactivity[2,3], radon[7] (pMCL), total coliform[2,3,*]
J 229	P	Carbonate	Iron (u)[3,4], total coliform[2,3,*]
L 181	P	Carbonate	Fluoride[2], radon[7] (pAMCL)
L 388	D	Carbonate	pH[4], sodium[4]
L 589	P	Carbonate	--
L 736	D	Crystalline	pH[4], radon[7] (pAMCL)
L 747	D	Carbonate	Sodium[4], chloride[2,3], dissolved solids[4], iron (u)[3,4], radon[7] (pAMCL)
OE1991	P	Crystalline	Radon[7] (pAMCL)
OE2425	D	Clastic (black shale)	Iron (f, u)[3,4], manganese (f, u)[4]
OW 809	D	Clastic (shale and sandstone)	Radon[7] (pAMCL)

Table 4. Constituents that exceeded primary and (or) secondary drinking-water standards in groundwater samples collected in New York, 2013.—Continued

[Well types: P, production; D, domestic; --, not applicable; pAMCL, proposed alternative maximum contaminant level; pMCL, proposed maximum contaminant level; f, in filtered water; u, in unfiltered water. Well locations are shown in figures 2 and 3 (Chemung River Basin), figures 5 and 6 (Eastern Lake Ontario Basin), and figures 8 and 9 (Lower Hudson River Basin)]

Well number[1]	Well type	Bedrock type	Constituents that exceeded drinking-water standards
Lower Hudson River Basin			
Sand-and-gravel wells			
A 227	P	--	Manganese[4] (f,u)
CB1526	D	--	Radon[7] (pAMCL)
CB1674	P	--	Radon[7] (pAMCL)
DU1096	P	--	Radon[7] (pAMCL)
O1348	P	--	pH4, radon[7] (pAMCL)
O1390	P	--	Radon[7] (pAMCL)
O1864	P	--	Radon[7] (pAMCL)
P1218	P	--	Sodium[5], manganese (f, u)[4], radon[7] (pAMCL)
RO 513	P	--	Radon[7] (pAMCL)
U1622	P	--	Iron (f, u)[3,4], manganese (f, u)[3,4], total coliform[2,3,*]
U1806	D	--	Radon[7] (pAMCL)
WE5014	P	--	Radon[7] (pAMCL)
Bedrock wells			
A 894	D	Clastic (shale)	Methane[6], sodium[5], aluminum[4], iron (u)[3,4]
DU4128	D	Carbonate and clastic (shale)	Radon[7] (pAMCL)
G1192	D	Carbonate	Methane[6], sodium[5], *E. coli*[2,3], fecal coliform[2,3], heterotrophic plate count[2], total coliform[2,3,*]
G1813	D	Clastic (sandstone and shale)	Radon[7] (pAMCL)
O7842	D	Crystalline	Color[4], iron (u)[3,4], manganese (u)[3,4], radon[7] (pAMCL), *Echerichia coli*[2,3,*], fecal coliform[2,3,*], total coliform[2,3,*]
P2066	D	Crystalline	pH[4], radon[7] (pMCL)
RE2041	D	Carbonate	Radon[7] (pAMCL)
RE2950	D	Clastic (shale)	Radon[7] (pAMCL)
RO 560	P	Clastic (sandstone)	Radon[7] (pAMCL)
RO 853	D	Crystalline	pH[4], radon[7] (pAMCL)
U1692	P	Clastic (sandstone)	pH[4], radon[7] (pAMCL)
U1863	D	Clastic (shale)	Iron (f, u)[3,4], manganese (f, u)[4]
WE5230	D	Carbonate	pH[4], iron (f, u)[3,4], manganese (f, u)[3,4], radon[7] (pAMCL)

[1]Prefix denotes county: A, Albany; CB, Columbia; DU, Dutchess; G, Greene; HE, Herkimer; J, Jefferson; L, Lewis; LV, Livingston; O, Orange; OE, Oneida; OW, Oswego; P, Putnam; RE, Rensselaer; RO, Rockland; SB, Steuben; SY, Schuyler; U, Ulster; WE, Westchester. Number is local well-identification number assigned by U.S. Geological Survey.

[2]U.S. Environmental Protection Agency (2009b) Maximum Contaminant Level.

[3]New York State Department of Health (2011) Maximum Contaminant Level.

[4]U.S. Environmental Protection Agency (2009b) Secondary Drinking Water Standard.

[5]U.S. Environmental Protection Agency (2009b) Drinking Water Advisory Taste Threshold.

[6]Methane concentration above recommended monitoring concentration (Eltschlager and others, 2001).

[7]U.S. Environmental Protection Agency (1999) proposed maximum contaminant level of 300 picocuries per liter for areas that do not implement an indoor-air radon mitigation program.

[*]Maximum Contaminant Level exceedances for bacteria in public drinking-water supplies are generally defined in terms of a certain number of positive samples per month on the basis of the number of samples collected.

Physiochemical Properties

Groundwater-quality samples were analyzed in the field for physiochemical properties, including water temperature, pH, specific conductivity, and dissolved oxygen. Samples were collected for analysis of color. Qualitative assessment of the presence of hydrogen sulfide was noted. Results of analyses are reported in table 5 and in appendix 1–2. The number of samples that exceeded drinking-water standards for physiochemical properties are reported in table 6. No drinking-water standards exist for specific conductivity, water temperature, and dissolved oxygen.

Most samples from the Chemung River Basin had a color of less than (<) 1 platinum-cobalt (Pt-Co) unit (table 5 and appendix 1–2), but two samples from sand-and-gravel wells (SB 399, SB1103) had color of 10 and 5 Pt-Co units, respectively. Sample pH was typically near neutral (median of 7.4 for all Chemung River Basin wells) and ranged from 6.9 to 7.9. Specific conductance ranged from 105 to 510 microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C); the median specific conductance was 482 µS/cm at 25 °C. Water temperature ranged from 9.3 to 14.3°C; the median temperature was 11.1 °C. Hydrogen sulfide odor was detected in 3 samples—2 from sand-and-gravel wells (SB 399 and SB1103) and 1 from a bedrock well (SY 922).

Most samples from the Eastern Lake Ontario Basin had a color of <1 Pt-Co unit (table 5, appendix 1–2), but two samples from bedrock wells (HE1840 and OE2425) had colors of 18 and 5 Pt-Co units, respectively. The color of the sample from bedrock well HE1840 (18 Pt-Co units) exceeded the EPA SDWS of 15 Pt-Co units (table 6 and appendix 1–2). Sample pH was typically near neutral (median 7.2 for all Eastern Lake Ontario Basin wells) and ranged from 6.3 to 8.3. The pH values for samples from bedrock wells HE1840, L388, L736, and OW809 (6.3, 6.4, 6.4, and 6.3, respectively) were lower than the EPA SDWS range for pH. Specific conductance ranged from 67 to 2,150 µS/cm at 25 °C; the median specific conductance was 486 µS/cm at 25 °C. Water temperature ranged from 8.7 to 14.4 °C; the median temperature was 10.6 °C. Hydrogen sulfide odor was not detected in any Eastern Lake Ontario Basin sample.

Most samples from the Lower Hudson River Basin had a color of <1 platinum-cobalt (Pt-Co) unit (table 5 and appendix 1–2), but 1 sample from a sand-and-gravel well (A 227) had a color of 2 Pt-Co units and 3 samples from bedrock wells (G1192, O7842, WE5230) had color ranging from 5 to 35 Pt-Co units. The color of the sample from bedrock well O7842 (35) exceeded the EPA SDWS of 15 Pt-Co units (table 6 and appendix 1–2). Sample pH was typically near neutral (median 7.2 for all Lower Hudson River Basin wells) and ranged from 5.1 to 10.2. The pH of one sample from bedrock well RO 853 (10.2) was higher than the EPA SDWS range for pH (6.5 to 8.5). The pH values of the sample from sand-and-gravel well O1348 (5.1) and three samples from bedrock wells—P2066, U1692, and WE5230 (5.5, 5.8, and 6.3, respectively)—were lower than the EPA SDWS range for pH. Specific conductance ranged from 35 to 991 µS/cm at 25 °C; the median specific conductance was 457 µS/cm at 25 °C. Water temperature ranged from 10.0 to 15.5 °C; the median temperature was 12.1 °C. Hydrogen sulfide odor was detected in three samples—1 sand-and-gravel well (U1622) and 2 bedrock wells (G1192, U1863).

Dissolved Gases

Dissolved oxygen was measured in the field. Groundwater-quality samples were analyzed for dissolved gases, including argon, carbon dioxide, methane, and nitrogen. Results are reported in table 5 and in appendix 1–2. The concentrations of carbon dioxide, argon, dissolved nitrogen gas, and methane were determined twice for each site; these data are listed in appendix 1–2. The results reported in this text are the median concentrations of the averages of the two samples collected per site. The number of samples that exceeded drinking-water standards for dissolved gases are reported in table 6. No drinking-water standards exist for carbon dioxide, argon, and nitrogen gas.

In the Chemung River Basin, dissolved oxygen concentrations ranged from 0.3 to 10.9 mg/L (table 5 and appendix 1–2). The median concentrations of these dissolved gases in the samples were 23.51 mg/L for nitrogen, 11.0 mg/L for carbon dioxide, 0.805 mg/L for argon, and 0.029 mg/L for methane. Methane was detected in 6 of the 8 samples, and most (4) of those detections were at trace level. The maximum methane concentration measured (average of two analyses) was 8.09 mg/L in a sample from a well completed in sand and gravel (SB 399).

In the Eastern Lake Ontario Basin, dissolved oxygen concentrations ranged from <0.3 to 7.6 mg/L (table 5 and appendix 1–2). The median concentrations of these dissolved gases in the samples were 21.44 mg/L for nitrogen, 12.0 mg/L for carbon dioxide, 0.747 mg/L for argon, and <0.001 mg/L for methane. Methane was detected in 5 of the 15 samples, and all of those detections were at trace level. The maximum methane concentration measured was 0.4730 mg/L in a sample from a well completed in bedrock (HE 1840).

In the Lower Hudson River Basin, dissolved oxygen concentrations ranged from <0.3 to 10.3 mg/L (table 5 and appendix 1–2) and typically were greater in samples from sand-and-gravel wells (median 3.9 mg/L) than in samples from bedrock wells (median 0.4 mg/L). The median concentrations of these dissolved gases in the samples were 22.46 mg/L for nitrogen, 15.4 mg/L for carbon dioxide, 0.737 mg/L for argon, and <0.001 mg/L for methane. Methane was detected in 9 of the 25 samples, and most (7) of those detections were at trace level. Although the EPA and NYSDOH do not have MCLs for methane, dissolved methane concentrations greater than 28 mg/L can pose explosion hazards as a result of methane accumulation in confined spaces. In addition, the U.S. Department of Interior, Office

Table 5. Summary statistics for physiochemical properties of groundwater samples collected in New York, 2013.

[All concentrations in unfiltered water; Min, minimum; Max, maximum; Pt-Co units, platinum-cobalt units; mg/L, milligrams per liter; µS/cm at 25 ºC, microsiemens per centimeter at 25 degrees Celsius; ºC, degrees Celsius; <, value less than reporting level. **Bold** values exceed one or more drinking-water or safety standards.]

Constituent	All samples			Chemung River Basin					Eastern Lake Ontario Basin			Eastern Lake Ontario Basin			Lower Hudson River Basin					
	All aquifers (48 samples)			Sand-and-gravel aquifers (2 samples)		Bedrock aquifers (6 samples)			Sand-and-gravel aquifers (5 samples)			Bedrock aquifers (10 samples)			Sand-and-gravel aquifers (12 samples)			Bedrock aquifers (13 samples)		
	Min	Median	Max	Min	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max
Color, filtered, Pt-Co units	<1	<1	**35**	5	10	<1	<1	<1	<1	<1	<1	<1	<1	**18**	<1	<1	2	<1	<1	**35**
Dissolved oxygen, mg/L	<0.3	2.7	10.9	0.3	0.3	0.3	0.5	10.9	1.2	2.9	7	<0.3	3.0	7.6	<0.3	3.9	9.2	<0.3	0.4	10.3
pH (standard units)	**5.1**	7.2	**10.2**	7.6	7.8	6.9	7.4	7.9	6.7	7.2	7.8	**6.3**	7.2	8.3	**5.1**	7.2	8.2	**5.5**	7.2	**10.2**
Specific conductance, µS/cm at 25 ºC	35	478	2,150	460	483	105	482	510	67	197	603	117	542	2,150	69	611	848	35	277	991
Temperature, ºC	8.7	11.8	15.5	10.7	11.7	9.3	11.0	14.3	8.7	12.0	13.9	8.7	10.6	14.4	10.2	11.6	14.0	10.0	12.7	15.5
Carbon dioxide, mg/L	<0.01	12.7	106.2	3.3	11.3	2.4	13.5	18.5	1.0	8.6	34.5	0.2	22.1	106.2	1.3	19.8	52.3	<0.01	6.7	68.5
Argon, mg/L	0.6370	0.7548	0.9002	0.7000	0.7700	0.7724	0.8271	0.9002	0.6370	0.7590	0.7805	0.6780	0.7454	0.8167	0.6590	0.7276	0.8890	0.6860	0.7725	0.8470
Nitrogen gas, mg/L	17.97	22.35	30.14	20.25	22.69	22.06	24.04	30.14	17.97	21.40	21.68	18.10	21.87	25.69	18.51	21.34	28.83	18.31	22.96	29.46
Methane, mg/L	<0.0010	<0.0010	**34.5**	1.03	8.15	<0.0010	0.0293	0.8692	<0.0010	<0.0010	0.3980	<0.0010	<0.0010	0.4730	<0.0010	0.1873	0.3760	<0.0010	<0.0010	**34.5**

Table 6. Drinking-water standards for physiochemical properties and dissolved gases and number of groundwater samples exceeding those standards collected in New York, 2013.

[All concentrations in unfiltered water; Pt-Co units, platinum-cobalt units; mg/L, milligrams per liter]

Constituent	Drinking-water standard	Number of samples exceeding drinking-water standards			
		All samples (48 samples)	Chemung River Basin (8 samples)	Eastern Lake Ontario Basin (15 samples)	Lower Hudson River Basin (25 samples)
Color, filtered, Pt-Co units	[1]15	2	0	1	1
pH	[1]6.5–8.5	9	0	4	5
Methane, mg/L	[2]10	2	0	0	2

[1]U.S. Environmental Protection Agency Secondary Drinking Water Standard, 2009b.

[2]Methane recommended monitoring concentration (Eltschlager and others, 2001).

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; if the concentration increases, enclosed areas should be vented to prevent methane gas buildup (Eltschlager and others, 2001). The concentrations of methane in two samples from bedrock wells (G1192, average concentration 33.7 mg/L, and A 894, average concentration 30.9 mg/L) were greater than 28 mg/L (table 6 and appendix 1–2).

Major Ions and Dissolved Solids

Groundwater-quality samples were analyzed for bicarbonate, chloride, fluoride, silica, and sulfate anions; for calcium, magnesium, potassium, and sodium cations; alkalinity; hardness; and dissolved solids. Results are reported in table 7 and in appendix 1–3. The numbers of samples that exceeded drinking-water standards for major ions and dissolved solids are reported in table 8. No drinking-water standards exist for calcium, magnesium, potassium, bicarbonate, silica, hardness, and alkalinity.

In the Chemung River Basin, the anions detected in the highest concentrations were bicarbonate (median concentration 202 mg/L) and sulfate (median concentration 18.6 mg/L) (table 7 and appendix 1–3). The cations detected in the highest concentrations were calcium (median concentration 52.2 mg/L) and sodium (median concentration 25.1 mg/L). The concentration of sodium in one sample (SY 922, 62.9 mg/L) exceeded the EPA Drinking Water Advisory Taste Threshold of 60 mg/L; the concentrations of chloride, fluoride, and sulfate did not exceed established MCLs in any sample (table 8 and appendix 1–3).

Most of the water samples (5 of 8) from the Chemung River Basin were classified as “very hard” (greater than 180 mg/L as calcium carbonate [$CaCO_3$]; Hem, 1985). The median hardness of the samples was 190 mg/L as $CaCO_3$, and the maximum hardness was 242 mg/L as $CaCO_3$. Of the remaining three samples, one bedrock well was classified as “soft” (0 to 60 mg/L as $CaCO_3$), one bedrock well was classified as “moderately hard” (61 to 120 mg/L as $CaCO_3$), and one sand-and-gravel well was classified as “hard” (121 to 180 mg/L as $CaCO_3$). Alkalinity ranged from 44 to 230 mg/L as $CaCO_3$; the median was 166 mg/L as $CaCO_3$. Dissolved solids concentrations ranged from 73 to 310 mg/L with a median of 276 mg/L.

In the Eastern Lake Ontario Basin, the anion detected with the highest concentrations was bicarbonate (median concentration 139 mg/L) (table 7 and appendix 1–3). The cations detected in the highest concentrations were calcium (median concentration 40.3 mg/L) and sodium (median concentration 12.7 mg/L). The concentration of sodium in two bedrock samples (L 388, 170 mg/L; L 747, 311 mg/L) exceeded the EPA Drinking Water Advisory Taste Threshold of 60 mg/L. The concentration of chloride in one bedrock sample (L 747, 636 mg/L) exceeded the EPA MCL and the NYSDOH MCL of 250 mg/L. The concentration of fluoride in one bedrock sample (L 181, 2.75 mg/L) exceeded the NYSDOH MCL of 2.2 mg/L and the EPA SDWS of 2.0 mg/L. The concentration of sulfate did not exceed established MCLs in any sample (table 8 and appendix 1–3).

The median hardness of samples from the Eastern Lake Ontario Basin was 131 mg/L as $CaCO_3$, and the maximum hardness was 332 mg/L as $CaCO_3$. Four samples were classified as “soft,” 3 as “moderately hard,” 4 (3 bedrock and 1 sand-and-gravel well) as “hard,” and 4 (3 bedrock and 1 sand-and-gravel well) as “very hard.” Alkalinity ranged from 19 to 346 mg/L as $CaCO_3$; the median was 114 mg/L as $CaCO_3$. Dissolved solids concentrations ranged from less than the detection level to 1,160 mg/L with a median of 220 mg/L; dissolved solids concentration in one sample (L 747, 1,160 mg/L) exceeded the EPA SDWS for total dissolved solids of 500 mg/L (table 8 and appendix 1–3). With the exception of magnesium, the median concentrations for all major ions and dissolved solids were lower in samples from sand-and-gravel wells than in samples from bedrock wells.

Table 7. Summary statistics for concentrations of major ions in groundwater samples collected in New York, 2013.

[All concentrations are in milligrams per liter in filtered water; <, less than; ºC, degrees Celsius; $CaCO_3$, calcium carbonate. **Bold** values exceed one or more drinking-water or safety standard]

Constituent		All samples			Chemung River Basin					Eastern Lake Ontario Basin						Lower Hudson River Basin					
		All aquifers (48 samples)			Sand-and-gravel aquifers (2 samples)		Bedrock aquifers (6 samples)			Sand-and-gravel aquifers (5 samples)			Bedrock aquifers (10 samples)			Sand-and-gravel aquifers (12 samples)			Bedrock aquifers (13 samples)		
		Minimum	Median	Maximum	Minimum	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum
Cations	Calcium	0.942	42.8	120	52.3	59.7	13.5	50.8	59.3	7.2	27.5	97.8	0.942	47.8	120	8.32	59.4	119	3.31	27.2	106
	Magnesium	0.043	7.96	64.6	8.33	9.35	2.98	15.2	27.1	1.94	5.73	15.6	0.043	5.02	11.5	2.22	9.47	30.3	0.722	7.87	64.6
	Potassium	0.25	1.10	3.53	0.74	0.80	0.45	1.17	2.82	0.82	1.14	1.39	0.56	1.48	3.45	0.34	1.20	3.53	0.25	0.63	2.64
	Sodium	0.9	25.0	**311**	24.9	25.3	1.87	22.5	**62.9**	1.85	5.84	34.5	4.33	23.0	**311**	2.28	35.5	**63.6**	0.9	14.6	**116**
Anions	Bicarbonate	10	172	521	167	186	53	228	280	24	92	317	43	162	421	32	208	390	10	135	521
	Chloride	0.38	15.0	**636**	53.2	53.3	0.84	4.87	38.1	0.38	6.37	61.3	2.15	18.2	**636**	0.96	66.4	142	0.69	9.69	95.4
	Fluoride	0.03	0.08	**2.75**	0.07	0.12	0.08	0.14	0.39	0.04	0.05	0.24	0.04	0.28	**2.75**	0.04	0.04	0.10	0.03	0.12	1.15
	Silica	3.26	10.3	55.7	8.41	10.3	7.07	10.4	14.3	5.58	8.51	20.3	5.12	11.3	15.8	5.93	9.04	13.1	3.26	12.7	55.7
	Sulfate	<0.09	12.2	95.6	0.16	11.4	8.01	29.8	66.2	5.81	8.83	15.4	4.77	12.5	31.4	4.2	17.6	57.9	<0.09	11.4	95.6
Hardness as $CaCO_3$		2.53	152	531	165	188	46.1	202	242	26	85.5	268	2.53	150	332	29.9	212	423	11.2	100	531
Alkalinity as $CaCO_3$		8	142	428	138	153	44	188	230	19	76	260	35	133	346	26	172	320	8	112	428
Dissolved solids, dried at 180 °C		<20	244	**1,160**	257	276	73	282	310	45	104	276	<20	232	**1,160**	52	359	480	26	183	**514**

Table 8. Drinking-water standards for concentrations of major ions and number of groundwater samples exceeding those standards collected in New York, 2013.

[All concentrations are in milligrams per liter in filtered water]

<table>
<tr><th colspan="2" rowspan="2">Constituent</th><th rowspan="2">Drinking-water standard</th><th colspan="4">Number of samples exceeding drinking-water standards</th></tr>
<tr><th>All samples (48 samples)</th><th>Chemung River Basin (8 samples)</th><th>Eastern Lake Ontario Basin (15 samples)</th><th>Lower Hudson River Basin (25 samples)</th></tr>
<tr><td>Cations</td><td>Sodium</td><td>[4]60</td><td>6</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td rowspan="5">Anions</td><td>Chloride</td><td>[2,3]250</td><td>1</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td rowspan="3">Fluoride</td><td>[1]4.0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>[2]2.2</td><td>1</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>[3]2</td><td>1</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>Sulfate</td><td>[2,3]250</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="2">Dissolved solids, dried at 180 ºC</td><td>[3]500</td><td>2</td><td>0</td><td>1</td><td>1</td></tr>
</table>

[1]U.S. Environmental Protection Agency Maximum Contaminant Level, 2009b.

[2]New York State Department of Health Maximum Contaminant Level, 2001.

[3]U.S. Environmental Protection Agency Secondary Drinking Water Standard, 2009b.

[4]U.S. Environmental Protection Agency Drinking Water Advisory Taste Threshold, 2009b.

In the Lower Hudson River Basin, the anions detected in the highest concentrations were bicarbonate (median concentration 165 mg/L) and chloride (median concentration 19.4 mg/L) (table 7 and appendix 1–3). The cations detected in the highest concentrations were calcium (median concentration 34.9 mg/L) and sodium (median concentration 25.0 mg/L). The concentration of sodium in three samples (P1218, 63.6 mg/L; A 894, 89.0 mg/L; and G1192, 116 mg/L) exceeded the EPA Drinking Water Advisory Taste Threshold of 60 mg/L. The concentrations of chloride, fluoride, and sulfate did not exceed established MCLs in any sample (table 8 and appendix 1–3).

Most of the water samples (11 of 25) from the Lower Hudson River Basin were classified as “very hard.” The median hardness of the samples was 129 mg/L as $CaCO_3$, and the maximum hardness was 531 mg/L as $CaCO_3$. Of the remaining 14 samples, 6 (5 bedrock wells and 1 sand-and-gravel well) were classified as “soft,” 6 (4 bedrock wells and 2 sand-and-gravel wells) as “moderately hard,” and 2 (bedrock wells) as “hard.” Alkalinity ranged from 8 to 428 mg/L as $CaCO_3$; the median was 136 mg/L of $CaCO_3$. Dissolved solids concentrations ranged from 26 to 514 mg/L with a median of 243 mg/L; the dissolved solids concentration in one sample (U1863, 514 mg/L) exceeded the EPA SDWS for total dissolved solids of 500 mg/L. The median concentrations for most constituents were higher in sand-and-gravel well samples than in bedrock well samples.

Nutrients and Total Organic Carbon

Groundwater-quality samples were analyzed for several nutrients, including ammonia plus organic nitrogen, ammonia, nitrate plus nitrite, nitrate, nitrite, and orthophosphate, as well as total organic carbon. Results are reported in table 9 and in appendix 1–4. The number of samples that exceeded drinking-water standards for major ions and dissolved solids are reported in table 10. No drinking-water standards exist for ammonia, orthophosphate, and total organic carbon.

The dominant nutrient detected in the Chemung River Basin was ammonia (table 9 and appendix 1–4). The concentrations of ammonia ranged from <0.010 to 0.340 mg/L as nitrogen (N) and were similar in samples from sand-and-gravel wells and in samples from bedrock wells. The concentrations of nitrate ranged from <0.040 to 0.146 mg/L as N and were similar in samples in sand-and-gravel wells and bedrock wells. The concentration of nitrate plus nitrite did not exceed the NYSDOH and EPA MCL of 10 mg/L as N in any sample (table 10 and appendix 1–4). Nitrite was not detected in any sample from Chemung River Basin wells. Orthophosphate concentrations ranged from <0.004 to 0.079 mg/L as phosphorus (P). Total organic carbon was detected in 3 of the 8 samples; the maximum concentration was 1.1 mg/L.

The dominant nutrient detected in the Eastern Lake Ontario Basin was nitrate (table 9 and appendix 1–4). The

Table 9. Summary statistics for concentrations of nutrients in groundwater samples collected in New York, 2013.

[All concentrations in milligrams per liter in filtered water except as noted. N, nitrogen; P, phosphorus; <, less than]

Constituent	All samples			Chemung River Basin					Eastern Lake Ontario Basin						Lower Hudson River Basin					
	All aquifers (48 samples)			Sand-and-gravel aquifers (2 samples)		Bedrock aquifers (6 samples)			Sand-and-gravel aquifers (5 samples)			Bedrock aquifers (10 samples)			Sand-and-gravel aquifers (12 samples)			Bedrock aquifers (13 samples)		
	Minimum	Median	Maximum	Minimum	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum
Ammonia plus organic N as N	<0.07	<0.07	0.66	0.15	0.16	<0.07	<0.07	0.35	<0.07	<0.07	<0.07	<0.07	<0.07	0.66	<0.07	<0.07	0.47	<0.07	<0.07	0.56
Ammonia ($NH_3 + NH_4^+$) as N	<0.010	<0.010	0.504	0.092	0.117	<0.010	0.038	0.340	<0.010	<0.010	0.038	<0.010	<0.010	0.41	<0.010	<0.010	0.384	<0.010	<0.010	0.504
Nitrate plus nitrite ($NO_2 + NO_3$) as N	<0.040	0.184	4.91	<0.040	<0.040	<0.040	<0.040	0.146	<0.040	0.643	0.982	<0.040	0.404	3.83	<0.040	0.582	4.91	<0.040	0.054	1.41
Nitrate (NO_3) as N	<0.039	0.184	4.91	<0.040	<0.040	<0.040	<0.040	0.146	<0.039	0.643	0.982	<0.040	0.404	3.83	<0.040	0.582	4.91	<0.040	0.054	1.41
Nitrite (NO_2) as N	<0.001	<0.001	0.015	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	0.015	<0.001	<0.001	0.007	<0.001	<0.001	<0.001
Orthophosphate (PO_4) as P	<0.004	0.007	0.088	0.034	0.079	<0.004	0.007	0.025	<0.004	<0.004	0.011	<0.004	0.004	0.013	<0.004	0.006	0.088	<0.004	0.007	0.062
Total organic carbon, unfiltered	<0.5	1.0	10	<0.5	1.1	<0.5	<0.5	1	<0.5	1.2	1.5	1.1	1.4	10	<0.5	1.1	1.9	<0.5	0.8	1.6

Table 10. Drinking-water standards for concentrations of nutrients and number of groundwater samples exceeding those standards collected in New York, 2013.

[All concentrations in milligrams per liter in filtered water except as noted. N, nitrogen]

Constituent	Drinking-water standard	Number of samples exceeding drinking-water standards			
		All samples (48 samples)	Chemung River Basin (8 samples)	Eastern Lake Ontario Basin (15 samples)	Lower Hudson River Basin (25 samples)
Nitrate plus nitrite (NO_2 + NO_3) as N	[1,2]10	0	0	0	0
Nitrate (NO_3) as N	[1,2]10	0	0	0	0
Nitrite (NO_2) as N	[1,2]1	0	0	0	0

[1]U.S. Environmental Protection Agency Maximum Contaminant Level, 2009b.

[2]New York State Department of Health Maximum Contaminant Level, 2011.

concentration of nitrate ranged from <0.039 to 3.83 mg/L as N and was generally greater in samples from sand-and-gravel wells (median 0.643 mg/L as N) than in samples from bedrock wells (median 0.404 mg/L as N). The concentration of nitrate plus nitrite did not exceed the NYSDOH and EPA MCL of 10 mg/L as N in any sample (table 10 and appendix 1–4). The concentrations of ammonia ranged from <0.010 to 0.41 mg/L as nitrogen (N) and were similar in samples from sand-and-gravel wells and in samples from bedrock wells. Nitrite was detected in 4 of the 15 samples with a maximum concentration of 0.015 mg/L as N. Orthophosphate concentrations ranged from <0.004 to 0.013 mg/L as phosphorus (P). Total organic carbon was detected in 14 of the 15 samples; the maximum concentration was 10 mg/L.

The dominant nutrient detected in the Lower Hudson River Basin was nitrate (table 9 and appendix 1–4). The concentrations of nitrate ranged from <0.040 to 4.91 mg/L as N and were generally greater in samples from sand-and-gravel wells (median 0.582 mg/L as N) than in samples from bedrock wells (median 0.054 mg/L as N). The concentration of nitrate plus nitrite did not exceed the NYSDOH and EPA MCL of 10 mg/L as N in any sample (table 10 and appendix 1–4). The concentrations of ammonia ranged from <0.010 to 0.504 mg/L as nitrogen (N) and were similar in samples from sand-and-gravel wells and in samples from bedrock wells. Nitrite was detected in 1 of the 25 samples (well A 227) at a concentration of 0.007 mg/L as N. Orthophosphate concentrations ranged from <0.004 to 0.088 mg/L as phosphorus (P). Total organic carbon was detected in 17 of the 25 samples; the maximum concentration was 1.9 mg/L.

Trace Elements

Twenty-four trace elements were analyzed for in filtered and (or) unfiltered groundwater-quality samples. Results are reported in table 11 and in appendix 1–5. The number of samples that exceeded drinking-water standards for major ions and dissolved solids are reported in table 12. No drinking-water standards exist for boron, cobalt, lithium, molybdenum, nickel, and strontium.

In the Chemung River Basin, the trace elements present in the highest median concentrations in the samples were strontium (median concentration 260 µg/L), manganese (median 192.5 µg/L in unfiltered water; 185 µg/L in filtered water), iron (median 120 µg/L in unfiltered water; 125.5 µg/L in filtered water), barium (median 54.7 µg/L in unfiltered water), and boron (median 45 µg/L in filtered water) (table 11 and appendix 1–5).

The concentration of aluminum in one sample from bedrock well SB2802 (258 µg/L) exceeded the EPA SDWS of 50–200 µg/L (table 11 and appendix 1–5). The concentrations of iron in three samples (2 from sand-and-gravel wells and 1 from a bedrock well) exceeded the NYSDOH MCL and EPA SDWS of 300 µg/L in the filtered and unfiltered samples; the maximum concentration (1,000 µg/L) was in an unfiltered sample from a sand-and-gravel well (table 12 and appendix 1–5). Samples from 6 of the 8 wells in the Chemung River Basin had concentrations of manganese that exceeded the EPA SDWS of 50 µg/L in unfiltered and filtered samples. Samples from three of these wells—SB 399, SB1212, and SB2802—further exceeded the NYSDOH MCL of 300 µg/L. The maximum concentration of manganese was 590 µg/L in an unfiltered sample from bedrock well SB2802. Drinking-water standards for antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, zinc, and uranium were not exceeded (table 12 and appendix 1–5), and antimony, cadmium, mercury, selenium, and silver were not detected in any of the eight Chemung River Basin samples (appendices 1–1 and 1–5).

In the Eastern Lake Ontario Basin, the trace elements present in the highest median concentrations in the samples were strontium (median concentration 188 µg/L), iron (median concentration 41.5 µg/L in unfiltered water and 8.1 µg/L in filtered water), barium (median 36.9 µg/L), boron (median

Table 11. Summary statistics for concentrations of trace elements in groundwater collected in New York, 2013.

[All concentrations in micrograms per liter in unfiltered water except as noted. <, less than. **Bold** values exceed one or more drinking-water or safety standard]

Constituent	All samples			Chemung River Basin					Eastern Lake Ontario Basin						Lower Hudson River Basin					
	All aquifers (48 samples)			Sand-and-gravel aquifers (2 samples)		Bedrock aquifers (6 samples)			Sand-and-gravel aquifers (5 samples)			Bedrock aquifers (10 samples)			Sand-and-gravel aquifers (12 samples)			Bedrock aquifers (13 samples)		
	Minimum	Median	Maximum	Minimum	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum
Aluminum	<3.8	<3.8	**258**	<3.8	<3.8	<3.8	4.4	**258**	<3.8	4.7	42	<3.8	<3.8	48.8	<3.8	<3.8	5	<3.8	13.3	**110**
Antimony	<0.018	<0.018	<0.018	<0.18	<0.18	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018
Arsenic	<0.28	<0.28	**25.9**	2.3	7.4	<0.28	<0.28	6.5	<0.28	<0.28	4.8	<0.28	<0.28	1.6	<0.28	<0.28	2.6	<0.28	0.53	**25.9**
Barium	0.67	36.8	896	184	896	16.4	42.4	434	1.6	42.2	136	0.67	34.8	238	2.71	34.3	261	0.98	32.5	312
Beryllium	<0.02	<0.02	0.28	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.28	<0.02	<0.02	<0.02	<0.02	<0.02	0.22
Boron, filtered	3.6	19	2,160	20	24	7.1	68	196	5.7	14	27	8.4	22	352	3.8	15	39	3.6	18	2,160
Cadmium	<0.016	<0.016	0.279	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	0.279	<0.016	<0.016	0.067	<0.016	<0.016	0.047
Chromium	<0.30	<0.30	0.86	<0.30	<0.30	<0.30	<0.30	0.6	<0.30	<0.30	0.38	<0.30	<0.30	0.4	<0.30	<0.30	0.47	<0.30	<0.30	0.86
Cobalt	<0.02	0.03	1.4	<0.02	0.06	<0.02	0.03	0.21	<0.02	0.02	0.1	<0.02	0.02	1.4	<0.02	0.04	0.21	<0.02	0.06	0.89
Copper	<0.70	3.0	43.9	<0.70	3.1	<0.70	<0.70	2.9	<0.70	3.1	11.6	<0.70	4.8	43.9	<0.70	2.4	16.4	<0.70	4.8	15.5
Iron, filtered	<4.0	7.0	**9,180**	433	**843**	<4.0	62.8	**546**	<4.0	8.1	29	<4.0	7.4	**794**	<4.0	4.6	**3,330**	<4.0	5.9	**9,180**
Iron	<4.6	33.2	**8,510**	429	**1,000**	11	74.4	**704**	<4.6	11.7	**783**	<4.6	60.0	**1,300**	<4.6	9.4	**3,690**	<4.6	38.9	**8,510**
Lead	<0.04	0.20	4.72	<0.04	0.27	<0.04	<0.08	2.56	0.1	0.15	0.28	0.1	0.52	4.45	<0.04	0.19	4.72	<0.04	0.18	1.97
Lithium	0.17	4.62	416	1.86	8.79	1.90	20.6	32.7	0.87	3.76	35	1.11	7.38	79.9	0.22	3.24	15	0.17	4.37	416
Manganese, filtered	<0.16	7.67	**2,330**	**116**	**323**	<0.16	**180**	**588**	<0.16	0.37	22	<0.16	6.72	**2,330**	0.3	2.2	**723**	0.25	17.4	**432**
Manganese	<0.20	5.44	**2,260**	**114**	**345**	<0.20	**192**	**590**	<0.20	0.64	25.7	<0.20	5.44	**2,260**	<0.4	1.3	**832**	<0.4	9.3	**793**
Mercury	<0.005	<0.005	0.016	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.016
Molybdenum	<0.05	0.34	9.08	0.62	0.84	0.11	0.32	0.5	0.07	0.07	0.67	<0.05	1.06	3.76	<0.05	0.14	1.99	<0.05	1.53	9.08
Nickel	<0.19	0.21	2.7	0.21	0.21	<0.19	<0.19	0.48	<0.19	0.23	0.89	<0.19	0.21	1.2	<0.19	0.24	2.5	<0.19	0.27	2.7
Selenium	<0.050	0.058	0.293	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.071	0.195	<0.050	0.086	0.175	<0.050	0.12	0.293	<0.050	<0.050	0.185
Silver	<0.015	<0.015	0.054	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.054	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
Strontium	4.33	172	1,650	123	193	33.7	433	901	27.3	74.7	314	4.33	361	919	25.3	168	340	19.1	119	1,650
Thallium	<0.06	<0.06	0.15	<0.06	<0.06	<0.06	<0.06	0.15	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Zinc	<3.0	4.0	53.8	<3.0	3.2	<3.0	<3.0	<3.0	<3.0	3.2	19.6	<3.0	16.2	51.4	<3.0	5.2	36.9	<3.0	4	53.8
Uranium	<0.014	0.278	**43.1**	0.024	0.027	<0.014	0.352	1.34	0.032	0.194	0.413	<0.014	0.678	**43.1**	<0.014	0.340	1.09	<0.014	0.100	4.7

Table 12. Drinking-water standards for concentrations of trace elements and number of groundwater samples exceeding those standards collected in New York, 2013.

[All concentrations in micrograms per liter in unfiltered water except as noted]

Constituent	Drinking-water standard	Number of samples exceeding drinking-water standards			
		All samples (48 samples)	Chemung River Basin (8 samples)	Eastern Lake Ontario Basin (15 samples)	Lower Hudson River Basin (25 samples)
Aluminum	[3]50–200	2	1	0	1
Antimony	[1,2]6	0	0	0	0
Arsenic	[1,2]10	1	0	0	1
Barium	[1,2]2,000	0	0	0	0
Beryllium	[1,2]4	0	0	0	0
Cadmium	[1,2]5	0	0	0	0
Chromium	[1,2]100	0	0	0	0
Copper	[3]1,000	0	0	0	0
Iron, filtered	[2,3]300	8	3	2	3
Iron	[2,3]300	13	3	5	5
Lead	[4]15	0	0	0	0
Manganese, filtered	[2]300 [3]50	6 13	3 6	1 2	2 5
Manganese	[2]300 [3]50	7 14	3 6	1 2	3 6
Mercury	[1,2]2	0	0	0	0
Selenium	[1,2]50	0	0	0	0
Silver	[2,3]100	0	0	0	0
Thallium	[1,2]2	0	0	0	0
Zinc	[2,3]5,000	0	0	0	0
Uranium	[1,2]30	1	0	1	0

[1]U.S. Environmental Protection Agency Maximum Contaminant Level, 2009b.

[2]New York State Department of Health Maximum Contaminant Level, 2011.

[3]U.S. Environmental Protection Agency Secondary Drinking Water Standard, 2009b.

[4]U.S. Environmental Protection Agency Treatment Technique, 2009b.

16 µg/L in filtered water), and zinc (median 12 µg/L) (table 11 and appendix 1–5). The median concentrations of some trace elements, for example, aluminum and barium, were higher in samples from sand-and-gravel wells than in samples from bedrock wells. The median concentrations of other trace elements, such as boron, copper, iron, lithium, manganese, molybdenum, strontium, and zinc, were greater in samples from bedrock wells than in samples from sand-and-gravel wells (table 11 and appendix 1–5).

The concentration of uranium in one sample from bedrock well HE1840 (43.1 µg/L) exceeded the EPA MCL and NYSDOH MCL of 30 µg/L (table 12 and appendix 1–5). The concentration of iron in five samples (4 bedrock wells and 1 sand-and-gravel well) exceeded the NYSDOH MCL and EPA SDWS of 300 µg/L in unfiltered samples; the maximum iron concentration was 1,300 µg/L (J 229). Two of the five samples, both from bedrock wells, also had concentrations of iron that exceeded the MCL and SDWS when filtered. The concentration of manganese in two samples from Eastern Lake Ontario Basin bedrock wells (HE1840 and OE2425) exceeded the EPA SDWS of 50 µg/L in filtered and unfiltered samples; the concentration of manganese in one of these samples (HE1840, 2,330 µg/L in filtered water) further exceeded the NYSDOH MCL of 300 µg/L. Drinking-water standards for aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, and zinc were not exceeded; antimony, mercury, and thallium were not detected in any of the 15 Eastern Lake Ontario Basin samples collected (appendix 1–5).

In the Lower Hudson Basin, the trace elements present in samples in the highest median concentrations were strontium (median concentration 161 µg/L), barium (median 32.5 µg/L), iron (median 25.2 µg/L in unfiltered water and 5.6 µg/L in filtered water), boron (median 16 µg/L in filtered water), and manganese (median 2.4 µg/L in unfiltered water and 6.6 µg/L in filtered water) (table 11 and appendix 1–5). The median concentrations of some trace elements, for example, barium, strontium, and zinc, were higher in samples from sand-and-gravel wells than in samples from bedrock wells. The median concentrations of other trace elements, such as aluminum, boron, copper, iron, manganese, and molybdenum, were greater in samples from bedrock wells than in samples from sand-and-gravel wells (table 12 and appendix 1–5).

The concentration of aluminum in one sample from the Lower Hudson River Basin (A 894, 110 µg/L) exceeded the EPA SDWS of 50–200 µg/L (table 12 and appendix 1–5). The concentration of arsenic in one sample (U1863, 25.9 µg/L) exceeded the EPA MCL and NYSDOH MCL of 10 µg/L. The concentrations of iron in 5 samples (4 from bedrock wells and 1 from a sand-and-gravel well) exceeded the NYSDOH MCL and EPA SDWS of 300 µg/L in unfiltered water; the concentrations of iron in 3 of the corresponding filtered samples also exceeded the MCL and SDWS. Concentrations of iron in 4 (3 bedrock wells and 1 sand-and-gravel well) of the 4 unfiltered samples that exceeded MCL and SDWS had concentrations of iron five or more times higher than those standards; the maximum concentration of iron (9,180 µg/L) was in a bedrock well sample (WE5230). The concentrations of manganese in 6 unfiltered samples exceeded the EPA SDWS of 50 µg/L; the concentrations of manganese in 5 of the corresponding filtered samples also exceeded the SDWS. The concentrations of manganese in 3 of the unfiltered samples and 2 of the filtered samples further exceeded the NYSDOH MCL of 300 µg/L. The maximum concentration of manganese, 832 µg/L, was in an unfiltered sample from a sand-and-gravel well (U1622). Drinking-water standards for antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, zinc, and uranium were not exceeded; antimony, silver, and thallium were not detected in any of the 25 Lower Hudson River Basin samples (appendices 1–1 and 1–5).

Pesticides

Fifty-two pesticides and (or) pesticide degradates were analyzed for in groundwater-quality samples. No concentrations exceeded established drinking-water standards set for pesticides and pesticide degradates. Results are reported in appendix 1–6.

In the Chemung River Basin, six pesticides and (or) pesticide degradates were detected at trace concentrations in one sample from a domestic bedrock well (SB2802) (appendix 1–6). Most of the pesticides detected were broadleaf herbicides or their degredates; an insecticide (carbaryl) was also detected. The pesticide detected at the highest concentration (0.019 µg/L) was atrazine. The other pesticides detected were the degradate 2-chloro-4-isopropylamino-6-amino-*s*-triazine (CIAT) (estimated at 0.1014 µg/L) and the pesticides metolachlor (0.013 µg/L), prometon (0.003 µg/L), simazine (0.007 µg/L), and carbaryl (estimated at 0.1003 µg/L). No pesticide concentrations exceeded established drinking-water standards; pesticide degradates currently are not regulated.

In the Eastern Lake Ontario Basin, eight pesticides and (or) pesticide degradates were detected at trace concentrations in seven samples (appendix 1–6). All of the pesticides detected were broadleaf herbicides or their degradates. Most of the wells (5 of 7) with pesticide detections are bedrock wells. Four of the 7 wells are production wells, and 3 are domestic wells. The most frequently detected pesticides were the degradate CIAT (7 samples) and the pesticide atrazine (3 samples). The pesticide detected at the highest concentration (0.487 µg/L) is metolachlor. More than one pesticide was detected in several samples. One sample had detections of 8 pesticides, 1 sample had detections of 3 pesticides, and 1 sample had detections of 2 pesticides. No pesticide concentrations exceeded established drinking-water standards. CIAT was the only pesticide detected at greater than the reporting level in samples from the sand-and-gravel wells.

In the Lower Hudson River Basin, seven pesticides and pesticide degradates were detected at trace concentrations in seven samples (appendix 1–6). Most of the pesticides detected were broadleaf herbicides or their degradates; an insecticide (dieldrin) was also detected. Most of the wells with pesticide detections were production wells (6 of 7), and most were sand-and-gravel wells (5 of 7). The most frequently detected pesticides were the degradate CIAT (7 samples) and the pesticides atrazine (3 samples), prometon (3 samples), and simazine (3 samples). The pesticide detected at the highest concentration (estimated 0.1023 µg/L) was tebuthiuron. More than one pesticide was detected in several samples. One sample had detections of 5 pesticides, and 4 samples had detections of 3 pesticides. No pesticide concentrations exceeded established drinking-water standards.

Volatile Organic Compounds

Thirty-four VOCs were analyzed for in groundwater-quality samples. No concentrations exceeded established drinking-water standards set for VOCs. Results are reported in appendix 1–7.

In the Chemung River Basin, one VOC, toluene, was detected in samples from 2 of the 8 sampled wells. The maximum concentration was V0.2 µg/L.

In the Eastern Lake Ontario Basin, three VOCs were detected in samples from 1 sand-and-gravel well (OW2055) and 2 bedrock wells (HE1840 and L 388) (appendix 1–7). The VOCs detected were trichloromethane (chloroform), a trihalomethane (THM, which is a byproduct formed when chlorine or bromine are used as disinfectants), a solvent (*cis*-1,2-dichloroethene), and the gasoline additive methyl *tert*-butyl ether (MTBE). Trichloromethane was detected in samples from two wells, OW2055 and HE1840, at concentrations of 0.1 µg/L and 0.2 µg/L, respectively. MTBE was detected in well HE1840 at a concentration of 0.3 µg/L, and *cis*-1,2-dichloroethene was detected in well L 388 at a concentration of 0.6 µg/L.

In the Lower Hudson River Basin, five VOCs were detected in samples from 4 sand-and-gravel wells (CB1526, P1218, RO 513, and WE5014) and 3 bedrock wells (G1192, RO 560, RO 853) (appendix 1–7). The VOCs detected were trichloromethane, and four solvents—1,1,1-trichloroethane, *cis*-1,2-dichloroethene, tetrachloroethene (PERC), and trichloroethene (TCE). Trichloromethane was the most frequently detected VOC and was detected in five samples; the maximum concentration of 1.1 µg/L was in a sample from a bedrock well (G1192). The VOC detected at the highest concentration was PERC, at 2.4 µg/L; it was detected in a sample from a sand-and-gravel well (P1218).

The sample from well P1218 contained detectable concentrations of three VOCs—PERC (2.4 µg/L), *cis*-1,2-dichloroethene (1. 0 µg/L), and TCE (0.6 µg/L). This well is affected by historical (1978 and earlier) contamination originating at a dry well adjacent to a dry cleaner. Soils on site have been remediated, and a packed-column air-stripping unit was used to remove VOCs from the water (U.S. Environmental Protection Agency, 2009a).

Radionuclides

Groundwater-quality samples were analyzed for radon-222 activity, gross-α activity, and gross-β activity. Radon is currently (2015) not regulated in drinking water. However, the EPA has proposed a two-part standard for radon-222 in drinking water: (1) a 300-picocuries per liter (pCi/L) MCL for areas that do not implement an indoor-air radon-222 mitigation program and (2) an alternative MCL (AMCL) of 4,000 pCi/L for areas that do implement an indoor-air radon-222 mitigation program (U.S. Environmental Protection Agency, 1999). The EPA and NYSDOH MCLs for gross-β 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-β 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-β radioactivity. Results are reported in appendix 1–8.

In the Chemung River Basin, gross-α activities were not detected in any samples (table 13 and appendix 1–8). Gross-β activities ranged from 2.1 to 6.6 pCi/L. Radon-222 activities in the water samples ranged from 155 to 1,200 pCi/L; the median was 705 pCi/L. The highest radon-222 activities were in samples from wells completed in bedrock. Radon-222 activities in six (2 sand-and-gravel wells and 4 bedrock wells) of the Chemung River Basin samples exceeded the proposed MCL of 300 pCi/L; no samples exceeded the proposed AMCL of 4,000 pCi/L (table 14 and appendix 1–8).

In the Eastern Lake Ontario Basin, gross-α activity ranged from non-detectable levels to 32 pCi/L; the median activity was 0.8 pCi/L (table 13 and appendix 1–8). The gross-α activity in one sample from bedrock well HE1840 (32 pCi/L) exceeded the NYSDOH and EPA MCLs of 15 pCi/L (table 14 and appendix 1–8). Gross-β activities ranged from non-detectable levels to 23 pCi/L; the median gross-β activity was 3 pCi/L. Radon-222 activities in the water samples ranged from 16 to 15,400 pCi/L; the median was 550 pCi/L. The highest gross-α, gross-β, and radon-222 activities were in a sample from one well, HE1840, which is completed in crystalline bedrock. The second highest radon-222 activity was also from a well completed in crystalline bedrock (L 747). The median radon-222 activity in samples from crystalline bedrock wells (1,210 pCi/L) was higher than the median radon-222 activity in samples from non-crystalline bedrock wells (300 pCi/L). Radon-222 activities in 10 of the 15 of the Eastern Lake Ontario Basin samples exceeded the proposed MCL of 300 pCi/L; the radon-222 activity in one sample exceeded the proposed AMCL of 4,000 pCi/L.

In the Lower Hudson River Basin, gross-α activity ranged from non-detectable levels to 2.3 pCi/L; the median activity was less than the detection level (table 13 and appendix 1–8). The gross-α activity did not exceed the NYSDOH and EPA MCLs of 15 pCi/L in any sample. Gross-β activities ranged from non-detectable levels to 4.8 pCi/L. Radon-222 activities in the groundwater samples ranged from 25 to 10,600 pCi/L; the median was 560 pCi/L. The two highest radon-222 activities were in samples from wells completed in crystalline bedrock (P2066 and O7842); the median radon-222 activity in samples from bedrock wells (790 pCi/L) was higher than the median radon-222 activity in samples from sand-and-gravel wells (475 pCi/L). The median radon-222 activity in samples from crystalline bedrock (1,210 pCi/L) was higher than the median radon-222 activity in samples from non-crystalline bedrock (300 pCi/L). Radon-222 activities in 20 of the 25 Lower Hudson River Basin samples exceeded the proposed MCL; radon-222 activities in one sample exceeded the proposed AMCL (table 14 and appendix 1–8).

Bacteria

Groundwater-quality samples were analyzed for total coliform bacteria, fecal coliform bacteria, and *Escherichia coli (E. coli)* bacteria. Heterotrophic plate count was also determined. The NYSDOH and EPA 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). Results are reported in appendix 1–9.

Table 13. Summary statistics for concentrations of radionuclides in groundwater samples collected in New York, 2013.

[All activities in picocuries per liter in unfiltered water. <, less than. **Bold** values exceed one or more drinking-water or safety standard]

Constituent	All samples			Chemung River Basin					Eastern Lake Ontario Basin						Lower Hudson River Basin					
	All aquifers (48 samples)			Sand-and-gravel aquifers (2 samples)		Bedrock aquifers (6 samples)			Sand-and-gravel aquifers (5 samples)			Bedrock aquifers (10 samples)			Sand-and-gravel aquifers (12 samples)			Bedrock aquifers (13 samples)		
	Minimum	Median	Maximum	Minimum	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum
Gross-α radioactivity	<0.465	<1.26	**32**	<0.992	<1.15	<0.465	<0.908	<1.35	<0.484	<0.612	2	<0.568	1.2	**32**	<0.636	<1.63	2.2	<0.554	<1.01	2.3
Gross-β radioactivity	<1.2	2.8	23	2.1	2.9	2.3	3.05	6.6	<1.49	2	4.1	<1.35	3.6	23	<1.27	2.8	4.7	<1.2	2.7	4.8
Radon-222	16	590	**15,400**	**520**	**670**	155	**850**	**1,200**	190	**550**	**830**	16	**570**	**15,400**	25	**475**	**940**	38	**790**	**10,600**

Table 14. Drinking-water standards for concentrations of radionuclides and number of groundwater samples exceeding those standards collected in New York, 2013.

[All activities in picocuries per liter in unfiltered water except as noted. mrem/yr, millirem per year; activity units (picocuries per liter) used to measure gross-β radioactivity in this study are not comparable to dosage units (millirems per year); --, not applicable]

Constituent	Drinking-water standard	Number of samples exceeding drinking-water standards			
		All samples (48 samples)	Chemung River Basin (8 samples)	Eastern Lake Ontario Basin (15 samples)	Lower Hudson River Basin (25 samples)
Gross-α radioactivity	[1,2]15	1	0	1	0
Gross-β radioactivity	[1,2]4 mrem/yr	--	--	--	--
Radon-222	[3]300	36	6	10	20
	[4]4,000	2	0	1	1

[1]U.S. Environmental Protection Agency Maximum Contaminant Level, 2009b.

[2]New York State Department of Health Maximum Contaminant Level, 2011.

[3]U.S. Environmental Protection Agency Proposed Maximum Contaminant Level, 2009b.

[4]U.S. Environmental Protection Agency Proposed Alternative Maximum Contaminant Level, 2009b.

In the Chemung River Basin, total coliform bacteria were detected in one sample from bedrock well SY 922 (appendix 1–9). Well SY 922 had a total coliform detection of 120 colony forming units (CFU) per 100 mL. Fecal coliform bacteria were not detected in any samples, though 1 CFU/100 mL of *E. coli* bacteria was detected in a sample from bedrock well SY 922, exceeding the EPA and NYSDOH MCLs for *E. coli* bacteria. The heterotrophic plate count ranged from <1 CFU/mL to 11 CFU/mL; no Chemung River Basin samples exceeded the EPA MCL for heterotrophic plate count of 500 CFU/mL.

In the Eastern Lake Ontario Basin, total coliform bacteria were detected in 1 sample from a sand-and-gravel well (J1118) and 2 samples from bedrock wells (HE1840 and J 229) (appendix 1–9). Well J1118 had a total coliform detection of 200 CFU/100 mL. Fecal coliform bacteria were detected in sand-and-gravel well J1118 at 16 CFU/100 mL, exceeding the EPA and NYSDOH MCLs. The heterotrophic plate count ranged from <1 CFU/mL to 54 CFU/mL; no Eastern Lake Ontario Basin samples exceeded the EPA MCL for heterotrophic plate count.

In the Lower Hudson River Basin, total coliform bacteria were detected in four samples from 2 sand-and-gravel production wells (O1390 and U1622) and 2 bedrock domestic wells (G1192 and O7842) (appendix 1–9). Wells G1192 and O7842 had total coliform detections of greater than (>) 200 CFU per 100 mL. Fecal coliform bacteria and *E. coli* bacteria were detected in wells G1192 and O7842. Fecal coliform bacteria at 7 CFU/100 mL and *E. coli* bacteria at 7 CFU/100 mL were detected in the sample from G1192, and 1 CFU/100 mL of fecal coliform bacteria and 1 CFU/100 mL of *E. coli* bacteria were detected in the sample from O7842, exceeding EPA and NYSDOH MCLs for fecal coliform bacteria and *E. coli* bacteria. The heterotrophic plate count ranged from <1 CFU per mL to 2,864 CFU per mL; one sample (G1192) exceeded the EPA MCL for the heterotrophic plate count of 500 CFU/mL.

Wells Sampled in 2008 and 2013

Ten wells sampled in 2013 were previously sampled in 2008 as part of this study. Of the 148 physical properties, organic compounds, and inorganic compounds analyzed for in 2013, 142 were also analyzed for in 2008. It is important to note that the NWQL annually updates the LRLs for all analytes, based on method performance during the previous year of analysis. Therefore, reporting levels and the determination of whether a concentration is considered "estimated" changes annually, and concentrations of compounds could differ between 2008 and 2013. The rules for determining and adjusting LRLs and long-term method detection levels are outlined by the USGS Branch of Quality Systems (U.S. Geological Survey, Branch of Quality Systems, 1999a, b). Results are reported in appendices 2–1 through 2–7.

One of the Chemung River Basin wells sampled in 2013 (well SB1103) was previously sampled in 2008 as part of this study. For well SB1103, there is very little variability between the samples collected in 2008 and in 2013. Pesticides and (or) pesticide degradates, VOCs, and bacteria were not detected in the SB1103 samples collected in 2008 and 2013. Physiochemical properties; concentrations of nutrients, major ions, and trace elements; and radon-222 activities differed slightly or did not differ at all. In both samples, concentrations of iron (in filtered and unfiltered water) and manganese (in filtered and unfiltered water) exceeded drinking-water standards, although concentrations of iron and manganese were slightly lower in 2013 than in 2008 (appendix 2–4).

Three of the Eastern Lake Ontario Basin wells sampled in 2013 (wells J 180, J1118, and OE1991) were sampled previously in 2008. Physiochemical properties; concentrations of nutrients, major ions, and trace elements; and radon-222 activities differed slightly or did not differ at all. One pesticide degradate, CIAT, was detected in the 2008 sample and the 2013 samples for wells J 180 and J1118. In 2008, concentrations of CIAT in samples from J 180 and J1118 were estimated to be 0.003 µg/L; in 2013, concentrations were estimated to be 0.005 µg/L. Two VOCs were detected in samples from two of the wells sampled in 2008 and 2013. In 2008, toluene was detected in the sample from well J1118 at a concentration of 0.1 µg/L, but toluene was not detected (<0.1 µg/L) in the 2013 sample. In 2008, trichloromethane was detected in the sample from well J 180 at a concentration of 0.1 µg/L; trichloromethane was not detected (<0.1 µg/L) in the 2013 sample. Total coliform bacteria and fecal coliform bacteria were detected in the sample from well J1118 in 2013 (200 CFU/100 mL of total coliform and 16 CFU/100 mL of fecal coliform) but were not detected in the 2008 sample. The heterotrophic plate count in the well J1118 sample increased from 8 CFU/mL in 2008 to 54 CFU/mL in 2013.

Six of the Lower Hudson River Basin wells sampled in 2013 (wells CB1674, DU1096, P1218, U1622, RO 560, and RO 853) were sampled previously in 2008 as part of this study. In the sample from well RO 853, pH was much higher in 2013 (10.2) than in 2008 (8.8; appendix 2–1). The pesticide atrazine was detected in the sample from well DU1096 in 2013 at a trace level (0.004 µg/L), but atrazine was not detected (<0.007 µg/L) in 2008. CIAT, a degradate of the pesticide atrazine, was detected in the well P1218 sample at a trace level (E0.003 µg/L) in 2008 but was not detected (<0.010 µg/L) in the 2013 sample (appendix 2–5). For well RO 560, two pesticides, dieldrin and metolachlor, were not detected in the 2008 sample (<0.009 µg/L and <0.010 µg/L, respectively) but were detected in the 2013 sample (0.003 µg/L and 0.005 µg/L, respectively; appendix 2–5). Six VOCs were detected in samples collected from 3 of the 6 wells sampled in 2008 and 2013 (appendix 2–6); all 3 of the wells (P1218, RO 560, and RO 853) had more detections of VOCs in 2008 than in 2013. No additional VOCs were detected in 2013 that were not detected in 2008.

Summary

In a study conducted by the U.S. Geological Survey (USGS), in cooperation with the New York Department of Environmental Conservation, groundwater samples were collected during June, July, and August 2013 from 8 wells in the Chemung River Basin, 15 wells in the Eastern Lake Ontario River Basin, and 25 wells in the Lower Hudson River Basin in order to characterize the overall groundwater quality in each of these basins. Sample collection and analysis followed standard USGS procedures and other documented procedures. Samples were measured for physical properties and concentrations of dissolved gases, major ions, nutrients, trace elements, pesticides, volatile organic compounds (VOCs), radionuclides, and bacteria. Sixty-seven of the 148 constituents analyzed for were not detected at greater than the reporting levels in any of the samples.

The depths of sand-and-gravel wells sampled in the Chemung River Basin were 76 and 80 feet (ft) below land surface; the depths of bedrock wells sampled range from 70 to 204 ft below land surface and are completed in clastic (shale and sandstone) bedrock. Four of the 8 wells sampled are production wells, and 4 are domestic wells. The samples generally had few exceedances of State and (or) Federal drinking-water standards, although concentrations of some constituents—sodium, arsenic, aluminum, iron, manganese, radon-222, total coliform bacteria, and *Escherichia coli* (*E. coli*) bacteria—equaled or exceeded primary, secondary, or proposed drinking-water standards. The constituents most frequently detected in concentrations exceeding drinking-water standards were radon-222 (6 of 8 samples had activities equal to or greater than the U.S. Environmental Protection Agency [EPA] proposed maximum contaminant level [MCL] of 300 picocuries per liter [pCi/L]) and manganese (6 of 8 samples had concentrations of manganese greater than the EPA secondary drinking-water standard of 50 micrograms per liter [µg/L]). The highest radon-222 activities were in samples from wells completed in bedrock.

In the Chemung River Basin, pH was typically near neutral. Methane was detected in 6 of the 8 samples; the action level that recommends monitoring was not exceeded. The water typically was very hard, and the median dissolved solids concentration was 276 milligrams per liter (mg/L). The ions detected in the highest median concentrations were bicarbonate, sulfate, calcium, and sodium. The dominant nutrient was ammonia. Strontium, manganese, iron, and boron were the trace elements with the highest median concentrations. Iron concentrations exceeded drinking-water standards in samples from three wells; the maximum concentration was 1,000 µg/L. Manganese concentrations in six samples exceeded drinking-water standards. Six pesticide and pesticide degradates were detected in one sample; all were trace-level detections. No VOCs were detected in any sample. Radon-222 activities in six samples exceeded a proposed MCL; no samples exceeded the proposed alternative maximum contaminant level (AMCL). Total coliform bacteria were detected in 1 sample, and *E. coli* bacteria were detected in 1 sample.

In the Eastern Lake Ontario Basin the depths of sand-and-gravel wells sampled range from 20 to 236.3 ft below land surface; the bedrock wells that were sampled range from 62 to 700 ft deep and are completed in carbonate, crystalline, or clastic (shale and sandstone) bedrock. Eight of the 15 wells sampled are production wells, and 7 are domestic wells. The samples generally had few exceedances of State and (or) Federal drinking-water standards, although properties and concentrations of some constituents—color, pH, sodium, dissolved solids, fluoride, iron, manganese, uranium, gross-α radioactivity, radon-222, total coliform bacteria, and fecal coliform bacteria—equaled or exceeded primary, secondary, or proposed drinking-water standards in 14 of the 15 wells sampled. The constituent most frequently detected in concentrations exceeding drinking-water standards was radon-222 (10 of 15 samples had activities equal to or greater than the EPA MCL of 300 pCi/L). The three highest radon-222 activities (each over 1,000 pCi/L, maximum radon-222 activity of 15,400 pCi/L) were in samples from wells completed in crystalline or carbonate bedrock.

In the Eastern Lake Ontario Basin, sample pH was typically near neutral. Methane was detected in 5 of the 15 samples; the action level was not exceeded. The water varied in hardness, and the median dissolved solids concentration was 220 mg/L. The ions detected in the highest median concentrations were bicarbonate, calcium, sodium, and chloride. The dominant nutrient was nitrate; concentrations of nitrate and nitrite did not exceed established drinking-water standards. Strontium, iron, and barium were the trace elements with the highest median concentrations. Iron concentrations exceeded drinking-water standards in samples from five wells; the concentration of iron (in unfiltered water) was greater than 1,000 µg/L in samples from two wells. Manganese concentrations in two samples exceeded drinking-water standards. Eight pesticides and pesticide degradates were detected in seven samples; all were trace-level detections. Three VOCs were detected in three samples. Radon-222 activities in 10 samples exceeded a proposed MCL and in 1 sample exceeded the proposed AMCL. Total coliform bacteria were detected in 3 samples, and fecal coliform bacteria were detected in 1 sample.

In the Lower Hudson River Basin, the depths of sand-and-gravel wells sampled range from 40 to 165 ft below land surface; the bedrock wells that were sampled range in depth from 100 to 575 ft below land surface and are completed in clastic (shale and sandstone), carbonate, or crystalline bedrock. Twelve of the 25 wells sampled are production wells, and 13 are domestic wells. The samples generally had few exceedances of State and (or) Federal drinking-water standards, although properties and concentrations of some constituents—pH, sodium, chloride, dissolved solids, arsenic, aluminum, iron, manganese, radon-222, total coliform bacteria, fecal coliform bacteria, *E. coli* bacteria, and heterotrophic plate count—equaled or exceeded primary, secondary, or proposed drinking-water standards. The constituent most frequently detected in concentrations exceeding drinking-water standards was radon-222 (20 out of 25 samples had activities equal to or greater than the EPA proposed MCL of 300 pCi/L; activity in one sample exceeded the EPA proposed AMCL of 4,000 pCi/L). The highest radon-222 activities (over 1,000 pCi/L) were in samples from wells completed in crystalline or carbonate bedrock.

In the Lower Hudson River Basin, sample pH was typically near neutral or slightly basic. One well, RO 853, had a sample pH of 10.2. Methane was detected in 9 of the 25 samples; 2 samples had a methane concentration greater than 28 mg/L, which is above the action level that indicates potential explosion hazard and recommends monitoring. The water typically was very hard, and the median dissolved solids concentration was 243 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, iron, barium, and manganese were the trace elements with the highest median concentrations. Iron concentrations exceeded drinking-water standards and were even greater than 1,000 µg/L (in unfiltered water) in samples from four wells. Manganese concentrations in six samples exceeded drinking-water standards. Seven pesticide and pesticide degradates were detected in seven samples; all were trace-level detections. Five VOCs were detected in seven samples. Total coliform bacteria were detected in four samples. Fecal coliform and *E. coli* bacteria were detected in two samples.

References Cited

American Public Health Association, 1998, Standard methods for the examination of water and wastewater (20th ed.): Washington, D.C., American Public Health Association, American Water Works Association, and Water Environment Federation [variously paged].

ASTM International, 2006, D5072-98(2006), Standard test method for radon in drinking water: ASTM International, accessed December 28, 2006, at http://www.astm.org.

Broughton, J.G., Fisher, D.W., Isachsen, Y.W., Rickard, L.V., and Offield, T.W., 1962, The geology of New York State: Albany, N.Y., New York State Museum—Geological Survey, Map and Chart Series no. 5, 5 sheets, scale 1:250,000.

Bugliosi, E.F., and Trudell, R.A., 1988, Potential yields of wells in unconsolidated aquifers in upstate New York—Adirondack Sheet: U.S. Geological Survey Water-Resources Investigations Report 87–4276, 1 sheet, 1:250,000 scale.

Bugliosi, E.F., Trudell, R.A., and Casey, G.D., 1988, Potential yields of wells in unconsolidated aquifers in upstate New York–Hudson-Mohawk Sheet: U.S. Geological Survey Water-Resources Investigations Report 87–4275, 1 sheet, 1:250,000 scale.

Busenberg, E., Plummer, L.N., Bartholomay, R.C., and Wayland, J.E., 1998, Chlorofluorocarbons, sulfur hexafluoride, and dissolved permanent gases in ground water from selected sites in and near the Idaho National Engineering and Environmental Laboratory, Idaho, 1994–97: U.S. Geological Survey Open-File Report 98–274, 72 p.

Butch, G.K., Murray, P.M., Hebert, G.J., and Weigel, J.F., 2003, Water resources data, New York, water year 2002: U.S. Geological Survey Water-Data Report NY-02-1, p. 502–520.

Cadwell, D.H., 1999, Surficial geologic map of New York: New York State Museum Map and Chart Series no. 40, scale 1:250,000.

Childress, C.J.O., Foreman, 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.

Coates, D.R., 1966, Glaciated Appalachian Plateau—Till shadows on hills: Science, v. 152, p. 1617–1619.

Connor, B.F., Rose, D.L., Noriega, M.C., Murtagh, L.K., and Abney, S.R., 1998, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of 86 volatile organic compounds in water by gas chromatography/mass spectrometry, including detections less than reporting limits: U.S. Geological Survey Open-File Report 97–829, 78 p., accessed February 27, 2014, at http://nwql.usgs.gov/Public/rpt.shtml?OFR-97-829.

Eckhardt, D.A., Reddy, J.E., and Shaw, S.B., 2009, Groundwater quality in central New York, 2007: U.S. Geological Survey Open-File Report 2009–1257, 40 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2009/1257/.

Eckhardt, D.A., Reddy, J.E., and Tamulonis, K.L., 2007, Ground-water quality in the Genesee River Basin, New York, 2005–06: U.S. Geological Survey Open-File Report 2007–1093, 26 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2007/1093/.

Eckhardt, D.A., Reddy, J.E., and Tamulonis, K.L., 2008, Ground-water quality in western New York, 2006: U.S. Geological Survey Open-File Report 2008–1140, 36 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2008/1140/.

Eltschlager, K.K., Hawkins, J.W., Ehler, W.C., and Baldassare, F.B., 2001, Technical measures for the investigation and mitigation of fugitive methane hazards in areas of coal mining: Pittsburgh, Pa., U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement, 124 p.

Fairchild, H.L., 1928, Geologic story of the Genesee Valley and drainage history of central New York: Rochester, Gas and Electric News, July 1926 to July 1928.

Fisher, D.W., Isachsen, Y.W., and Rickard, L.V., 1970, Geologic map of New York State: New York State Museum Map and Chart Series no. 15, scale 1:250,000.

Fishman, M.J., ed., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of inorganic and organic constituents in water and fluvial sediments: U.S. Geological Survey Open-File Report 93–125, 217 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/1993/0125/report.pdf.

Fishman, M.J., and Friedman, L.C., ed., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p., accessed February 27, 2014, at http://pubs.usgs.gov/twri/twri5-a1/html/pdf.html.

Furlong, E.T., Anderson, B.D., Werner, S.L., Soliven, P.P., Coffey, L.J., and Burkhardt, M.R., 2001, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of pesticides in water by graphitized carbon-based solid-phase extraction and high-performance liquid chromatography/mass spectrometry: U.S. Geological Survey Water-Resources Investigations Report 01–4134, 73 p., accessed February 27, 2014, at http://nwql.usgs.gov/WRIR-01-4134.shtml.

Garbarino, J.R., and Damrau, D.L., 2001, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of organic plus inorganic mercury in filtered and unfiltered natural water with cold vapor-atomic fluorescence spectrometry: U.S. Geological Survey Water-Resources Investigations Report 01–4132, 16 p., accessed February 27, 2014, at http://nwql.usgs.gov/WRIR-01-4132.shtml.

Garbarino, J.R., Kanagy, L.K., and Cree, M.E., 2006, Determination of elements in natural-water, biota, sediment and soil samples using collision/reaction cell inductively coupled plasma-mass spectrometry: U.S. Geological Survey Techniques and Methods, book 5, chap. B1, 88 p., accessed February 27, 2014, at http://pubs.usgs.gov/tm/2006/tm5b1/.

Garbarino, J.R., and Struzeski, T.M., 1998, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of elements in whole-water digests using inductively coupled plasma-optical emission spectrometry and inductively coupled plasma-mass spectrometry: U.S. Geological Survey Open-File Report 98–165, 101 p., accessed February 27, 2014, at http://nwql.usgs.gov/OFR-98-165.shtml.

Hammond, D.S., Heath, R.C., and Waller, R.M., 1978, Ground-water data on the Hudson River Basin, New York: U. S. Geological Survey Open File Report 78–710, 18 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/1978/0710/report.pdf.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water (3d ed.): U.S. Geological Survey Water-Supply Paper 2254, 264 p.

Hetcher-Aguila, K.K., 2005, Ground-water quality in the Chemung River Basin, New York, 2003: U.S. Geological Survey Open-File Report 2004–1329, 19 p., accessed February 27, 2014, at http://ny.water.usgs.gov/pubs/of/of041329/.

Hetcher-Aguila, K.K., and Eckhardt, D.A., 2006, Ground-water quality in the upper Susquehanna River Basin, New York, 2004: U.S. Geological Survey Open-File Report 2006–1161, 21 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2006/1161/.

Hoffman, G.L., Fishman, M.J., and Garbarino, J.R., 1996, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—In-bottle acid digestion of whole-water samples: U.S. Geological Survey Open-File Report 96–225, 28 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/1996/0225/report.pdf.

Isachsen, Y.W., Landing, E., Lauber, J.M., Rickard, L.V., and Rogers, W.B., eds., 2000, Geology of New York—A simplified account (2d ed.): Albany, N.Y., New York State Museum/Geological Survey, 294 p.

Kenny, J.F., Barber, N.L., Hutson, S.S., Linsey, K.S., Lovelace, J.K., and Maupin, M.A., 2009, Estimated use of water in the United States in 2005: U.S. Geological Survey Circular 1344, 52 p.

Kontis, A.L., Randall, A.D., and Mazzaferro, D.L., 2004, Regional hydrology and simulation of flow of stratified-drift aquifers in the glaciated northeastern United States: U.S. Geological Survey Professional Paper 1415–C, 156 p.

Miller, T.S., 1982, Geology and ground-water resources of Oswego County, New York: U.S. Geological Survey Water-Resources Investigations Report 81–60, 37 p.

Miller, T.S., 1988, Unconsolidated aquifers in upstate New York – Finger Lakes sheet: U.S. Geological Survey Water-Resources Investigations Report 87–4122, 1 sheet, scale 1:250,000.

Miller, T.S., 1990, sand-and-gravel aquifers of Schuyler County, New York: U.S. Geological Survey Water-Resources Investigations Report 90–4073, 1 sheet, scale 1:48,000.

Miller, T.S., Sherwood, D.A., and Krebs, M.M., 1989, Hydrogeology and water quality of the Tug Hill Glacial Aquifer in northern New York: U. S. Geological Survey Water-Resources Investigations Report 88–4014, 60 p.

New York State Department of Health, 2011, New York State Health Department public water systems regulations: Albany, N.Y. [variously paged], accessed February 27, 2014, at http://www.health.ny.gov/regulations/nycrr/title_10/part_5/subpart_5-1_tables.htm.

Nystrom, E.A., 2006, Ground-water quality in the Lake Champlain Basin, New York, 2004: U.S. Geological Survey Open-File Report 2006–1088, 22 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2006/1088/.

Nystrom, E.A., 2007a, Ground-water quality in the St. Lawrence River Basin, New York, 2005–06: U.S. Geological Survey Open-File Report 2007–1066, 33 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2007/1066/.

Nystrom, E.A., 2007b, Ground-water quality in the Delaware River Basin, New York, 2001 and 2005–06: U.S. Geological Survey Open-File Report 2007–1098, 36 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2007/1098/.

Nystrom, E.A., 2008, Ground-water quality in the Mohawk River Basin, New York, 2006: U.S. Geological Survey Open-File Report 2008–1086, 33 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2008/1086/.

Nystrom, E.A., 2009, Groundwater quality in the Upper Hudson River Basin, New York, 2007: U.S. Geological Survey Open-File Report 2009–1240, 37 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2009/1240/.

Nystrom, E.A., 2010, Groundwater quality in the Lower Hudson River Basin, New York, 2008: U.S. Geological Survey Open-File Report 2010–1197, 39 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2010/1197/.

Nystrom, E.A., 2011, Groundwater quality in the Lake Champlain Basin, New York, 2009: U.S. Geological Survey Open-File Report 2011–1180, 42 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2011/1180/.

Nystrom, E.A., 2012, Groundwater quality in the Delaware and St. Lawrence River Basins, New York, 2010: U.S. Geological Survey Open-File Report 2011–1320, 58 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2011/1320/.

Nystrom, E.A., and Scott, T., 2013, Groundwater quality in the Mohawk River Basin, New York, 2011: U.S. Geological Survey Open-File Report 2013–1021, 43 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2013/1021/.

Patton, C.J., and Truitt, E.P., 2000, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of ammonium plus organic nitrogen by a Kjeldahl digestion method and an automated photometric finish that includes digest cleanup by gas diffusion: U.S. Geological Survey Open-File Report 00–170, 31 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2000/0170/report.pdf.

Randall, A.D., 1996, Mean annual runoff, precipitation, and evapotranspiration in the glaciated northeastern United States, 1951–80: U.S. Geological Survey Open-File Report 96–395, 2 pl., 1:250,000.

Randall, A.D., 2001, Hydrogeologic framework of stratified-drift aquifers in the glaciated Northeastern United States: U.S. Geological Survey Professional Paper 1415–B, 179 p.

Reddy, J.E., 2012, Groundwater quality in the Genesee River Basin, 2010: U.S. Geological Survey Open-File Report 2012–1135, 29 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2012/1135/.

Reddy, J.E., 2013, Groundwater quality in western New York, 2011: U.S. Geological Survey Open-File Report 2013–1095, 28 p., accessed March 10, 2014 at http://pubs.usgs.gov/of/2013/1095/.

Reddy, J.E., 2014, Groundwater quality in central New York, 2012: U.S. Geological Survey Open-File Report 2014–1226, 13p., accessed March 9, 2015, at http://pubs.usgs.gov/of/2014/1226/.

Reddy, J.E., and Risen, A.J., 2012, Groundwater quality in the Upper Susquehanna River Basin, 2009: U.S. Geological Survey Open-File Report 2012–1045, 30 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2012/1045/.

Risen, A.J., and Reddy, J.E., 2011a, Groundwater quality in the Chemung River Basin, 2008: U.S. Geological Survey Open-File Report 2011–1112, 25 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2011/1112/.

Risen, A.J., and Reddy, J.E., 2011b, Groundwater quality in the Eastern Lake Ontario Basin New York, 2008: U.S. Geological Survey Open-File Report 2011–1074, 32 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/2011/1074/.

Sandstrom, M.W., Stroppel, M.E., Foreman, W.T., and Schroeder, M.P., 2001, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of moderate-use pesticides and selected degradates in water by C-18 solid-phase extraction and gas chromatography/mass spectrometry: U.S. Geological Survey Water-Resources Investigations Report 01–4098, 70 p., accessed February 27, 2014, at http://nwql.usgs.gov/Public/WRIR-01-4098.shtml.

Scott, T., and Nystrom, E.A., 2014, Groundwater Quality in the Upper Hudson River Basin, 2012: U.S. Geological Survey Open-File Report 2014–1084, 21 p., accessed, September 8, 2014, at http://pubs.usgs.gov/of/2014/1084/.

Struzeski, T.M., DeGiacomo, W.J., and Zayhowski, E.J., 1996, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of dissolved aluminum and boron in water by inductively coupled plasma-atomic emission spectrometry: U.S. Geological Survey Open-File Report 96–149, 17 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/1996/0149/report.pdf.

U.S. Environmental Protection Agency, 1980, Prescribed procedures for measurement of radioactivity in drinking water: EPA 600/4-80-032, accessed February 27, 2014, at http://water.epa.gov/scitech/methods/cwa/bioindicators/upload/2007_07_10_methods_method_900_0.pdf.

U.S. Environmental Protection Agency, 1997, Guidelines for preparation of the comprehensive state water quality assessments (305(b) Reports) and electronic updates: Washington, D.C., U.S. Environmental Protection Agency, Office of Water, EPA 841-B-97-002A and EPA 841-B-97-002B, PL95-217, 271 p.

U.S. Environmental Protection Agency, 1999, Proposed radon in drinking water rule: Washington, D.C., U.S. Environmental Protection Agency, Office of Water, EPA 815-F-99-006, 6 p.

U.S. Environmental Protection Agency, 2009a, Brewster Well Field Site Description: U.S. Environmental Protection Agency, Region 2, available online at http://www.epa.gov/region02/superfund/npl/0202153c.pdf.

U.S. Environmental Protection Agency, 2009b, National primary drinking water standards and national secondary drinking water standards: Washington, D.C., U.S. Environmental Protection Agency, Office of Water, EPA 816-F-09-0004, 6 p., accessed February 27, 2014, at http://www.epa.gov/safewater/consumer/pdf/mcl.pdf.

U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resource Investigations, book 9, chaps. A1–A9 [variously paged]. [Also available online at http://pubs.water.usgs.gov/twri9A.]

U.S. Geological Survey, 2006, Collection of water samples (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A4, September, accessed February 27, 2014, at http://pubs.water.usgs.gov/twri9A4/.

U.S. Geological Survey, Branch of Quality Systems, 1999a, Long-term method detection levels (LT-MDL) for the U.S. Geological Survey, National Water Quality Laboratory–Definitions, accessed March 9, 2015, at http://bqs.usgs.gov/ltmdl/definition.shtml.

U.S. Geological Survey, Branch of Quality Systems, 1999b, Long-term method detection levels (LT-MDL) for the U.S. Geological Survey, National Water Quality Laboratory–Calculations, accessed March 9, 2015, at http://bqs.usgs.gov/ltmdl/calculation.shtml.

Vogelmann, J.E., Howard, S.M., Yang, L., Larson, C.R., Wylie, B.K., and Van Driel, J.N., 2001, Completion of the 1990's National Land Cover Data Set for the conterminous United States: Photogrammetric Engineering and Remote Sensing, v. 67, p. 650–662.

Waller, R.M., and Ayer, G.R., 1975, Water resources of the Black River Basin, New York: U.S. Geological Survey in cooperation with New York State Department of Environmental Conservation. Basin Planning Report BRB–1, 205 p.

Wilde, F.D., Radtke, D.B., Gibs, Jacob, and Iwatsubo, R.T., eds., 2004 with updates through 2009, Processing of water samples (version 2.2): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A5, April, accessed February 27, 2014, at http://pubs.water.usgs.gov/twri9A5/.

Zarriello, P.J., 1993, Determination of the contributing area to six municipal groundwater supplies in the Tug Hill glacial aquifer of northern New York, with emphasis on the Lacona-Sandy Creek well field: U.S. Geological Survey Water-Resources Investigations Report 90–4145, 51 p.

Zaugg, S.D., Sandstrom, M.W., Smith, S.G., and Fehlberg, K.M., 1995, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of pesticides in water by C-18 solid-phase extraction and capillary-column gas chromatography/mass spectrometry with selected-ion monitoring: U.S. Geological Survey Open-File Report 95–181, 60 p., accessed February 27, 2014, at http://pubs.usgs.gov/of/1995/0181/report.pdf.

Appendixes

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Appendix 1. Results of Water-Sample Analyses, 2013

Appendix 2. Results of Water-Sample Analyses, 2008 and 2013

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