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Groundwater Quality in the Lake Champlain Basin, New York, 2009

Open-File Report 2011–1180

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

Cover. View of Lake Champlain from the west shore of the lake

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By Elizabeth A. Nystrom

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

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
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Conversion Factors, Datums, and Acronyms

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	0.004047	square kilometer (km^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
liter (L)	0.2642	gallon (gal)
	Flow rate	
gallon per minute (gal/min)	0.06309	liter per second (L/s)
	Pressure	
inch of mercury at 60ºF (in Hg)	3.377	kilopascal (kPa)
	Radioactivity	
picocurie per liter (pCi/L)	0.037	becquerel per liter (Bq/L)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F=(1.8×°C)+32
Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:
°C=(°F-32)/1.8
Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).
Elevation, as used in this report, refers to distance above the vertical datum.
Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C).
Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).
Radon-222 activities are given in picocuries per liter (pCi/L).

Acronyms used in this report

AMCL	Alternative maximum contaminant level
CFCL	USGS Chlorofluorocarbon Laboratory
CFU	Colony-forming units
CIAT	2-Chloro-4-isopropylamino-6-amino-*s*-triazine
cICP-MS	Collision/reaction cell inductively coupled plasma-mass spectrometry
E. coli	*Escherichia coli*
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
NWQL	USGS National Water Quality Laboratory
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
PVC	Polyvinyl chloride
RIBS	Rotating Integrated Basin Studies
SDWS	Secondary drinking-water standards
THM	Trihalomethane
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile organic compound

Groundwater Quality in the Lake Champlain Basin, New York, 2009

By Elizabeth A. Nystrom

Abstract

Water was sampled from 20 production and domestic wells from August through November 2009 to characterize groundwater quality in the Lake Champlain Basin in New York. Of the 20 wells sampled, 8 were completed in sand and gravel, and 12 were completed in bedrock. The samples were collected and processed by standard U.S. Geological Survey procedures and were analyzed for 147 physiochemical properties and constituents, including major ions, nutrients, trace elements, pesticides, volatile organic compounds (VOCs), radionuclides, and indicator bacteria.

Water quality in the study area is generally good, but concentrations of some constituents equaled or exceeded current or proposed Federal or New York State drinking-water standards; these were color (1 sample), pH (3 samples), sodium (3 samples), total dissolved solids (4 samples), iron (4 samples), manganese (3 samples), gross alpha radioactivity (1 sample), radon-222 (10 samples), and bacteria (5 samples). The pH of all samples was typically neutral or slightly basic (median 7.1); the median water temperature was 9.7°C. The ions with the highest median concentrations were bicarbonate [median 158 milligrams per liter (mg/L)] and calcium (median 45.5 mg/L). Groundwater in the study area is soft to very hard, but more samples were hard or very hard (121 mg/L or more as $CaCO_3$) than were moderately hard or soft (120 mg/L or less as $CaCO_3$); the median hardness was 180 mg/L as $CaCO_3$. The maximum concentration of nitrate plus nitrite was 3.79 mg/L as nitrogen, which did not exceed established drinking-water standards for nitrate plus nitrite (10 mg/L as nitrogen). The trace elements with the highest median concentrations were strontium (median 202 micrograms per liter [µg/L]), and iron (median 55 µg/L in unfiltered water). Six pesticides and pesticide degradates, including atrazine, fipronil, disulfoton, prometon, and two pesticide degradates, CIAT and desulfinylfipronil, were detected among five samples at concentrations of 0.02 µg/L or less; they included herbicides, herbicide degradates, insecticides, and insecticide degradates. Six VOCs were detected among six samples; these included a solvent, the gasoline additive methyl *tert*-butyl ether (MTBE), and four trihalomethanes. The highest radon-222 activities were in samples from crystalline bedrock wells (maximum 4,100 picocuries per liter [pCi/L]); half of all samples exceeded a proposed U.S. Environmental Protection Agency (USEPA) drinking-water standard of 300 pCi/L. Total coliform bacteria were detected in five samples, fecal coliform bacteria were detected in one sample, and *Escherichia coli* (*E. coli*) were not detected in any sample.

Introduction

The Federal Clean Water Act Amendments of 1977 require biennial reports from states on the chemical quality of surface water and groundwater within their boundaries (U.S. Environmental Protection Agency, 1997). 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 USGS 305(b) water-quality monitoring program parallels the NYSDEC Rotating Integrated Basin Studies program (RIBS), which evaluates surface-water quality in 2 or 3 of the 14 major river basins in the State each year. The groundwater-quality program began in 2002 with a pilot study in the Mohawk River Basin and has continued throughout upstate New York since then (table 1). Sampling completed in 2008 represented the conclusion of a first round of groundwater-quality sampling throughout New York State (excluding Long Island, which is monitored through local County programs). Groundwater-quality sampling was conducted in 2009 in the Lake Champlain Basin and the Susquehanna River Basin; these basins also were sampled in 2004 as part of this study.

Table 1. Previous USGS 305(b) groundwater-quality sampling and reports.

Study Area	Year	USGS 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

Purpose and Scope

This report presents the findings of the 2009 study in the Lake Champlain Basin, in which 20 groundwater-quality samples were collected from August through November 2009. This report (1) describes the hydrogeologic setting and the methods of site selection, sample collection, and chemical analysis, (2) discusses the analytical results for physiochemical properties and concentrations of major ions, nutrients, trace elements and radionuclides, pesticides, volatile organic compounds (VOCs), and indicator bacteria, and (3) compares the results of this study to results at selected wells that were sampled in 2004 (Nystrom, 2006). Information about the sampled wells and results of the analyses are presented.

Hydrogeologic Setting

The Lake Champlain Basin encompasses 8,250 mi^2 in New York, Vermont, and Quebec, Canada. This study addressed the 3,050-mi^2 part of the Lake Champlain Basin that lies within New York (hereafter referred to as the “study area”; fig. 1). The study area contains parts of five counties, including Clinton, Essex, Franklin, Warren, and Washington Counties (fig. 1). Major tributaries to Lake Champlain in New York include the Ausable River, Saranac River, Great Chazy River, Boquet River, La Chute, and the Mettawee River; large lakes in the Basin include Lake Champlain and Lake George. The Champlain Canal connects Lake Champlain to the Hudson River at Fort Edward.

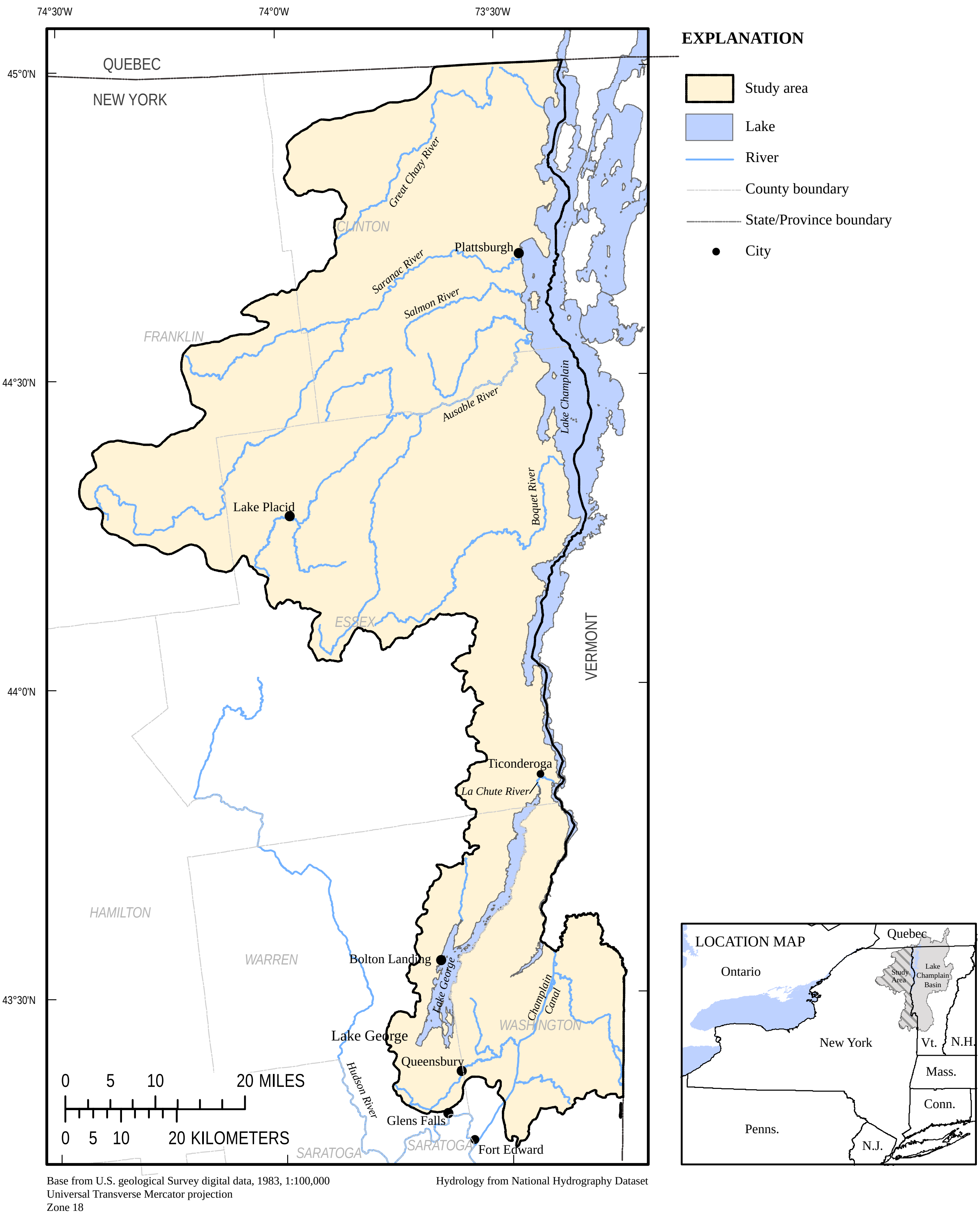


Figure 1. Principal hydrologic and geographic features of the Lake Champlain Basin in New York.

The highest elevations in the study area are more than 5,000 ft above sea level (the North American Vertical Datum of 1988 [NAVD 88] along the western edge of the basin, in the Adirondack Mountains (fig. 2); the lowest elevations in the basin occur at Lake Champlain (about 100 ft above NAVD 88). The study area is predominantly forested, especially in upland areas, with urban and agricultural uses mainly in valleys and other low-lying areas (Vogelmann and others, 2001) (fig. 3). Urban centers and adjacent developed areas in the study area include Glens Falls, Queensbury, and Plattsburgh (fig. 1).

Bedrock in the study area (fig. 4) is mainly crystalline rock with smaller areas of carbonate rock, sandstone, shale, and other rocks. The Adirondack Mountains are underlain mainly by crystalline metamorphic rock, including granitic gneiss, metanorthosite, and olivine metagabbro (Isachsen and others, 2000). The Champlain and St. Lawrence Valleys are underlain by sandstone, carbonate rocks (including limestone and dolostone), shale, and other metamorphic clastic rocks (Isachsen and others, 2000). Yields from bedrock wells in the study area vary greatly, but the carbonate units generally produce the greatest yields, and the crystalline units generally produce the smallest (Giese and Hobba, 1970).

The surficial material throughout the study area was deposited primarily during the Pleistocene epoch when the Wisconsin glaciers covered most of the Northeast (Isachsen and others, 2000). Till was deposited by glaciers over most of the study area (fig. 5); alluvial, outwash, and ice-contact sand and gravel deposits occur mainly in valleys. Glacial till generally yields low amounts of water, whereas sand and gravel deposits can form the most productive aquifers in the study area (Giese and Hobba, 1970).

Methods of Investigation

The methods used in this study, including (1) well-selection criteria, (2) sampling methods, and (3) analytical methods, were designed to maximize data precision, accuracy, and comparability. Groundwater-sample collection and processing followed standard USGS procedures as documented in the National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, variously dated). Samples were analyzed by documented methods at the USGS National Water Quality Laboratory (NWQL) in Denver, CO; the USGS Chlorofluorocarbon Laboratory (CFCL) in Reston, VA; Eberline Services in Richmond, CA; and a New York State Department of Health (NYSDOH)-certified laboratory.

Well Selection

Wells were selected to provide adequate spatial coverage of the study area; areas of greatest groundwater use were emphasized. 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 20 wells selected for sampling represent forested, developed, and agricultural areas (fig. 3). The characteristics of the wells sampled and the type of land cover surrounding each well are listed in table 2. The depths of the wells, the geologic units from which samples were collected, and the numbers of production and domestic wells are summarized in table 3. Four wells sampled in 2009 (CL149, EX155, EX535, and W534) were also sampled in 2004 (Nystrom, 2006).

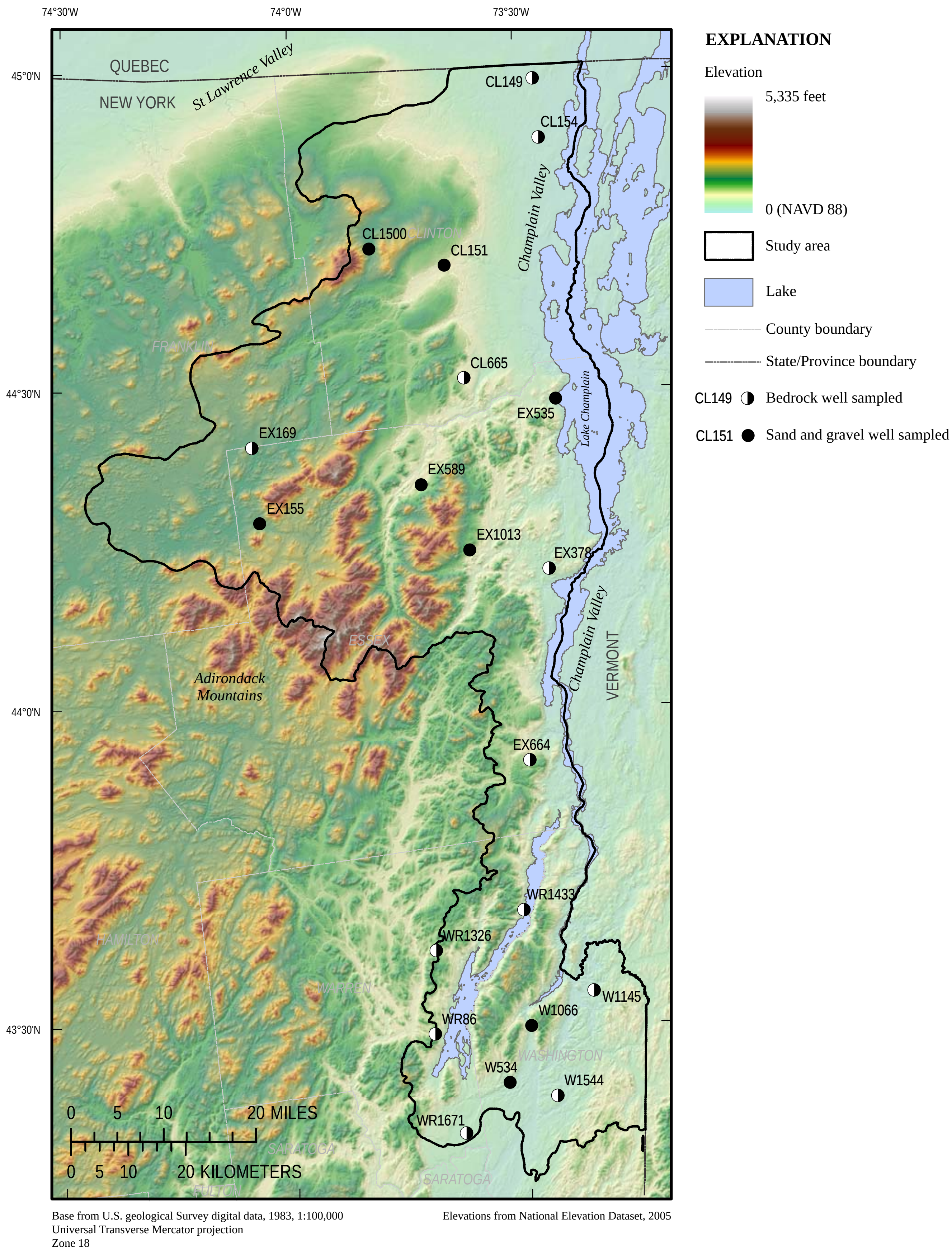


Figure 2. Topography of the Lake Champlain Basin in New York, and locations of wells sampled in 2009.

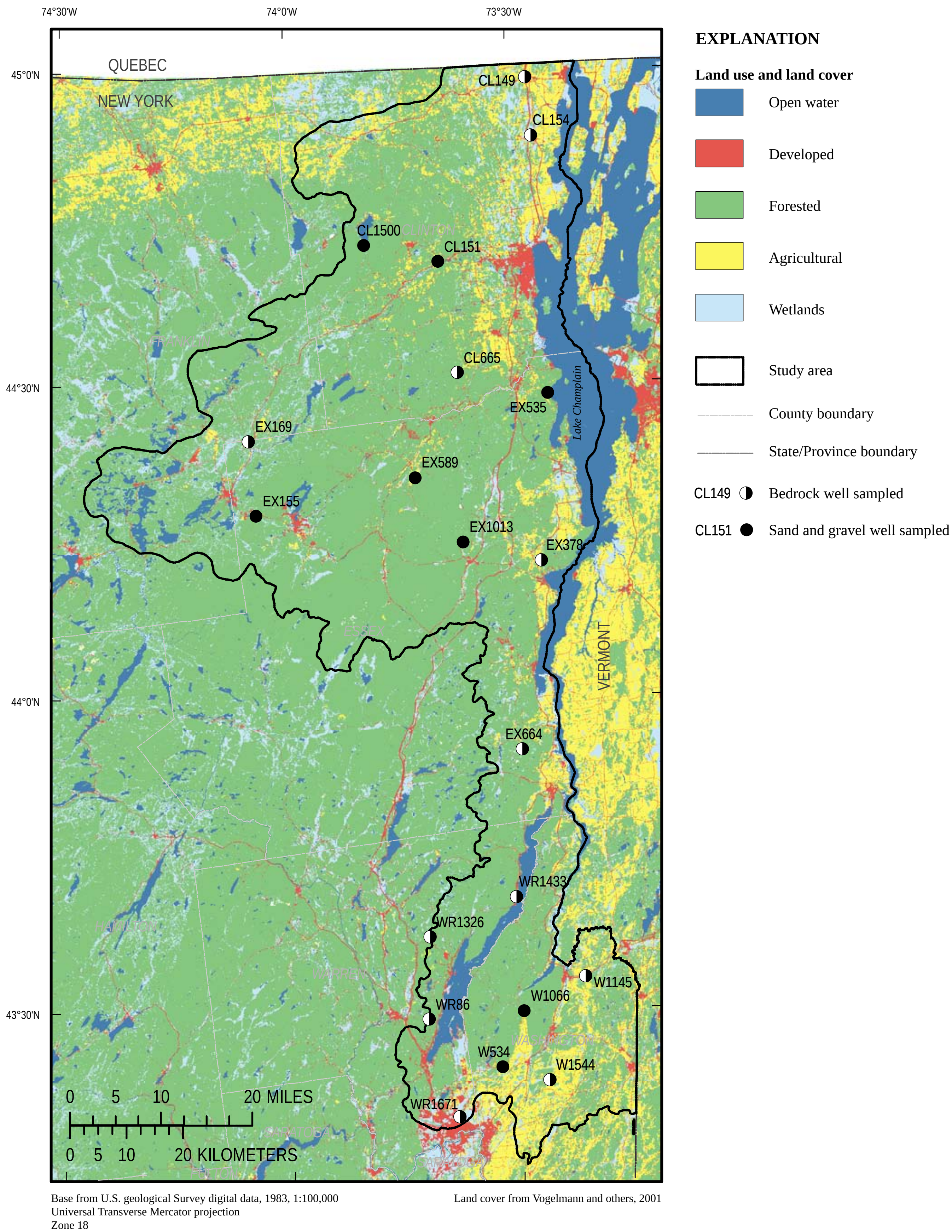
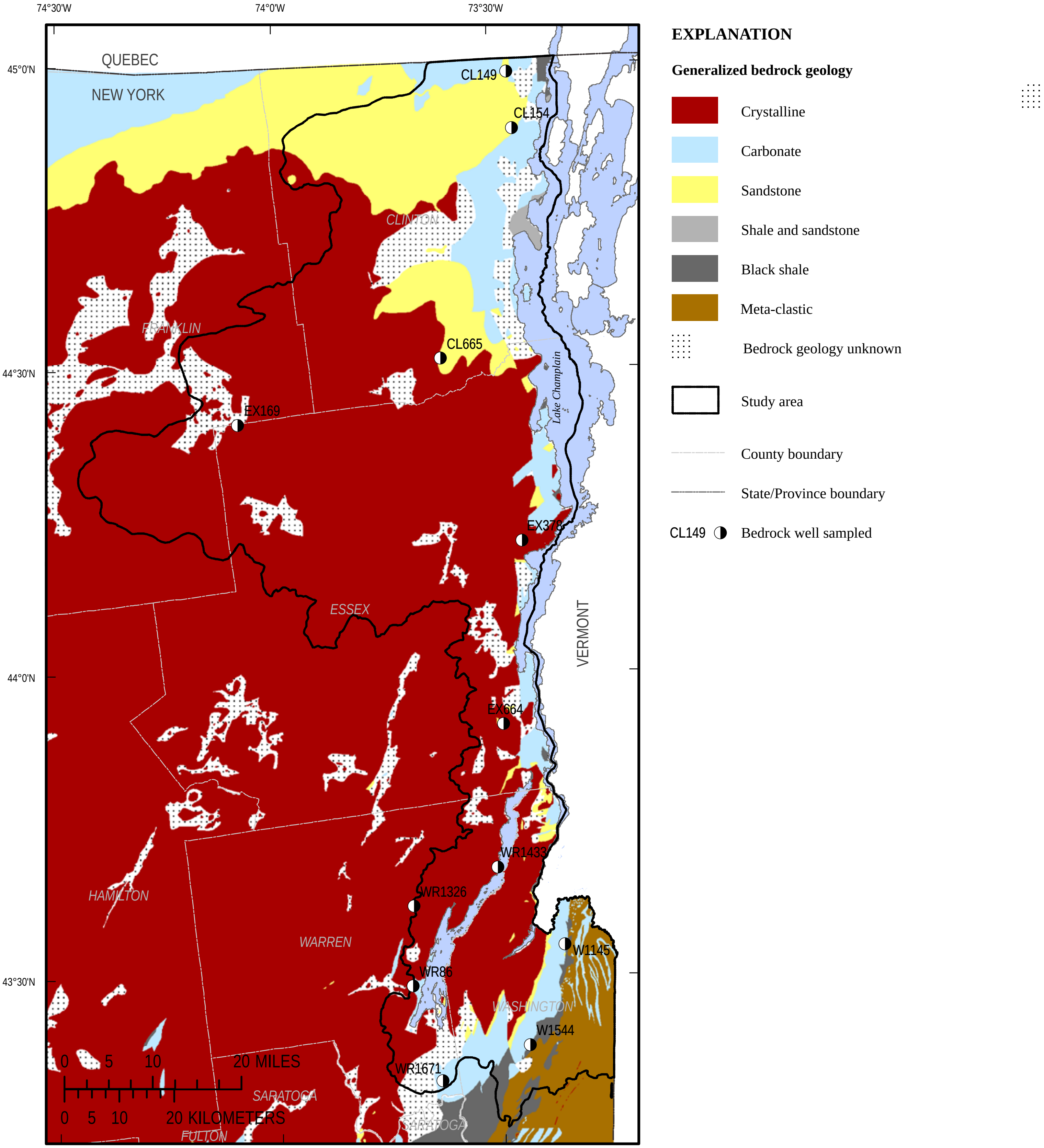


Figure 3. Land use and land cover of the Lake Champlain Basin in New York, and locations of wells sampled in 2009.



Base from U.S. geological Survey digital data, 1983, 1:100,000
Universal Transverse Mercator projection
Zone 18

Geology modified from Fisher and others, 1970

Figure 4. Generalized bedrock geology of the Lake Champlain Basin in New York, and locations of bedrock wells sampled in 2009.

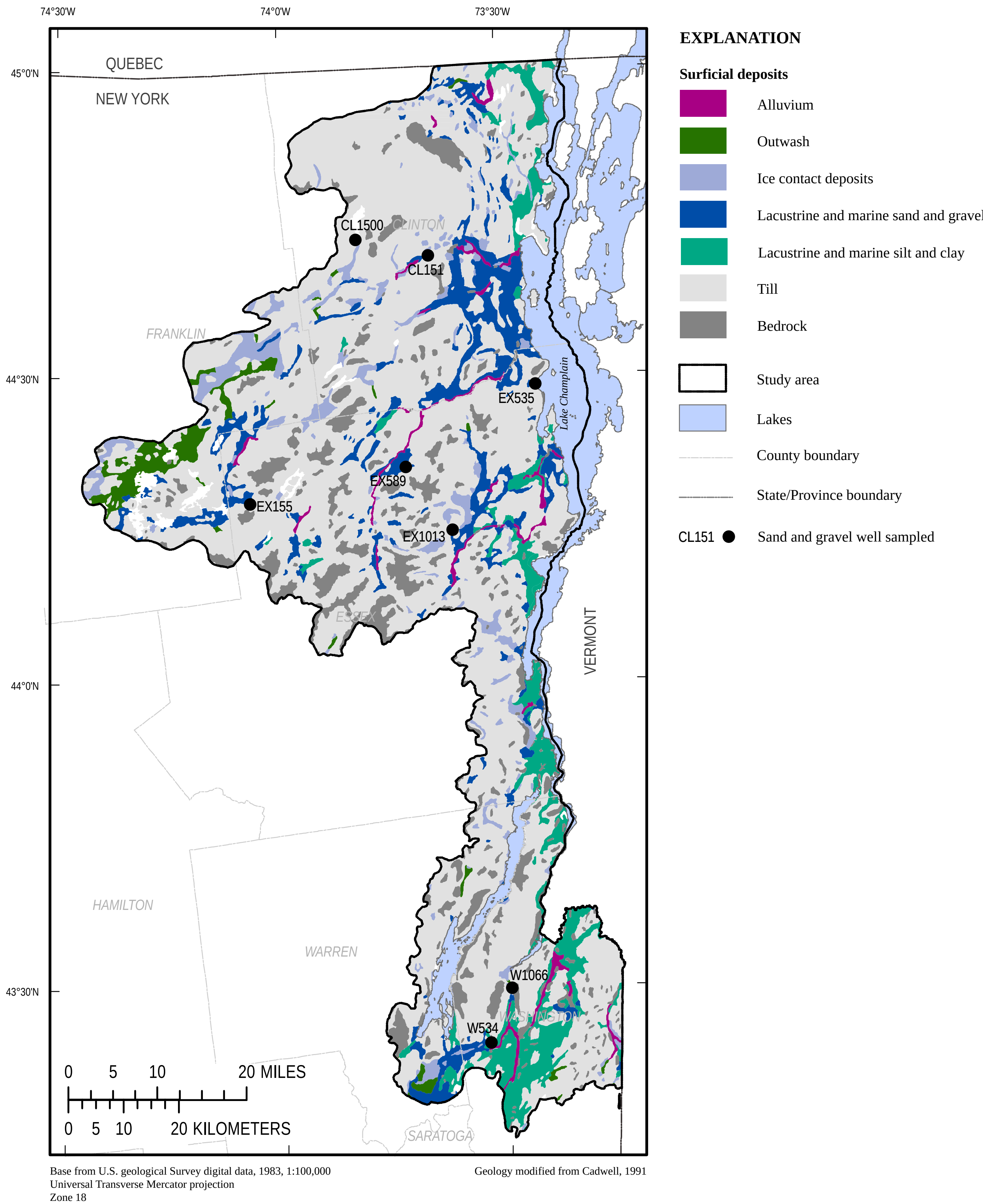


Figure 5. Generalized surficial geology of the Lake Champlain Basin in New York, and locations of sand and gravel wells sampled in 2009.

Table 2. Information on wells from which water samples were collected in the Lake Champlain Basin, New York, 2009.

[--, 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 figure 2.]

Well number[1]	Date sampled	Well depth, feet below land surface	Casing depth, feet below land surface	Well type	Bedrock type	Land cover[2], percentage by category, within 0.5-mile radius surrounding the well: D	F	A	W	WL
Sand and gravel wells										
CL151	8/27/2009	78	--	P		17	68	5	7	2
CL1500	9/29/2009	125	125	D		4	57		36	4
EX155	8/31/2009	57	--	P		7	57	10	5	21
EX535	9/2/2009	128	128	P		12	45	4	37	2
EX589	9/21/2009	67.1	55	P		4	72	7		17
EX1013	10/19/2009	154	130	D		4	84			13
W534	9/15/2009	140	--	P		8	31	52		8
W1066	9/22/2009	147	147	D		3	68	27		2
Bedrock wells										
CL149	10/5/2009	137	--	P	Sandstone	55	8	30		6
CL154	9/16/2009	--	--	P	Carbonate	20	18	10		52
CL665	10/20/2009	225	56	D	Sandstone	4	96			
EX169	9/28/2009	300	--	P	Crystalline	26	58	1		15
EX378	10/21/2009	400	20	D	Crystalline	3	38	57		3
EX664	9/30/2009	460	37	D	Crystalline	3	87	1	2	8
W1145	10/28/2009	385	38	D	Shale	13	21	61		5
W1544	9/15/2009	300	20	D	Carbonate	5	33	59		4
WR86	11/4/2009	198	--	P	Crystalline	6	94			
WR1326	9/14/2009	265	20	D	Crystalline	3	85		2	9
WR1433	8/26/2009	600	28	D	Crystalline	10	36		51	3
WR1671	9/14/2009	540	40	P	Carbonate	57	9			33

[1] CL, Clinton County; EX, Essex County; W, Washington County; WR, Warren County.

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

Table 3. Summary of information on wells from which water samples were collected in the Lake Champlain Basin, New York, 2009.

Type of Well		Number of wells: Production	Domestic	Total
Wells completed in sand and gravel	(57 to 154 feet deep)	5	3	8
Wells completed in bedrock	(137 to 600 feet deep)	5	7	12
Carbonate bedrock		2	1	3
Shale bedrock		0	1	1
Sandstone bedrock		1	1	2
Crystalline bedrock		2	4	6
Total number of wells		10	10	20

The 10 domestic wells were selected from an inventory of about 3,000 wells in the NYSDEC Water Well program database, which contains information on wells drilled since 2000. Well owners who granted permission were contacted 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 (USEPA) Safe Drinking Water Information System and the NYSDEC Water Well program. 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 verified through inspection of published geologic maps including Fisher and others (1970) and Cadwell (1991).

Sampling Methods

The 20 wells were sampled from August through November 2009, and samples were collected and processed in accordance with documented USGS standard operating procedures (U.S. Geological Survey, variously dated). Water samples from the domestic wells were collected before any water-treatment system to be as representative of the aquifer water quality as possible. Water samples from production wells were collected at the spigot or faucet used for collection of raw-water samples by water managers.

Typically, samples were collected from one or more 10-ft lengths of Teflon tubing attached to the spigot. Domestic wells were purged after the tubing was connected by running to waste for at least 20 minutes at pumping rates ranging from about 2 to 5 gal/min, or until at least one well-casing volume of water had passed the sampling point. Wells that had been used recently required removal of less than three well-casing volumes (U.S. Geological Survey, 2006). Domestic wells were actively pumped during sampling. 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 taken, including a global positioning system (GPS) measurement of latitude and longitude. After the well was purged, field measurements of water temperature, pH, specific conductance, and dissolved oxygen concentration were recorded at regular intervals until these values had stabilized, after which the sample was collected (U.S. Geological Survey, variously dated).

The flow rate for sample collection was adjusted to less than 0.5 gal/min when possible. Equipment for filtration of pesticide samples was rinsed with methanol as described in Wilde (2004). Samples were collected and preserved in the sampling chamber according to standard USGS procedures. Samples for nutrient, major-ion, and some trace-element analyses were filtered through disposable (one-time use) 0.45-µm-pore-size polyether sulfone capsule filters that were preconditioned in the laboratory with 3 L of deionized water the day of sample collection. Samples for pesticide analyses were filtered through baked 0.7-µm-pore-size glass fiber filters. Acid preservation was required for trace element, VOC, major-cation analyses, and some radiochemical analyses. 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. Bacterial samples were collected in accordance with NYSDEC and NYSDOH protocols, except that the tap from which each water sample was collected was not flame sterilized. Water samples for radon analysis were collected through a septum chamber with a glass syringe according to standard USGS procedures. Water samples for dissolved gas analyses were filled and sealed while submerged in a beaker of water to prevent exposure to the atmosphere. Water samples analyzed by NYSDOH-certified laboratories were collected in bottles provided by the analyzing laboratory. After collection, all water samples except those for radiochemical analyses were chilled to 4°C or less and were kept chilled until delivery to the analyzing laboratory. Bacterial samples were hand-delivered to the analyzing laboratory within 6 hours of collection; all other samples were shipped by overnight delivery to the designated laboratories.

Most sampling sites had easy access to a garden-hose type spigot; however, some supply wells did not. Wells CL149, CL151, EX169, and EX589 (fig. 2 and table 1) were sampled from smooth-ended taps at which water-system personnel routinely collect raw-water samples. The syringe for radon-222 sample collection at these sites was inserted directly into the flowing water in the throat of the tap to minimize sample exposure to the atmosphere.

Analytical Methods

Samples were analyzed for 147 physiochemical properties and constituents, including major ions, nutrients, trace elements, radionuclides, pesticides and pesticide degradates, VOCs, and bacteria. Physiochemical properties such as water temperature, pH, dissolved oxygen concentration, and specific conductance were measured at the sampling site using a multiparameter meter; the multiparameter meter was contained in a flow cell at sites with garden-hose type spigots. Major ions, nutrients, total organic carbon, trace elements, radon-222, pesticides and pesticide degradates, and VOCs were analyzed at the USGS NWQL in Denver, CO. Select dissolved gases (argon, carbon dioxide, nitrogen, and methane) were analyzed at the USGS CFCL in Reston, VA. Gross alpha and gross beta radioactivities were analyzed at Eberline Services in Richmond, CA. Indicator bacteria were analyzed at the NYSDOH-certified Darrin Fresh Water Institute in Bolton Landing, NY.

Anion concentrations were measured by ion-exchange chromatography, and cation concentrations were measured by inductively coupled plasma-atomic emission spectrometry (ICP-AES), as described in Fishman (1993). Nutrients were analyzed by colorimetry, as described by Fishman (1993), and Kjeldahl digestion with photometric finish, as described by Patton and Truitt (2000). Total organic carbon samples collected on or before September 22, 2009 were analyzed by wet oxidation (method O-3100-83) for measurement by infrared detection (Wershaw and others, 1987); samples collected after this date were analyzed by high temperature combustion and catalytic oxidation for measurement by infrared detection according to Standard method 5310 (American Public Health Association, 1998). Mercury concentrations were measured through cold vapor–atomic fluorescence spectrometry according to methods described by Garbarino and Damrau (2001). Arsenic, chromium, and nickel samples were analyzed by use of collision/reaction cell inductively coupled plasma-mass spectrometry (cICP-MS), as described by Garbarino and others (2006). The remaining trace elements were analyzed by ICP-AES (Struzeski and others, 1996), inductively coupled plasma-optical emission spectrometry (ICP-OES), and inductively coupled plasma-mass spectrometry (ICP-MS) (Garbarino and Struzeski, 1998). Procedures for in-bottle digestions for trace-element analyses described by Hoffman and others (1996) were followed. Radon-222 activities were measured through liquid-scintillation counting (ASTM International, 2006). Samples for pesticide analyses were processed as described by Wilde and others (2004) and were analyzed using gas chromatography-mass spectrometry (GC-MS) and high-performance liquid chromatography-mass spectrometry (HPLC-MS), as described by Zaugg and others (1995), Sandstrom and others (2001), and Furlong and others (2001). VOCs were analyzed by GC-MS using methods described by Connor and others (1998).

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

Quality Control Samples

In addition to the 20 groundwater samples, one blank sample and one concurrent replicate sample were collected for quality assurance. Nitrogen-purged VOC/pesticide-grade blank water and inorganic-grade blank water supplied by the USGS-NWQL were used for a laboratory equipment blank sample. The water for unfiltered constituents was run through a piece of the Teflon tubing used for sampling; water for filtered-water constituents was pumped through the Teflon tubing into cleaned, preconditioned filters. Quality-assurance samples were acidified in the same manner as environmental well-water samples. The only property that exceeded laboratory reporting levels (LRLs) in the blank was sample color, which was measured at 2 platinum-cobalt (Pt-Co) units (LRL 1 Pt-Co unit). The concentration differences between the replicate sample and the corresponding environmental sample were 5 percent or less for all constituents detected above the LRL in both samples, except for methane, arsenic, gross beta radioactivity, radon-222, and the heterotrophic plate count, which were detected in the replicate sample at levels close to the LRL; small differences in concentration result in large relative percent-concentration differences. No VOCs or pesticides were detected in the replicate sample.

Groundwater Quality

The 20 samples were analyzed for 147 constituents and physiochemical properties. Most (77) of these were not detected above the LRLs in any sample (appendix table 1-1). Results for the remaining 70 constituents and properties that were detected are presented in appendix 1 (tables 1-2 through 1-9). Some concentrations are reported as “estimated.” Concentrations are reported as estimated where the detected value is less than the established LRL, or when recovery of a compound has been shown to be highly variable (Childress and others, 1999). Concentrations of some constituents exceeded maximum contaminant levels (MCLs) or secondary drinking-water standards (SDWS) set by the USEPA (U.S. Environmental Protection Agency, 2009) or NYSDOH (New York State Department of Health, 2007). MCLs are enforceable standards for finished water of public water supplies; they are not enforceable for private homeowner wells but are presented here as a standard for evaluation of the water-quality results. SDWS are nonenforceable drinking-water standards that typically relate to aesthetic concerns such as taste, odor, or staining of plumbing fixtures.

Physiochemical Properties

The color of samples ranged from less than (<) 1 to 20 Pt-Co units; the median sample color was <2 Pt-Co units (table 4 and appendix table 1-2). The color of one sample from a bedrock well, 20 Pt-Co units, exceeded the NYSDOH MCL and USEPA SDWS of 15 Pt-Co units. Dissolved oxygen concentration ranged from <0.1 to 13.6 mg/L and was generally greater in samples from sand and gravel wells (median 7.0 mg/L) than in samples from bedrock wells (median 1.6 mg/L). Sample pH was typically near neutral or slightly basic (median 7.1 in all wells) and ranged from 5.9 to 8.5. The pH of three samples was lower than the USEPA SDWS range for pH (6.5 to 8.5); all three samples were from bedrock wells. Specific conductance ranged from 65 to 1,310 µS/cm at 25°C, the median conductance was 412 µS/cm at 25°C. Water temperature ranged from 7.9 to 15.1°C; the median temperature was 9.7°C. The concentration of carbon dioxide ranged from 0.5 to 61.1 mg/L and was generally greater in samples from bedrock wells (median 10.0 mg/L) than in samples from sand and gravel wells (median 3.2 mg/L). Argon concentrations ranged from 0.72 to 0.96 mg/L, with a median of 0.80 mg/L. Nitrogen gas concentrations ranged from 20.18 to 32.98 mg/L with a median concentration of 22.60 mg/L. Methane was detected in five samples with a maximum concentration of 0.072 mg/L.

Table 4. Drinking-water standards and summary statistics for physiochemical properties of groundwater samples from the Lake Champlain Basin, New York, 2009.

[All concentrations in unfiltered water except as noted; --, not applicable; <, less than; E, estimated concentration; Pt-Co units, platinum-cobalt units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; --, not applicable]

Constituent	Drinking-water standard	Number of samples exceeding standard	Median (all samples)	Sand and gravel aquifers (8 samples) Minimum	Sand and gravel aquifers Median	Sand and gravel aquifers Maximum	Bedrock aquifers (12 samples) Minimum	Bedrock aquifers Median	Bedrock aquifers Maximum
Color, filtered, Pt-Co units	[1]15	1	<2	<1	2	5	<1	<1	20
Carbon dioxide, mg/L	--		7.6	.5	3.2	11.8	1.4	10.0	61.1
Dissolved oxygen, mg/L	--		2.7	1.6	7.0	13.6	<.1	1.6	10.0
pH, unfiltered	[1]6.5-8.5	3	7.1	6.8	7.4	8.5	5.9	6.8	7.7
Specific conductance, µS/cm	--		412	65	234	482	139	480	1,310
Temperature, ºC	--		9.7	7.9	8.6	13.5	8.7	9.9	15.1
Argon, mg/L	--		.80	.72	.79	.96	.74	.82	.94
Nitrogen gas, mg/L	--		22.60	20.18	21.66	29.53	21.22	23.10	32.98
Methane, mg/L	--		.000	.000	.000	.002	.000	.000	.072

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

Major Ions

The anions detected in the highest concentrations were bicarbonate (median concentration 158 mg/L estimated, maximum concentration 413 mg/L) and sulfate (median concentration 17.6 mg/L, maximum concentration 239 mg/L) (table 5 and appendix table 1-3). The cation detected in the highest concentration was calcium (median concentration 45.5 mg/L, maximum concentration 149 mg/L). The median concentrations of most ions were greater in samples from bedrock wells than in samples from sand and gravel wells.

The concentration of sodium in three samples from bedrock wells exceeded the USEPA nonregulatory drinking-water advisory taste threshold of 60 mg/L; the maximum concentration of sodium was 148 mg/L. Concentrations of chloride, fluoride, and sulfate did not exceed established drinking-water standards in any of the samples.

Water hardness ranged from 31 to 490 mg/L as $CaCO_3$, with a median value of 180 mg/L as $CaCO_3$. Three samples were soft (0 to 60 mg/L as $CaCO_3$), 5 samples were moderately hard (61 to 120 mg/L as $CaCO_3$), 2 samples were hard (121 to 180 mg/L as $CaCO_3$), and 10 samples were very hard (181 mg/L as $CaCO_3$ or more; Hem, 1985). The median hardness in samples from bedrock wells was 215 mg/L as $CaCO_3$ (very hard); the median in samples from sand and gravel wells was 126 mg/L as $CaCO_3$ (hard). Alkalinity ranged from 26 to 340 mg/L as $CaCO_3$; the median was 130 mg/L of $CaCO_3$. The median alkalinity of samples from bedrock wells (154 mg/L as $CaCO_3$) was higher than the median alkalinity of samples from sand and gravel wells (96 mg/L as $CaCO_3$). Dissolved solids, dried at 180°C, ranged from 49 to 779 mg/L with a median of 218 mg/L. The dissolved solids in samples from four bedrock wells exceeded the USEPA SDWS for total dissolved solids of 500 mg/L.

Table 5. Drinking-water standards and summary statistics for concentrations of major ions in filtered groundwater samples from the Lake Champlain Basin, New York, 2009.

[All concentrations are in milligrams per liter; --, not applicable; <, less than; E, estimated concentration; ºC, degrees Celsius]

	Constituent	Drinking-water standard	Number of samples exceeding standard	Median (all samples)	Sand and gravel aquifers (8 samples) Minimum	Sand and gravel aquifers (8 samples) Median	Sand and gravel aquifers (8 samples) Maximum	Bedrock aquifers (12 samples) Minimum	Bedrock aquifers (12 samples) Median	Bedrock aquifers (12 samples) Maximum
Cations	Calcium	--		45.5	8.68	33.2	57.1	15.4	53.5	149
Cations	Magnesium	--		13.8	2.37	9.98	27.0	3.67	16.0	56.0
Cations	Potassium	--		.88	.33	.78	.96	.24	1.20	11.0
Cations	Sodium	[1]60	3	6.34	1.79	3.44	6.55	2.10	19.2	148
Anions	Bicarbonate	--		E 158	E 32	E 116	277	E 54	187	413
Anions	Chloride	[2,3]250	0	6.66	.43	1.49	26.5	.89	20.0	210
Anions	Fluoride	[4]4.0 [2]2.2 [3]2	0 0 0	.10	<.08	E .06	.10	E .08	.20	.80
Anions	Silica	--		13.8	9.52	15.2	19.0	5.57	11.0	18.7
Anions	Sulfate	[2,3]250	0	17.6	5.96	9.67	29.6	8.01	21.2	239
Hardness as $CaCO_3$				180	31	126	250	55	215	490
Alkalinity as $CaCO_3$				130	26	96	228	44	154	340
Dissolved solids, dried at 180ºC		[3]500	4	218	49	148	268	81	289	779

[1] U.S. Environmental Protection Agency Drinking Water Advisory Taste Threshold.

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

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

[4] U.S. Environmental Protection Agency Maximum Contaminant Level.

Nutrients and Organic Carbon

The dominant nutrient detected was nitrate, reported as nitrate plus nitrite, as nitrogen (N) in this report. Concentrations of ammonia ranged from <0.020 to 0.474 mg/L as nitrogen (N). Nitrite was detected in only one sample at a concentration of 0.002 mg/L as N; the concentration of nitrite did not exceed the USEPA and NYSDOH MCLs (1 mg/L as N) in any sample. Concentrations of nitrate ranged from <0.04 to 3.79 mg/L as N (table 6 and appendix table 1-4); the median nitrate concentration was 0.15 mg/L as N. None of the water samples equaled or exceeded the USEPA and NYSDOH MCL of 10 mg/L for nitrate-N. Orthophosphate was detected in all samples; concentrations ranged from an estimated concentration of 0.004 to 0.086 mg/L as phosphorus (P). Total organic carbon was detected in 15 samples; the maximum concentration was 1.5 mg/L.

Table 6. Drinking-water standards and summary statistics for concentrations of nutrients in filtered groundwater samples from the Lake Champlain Basin, New York, 2009.

[All concentrations in milligrams per liter. N, nitrogen; P, phosphorus; --, not applicable; <, less than; E, estimated concentration.]

Constituent	Drinking-water standard	Number of samples exceeding standard	Median (all samples)	Sand and gravel aquifers (8 samples) Minimum	Sand and gravel aquifers (8 samples) Median	Sand and gravel aquifers (8 samples) Maximum	Bedrock aquifers (12 samples) Minimum	Bedrock aquifers (12 samples) Median	Bedrock aquifers (12 samples) Maximum
Ammonia plus organic N, as N	--		<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.53
Ammonia (NH_3), as N	--		<.020	<.020	<.020	E .014	<.020	<.020	.474
Nitrate plus nitrate (NO_2 + NO_3), as N	[1,2]10	0	.15	<.04	.18	3.79	<.04	.06	2.33
Nitrite (NO_2), as N	[1,2]1	0	<.002	<.002	<.002	<.002	<.002	<.002	.002
Orthophosphate (PO_4), as P	--		.010	E .004	.014	.050	E .005	E .008	.086
Total organic carbon (TOC), unfiltered	--		.6	<.6	E.5	.8	<.6	.6	1.5

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

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

Trace Elements

The highest median concentrations for the trace-element samples were of strontium (median 202 µg/L), iron (median 55 µg/L in unfiltered water; 4 µg/L in filtered water), barium (median 14.6 µg/L), boron (median 8.4 µg/L), and manganese (median 5.1 µg/L in unfiltered water and 3.6 µg/L in filtered water) (table 7 and appendix table 1-5). The highest detected trace-element concentration (3,020 µg/L) was for strontium in a sample from a bedrock well. The concentration of iron in four unfiltered samples from three bedrock wells and one sand and gravel well, and one filtered sample from a sand and gravel well exceeded the USEPA SDWS and NYSDOH MCL for iron of 300 µg/L. The concentration of manganese in three unfiltered and three filtered samples from bedrock wells exceeded the USEPA SDWS of 50 µg/L; the NYSDOH MCL of 300 µg/L was not exceeded in any sample. Drinking-water standards for aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, and zinc were not exceeded in any of the water samples. Antimony, mercury, and thallium were not detected in any of the samples (appendix table 1-1).

Pesticides

Pesticides were rarely detected in the water samples and all detected concentrations were in the hundredths or thousandths of a microgram per liter. Six pesticides and pesticide degradates were detected in five samples (appendix table 1-6). Three of the pesticides detected are broadleaf herbicides or their degradates; three are insecticides or their degradates. Pesticides were detected in two samples from sand and gravel wells and in three samples from bedrock wells. The highest pesticide concentration (maximum 0.02 µg/L) was for disulfoton.

CIAT (2-chloro-4-isopropylamino-6-amino-*s*-triazine, or deethyl atrazine), a degradate product of triazine herbicides including atrazine, was detected in four samples with an estimated maximum concentration of 0.003 µg/L, and the herbicide atrazine was detected in two samples with an estimated maximum concentration of 0.002 µg/L. The remaining four pesticides—desulfinylfipronil (an insecticide degradate), disulfoton (an insecticide), fipronil (an insecticide), and prometon (an herbicide)—were detected in one sample each. One sample (EX378) had detections of four pesticides and another sample

(W1544) had detections of three pesticides. No pesticide concentrations exceeded established drinking-water standards; pesticide degradates are not currently regulated.

Table 7. Drinking-water standards and summary statistics for concentrations of trace elements in groundwater samples from the Lake Champlain Basin, New York, 2009.

[µg/L, micrograms per liter; <, less than; E, estimated concentration; --, not applicable]

Constituent	Drinking-water standard	Number of samples exceeding standard	Median (all samples)	Sand and gravel aquifers (8 samples) Minimum	Sand and gravel aquifers (8 samples) Median	Sand and gravel aquifers (8 samples) Maximum	Bedrock aquifers (12 samples) Minimum	Bedrock aquifers (12 samples) Median	Bedrock aquifers (12 samples) Maximum
Aluminum, unfiltered, µg/L	[3]50-200	0	<6	<6	<6	9	<6	<6	12
Antimony, unfiltered, µg/L	[1,2]6	0	<.4	<.4	<.4	<.4	<.4	<.4	<.4
Arsenic, unfiltered, µg/L	[1,2]10	0	.62	.20	.58	.97	.26	.72	5.4
Barium, unfiltered, µg/L	[1,2]2,000	0	14.6	1.5	10.4	14.2	<.6	37.1	120
Beryllium, unfiltered, µg/L	[1,2]4	0	<.02	<.02	<.02	<.04	<.02	<.04	.03
Boron, filtered, µg/L	--	--	8.4	E 1.5	4.2	8.7	4.3	16	184
Cadmium, unfiltered, µg/L	[1,2]5	0	<.06	<.04	<.06	<.06	<.04	<.06	E .03
Chromium, unfiltered, µg/L	[1,2]100	0	<.42	<.40	E .36	1.3	<.40	<.42	.54
Cobalt, unfiltered, µg/L	--	--	<.10	<.10	<.10	.12	<.04	<.10	.92
Copper, unfiltered, µg/L	[3]1,000	0	3.0	<1.4	<4.0	25.9	<1.4	E 4.8	37.1
Iron, filtered, µg/L	[2,3]300	1	4	<4	E 5	573	<4	4	154
Iron, unfiltered, µg/L	[2,3]300	4	55	<14	33	649	<9	78	519
Lead, unfiltered, µg/L	[4]15	0	.24	<.06	E .11	.35	<.10	.54	3.26
Lithium, unfiltered, µg/L	--	--	1.4	<.3	E .07	1.7	.7	4.2	62.7
Manganese, filtered, µg/L	[2]300 [3]50	0 3	3.6	<.2	3.6	15.9	<.2	3.9	135
Manganese, unfiltered, µg/L	[2]300 [3]50	0 3	5.1	<.4	5.1	15.8	<.8	4.6	205
Mercury, unfiltered, µg/L	[1,2]2	0	<.010	<.010	<.010	<.010	<.010	<.010	<.010
Molybdenum, unfiltered, µg/L	--	--	.8	.2	.2	1.8	.2	2.0	7.3
Nickel, unfiltered, µg/L	--	--	.18	<.20	<.20	1.3	<.20	E .28	3.4
Selenium, unfiltered, µg/L	[1,2]50	0	<.12	<.12	<.12	E .12	<.10	<.11	.41
Silver, unfiltered, µg/L	[2,3]100	0	<.06	<.02	<.06	<.06	<.02	<.06	E .01
Strontium, unfiltered, µg/L	--	--	202	32.0	90.6	253	75.8	262	3,020
Thallium, unfiltered, µg/L	[1,2]2	0	<.12	<.12	<.12	<.12	<.12	<.12	<.12
Zinc, unfiltered, µg/L	[2,3]5,000	0	3.4	<2.0	2.2	8.4	E 1.5	8.7	360

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

Volatile Organic Compounds

Six VOCs were detected in untreated water samples from six wells—one sand and gravel well and five bedrock wells (appendix table 1-7). Four wells had detections of one VOC each, one well (CL154) had detections of four VOCs, and one well (CL149) had detections of five VOCs. The VOCs detected include 1,1-dichloroethene, detected in one sample with a concentration of 0.3 µg/L; methyl *tert*-butyl ether (MTBE), a gasoline additive, detected in two samples with a maximum concentration of 6.0 µg/L; and four trihalomethanes (THMs). THMs are byproducts that form when chlorine or bromine are used as disinfectants; they are also used as solvents. Bromodichloromethane was detected in two samples; the maximum concentration was 4.4 µg/L. Tribromomethane was detected in two samples; the maximum concentration was 11.8 µg/L. Dibromochloromethane was detected in two samples; the maximum concentration was 7.8 µg/L. Trichloromethane (chloroform) was detected in four samples; the maximum concentration was 5.0 µg/L. The USEPA and NYSDOH MCLs for total THMs, 80 µg/L, was not exceeded in any sample; the maximum total THM concentration was 21.6 µg/L in the sample from well CL149.

Radionuclides

Gross alpha-particle radioactivity ranged from non-detectable levels to 15 pCi/L; the median activity was 1.2 pCi/L (table 8 and appendix table 1-8). The gross alpha radioactivity in one sample equaled the USEPA and NYSDOH MCLs for gross alpha of 15 pCi/L. Gross beta-particle radioactivity ranged from non-detectable levels to 9.7 pCi/L. The USEPA and NYSDOH MCLs for gross beta radioactivity are expressed as a dose of 4 millirem per year. Radon-222 activities in the water samples ranged from 19 to 4,100 pCi/L; the median was 240 pCi/L. The median radon-222 activity was 155 pCi/L in samples from sand and gravel wells and was 355 pCi/L in samples from bedrock wells. Radon is currently not regulated in drinking water; however, the USEPA has proposed a two-part standard for radon in community drinking-water systems: (1) a 300 pCi/L MCL for areas that do not implement an indoor-air radon mitigation program, and (2) an alternative MCL (AMCL) of 4,000 pCi/L for areas that do (U.S. Environmental Protection Agency, 1999). Activities in 10 (half) of the samples exceeded the proposed MCL. The activity in one sample exceeded the proposed AMCL; this sample was from a bedrock well. The maximum concentration of uranium was 6.41 µg/L in a sample from a bedrock well; the concentration of uranium did not exceed the USEPA and NYSDOH MCLs of 30 µg/L in any sample. The two wells with the highest uranium concentrations also had the highest radon-222 activities. The median activities or concentrations of all four measured radionuclides were higher in samples from bedrock wells than in samples from sand and gravel wells.

Bacteria

Coliform bacteria were detected in five samples (appendix table 1-9). Fecal coliform bacteria were detected in one sample. *E. coli* were not detected in any sample. The NYSDOH and USEPA MCL for total coliform bacteria is exceeded when five percent of samples of finished water collected in one month test positive for total coliform (if 40 or more samples are collected per month) or when two samples test positive for total coliform (if fewer than 40 samples are collected per month). The heterotrophic plate count ranged from < 1 colony-forming unit (CFU) per milliliter (mL) to 34 CFU/mL. The USEPA MCL for the heterotrophic plate count is 500 CFU/mL; this limit was not exceeded in any sample.

Table 8. Drinking-water standards and summary statistics for concentrations of radionuclides in groundwater samples from the Lake Champlain Basin, New York, 2009.

[pCi/L, picocuries per liter, mrem/yr, millirem per year; --, not applicable; <, less than]

Constituent	Summary statistics and concentrations								
	Drinking-water standard	Number of samples exceeding standard	Median (all samples)	Sand and gravel aquifers (8 samples)			Bedrock aquifers (12 samples)		
				Minimum	Median	Maximum	Minimum	Median	Maximum
Gross alpha radioactivity, unfiltered, pCi/L	[1,2]15	0	1.2	<0.55	<1.3	2.0	<.81	1.3	15
Gross beta radioactivity, unfiltered, pCi/L	[1,2]4 mrem/yr	--	1.2	<.82	<1.1	1.1	<1.1	2.2	9.7
Radon-222, unfiltered, pCi/L	[3]300 [4]4,000	10 1	240	72	155	380	19	355	4,100
Uranium, unfiltered, µg/L	[1,2]30	0	.470	E .012	.236	.585	.069	2.20	6.41

[1] U.S. Environmental Protection Agency Maximum Contaminant Level.
[2] New York State Department of Health Maximum Contaminant Level.
[3] U.S. Environmental Protection Agency Proposed Maximum Contaminant Level.
[4] U.S. Environmental Protection Agency Proposed Alternative Maximum Contaminant Level.

Wells Sampled in 2004 and 2009

Four of the wells sampled in 2009 (wells CL149, EX155, EX535, and W534) were sampled previously in 2004 as part of this study. Of the 147 constituents and physiochemical properties for which samples were analyzed in 2009, 140 were common to 2004 and 2009 analyses (appendix tables 2-1 through 2-4). The differences between 2004 and 2009 results for a single well were typically smaller than those between the results from different wells.

Summary

Groundwater samples were collected from August through November 2009 from 8 wells completed in sand and gravel and 12 wells completed in bedrock to characterize the groundwater quality in the Lake Champlain Basin in New York State. The sand and gravel wells sampled ranged from 57 to 154 ft in depth; the bedrock wells ranged from 137 to 600 ft in depth and were typically completed in crystalline bedrock. Ten of the 20 wells sampled were production wells and 10 were domestic wells. Of the 147 major ion, nutrient, trace-element, pesticide, VOC, radionuclide, and bacteria constituents, 77 were not detected in any of the samples.

The samples generally indicated good water quality, although properties and concentrations of some constituents—color, pH, sodium, total dissolved solids, iron, manganese, gross alpha-particle radioactivity, radon-222, and 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 (10 samples had concentrations greater than the USEPA proposed MCL of 300 pCi/L), coliform bacteria (5 samples with detections), iron (4 unfiltered samples with concentrations greater than the USEPA SDWS and NYSDOH MCL of 300 µg/L), and total dissolved solids (4 samples with dissolved solids greater than the USEPA SDWS of 500 mg/L).

Sample pH was typically near neutral or slightly basic. Water hardness ranged from soft to very hard; more samples were hard than were soft. The ions detected in the highest median concentrations were bicarbonate, calcium, and sulfate. The dominant nutrient was nitrate, but concentrations of nitrate did not exceed established drinking-water standards. Strontium was the trace element with the highest median concentrations. The highest radon-222 activities were in samples from bedrock wells completed in crystalline rock (maximum 4,100 pCi/L). Six pesticides and pesticide degradates were detected in five samples—two samples from sand and gravel wells and three from bedrock wells—most were trace-level detections of broadleaf herbicides, insecticides, or their degradates. Six VOCs were detected in six samples, including MTBE and four trihalomethanes (disinfection byproducts). Coliform bacteria were detected in five samples. Fecal coliform bacteria were detected in one sample, and *E. coli* bacteria were not detected in any sample.

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Appendix 1: Results of Water-Sample Analyses

The following tables summarize results of the chemical analyses of the 20 samples collected in the Lake Champlain Basin of eastern New York from August through November 2009.

Table 1-1. Constituents that were not detected in groundwater samples collected in the Lake Champlain Basin, New York, 2009.

[NWIS, National Water Information System; WY, water year, the 12-month period from October 1 through September 30 of the following year. The water year is designated by the calendar year in which it ends.]

U.S. Geological Survey NWIS parameter code	Constituent	Laboratory reporting level WY09	Laboratory reporting level WY10
Trace elements in unfiltered water, micrograms per liter			
01097	Antimony	0.4	0.4
71900	Mercury	.010	.010
01059	Thallium	.12	.12
Pesticides in filtered water, micrograms per liter			
82660	2,6-Diethylaniline	.006	.006
49260	Acetochlor	.010	.010
46342	Alachlor	.008	.008
34253	*alpha*-HCH	.008	.004
82686	Azinphos-methyl	.120	.120
82673	Benfluralin	.014	.014
04028	Butylate	.002	.004
82680	Carbaryl	.200	.060
82674	Carbofuran	.060	.060
38933	Chlorpyrifos	.010	.010
82687	*cis*-Permethrin	.014	.014
04041	Cyanazine	.040	.022
82682	DCPA	.006	.008
39572	Diazinon	.005	.005
39381	Dieldrin	.009	.009
82668	EPTC	.002	.002
82663	Ethalfluralin	.009	.006
82672	Ethoprop	.016	.016
62169	Desulfinylfipronil amide	.029	.029
62167	Fipronil sulfide	.013	.013
62168	Fipronil sulfone	.024	.024
04095	Fonofos	.010	.004
39341	Lindane	.014	.004
82666	Linuron	.060	.060
39532	Malathion	.020	.016
82667	Methyl parathion	.008	.008
39415	Metolachlor	.014	.014
82630	Metribuzin	.016	.012
82671	Molinate	.002	.003
82684	Napropamide	.018	.008
34653	*p,p*'-DDE	.003	.002
39542	Parathion	.020	.020
82669	Pebulate	.016	.016
82683	Pendimethalin	.012	.012

Table 1-1. Constituents that were not detected in groundwater samples collected in the Lake Champlain Basin, New York, 2009.—Continued

[NWIS, National Water Information System; WY, water year, the 12-month period from October 1 through September 30 of the following year. The water year is designated by the calendar year in which it ends.]

U.S. Geological Survey NWIS parameter code	Constituent	Laboratory reporting level WY09	Laboratory reporting level WY10
Pesticides in filtered water, micrograms per liter			
82664	Phorate	0.020	0.020
82676	Propyzamide	.004	.004
04024	Propachlor	.012	.006
82679	Propanil	.014	.010
82685	Propargite	.02	.02
04035	Simazine	.010	.006
82670	Tebuthiuron	.02	.03
82665	Terbacil	.040	.024
82675	Terbufos	.02	.02
82681	Thiobencarb	.016	.016
82678	Triallate	.006	.006
82661	Trifluralin	.012	.018
Volatile organic compounds in unfiltered water, micrograms per liter			
34506	1,1,1-Trichloroethane	.1	.1
77652	1,1,2-Trichloro-1,2,2-trifluoroethane	.1	.1
34496	1,1-Dichloroethane	.1	.1
34536	1,2-Dichlorobenzene	.1	.1
32103	1,2-Dichloroethane	.2	.2
34541	1,2-Dichloropropane	.1	.1
34566	1,3-Dichlorobenzene	.1	.1
34571	1,4-Dichlorobenzene	.1	.1
34030	Benzene	.1	.1
34301	Chlorobenzene	.1	.1
77093	*cis*-1,2-Dichloroethene	.1	.1
34668	Dichlorodifluoromethane	.2	.2
34423	Dichloromethane	.2	.2
81576	Diethyl ether	.2	.2
81577	Diisopropyl ether	.2	.2
34371	Ethylbenzene	.1	.1
50005	Methyl *tert*-pentyl ether	.2	.2
85795	*m*-Xylene plus *p*-xylene	.2	.2
77135	*o*-Xylene	.1	.1
77128	Styrene	.1	.1
50004	*tert*-Butyl ethyl ether	.1	.1
34475	Tetrachloroethene	.1	.1
32102	Tetrachloromethane	.2	.2
34010	Toluene	.1	.1
34546	*trans*-1,2-Dichloroethene	.1	.1
39180	Trichloroethene	.1	.1
34488	Trichlorofluoromethane	.2	.2
39175	Vinyl chloride	.2	.2

Table 1-2. Physiochemical properties of groundwater samples collected in the Lake Champlain Basin, New York, 2009.

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; (00080), U.S. Geological Survey National Water Information System parameter code; <, less than. **Bold** values exceed one or more drinking-water standards. Well locations are shown in figure 2.]

Well number[1]	Color, platinum-cobalt units (00080)	Carbon dioxide, mg/L (00405)	Dissolved oxygen, mg/L (00300)	pH, standard units (00400)	Specific conductance, µS/cm (00095)
Sand and gravel wells					
CL151	2	2.5	11.0	7.4	353
CL1500	<1	2.0	5.1	7.7	94
EX155	<1	8.7	5.4	7.0	95
EX535	2	11.8	1.6	7.0	482
EX589	<1	1.1	9.7	7.7	115
EX1013	5	.5	13.6	8.5	65
W534	2	11.5	3.3	6.8	422
W1066	2	3.8	8.6	7.5	403
Bedrock wells					
CL149	**20**	16.2	.3	7.2	1,250
CL154	5	11.9	.2	6.7	1,220
CL665	<1	2.6	1.5	7.0	274
EX169	<1	5.1	7.2	7.5	241
EX378	<1	19.5	2.1	6.6	531
EX664	<1	1.4	1.8	7.2	221
W1145	<1	40.9	<.1	**6.4**	827
W1544	2	61.1	1.7	**6.2**	761
WR86	<1	1.9	10.0	7.7	428
WR1326	2	26.0	3.8	**5.9**	139
WR1433	<1	7.3	.1	7.4	1,310
WR1671	5	8.0	.6	6.7	427

[1] CL, Clinton County; EX, Essex County; W, Washington County; WR, Warren County.

Table 1-2. Physiochemical properties of groundwater samples collected in the Lake Champlain Basin, New York, 2009. —Continued

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; (00080), U.S. Geological Survey National Water Information System parameter code; <, less than. **Bold** values exceed one or more drinking-water standards. Well locations are shown in figure 2.]

Well number[1]	Water temperature, degrees Celsius (00010)	Argon, unfiltered, mg/L (82043)	Dissolved nitrogen gas, unfiltered, mg/L (00597)	Hydrogen sulfide odor (71875)	Methane, unfiltered, mg/L (76994)
Sand and gravel wells					
CL151	8.5	0.80	22.95	Absent	0.000
CL1500	8.4	.75	20.18	Absent	.000
EX155	7.9	.75	20.21	Absent	.000
EX535	13.5	.96	29.53	Absent	.000
EX589	8.3	.77	21.14	Absent	.002
EX1013	8.8	.81	22.69	Absent	.000
W534	9.8	.72	20.23	Absent	.000
W1066	10.8	.80	22.18	Absent	.000
Bedrock wells					
CL149	9.0	.74	21.22	Absent	.030
CL154	9.9	.86	25.80	Absent	.072
CL665	9.6	.82	22.90	Absent	.000
EX169	8.7	.78	21.25	Absent	.000
EX378	9.3	.82	23.78	Absent	.000
EX664	15.1	.82	23.58	Absent	.000
W1145	9.9	.94	32.98	Present	.006
W1544	10.2	.76	21.32	Absent	.000
WR86	8.7	.81	23.30	Absent	.000
WR1326	10.1	.79	22.51	Absent	.000
WR1433	14.3	.80	22.30	Absent	.002
WR1671	12.2	.82	25.83	Absent	.000

[1] CL, Clinton County; EX, Essex County; W, Washington County; WR, Warren County.

Table 1-3. Concentrations of major ions in groundwater samples collected in the Lake Champlain Basin, New York, 2009.

[mg/L, milligrams per liter; $CaCO_3$, calcium carbonate; (00900), U.S. Geological Survey National Water Information System parameter code. **Bold** values exceed one or more drinking-water standards. Well locations are shown in figure 2.]

Well number[1]	Hardness, filtered, mg/L as $CaCO_3$ (00900)	Calcium, filtered, mg/L (00915)	Magnesium, filtered, mg/L (00925)	Potassium, filtered, mg/L (00935)	Sodium, filtered, mg/L (00930)	Acid neutralizing capacity, unfiltered, mg/L as $CaCO_3$ (90410)	Alkalinity, filtered, incremental titration, field, mg/L as $CaCO_3$ (39086)
Sand and gravel wells							
CL151	170	44.1	13.9	0.95	6.13	121	115
CL1500	73	19.4	5.91	.83	2.66	76	62
EX155	31	8.68	2.37	.54	2.25	28	26
EX535	250	57.1	27.0	.78	3.61	194	228
EX589	81	22.4	6.07	.43	3.27	79	77
EX1013	40	11.4	2.83	.33	1.79	38	30
W534	210	55.9	16.6	.79	3.72	190	170
W1066	190	50.9	14.2	.96	6.55	148	145
Bedrock wells							
CL149	320	69.2	35.0	8.85	**125**	264	230
CL154	240	60.6	21.8	11.0	**148**	262	228
CL665	130	29.0	13.7	2.08	3.71	126	111
EX169	86	26.6	4.73	.83	9.94	72	70
EX378	280	60.1	30.4	.69	19.4	273	243
EX664	90	30.1	3.67	.57	5.23	80	64
W1145	440	84.7	56.0	2.44	20.1	383	340
W1544	360	135	5.53	.24	19.1	211	301
WR86	120	38.9	4.87	.94	33.8	69	56
WR1326	55	15.4	4.00	1.03	2.10	51	44
WR1433	490	149	28.4	1.66	**67.9**	148	151
WR1671	190	46.9	18.4	1.37	7.31	166	158

[1] CL, Clinton County; EX, Essex County; W, Washington County; WR, Warren County.

Table 1-3. Concentrations of major ions in groundwater samples collected in the Lake Champlain Basin, New York, 2009.—Continued

[mg/L, milligrams per liter; $CaCO_3$, calcium carbonate; (00900), U.S. Geological Survey National Water Information System parameter code; ºC, degrees Celsius; <, less than; E, estimated concentration. **Bold** values exceed one or more drinking-water standards. Well locations are shown in figure 2.]

Well number[1]	Bicarbonate, filtered, incremental titration, field, mg/L (00453)	Chloride, filtered, mg/L (00940)	Fluoride, filtered, mg/L (00950)	Silica, filtered, mg/L (00955)	Sulfate, filtered, mg/L (00945)	Dissolved solids, dried at 180ºC, filtered, mg/L (70300)
Sand and gravel wells						
CL151	E 139	26.5	E 0.06	12.6	8.54	196
CL1500	E 75	.43	.10	17.4	6.14	101
EX155	E 32	1.67	<.08	18.4	7.90	65
EX535	277	.74	E .07	15.4	29.6	268
EX589	E 93	1.31	E .06	19.0	10.8	100
EX1013	E 36	1.15	<.08	15.0	5.96	49
W534	207	6.46	E .08	10.5	23.2	236
W1066	176	18.1	E .05	9.52	17.6	211
Bedrock wells						
CL149	280	193	.15	8.68	89.4	**700**
CL154	278	210	.22	6.96	44.2	**677**
CL665	134	.97	.49	10.8	13.1	144
EX169	E 85	18.3	E .08	18.7	11.4	135
EX378	295	4.26	.19	15.6	19.6	320
EX664	E 77	1.03	.80	8.61	24.4	132
W1145	413	6.86	.13	16.2	74.7	**501**
W1544	E 367	31.7	E .08	5.57	22.7	431
WR86	67	91.6	.41	10.4	8.01	258
WR1326	E 54	.89	E .09	16.6	11.1	81
WR1433	183	170	.36	17.4	239	**779**
WR1671	192	21.8	.25	11.1	17.6	226

[1] CL, Clinton County; EX, Essex County; W, Washington County; WR, Warren County.

Table 1-4. Concentrations of nutrients and organic carbon in groundwater samples collected in the Lake Champlain Basin, New York, 2009.

[N, nitrogen; P, phosphorus; mg/L, milligrams per liter; (00623), U.S. Geological Survey National Water Information System parameter code; <, less than; E, estimated concentration. Well locations are shown in figure 2.]

Well number[1]	Ammonia plus organic-N, filtered, mg/L as N (00623)	Ammonia, filtered, mg/L as N (00608)	Nitrate plus nitrite, filtered, mg/L as N (00631)	Nitrite, filtered, mg/L as N (00613)	Ortho-phosphate, filtered, mg/L as P (00671)	Organic carbon, unfiltered, mg/L (00680)
Sand and gravel wells						
CL151	<0.10	<0.020	1.67	<0 .002	0.019	E 0.4
CL1500	<.10	<.020	.19	<.002	.035	<.6
EX155	<.10	E .014	.15	<.002	.009	.7
EX535	<.10	<.020	<.04	<.002	.009	E .5
EX589	<.10	<.020	.12	<.002	.050	.6
EX1013	<.10	<.020	.17	<.002	.039	<.6
W534	<.10	<.020	.23	<.002	.009	E .5
W1066	<.10	<.020	3.79	<.002	E .004	.8
Bedrock wells						
CL149	<.10	<.020	<.04	<.002	.086	1.3
CL154	<.10	<.020	<.04	<.002	E .005	E 1.3
CL665	<.10	<.020	.29	<.002	.010	<.6
EX169	<.10	<.020	.37	<.002	.020	1.5
EX378	E .07	<.020	2.33	<.002	E .007	.7
EX664	<.10	<.020	E .03	<.002	E .005	<.6
W1145	.53	.474	<.04	<.002	.010	E .3
W1544	E .07	<.020	.68	<.002	E .006	1.1
WR86	<.10	<.020	.06	<.002	E .005	E .4
WR1326	<.10	<.020	.15	<.002	.010	.6
WR1433	<.10	<.020	E .02	<.002	E .005	.7
WR1671	.26	.023	.06	.002	.011	<.6

[1] CL, Clinton County; EX, Essex County; W, Washington County; WR, Warren County.

Table 1-5. Concentrations of trace elements in groundwater samples collected in the Lake Champlain Basin, New York, 2009.

[µg/L, micrograms per liter; (01105), U.S. Geological Survey National Water Information System parameter code; <, less than; E, estimated concentration. Well locations are shown in figure 2.]

Well number[1]	Aluminum, unfiltered, µg/L (01105)	Arsenic, unfiltered, µg/L (01002)	Barium, unfiltered, µg/L (01007)	Beryllium, unfiltered, µg/L (01012)	Boron, filtered, µg/L (01020)	Cadmium, unfiltered, µg/L (01027)	Chromium, unfiltered, µg/L (01034)
Sand and gravel wells							
CL151	<6	0.67	12.2	<0.02	2.8	<0.06	1.3
CL1500	<6	.34	9.0	<.02	4.1	<.06	.47
EX155	<6	.20	1.5	<.02	4.3	<.06	<.40
EX535	9	.92	11.8	<.02	E 1.9	<.06	<.40
EX589	E 4	.89	2.8	<.02	8.7	<.06	.51
EX1013	E 4	.50	2.2	<.04	E 1.5	<.04	.87
W534	<6	.97	13.8	<.02	7.9	<.06	<.40
W1066	<6	.31	14.2	<.02	8.2	<.06	E .24
Bedrock wells							
CL149	<6	1.2	86.9	<.04	110	<.04	E .27
CL154	<6	.87	103	E .01	98	<.06	<.40
CL665	<6	.49	120	<.04	14	<.04	.54
EX169	<6	.44	14.9	<.02	10	<.06	E .39
EX378	<6	.56	<.6	<.04	16	<.04	.50
EX664	12	.29	25.0	.03	26	<.06	<.40
W1145	<6	1.6	53.7	<.04	33	<.04	<.42
W1544	8	1.9	30.5	<.02	4.3	E .03	<.40
WR86	E 5	.30	3.4	<.04	5.9	<.04	<.42
WR1326	E 3	.26	44.7	<.02	7.0	<.06	E .23
WR1433	<6	1.6	29.1	<.02	184	<.06	<.40
WR1671	E 4	5.4	43.7	<.02	16	<.06	<.40

[1] CL, Clinton County; EX, Essex County; W, Washington County; WR, Warren County.

Table 1-5. Concentrations of trace elements in groundwater samples collected in the Lake Champlain Basin, New York, 2009.—Continued

[µg/L, micrograms per liter; (01105), U.S. Geological Survey National Water Information System parameter code; <, less than; E, estimated concentration. **Bold** values exceed one or more drinking water standards. Well locations are shown in figure 2.]

Well number[1]	Cobalt, unfiltered, µg/L (01037)	Copper, unfiltered, µg/L (01042)	Iron, filtered, µg/L (01046)	Iron, unfiltered, µg/L (01045)	Lead, unfiltered, µg/L (01051)	Lithium, unfiltered, µg/L (01132)	Manganese, filtered, µg/L (01056)	Manganese, unfiltered, µg/L (01055)
Sand and gravel wells								
CL151	<0 .10	<4.0	<4	<14	0.35	E0 .4	<0.2	<0.4
CL1500	<.10	E 2.3	6	75	E .07	1.0	14.7	15.0
EX155	<.10	25.9	25	42	.24	<.6	4.7	4.3
EX535	.12	<4.0	**573**	**649**	.16	1.2	15.9	15.8
EX589	E .08	6.7	<4	<14	<.10	<.6	E .2	E .3
EX1013	E .02	<1.4	46	198	<.06	<.3	2.4	5.9
W534	<.10	<4.0	<4	<14	.15	1.2	8.3	11.0
W1066	<.10	16.8	E 4	24	E .07	1.7	.3	.5
Bedrock wells								
CL149	<.04	<1.4	46	**519**	E .04	14.0	**135**	**205**
CL154	<.10	6.8	116	**328**	2.52	15.8	7.3	17.2
CL665	<.04	10.4	<6	E 5	E .05	3.3	<.2	<.8
EX169	<.10	<4.0	5	<14	<.10	1.7	7.2	6.8
EX378	E .03	2.2	<6	<9	.26	1.1	<.2	<.8
EX664	<.10	E 3.7	6	E 11	.83	11.5	.4	2.3
W1145	E .04	E 1.2	154	161	.24	33.1	**117**	**130**
W1544	.92	16.2	<4	89	3.26	1.2	E .1	.6
WR86	<.04	<1.4	<6	68	.30	4.8	.2	1.8
WR1326	E .09	24.9	E 2	E 10	2.13	.7	.6	.8
WR1433	<.10	37.1	4	215	.97	62.7	9.9	11.6
WR1671	E .07	6.0	13	**382**	.77	3.6	**59.0**	**56.4**

[1] CL, Clinton County; EX, Essex County; W, Washington County; WR, Warren County.

Table 1-5. Concentrations of trace elements in groundwater samples collected in the Lake Champlain Basin, New York, 2009.—Continued

[µg/L, micrograms per liter; (01105), U.S. Geological Survey National Water Information System parameter code; <, less than; E, estimated concentration. Well locations are shown in figure 2.]

Well number[1]	Molybdenum, unfiltered, µg/L (01062)	Nickel, unfiltered, µg/L (01067)	Selenium, unfiltered, µg/L (01147)	Silver, unfiltered, µg/L (01077)	Strontium, unfiltered, µg/L (01082)	Zinc, unfiltered, µg/L (01092)
Sand and gravel wells						
CL151	0.2	<0.20	<0.12	<0.06	126	3.1
CL1500	.2	<.20	<.12	<.06	49.8	2.1
EX155	.2	<.20	<.12	<.06	32.0	8.4
EX535	1.8	.36	<.12	<.06	118	E 1.4
EX589	.4	1.3	E .06	<.06	63.2	2.3
EX1013	.2	E .19	E .07	<.02	35.2	<2.0
W534	.3	<.20	E .12	<.06	236	E 1.0
W1066	.3	E .13	E .09	<.06	253	2.3
Bedrock wells						
CL149	4.3	.78	<.10	<.02	1,160	14.5
CL154	3.9	.30	<.12	<.06	1,100	360
CL665	3.1	<.36	E .09	<.02	282	3.6
EX169	.2	E .18	<.12	<.06	177	2.5
EX378	2.1	<.36	.41	<.02	226	4.7
EX664	7.3	<.20	<.12	<.06	129	40.9
W1145	1.9	E .28	<.10	E .01	3,020	E 1.5
W1544	.3	3.4	.18	<.06	495	17.4
WR86	1.2	<.36	<.10	<.02	168	32.3
WR1326	.2	.71	<.12	<.06	75.8	6.8
WR1433	1.2	.54	E .12	<.06	1,280	10.6
WR1671	5.7	.29	<.12	<.06	243	2.5

[1] CL, Clinton County; EX, Essex County; W, Washington County; WR, Warren County.

Table 1-6. Concentrations of pesticides and pesticide degradates detected in groundwater samples collected in the Lake Champlain Basin, New York, 2009.

[µg/L, micrograms per liter; CIAT, 2-chloro-4-isopropylamino-6-amino-*s*-triazine (04040), U.S. Geological Survey National Water Information System parameter code; <, less than; E, estimated concentration; --, no data; M, presence verified but not quantified. Well locations are shown in figure 2.]

Well number[1]	CIAT, filtered, µg/L (04040)	Atrazine, filtered, µg/L (39632)	Desulfinylfipronil, filtered, µg/L (62170)	Disulfoton, filtered, µg/L (82677)	Fipronil, filtered, µg/L (62166)	Prometon, filtered, µg/L (04037)
Sand and gravel wells						
CL151	<0.014	<0.007	<0.012	<0.04	<0.040	<0.01
CL1500	E.002	<.007	<.012	<.04	<.040	<.01
EX155	<.014	<.007	<.012	<.04	<.040	<.01
EX535	<.014	<.007	<.012	<.04	<.040	<.01
EX589	<.014	<.007	<.012	<.04	<.040	<.01
EX1013	<.014	<.007	<.012	<.04	<.018	<.01
W534	E.001	<.007	<.012	<.04	<.040	<.01
W1066	<.014	<.007	<.012	<.04	<.040	<.01
Bedrock wells						
CL149	<.014	<.007	<.012	<.04	<.018	<.01
CL154	<.014	<.007	<.012	<.04	<.040	<.01
CL665	<.014	<.007	<.012	<.04	<.018	<.01
EX169	<.014	<.007	<.012	<.04	<.040	<.01
EX378	E.002	E.002	E.001	<.04	E.002	<.01
EX664	--	--	--	--	--	--
W1145	<.014	<.007	<.012	<.04	<.018	<.01
W1544	E.003	E.002	<.012	<.04	<.040	M
WR86	<.014	<.007	<.012	<.04	<.018	<.01
WR1326	<.014	<.007	<.012	E.02	<.040	<.01
WR1433	<.014	<.007	<.012	<.04	<.040	<.01
WR1671	<.014	<.007	<.012	<.04	<.040	<.01

[1] CL, Clinton County; EX, Essex County; W, Washington County; WR, Warren County.

Table 1-7. Concentrations of volatile organic compounds detected in groundwater samples collected in the Lake Champlain Basin, New York, 2009.

[µg/L, micrograms per liter; (34501), U.S. Geological Survey National Water Information System parameter code; <, less than. Well locations are shown in figure 2.]

Well number[1]	1,1-Dichloro-ethene, unfiltered, µg/L (34501)	Bromo-dichloro-methane, unfiltered, µg/L (32101)	Tribromo-methane, unfiltered, µg/L (32104)	Dibromo-chloro-methane, unfiltered, µg/L (32105)	Methyl *tert*-butyl ether, unfiltered, µg/L (78032)	Trichloro-methane, unfiltered, µg/L (32106)
Sand and gravel wells						
CL151	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1
CL1500	<.1	<.1	<.2	<.2	<.2	<.1
EX155	<.1	<.1	<.2	<.2	<.2	<.1
EX535	<.1	<.1	<.2	<.2	<.2	<.1
EX589	.3	<.1	<.2	<.2	<.2	<.1
EX1013	<.1	<.1	<.2	<.2	<.2	<.1
W534	<.1	<.1	<.2	<.2	<.2	<.1
W1066	<.1	<.1	<.2	<.2	<.2	<.1
Bedrock wells						
CL149	<.1	1.7	11.8	7.8	.9	.3
CL154	<.1	4.4	2.4	4.5	<.2	5.0
CL665	<.1	<.1	<.2	<.2	<.2	<.1
EX169	<.1	<.1	<.2	<.2	<.2	<.1
EX378	<.1	<.1	<.2	<.2	<.2	<.1
EX664	<.1	<.1	<.2	<.2	<.2	<.1
W1145	<.1	<.1	<.2	<.2	<.2	<.1
W1544	<.1	<.1	<.2	<.2	<.2	.3
WR86	<.1	<.1	<.2	<.2	<.2	.3
WR1326	<.1	<.1	<.2	<.2	<.2	<.1
WR1433	<.1	<.1	<.2	<.2	<.2	<.1
WR1671	<.1	<.1	<.2	<.2	6.0	<.1

[1] CL, Clinton County; EX, Essex County; W, Washington County; WR, Warren County.

Table 1-8. Activities of radionuclides in groundwater samples from the Lake Champlain Basin, New York, 2009.
[pCi/L, picocuries per liter; µg/L, micrograms per liter; (01519), USGS National Water Information System parameter code; <, less than. **Bold** values equal or exceed one or more existing or proposed drinking-water standards. Well locations are shown in figure 2]

Well number[1]	Gross alpha radioactivity, unfiltered, pCi/L (01519)	Gross beta radioactivity, unfiltered, pCi/L (85817)	Radon-222, unfiltered, pCi/L (82303)	Uranium, unfiltered, µg/L (28011)
Sand and gravel wells				
CL151	1.6	1.1	151	0.466
CL1500	.7	1.1	**370**	.158
EX155	<.55	<.88	72	E .012
EX535	2.0	.9	143	.585
EX589	<.56	<.85	159	.222
EX1013	<.57	<.82	86	.045
W534	<1.3	<1.2	**340**	.475
W1066	1.2	<.93	**380**	.249
Bedrock wells				
CL149	3.1	9.3	154	.439
CL154	**15**	9.7	**320**	3.07
CL665	1.3	2.9	**550**	2.60
EX169	<.81	1.6	159	.173
EX378	<1.2	<1.1	19	1.81
EX664	10.6	1.9	**1,230**	6.41
W1145	1.3	7.9	108	4.12
W1544	<1.6	1.5	**390**	.388
WR86	5.3	4.4	**4,100**	4.80
WR1326	1.1	<1.1	**820**	.069
WR1433	<2.2	1.3	34	.602
WR1671	7.5	2.5	**700**	2.61

[1] CL, Clinton County; EX, Essex County; W, Washington County; WR, Warren County.

Table 1-9. Bacteria in groundwater samples collected in the Lake Champlain Basin, New York, 2009.

[CFU, colony-forming unit; mL, milliliter; (31691), U.S. Geological Survey National Water Information System parameter code; <, less than. **Bold** values indicate detections of coliform bacteria. Well locations are shown in figure 2]

Well number[1]	*Escherichia coli,* unfiltered, CFU/100mL (31691)	Fecal coliform, unfiltered, CFU/100mL (61215)	Heterotrophic plate count, unfiltered, CFU/mL (31692)	Total coliform, unfiltered, CFU/100mL (61213)
Sand and gravel wells				
CL151	<1	<1	2	<1
CL1500	<1	<1	8	<1
EX155	<1	<1	3	<1
EX535	<1	**1**	23	<1
EX589	<1	<1	9	<1
EX1013	<1	<1	34	**42**
W534	<1	<1	5	<1
W1066	<1	<1	25	<1
Bedrock wells				
CL149	<1	<1	7	<1
CL154	<1	<1	2	<1
CL665	<1	<1	8	<1
EX169	<1	<1	13	<1
EX378	<1	<1	5	**4**
EX664	<1	<1	11	<1
W1145	<1	<1	<1	<1
W1544	<1	<1	7	**3**
WR86	<1	<1	<1	<1
WR1326	<1	<1	11	<1
WR1433	<1	<1	8	**1**
WR1671	<1	<1	18	<1

[1] CL, Clinton County; EX, Essex County; W, Washington County; WR, Warren County.

Appendix 2: Comparison of Data from 2004 and 2009

The following tables summarize results of the chemical analyses of the samples collected in 2004 and 2009 from four wells in the Lake Champlain Basin of eastern New York.

Table 2-1. Physiochemical properties and concentrations of major ions, nutrients, and bacteria in groundwater samples collected in the Lake Champlain Basin, New York, 2004 and 2009.

[NWIS, National Water Information System; wu, unfiltered water; wf, filtered water; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; $CaCO_3$, calcium carbonate; ºC, Celsius; N, nitrogen; P, phosphorus; CFU, colony-forming unit; mL, milliliter; <, less than, E, estimated concentration; lab, laboratory]

U.S. Geological Survey NWIS parameter code	Constituent	Well EX 155		Well EX 535		Well W 534		Well CL 149	
		2004	2009	2004	2009	2004	2009	2004	2009
00080	Color, wf, platinum-cobalt units	2	<1	18	2	2	2	15	20
00300	Dissolved oxygen, wu, mg/L	4.0	5.4	<.1	1.6	5.3	3.3	1.0	.3
00400	pH, wu	6.6	7.0	7.3	7.0	7.2	6.8	7.4	7.2
00095	Specific conductance, wu, µS/cm	112	95	478	482	453	422	1,090	1,250
00010	Temperature, wu, degrees Celsius	6.8	7.9	9.8	13.5	9.0	9.8	9.0	9.0
00900	Hardness, wf, mg/L as $CaCO_3$	50	31	290	250	250	210	310	320
00915	Calcium, wf, mg/L	14.5	8.68	66.6	57.1	67.5	55.9	65.8	69.2
00925	Magnesium, wf, mg/L	3.33	2.37	30.2	27.0	19.6	16.6	35.8	35.0
00935	Potassium, wf, mg/L	.47	.54	.86	.78	.97	.79	9.25	8.85
00930	Sodium, wf, mg/L	2.74	2.25	3.87	3.61	3.05	3.72	127	125
90410	Acid neutralizing capacity, wu, fixed end point, lab, mg/L as $CaCO_3$	34	28	179	194	146	190	244	264
29801	Alkalinity, wf, fixed end point, laboratory, mg/L as $CaCO_3$	34	29	235	216	210	192	253	264
29805	Bicarbonate, wf, fixed end point, laboratory, mg/L	41	35	287	264	256	234	309	322
00940	Chloride, wf, mg/L	8.29	1.67	.76	.74	4.67	6.46	189	193
00950	Fluoride, wf, mg/L	<.17	<.08	<.17	E .07	<.17	E .08	<.17	.15
00955	Silica, wf, mg/L	22.1	18.4	18.0	15.4	12.3	10.5	9.19	8.68
00945	Sulfate, wf, mg/L	7.33	7.90	30.7	29.6	31.5	23.2	97.6	89.4
70300	Dissolved solids, dried at 180ºC, wf, mg/L	82	65	289	268	264	236	703	700
00623	Ammonia + organic-N, wf, mg/L as N	<.10	<.10	<.10	<.10	<.10	<.10	.12	<.10
00608	Ammonia, wf, mg/L as N	<.04	E .014	<.04	<.020	<.04	<.020	.07	<.020
00631	Nitrate plus nitrite, wf, mg/L as N	.06	.15	<.06	<.04	.55	.23	<.06	<.04
00613	Nitrite, wf, mg/L as N	<.008	<.002	<.008	<.002	<.008	<.002	<.008	<.002
00671	Orthophosphate, wf, mg/L as P	<.02	.009	<.02	.009	<.02	.009	<.02	.086
00680	Organic carbon, wu, mg/L	1.35	.7	E 1.42	E .5	1.21	E .5	2.01	1.3
31691	*Escherichia coli*, wu, CFU per 100 mL	<1	<1	<1	<1	<1	<1	<1	<1
61215	Fecal coliform, wu, CFU per 100 mL	<1	<1	<1	1	<1	<1	<1	<1
31692	Heterotrophic plate count, wu, CFU per mL	1	3	1	23	8	5	3	7
61213	Total coliform, wu, CFU per 100 mL	<1	<1	<1	<1	<1	<1	<1	<1

Table 2-2. Concentrations of trace elements and radionuclides in groundwater samples collected in the Lake Champlain Basin, New York, 2004 and 2009.

[NWIS, National Water Information System; wu, unfiltered water; wf, filtered water; µg/L, micrograms per liter, pCi/L, picocuries per liter; <, less than, E, estimated concentration]

U.S. Geological Survey NWIS parameter code	Constituent	Well EX 155		Well EX 535		Well W 534		Well CL 149	
		2004	2009	2004	2009	2004	2009	2004	2009
01105	Aluminum, wu, µg/L	<2	<6	2	9	<2	<6	E 2	<6
01097	Antimony, wu, µg/L	<.2	<.4	<.2	<.4	<.2	<.4	<.2	<.4
01002	Arsenic, wu, µg/L	<2	.20	<2	.92	<2	.97	<2	1.2
01007	Barium, wu, µg/L	1.9	1.5	11.6	11.8	15.4	13.8	65.9	86.9
01012	Beryllium, wu, µg/L	<.06	<.02	<.06	<.02	<.06	<.02	<.06	<.04
01020	Boron, wf, µg/L	8.5	4.3	E 4.4	E 1.9	E 6.6	7.9	115	110
01027	Cadmium, wu, µg/L	<.04	<.06	<.04	<.06	<.04	<.06	E .02	<.04
01034	Chromium, wu, µg/L	E .4	<.40	<.8	<.40	<.8	<.40	<.8	E .27
01037	Cobalt, wu, µg/L	.047	<.10	.312	.12	.249	<.10	.397	<.04
01042	Copper, wu, µg/L	2.5	25.9	1.5	<4.0	1.6	<4.0	1.4	<1.4
01046	Iron, wf, µg/L	7	25	662	573	<6	<4	543	46
01045	Iron, wu, µg/L	41	42	616	649	<9	<14	544	519
01051	Lead, wu, µg/L	.62	.24	.16	.16	.09	.15	<.06	E .04
01132	Lithium, wu, µg/L	<.6	<.6	.9	1.2	1.2	1.2	12.5	14.0
01056	Manganese, wf, µg/L	<.8	4.7	16.9	15.9	9.5	8.3	172	135
01055	Manganese, wu, µg/L	<1.2	4.3	16.1	15.8	15.3	11.0	176	205
71900	Mercury, wu, µg/L	<.018	<.010	<.018	<.010	<.018	<.010	<.018	<.010
01062	Molybdenum, wu, µg/L	<.2	.2	1.7	1.8	.3	.3	4.1	4.3
01067	Nickel, wu, µg/L	.23	<.20	.76	.36	.63	<.20	2.09	.78
01147	Selenium, wu, µg/L	<.4	<.12	<.4	<.12	<.4	E .12	E .3	<.10
01077	Silver, wu, µg/L	<.16	<.06	<.16	<.06	<.16	<.06	<.16	<.02
01082	Strontium, wu, µg/L	49.0	32.0	125	118	280	236	1,090	1,160
01059	Thallium, wu, µg/L	<.18	<.12	<.18	<.12	<.18	<.12	<.18	<.12
01092	Zinc, wu, µg/L	10	8.4	<2	E 1.4	E 1	E 1.0	<2	14.5
82303	Radon-222, wu, pCi/L	100	72	160	143	400	340	230	154
28011	Uranium, wu, µg/L	.018	E .012	.531	.585	.512	.475	.309	.439

Table 2-3. Concentrations of pesticides in groundwater samples collected in the Lake Champlain Basin, New York, 2004 and 2009.

[NWIS, National Water Information System; wf, filtered water; µg/L, micrograms per liter, <, less than, E, estimated concentration. **Bold** value indicates detected concentration.]

U.S. Geological Survey NWIS parameter code	Constituent	Well EX 155		Well EX 535		Well W 534		Well CL 149	
		2004	2009	2004	2009	2004	2009	2004	2009
82660	2,6-Diethylaniline, wf, µg/L	<0.006	<0.006	<0.006	<0.006	<0.006	< .006	<0.006	<0.006
04040	2-Chloro-4-isopropylamino-6-amino-*s*-triazine (CIAT), wf, µg/L	<.006	<.014	<.006	<.014	<.006	**E .001**	<.006	<.014
49260	Acetochlor, wf, µg/L	<.006	<.010	<.006	<.010	<.006	<.010	<.006	<.010
46342	Alachlor, wf, µg/L	<.004	<.008	<.004	<.008	<.004	<.008	<.004	<.008
34253	*alpha*-HCH, wf, µg/L	<.005	<.008	<.005	<.008	<.005	<.008	<.005	<.004
39632	Atrazine, wf, µg/L	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007
82686	Azinphos-methyl, wf, µg/L	<.050	<.120	<.050	<.120	<.050	<.120	<.050	<.120
82673	Benfluralin, wf, µg/L	<.010	<.014	<.010	<.014	<.010	<.014	<.010	<.014
04028	Butylate, wf, µg/L	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.004
82680	Carbaryl, wf, µg/L	<.041	<.200	<.041	<.200	<.041	<.200	<.041	<.060
82674	Carbofuran, wf, µg/L	<.020	<.060	<.020	<.060	<.020	<.060	<.020	<.060
38933	Chlorpyrifos, wf, µg/L	<.005	<.010	<.005	<.010	<.005	<.010	<.005	<.010
82687	*cis*-Permethrin, wf, µg/L	<.006	<.014	<.006	<.014	<.006	<.014	<.006	<.014
04041	Cyanazine, wf, µg/L	<.018	<.040	<.018	<.040	<.018	<.040	<.018	<.022
82682	DCPA, wf, µg/L	<.003	<.006	<.003	<.006	<.003	<.006	<.003	<.008
62170	Desulfinylfipronil, wf, µg/L	<.004	<.012	<.004	<.012	<.004	<.012	<.004	<.012
39572	Diazinon, wf, µg/L	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005
39381	Dieldrin, wf, µg/L	<.005	<.009	<.005	<.009	<.005	<.009	<.005	<.009
82677	Disulfoton, wf, µg/L	<.02	<.04	<.02	<.04	<.02	<.04	<.02	<.04
82668	EPTC, wf, µg/L	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
82663	Ethalfluralin, wf, µg/L	<.009	<.009	<.009	<.009	<.009	<.009	<.009	<.006
82672	Ethoprop, wf, µg/L	<.005	<.016	<.005	<.016	<.005	<.016	<.005	<.016
62169	Desulfinylfipronil amide, wf, µg/L	<.009	<.029	<.009	<.029	<.009	<.029	<.009	<.029
62167	Fipronil sulfide, wf, µg/L	<.005	<.013	<.005	<.013	<.005	<.013	<.005	<.013
62168	Fipronil sulfone, wf, µg/L	<.005	<.024	<.005	<.024	<.005	<.024	<.005	<.024
62166	Fipronil, wf, µg/L	<.007	<.040	<.007	<.040	<.007	<.040	<.007	<.018
04095	Fonofos, wf, µg/L	<.003	<.010	<.003	<.010	<.003	<.010	<.003	<.004
39341	Lindane, wf, µg/L	<.004	<.014	<.004	<.014	<.004	<.014	<.004	<.004
82666	Linuron, wf, µg/L	<.035	<.060	<.035	<.060	<.035	<.060	<.035	<.060
39532	Malathion, wf, µg/L	<.027	<.020	<.027	<.020	<.027	<.020	<.027	<.016

Table 2-3. Concentrations of pesticides in groundwater samples collected in the Lake Champlain Basin, New York, 2004 and 2009. —Continued

[NWIS, National Water Information System; wf, filtered water; µg/L, micrograms per liter, <, less than, E, estimated concentration. **Bold** values indicate detections.]

U.S. Geological Survey NWIS parameter code	Constituent	EX 155		EX 535		W 534		CL 149	
		2004	2009	2004	2009	2004	2009	2004	2009
82667	Methyl parathion, wf, µg/L	<.006	<.008	<.006	<.008	<.006	<.008	<.006	<.008
39415	Metolachlor, wf, µg/L	<.013	<.014	<.013	<.014	<.013	<.014	<.013	<.014
82630	Metribuzin, wf, µg/L	<.006	<.016	<.006	<.016	<.006	<.016	<.006	<.012
82671	Molinate, wf, µg/L	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.003
82684	Napropamide, wf, µg/L	<.007	<.018	<.007	<.018	<.007	<.018	<.007	<.008
34653	*p,p*'-DDE, wf, µg/L	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.002
39542	Parathion, wf, µg/L	<.010	<.020	<.010	<.020	<.010	<.020	<.010	<.020
82669	Pebulate, wf, µg/L	<.004	<.016	<.004	<.016	<.004	<.016	<.004	<.016
82683	Pendimethalin, wf, µg/L	<.022	<.012	<.022	<.012	<.022	<.012	<.022	<.012
82664	Phorate, wf, µg/L	<.011	<.020	<.011	<.020	<.011	<.020	<.011	<.020
04037	Prometon, wf, µg/L	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
82676	Propyzamide, wf, µg/L	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004
04024	Propachlor, wf, µg/L	<.010	<.012	<.010	<.012	<.010	<.012	<.010	<.006
82679	Propanil, wf, µg/L	<.011	<.014	<.011	<.014	<.011	<.014	<.011	<.010
82685	Propargite, wf, µg/L	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02
04035	Simazine, wf, µg/L	<.005	<.010	<.005	<.010	<.005	<.010	<.005	<.006
82670	Tebuthiuron, wf, µg/L	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.03
82665	Terbacil, wf, µg/L	<.034	<.040	<.034	<.040	<.034	<.040	<.034	<.024
82675	Terbufos, wf, µg/L	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02
82681	Thiobencarb, wf, µg/L	<.005	<.016	<.005	<.016	<.005	<.016	<.005	<.016
82678	Triallate, wf, µg/L	<.002	<.006	<.002	<.006	<.002	<.006	<.002	<.006
82661	Trifluralin, wf, µg/L	<.009	<.012	<.009	<.012	<.009	<.012	<.009	<.018

Table 2-4. Concentrations of volatile organic compounds in groundwater samples collected in the Lake Champlain Basin, New York, 2004 and 2009.

[NWIS, National Water Information System; wu, unfiltered water; µg/L, micrograms per liter; <, less than. **Bold** values indicate detected concentrations.]

U.S. Geological Survey NWIS parameter code	Constituent	EX 155		EX 535		W 534		CL 149	
		2004	2009	2004	2009	2004	2009	2004	2009
34506	1,1,1-Trichloroethane, wu, µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
77652	1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113), wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
34496	1,1-Dichloroethane, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
34501	1,1-Dichloroethene, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
34536	1,2-Dichlorobenzene, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
32103	1,2-Dichloroethane, wu, µg/L	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
34541	1,2-Dichloropropane, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
34566	1,3-Dichlorobenzene, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
34571	1,4-Dichlorobenzene, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
34030	Benzene, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
32101	Bromodichloromethane, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	**1.7**
32104	Tribromomethane, wu, µg/L	<.2	<.2	<.2	<.2	<.2	<.2	<.2	**11.8**
34301	Chlorobenzene, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
77093	*cis*-1,2-Dichloroethene, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
32105	Dibromochloromethane, wu, µg/L	<.2	<.2	<.2	<.2	<.2	<.2	<.2	**7.8**
34668	Dichlorodifluoromethane, wu, µg/L	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
34423	Dichloromethane, wu, µg/L	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
81576	Diethyl ether, wu, µg/L	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
81577	Diisopropyl ether, wu, µg/L	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
34371	Ethylbenzene, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
50005	Methyl *tert*-pentyl ether, wu, µg/L	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
85795	*m*- + *p*-Xylene, wu, µg/L	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
77135	*o*-Xylene, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
77128	Styrene, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
50004	*tert*-Butyl ethyl ether, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
78032	Methyl *tert*-butyl ether (MTBE), wu, µg/L	<.2	<.2	<.2	<.2	<.2	<.2	**.7**	**.9**
34475	Tetrachloroethene, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
32102	Tetrachloromethane, wu, µg/L	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
34010	Toluene, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
34546	*trans*-1,2-Dichloroethene, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
39180	Trichloroethene, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
34488	Trichlorofluoromethane (CFC-11), wu, µg/L	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
32106	Trichloromethane, wu, µg/L	<.1	<.1	<.1	<.1	<.1	<.1	<.1	**.3**
39175	Vinyl chloride, wu, µg/L	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

For more information concerning this report, contact

Director
U.S. Geological Survey
New York Water Science Center
425 Jordan Road
Troy, NY 12180-8349
dc_ny@usgs.gov

or visit our Web site at:
http://ny.water.usgs.gov

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