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Geophysical, Stratigraphic, and Flow-Zone Logs of Selected Wells in Cayuga County, New York, 2001–2011

Open-File Report 2011–1319

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

Cover. Geophysical logging at monitor well CY–229 (EPA-20) near Clark Street in Auburn, New York, in 2005.

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

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2012

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Conversion Factors and Datum

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
	Flow rate	
gallon per minute (gal/min)	0.06309	liter per second (L/s)
	Hydraulic gradient	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
	Transmissivity*	
square foot per day (ft^2/d)	0.09290	square meter per day (m^2/d)

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

°F=(1.8×°C)+32

Vertical coordinate information (above mean sea level) is referenced to either “North American Vertical Datum of 1988 (NAVD 88)” or “National Geodetic Vertical Datum of 1929 (NGVD 29).”

Horizontal coordinate information is referenced to “North American Datum of 1983 (NAD83)”

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

*Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness [(ft^3/d)/ft^2]ft. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

Acronyms

ATV	acoustic televiewer
CY	Cayuga County (prefix to well identifier)
Deg	degree (temperature)
GE	General Electric Company
MN	magnetic north
NYSDEC	New York State Department of Environmental Conservation
NYSEG	New York State Electric and Gas utility company
OTV	optical televiewer
PDF	portable document format
PVC	polyvinyl-chloride
REAC	Response Engineering and Analytical Contractor
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOCs	volatile-organic compounds

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Abstract

Geophysical logs were collected and analyzed along with bedrock core samples and bedrock outcrops to define the bedrock stratigraphy and flow zones penetrated by 93 monitor and water-supply wells in Cayuga County, New York. The work was completed from 2001 through 2011 as part of an investigation of volatile-organic compound contamination in the carbonate-bedrock aquifer system between Auburn and Union Springs. The borehole logs included gamma, caliper, wellbore image, fluid property, and flow logs. The log information was used with bedrock core samples to define the regional stratigraphy, evaluate flow zones within the bedrock aquifers, and develop and implement a multilevel monitoring design for groundwater levels and water quality within the study area.

Introduction

Volatile-organic compounds (VOCs) have been detected in water sampled from more than 50 water-supply wells between the city of Auburn and the village of Union Springs in central Cayuga County, New York (fig. 1). More than 300 wells were sampled in the area by the Cayuga County Environmental Health Department, the New York State Department of Environmental Conservation (NYSDEC), the New York State Department of Health, and the U.S. Environmental Protection Agency (USEPA) following the detection of VOCs in the Union Springs municipal wells in 2000. The area was declared a Superfund Site and listed on the National Priorities List in 2002 (U.S. Environmental Protection Agency, 2002).

Geophysical logs record measurements of physical properties of the bedrock penetrated by wells. The geophysical probes are lowered into a well to collect continuous and point data that are graphically displayed on a depth scale. Multiple logs and descriptions of rock core samples, when available, are typically integrated as a suite of logs that can provide a composite analysis of the borehole. The log information is used in hydrogeologic and environmental investigations to evaluate well construction, rock lithology, stratigraphy, fracture patterns, permeability and porosity, and water quality. The information is also useful for placement of monitoring zones in wells and for characterizing the hydrogeology of contamination sites.

From 2001 through 2011, the U.S. Geological Survey (USGS) collected and compiled geophysical logs from selected monitor and water-supply wells as part of the investigation of VOC contamination in the carbonate-bedrock aquifer in Cayuga County. The USGS analyzed the geophysical logs along with core samples and inspected outcrops of the bedrock to define the stratigraphic units penetrated by wells, evaluate flow zones within the bedrock aquifers, and develop and install a multilevel monitoring system for the study area. Thirty-seven borehole logs available prior to 2003 were presented in Anderson and others (2004). This report revises and updates the information in Anderson and others (2004) and includes information on geophysical logs that have been conducted at an additional 56 wells from 2003 through 2011. This report describes the methods used in the study and presents the updated geophysical, stratigraphic, and flow-zone logs for the 93 wells logged within the study area.

The study area occupies 7 square miles (mi^2) between the City of Auburn and the Village of Union Springs in central Cayuga County (fig. 1). The area is underlain by glacial till of varying thickness and carbonate, clastic, and evaporite bedrock units of Silurian and Devonian age that regionally dip southward at about 50 feet per mile (ft/mi) (Kantrowitz, 1970). The area is part of the Finger Lakes region and lies between Owasco Lake to the east and Cayuga Lake to the west (fig. 1). The local topography consists of gently rolling hills of the glaciated Appalachian Plateau and has altitudes that range from about 800 feet (ft) above sea level in the south-central part of the study area to about 485 ft above sea level at Cayuga Lake.

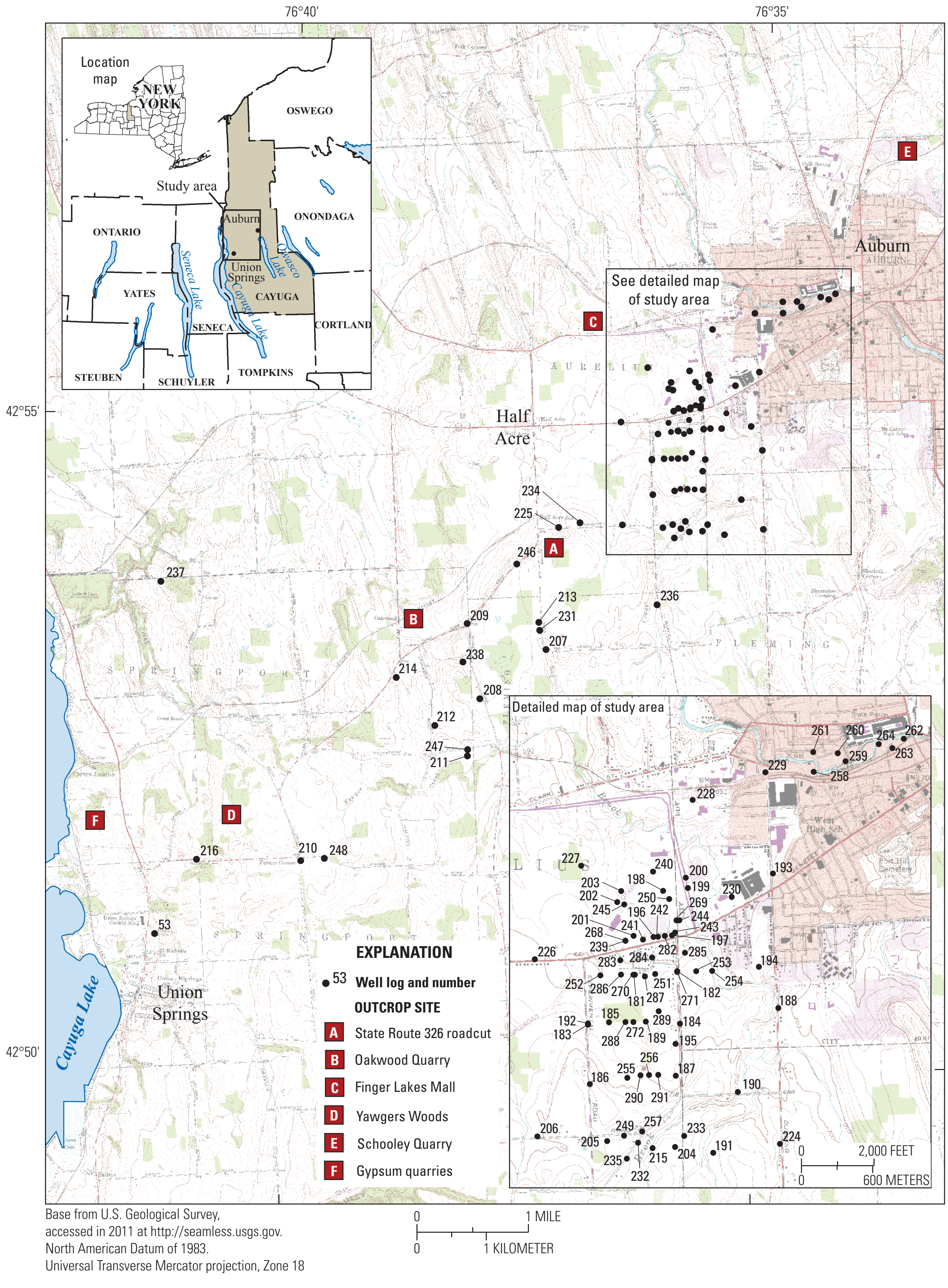

Figure 1. Location of study area and selected wells and outcrops in Cayuga County, New York.

Description of Wells

Geophysical logs were collected from 93 wells—26 USEPA and NYSDEC monitor wells, 38 private monitor wells, 20 private residential wells, 7 monitor wells owned by a utility company, and 2 municipal wells. Core samples were examined from 41 wells, and the lithologic, stratigraphic, structural, and faunal descriptions are available from three of the cored wells (CY–181, CY–186, and CY–196) to supplement the geophysical logs. The well locations are shown in figure 1, and well information and logging dates are given in table 1. The types and sources of logs and core samples collected from the wells are given in table 2. The logs are available online for display and download in log Ascii standard (LAS), portable document format (PDF), and WellCad (WCL) formats. Below is a link to the Web site for online access:

http://ny.water.usgs.gov/projects/geologs.

Most monitor wells (table 1) were constructed as test wells with open 4-inch (in.)-diameter boreholes below steel casing that is sealed with grout into the bedrock. After logging was completed, the USEPA boreholes were completed with multizone monitoring systems of 1.5-in.-diameter polyvinyl-chloride (PVC) casing and inflated packers that isolate as many as 10 discrete stratigraphic intervals, except CY–191, which remains as an open borehole. Four monitor wells (CY–192—CY–195) were constructed by the NYSDEC as test wells with multiple telescopic steel casings and an open-hole interval near the bottom. The private monitor wells, which are associated with a former industrial facility, were completed after logging the 4-in.-diameter open boreholes with grouted 2-in.-diameter PVC casing and screens with sand-packed discrete intervals near the bottom. Natural gamma logs were collected in seven of the private monitor wells through the completed 2-in.-diameter PVC casing. One private monitor well (CY–196) was not accessible for logging, but its core is described. Twenty wells constructed for domestic water supply were completed as 6-in.-diameter open holes below steel casing set into the top of bedrock. Well CY–216 is used for a municipal town hall and is cased more than 100 ft into bedrock. Well CY–53 provides municipal water supply and is an open borehole below steel casing that terminates near the top of bedrock.

Description of Logs

The geophysical logs collected from November 2001 through January 2011 include natural gamma, single-point resistance, mechanical-and acoustic-caliper, optical-televiewer (OTV) and acoustic-televiewer (ATV), single-point resistance, fluid-resistivity, temperature, and flow logs (appendix 1). The geophysical logs and rock core descriptions presented in this report were collected from 58 wells by the USGS, 4 wells by a USEPA contractor, and 31 wells by a private contractor.

The geophysical logs summarized in this report are available in LAS, text file (TXT), PDF, and WCL formats from the USGS geophysical log archive at *http://ny.water.usgs.gov/projects/geologs/*. The WellCad Reader[1] program, which may be obtained free of charge through *http://www.alt.lu/downloads.htm*, allows the logs to be displayed, tabulated, and printed at user-specified vertical scales. Core samples for selected wells are available for inspection at the USGS office in Ithaca, N.Y. The following sections describe details of the composite geophysical, flow-zone, and stratigraphic logs that are summarized in tables 1 and 2.

Geophysical Logs

The geophysical logs used in this investigation are described briefly below. The logs include natural gamma, caliper, single-point resistance, wellbore image, fluid properties, and flowmeter. Gamma logs were collected by a borehole tool that senses natural gamma radiation from the earth material around the wellbore. The caliper logs were collected by mechanical and acoustical methods. Wellbore-image logs were collected with video cameras and ATVs and OTVs. Fluid-property logs included fluid-resistivity and temperature measurements. Flowmeter logs were collected by heat-pulse, electromagnetic, and spinner methods. Additional information on geophysical logs and logging for groundwater investigations is presented in Keys (1990), American Society for Testing and Materials (2010), and Williams and Lane (1998).

Gamma logs measure the gamma radiation of rocks surrounding the wellbore. Major natural gamma emitters are uranium, thorium, and daughter (radioactive decay) products of potassium-40. Rock units with relatively high gamma radiation when compared with other lithologic units include shales, bentonites, and other argillaceous units as well as phosphate-rich zones. The gamma tool has a vertical resolution of 1 to 2 ft. Gamma logs collected in open holes and through steel and PVC casing were the primary logs used for lithologic identification and stratigraphic correlation.

[1]Use of the trade name WellCAD Reader in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Table 1. Information for surveyed wells with borehole logs in Cayuga County, New York, 2001–2011.

[ft, foot; GE, General Electric Company; in., inch; NAD83, North American Datum of 1983; NGVD29, National Geodetic Vertical Datum of 1929; NAVD88, North American Vertical Datum of 1988; NYSDEC, New York State Department of Environmental Conservation; NYSEG, New York State Electric and Gas utility company; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available. Well numbers and site numbers assigned by the U.S. Geological Survey]

Well number	Site number	Well owner	Local well name	Land surface altitude (ft)	Well depth (ft)	Casing depth (ft)	Well diameter (in.)	Date of log	Vertical datum	Horizontal datum
CY–53	425056076412201	Municipal	South Well	439.0	120	18	8	11/13/2002	NAVD88	NAD83
CY–181	425456076355401	USEPA	EPA–1	658.3	187	13	4	10/24/2001	NAVD88	NAD83
CY–182	425458076353801	USEPA	EPA–2	659.4	205	19	4	12/13/2001	NAVD88	NAD83
CY–183	425443076361101	USEPA	EPA–3	670.2	195	8	4	12/10/2001	NAVD88	NAD83
CY–184	425443076353701	USEPA	EPA–4	671.7	211	14	4	12/12/2001	NAVD88	NAD83
CY–185	425443076360301	USEPA	EPA–5	675.1	210	102	4	07/09/2002	NAVD88	NAD83
CY–186	425426076361001	USEPA	EPA–6	719.5	244	32	4	10/24/2001	NAVD88	NAD83
CY–187	425429076353801	USEPA	EPA–7	691.3	250	13.5	4	03/12/2004	NAVD88	NAD83
CY–188	425448076350001	USEPA	EPA–8	679.1	242	19	4	03/09/2004	NAVD88	NAD83
CY–189	425444076354901	USEPA	EPA–9	661.5	202	103	4	07/10/2002	NAVD88	NAD83
CY–190	425425076351301	USEPA	EPA–10	701.9	262	142	4	03/11/2004	NAVD88	NAD83
CY–191	425407076352401	USEPA	EPA–11	712.6	250	150	4	07/11/2002	NAVD88	NAD83
CY–192	425443076361102	NYSDEC	DEC–3	670.5	310	290	8	10/16/2001	NAVD88	NAD83
CY–193	425525076350301	NYSDEC	DEC–4	643.3	198.5	180	8	10/16/2001	NAVD88	NAD83
CY–194	425459076350801	NYSDEC	DEC–5	665.7	285	266	8	10/16/2001	NAVD88	NAD83
CY–195	425438076353801	NYSDEC	DEC–6	681.7	311	290	8	10/16/2001	NAVD88	NAD83
CY–196	425507076354701	GE	CH–1D	636.9	100	70	1.25	--	NGVD29	NAD83
CY–197	425507076354001	GE	B–02D	643.1	100	69	2	07/16/2002	NGVD29	NAD83
CY–198	425519076354401	GE	B–04D	638.8	96	81	2	07/16/2002	NGVD29	NAD83
CY–199	425520076353501	GE	B–21D	630.0	130	85	2	07/16/2002	NGVD29	NAD83
CY–200	425523076353601	GE	B–22D	629.0	130	100	2	07/16/2002	NGVD29	NAD83
CY–201	425507076355501	GE	B–25D	639.0	100	85	2	07/16/2002	NGVD29	NAD83
CY–202	425516076360101	GE	B–26D	628.0	100	85	2	07/17/2002	NGVD29	NAD83
CY–203	425519076355901	GE	B–28D	627.0	100	85	2	07/17/2002	NGVD29	NAD83
CY–204	425410076353801	Private	Residential	737.7	222	64.5	6	08/26/2002	NAVD88	NAD83
CY–205	425411076360301	Private	Residential	718.5	222	40	6	08/27/2002	NAVD88	NAD83
CY–206	425412076362901	Private	Residential	691.6	204	25	6	08/28/2002	NAVD88	NAD83
CY–207	425313076371601	Private	Residential	760.0	322	29	6	09/23/2002	NAVD88	NAD83
CY–208	425249076375801	Private	Residential	717.0	269	25	6	09/24/2002	NAVD88	NAD83
CY–209	425324076380701	Private	Residential	705.0	243	30	6	09/25/2002	NAVD88	NAD83
CY–210	425132076395001	Private	Residential	587.2	178	32	6	10/08/2002	NAVD88	NAD83

Table 1. Information for surveyed wells with borehole logs in Cayuga County, New York, 2001–2011.

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Well number	Site number	Well owner	Local well name	Land surface altitude (ft)	Well depth (ft)	Casing depth (ft)	Well diameter (in.)	Date of log	Vertical datum	Horizontal datum
CY–211	425222076380501	Private	Residential	711.0	273	25	6	10/10/2002	NAVD88	NAD83
CY–212	425236076382601	Private	Residential	684.6	240	16	6	10/11/2002	NAVD88	NAD83
CY–213	425325076372101	Private	Residential	734.0	289	53	6	10/08/2002	NAVD88	NAD83
CY–214	425258076385101	Private	Residential	639.4	162	20	6	11/12/2002	NAVD88	NAD83
CY–215	425409076354601	Private	Residential	723.0	221	39	6	11/14/2002	NAVD88	NAD83
CY–216	425131076405601	Municipal	Town hall	499.6	120	112	6	10/07/2002	NAVD88	NAD83
CY–224	425411076345901	USEPA	EPA–14	717.3	377	114	4	05/25/2006	NAVD88	NAD83
CY–225	425410076371001	USEPA	EPA–16	688.9	291	17	4	10/26/2005	NAVD88	NAD83
CY–226	425502076363201	USEPA	EPA–17	650.1	219	17	4	10/26/2005	NAVD88	NAD83
CY–227	425526076361501	USEPA	EPA–18	637.5	155	28	4	11/21/2005	NAVD88	NAD83
CY–228	425544076353401	USEPA	EPA–19	633.9	161	43	4	11/15/2005	NAVD88	NAD83
CY–229	425559076351101	USEPA	EPA–20	643.5	155	33	4	10/25/2005	NAVD88	NAD83
CY–230	425518076351901	USEPA	EPA–21	633.7	171	38	4	12/13/2005	NAVD88	NAD83
CY–231	425322076372101	USEPA	EPA–23	732.8	327	18	4	11/15/2005	NAVD88	NAD83
CY–232	425411076355201	Private	Residential	726.1	207	40	6	12/15/2005	NAVD88	NAD83
CY–233	425413076343501	Private	Residential	725.0	198	67.5	6	05/24/2006	NAVD88	NAD83
CY–234	425413076365601	Private	Residential	722.0	206	33	6	05/26/2006	NAVD88	NAD83
CY–235	425407076355601	Private	Residential	727.9	240	79	6	08/16/2006	NAVD88	NAD83
CY–236	425335076360601	Private	Residential	748.3	299	48.5	6	08/17/2006	NAVD88	NAD83
CY–237	425342076412301	Private	Residential	505.0	42.5	20	6	08/21/2006	NAVD88	NAD83
CY–238	425307076380901	Private	Residential	710.2	327	55	6	08/22/2006	NAVD88	NAD83
CY–239	425506076355801	GE	B–29D3	638.3	160	21	4	12/17/2003	NGVD29	NAD83
CY–240	425524076354601	GE	B–30D3	629.7	140	25.2	4	12/10/2003	NGVD29	NAD83
CY–241	425507076355101	GE	B–31D3	641.9	160	18.2	4	01/13/2004	NGVD29	NAD83
CY–242	425508076354701	GE	B–32D3	636.8	160	24.3	4	01/22/2004	NGVD29	NAD83
CY–243	425509076354001	GE	B–33D3	642.1	167.4	23.5	4	03/2004	NGVD29	NAD83
CY–244	425511076354001	GE	B–34D3	642.2	170	24	4	02/05/2004	NGVD29	NAD83
CY–245	425516076355901	GE	B–41D3	632.1	136.5	70.2	4	09/21/2004	NGVD29	NAD83
CY–246	425353076373601	USEPA	EPA–24	724.1	321	82	5	04/09/2007	NAVD88	NAD83
CY–247	425226076380501	USEPA	EPA–25	712.5	351	112	5	05/30/2007	NAVD88	NAD83
CY–248	425132076393501	USEPA	EPA–26	581.4	271	52	5	05/30/2007	NAVD88	NAD83

Table 1. Information for surveyed wells with borehole logs in Cayuga County, New York, 2001–2011.

[ft, foot; GE, General Electric Company; in., inch; NAD83, North American Datum of 1983; NGVD29, National Geodetic Vertical Datum of 1929; NAVD88, North American Vertical Datum of 1988; NYSDEC, New York State Department of Environmental Conservation; NYSEG, New York State Electric and Gas utility company; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available. Well numbers and site numbers assigned by the U.S. Geological Survey]

Well number	Site number	Well owner	Local well name	Land surface altitude (ft)	Well depth (ft)	Casing depth (ft)	Well diameter (in.)	Date of log	Vertical datum	Horizontal datum
CY–249	425413076355701	Private	Residential	717.2	201	28.5	6	06/01/2007	NAVD88	NAD83
CY–250	425518076354201	GE	B–42D3	640.7	158	23.5	4	10/2004	NGVD29	NAD83
CY–251	425457076354701	GE	B–43D3	659.8	190	99	4	10/2005	NGVD29	NAD83
CY–252	425455076360801	GE	B–44D3	650.9	168	18	4	11/2005	NGVD29	NAD83
CY–253	425458076353401	GE	B–45D3	662.3	190	15	4	01/2006	NGVD29	NAD83
CY–254	425458076352701	GE	B–46D3	649.0	177	9	4	01/2006	NGVD29	NAD83
CY–255	425429076355601	GE	B–47D3	695.1	237	24.5	4	06/06/2006	NGVD29	NAD83
CY–256	425430076354801	GE	B–48D3	696.6	241.5	12.5	4	06/09/2006	NGVD29	NAD83
CY–257	425415076354901	GE	B–49D3	734.3	305	98	4	02/19/2007	NGVD29	NAD83
CY–258	425553076344901	NYSEG	MW–1D	635.9	79.5	30	4	11/29/2006	NAVD88	NAD83
CY–259	425556076343801	NYSEG	MW–14D	650.7	70	19	4	11/29/2006	NAVD88	NAD83
CY–260	425559076344101	NYSEG	MW–15D	637.5	62	8.2	4	11/29/2006	NAVD88	NAD83
CY–261	425558076345001	NYSEG	MW–17D	635.7	65	12.5	4	11/29/2006	NAVD88	NAD83
CY–262	425602076341601	NYSEG	MW–06–1R	664.0	79.2	17.2	4	01/11/2007	NAVD88	NAD83
CY–263	425560076342001	NYSEG	MW–06–6R	668.7	79.8	22.5	4	01/11/2007	NAVD88	NAD83
CY–264	425601076342601	NYSEG	MW–06–16R	660.0	79.4	14	4	01/12/2007	NAVD88	NAD83
CY–268	425506076355802	GE	B–29D5	638.8	225.5	161	4	01/06/2009	NGVD29	NAD83
CY–269	425511076354002	GE	B–34D5	642.0	233.5	173	4	01/14/2009	NGVD29	NAD83
CY–270	425456076355501	GE	B–50D5	660.5	249.5	190	4	01/15/2009	NGVD29	NAD83
CY–271	425457076353801	GE	B–51D5	661.0	270.0	208	4	01/13/2009	NGVD29	NAD83
CY–272	425444076355401	GE	B–52D3	662.5	195.5	12	4	01/12/2009	NGVD29	NAD83
CY–282	425507076354401	GE	B–53D3	637.1	160.0	44.9	4	05/17/2009	NGVD29	NAD83
CY–283	425500076355701	GE	B–54D3	644.9	164.0	6	4	05/25/2009	NGVD29	NAD83
CY–284	425501076354801	GE	B–55D3	650.0	189.0	24.3	4	05/24/2009	NGVD29	NAD83
CY–285	425503076353601	GE	B–56D3	647.7	207.5	137	4	05/17/2009	NGVD29	NAD83
CY–286	425456076355701	GE	B–57D3	661.4	186.0	14.5	4	05/27/2009	NGVD29	NAD83
CY–287	425455076355101	GE	B–58D3	657.3	184.5	11.1	4	05/19/2009	NGVD29	NAD83
CY–288	425444076355801	GE	B-59D3	664.2	191.4	11.3	4	02/07/2011	NGVD29	NAD83
CY–289	425449076354401	GE	B-60D3	662.9	203.1	15.8	4	12/21/2010	NGVD29	NAD83
CY–290	425429076354901	GE	B-61D3	698.0	242.5	19	4	01/17/2011	NGVD29	NAD83
CY–291	425429076354301	GE	B-62D3	693.7	242.8	19	4	01/19/2011	NGVD29	NAD83

Table 2. Borehole information collected for wells surveyed in Cayuga County, New York, 2001–2011.

[GE, General Electric Company; REAC, Response Engineering and Analytical Contractor; USGS, U.S. Geological Survey. Well number assigned by the USGS. USGS standard log suite: Gamma, caliper, optical-and(or) acoustic-televiewer, deviation, fluid-resistivity, and temperature logs; caliper, televiewer, and deviation were not collected from wells CY 259 and 260; REAC standard log suite: Gamma, fluid-resistivity, and temperature logs; GE standard log suite: Gamma, single-point resistance, caliper, optical-and/or acoustic-televiewer, deviation, fluid-resistivity, and temperature logs.]

Well no.	Local well name	Log source	Standard log suite	Ambient flow log	Pumped flow log	Borehole video	Core samples
CY–53	South Well	USGS	X	X	X	X	
CY–181	EPA–1	USGS	X	X	X	X	X
CY–182	EPA–2	USGS	X	X			
CY–183	EPA–3	USGS	X	X			
CY–184	EPA–4	USGS	X	X			
CY–185	EPA–5	USGS	X	X	X		
CY–186	EPA–6	USGS	X	X		X	X
CY–187	EPA–7	USGS	X	X	X		
CY–188	EPA–8	USGS	X	X			
CY–189	EPA–9	USGS	X	X			
CY–190	EPA–10	USGS	X	X			
CY–191	EPA–11	USGS	X	X			
CY–192	DEC–3	REAC	X				
CY–193	DEC–4	REAC	X				
CY–194	DEC–5	REAC	X				
CY–195	DEC–6	REAC	X				
CY–196	CH–1D	GE					X
CY–197	B–02D	USGS	X	X			
CY–198	B–04D	USGS	X	X			
CY–199	B–21D	USGS	X	X			
CY–200	B–22D	USGS	X	X			
CY–201	B–25D	USGS	X	X			
CY–202	B–26D	USGS	X	X			
CY–203	B–28D	USGS	X	X			
CY–204	Residential	USGS	X	X			
CY–205	Residential	USGS	X	X			
CY–206	Residential	USGS	X	X			
CY–207	Residential	USGS	X	X			
CY–208	Residential	USGS	X	X			
CY–209	Residential	USGS	X	X			
CY–210	Residential	USGS	X	X			
CY–211	Residential	USGS	X	X			
CY–212	Residential	USGS	X	X			
CY–213	Residential	USGS	X	X			
CY–214	Residential	USGS	X	X			
CY–215	Residential	USGS	X	X			
CY–216	Town hall	USGS	X	X	X		
CY–224	EPA–14	USGS	X	X	X		X
CY–225	EPA–16	USGS	X	X	X	X	X

Table 2. Borehole information collected for wells surveyed in Cayuga County, New York, 2001–2011.

[USGS, U.S. Geological Survey; REAC, Response Engineering and Analytical Contractor; GE, General Electric Company. Well number assigned by U.S. Geological Survey. USGS standard log suite: Gamma, caliper, optical-and/or acoustic-televiewer, deviation, fluid-resistivity, and temperature logs; caliper, televiewer, and deviation were not collected from wells CY 259 and 260; REAC standard log suite: Gamma, fluid-resistivity, and temperature logs; GE standard log suite: Gamma, single-point resistance, caliper, optical-and/or acoustic-televiewer, deviation, fluid-resistivity, and temperature logs.]

Well no.	Local well name	Log source	Standard log suite	Ambient flow log	Pumped flow log	Borehole video	Core samples
CY–226	EPA–17	USGS	X	X	X		
CY–227	EPA–18	USGS	X	X	X		X
CY–228	EPA–19	USGS	X	X	X		
CY–229	EPA–20	USGS	X	X	X		
CY–230	EPA–21	USGS	X	X			X
CY–231	EPA–23	USGS	X	X			
CY–232	Residential	USGS	X	X			
CY–233	Residential	USGS	X	X			
CY–234	Residential	USGS	X	X			
CY–235	Residential	USGS	X	X			
CY–236	Residential	USGS	X	X			
CY–237	Residential	USGS	X	X			
CY–238	Residential	USGS	X	X		X	X
CY–239	B–29D3	GE	X	X	X	X	X
CY–240	B–30D3	GE	X	X	X	X	X
CY–241	B–31D3	GE	X	X	X	X	X
CY–242	B–32D3	GE	X	X	X	X	X
CY–243	B–33D3	GE	X	X	X	X	X
CY–244	B–34D3	GE	X	X	X	X	X
CY–245	B–41D3	GE	X	X	X	X	X
CY–246	EPA–24	USGS	X	X	X		X
CY–247	EPA–25	USGS	X	X	X		X
CY–248	EPA–26	USGS	X	X	X		X
CY–249	Residential	USGS	X	X	X		
CY–250	B–42D3	GE	X	X	X	X	X
CY–251	B–43D3	GE	X	X	X	X	X
CY–252	B–44D3	GE	X	X	X	X	X
CY–253	B–45D3	GE	X	X	X	X	X
CY–254	B–46D3	GE	X	X	X	X	X
CY–255	B–47D3	GE	X	X	X	X	X
CY–256	B–48D3	GE	X	X	X	X	X
CY–257	B–49D3	GE	X	X	X		X
CY–258	MW–1D	USGS	X	X	X		
CY–259	MW–14D	USGS	X	X	X		
CY–260	MW–15D	USGS	X	X	X		
CY–261	MW–17D	USGS	X	X			
CY–262	MW–06–1R	USGS	X	X	X		
CY–263	MW–06–6R	USGS	X	X	X		
CY–264	MW–06–16R	USGS	X	X	X		

Table 2. Borehole information collected for wells surveyed in Cayuga County, New York, 2001–2011.

[USGS, U.S. Geological Survey; REAC, Response Engineering and Analytical Contractor; GE, General Electric Company. Well number assigned by U.S. Geological Survey. USGS standard log suite: Gamma, caliper, optical-and/or acoustic-televiewer, deviation, fluid-resistivity, and temperature logs; caliper, televiewer, and deviation were not collected from wells CY 259 and 260; REAC standard log suite: Gamma, fluid-resistivity, and temperature logs; GE standard log suite: Gamma, single-point resistance, caliper, optical-and/or acoustic-televiewer, deviation, fluid-resistivity, and temperature logs.]

Well no.	Local well name	Log source	Standard log suite	Ambient flow log	Pumped flow log	Borehole video	Core samples
CY–268	B–29D5	GE	X	X	X	X	X
CY–269	B–34D5	GE	X	X	X	X	X
CY–270	B–50D5	GE	X	X	X	X	X
CY–271	B–51D5	GE	X	X		X	X
CY–272	B–52D3	GE	X	X	X	X	X
CY–282	B–53D3	GE	X	X	X	X	X
CY–283	B–54D3	GE	X	X	X	X	X
CY–284	B–55D3	GE	X	X	X	X	X
CY–285	B–56D3	GE	X	X			X
CY–286	B–57D3	GE	X	X	X	X	X
CY–287	B–58D3	GE	X	X	X	X	X
CY–288	B–59D3	GE	X	X	X	X	X
CY–289	B–60D3	GE	X	X	X	X	X
CY–290	B–61D3	GE	X	X	X	X	X
CY–291	B–62D3	GE	X	X	X	X	X

Single-point resistance logs record the electrical resistance from points within the borehole to an electrical ground at land surface. Resistance generally increases with increasing grain size and decreases with increasing borehole diameter, fracture density, and the concentration of dissolved solids in the water. Single-point resistance logs are useful in the determination of lithology, water quality, and location of fracture zones and solution features.

Mechanical- and acoustic-caliper logs record the diameter of the wellbore. Changes in wellbore diameter are related to drilling and construction procedures and competency of lithologic units, fractures, and solution features. Mechanical-caliper logs were collected with a spring-loaded, three-arm averaging tool; acoustic-caliper logs were calculated from acoustic travel times collected with the acoustic-televiewer tool. Caliper logs were used in the delineation of fractures, solution features, and lithology, and to confirm or determine well and casing depths and diameters.

Video-camera logs record an optical “fisheye” view of the wellbore and can be collected above water level and in areas below the surface of the water where the water is clear. Video-camera logs were used to directly view well and casing conditions, bedding and lithologic contacts, fractures, solution features, and cascading water from flow zones above the water level. The video logs are on file on DVD and are available for viewing at the USGS office in Troy, N.Y. (*http://ny.usgs.gov/*).

OTV and ATV logs record 360-degree, magnetically oriented images of the wellbore wall (Williams and Johnson, 2000, 2004). The OTV and ATV logs were used to characterize the distribution and orientation of planar fracture and bedding features intersected by the test wells. Fracture delineations from OTV and ATV logs of near-vertical wells may oversample low-angle fractures and undersample high-angle fractures.

Borehole-deviation logs show the tilt angle (in degrees from the vertical datum) and the azimuth of the tilt (in degrees from magnetic north) of the borehole.

Fluid-resistivity and temperature logs record the electrical resistivity and temperature of water in the wells. Fluid resistivity is directly related to the concentration of dissolved solids in the water. Slope changes in fluid-resistivity and temperature logs collected under ambient conditions may indicate zones of inflow to or outflow from the well. Collection of fluid-resistivity and temperature logs under pumped conditions provided an additional level of enhancement in flow-zone delineation in selected wells.

Flow logs record the direction and rate of vertical flow in the well. Vertical flow occurs under ambient conditions in wells that penetrate two or more flow zones under differing hydraulic head. Borehole flow under ambient conditions and, in selected wells, pumped or injection conditions was measured using heat-pulse, electromagnetic, and spinner flowmeters. Heat-pulse flowmeters, which are used in a stationary measurement mode, determines vertical flow based on the travel time of a thermal pulse between a set of upper and lower thermisters (Hess, 1982; Herman, 2006). The heat-pulse flowmeter used by the USGS, which was configured with a flexible rubber diverter fitted to the borehole diameter, has a measurement range of 0.005 to 1.0 gallon per minute (gal/min). The heat-pulse flowmeter used by the private contractor, which was not configured with a diverter, has a measurement range of 0.2 to 6.5 gal/min in the 4-in. diameter monitor wells in which it was deployed. Electromagnetic flowmeters (Young and Pearson, 1995), which are used in stationary and trolling modes, measure fluid velocity based on Faraday's Law; in application, the flow of the electrically-conductive fluid (water) through a magnetic field induced by the flowmeter generates a measurable voltage gradient that is proportional to the fluid's velocity. The electromagnetic flowmeter used by the USGS, which was configured with a flexible rubber diverter fitted to the borehole diameter, has a measurement range of 0.05 to 10 gal/min. Spinner flowmeters measure vertical flow by recording the rotation rate of a multiple-bladed impeller mounted with adjustable needle bearings on a freely rotating shaft (Keys, 1990). The spinner flowmeter used by the private contractor in a trolling mode has a low-threshold measurement of 2.1 gal/min in the 4-in. diameter monitor wells in which it was deployed.

Stratigraphic Logs

The stratigraphic logs delineate the geologic formations and members penetrated by the wells. The stratigraphy of central New York has been described by Harris (1905), Luther (1910), Oliver (1954), Rickard (1962, 1975, 1989), Demicco and others (1992), Brett and Ver Straeten (1994), and Brett and others (2000). The stratigraphic units penetrated by 41 of the 93 wells were identified by characterization of available core samples and their correlation to gamma logs. The stratigraphic units penetrated by wells without rock core samples were identified by characteristic signatures in the gamma logs; supporting information from the OTV and ATV logs was used where available.

The wells penetrate limestones, dolostones, shales, sandstones, and evaporites of Silurian to Devonian age. The identified stratigraphic units of Silurian age, in ascending order, are the Camillus Shale; the Fiddlers Green, Forge Hollow, and Oxbow Members of the Bertie Formation; the Cobleskill Limestone; and the lower part of the Chrysler Member of the Rondout Formation. The contact between the Camillus Shale and the Fiddlers Green dolostone (basal unit of the Bertie Formation) was identified in wells from characteristic core-sample lithologies and gamma signatures. The upper part of the Forge Hollow Member of the Bertie Formation (referred to as the D3 flow zone) is gypsum and argillaceous gypsiferous dolostone that has significant solution features that are seen in many borehole logs as open voids, typically within the top 15 ft of the Forge Hollow Member contact with the overlying Oxbow Member. The presence of the Akron Dolomite, which may interfinger locally with the Cobleskill Limestone as an equivalent dolomitized facies (Brett and others, 2000) and which may be penetrated by some wells, could not be confirmed through the geophysical log analysis.

The identified stratigraphic units of Devonian age, in ascending order, are the upper part of the Chrysler Member of the Rondout Formation; the Olney Member of the Manlius Formation; the Edgecliff, Nedrow, Moorehouse, and Seneca Members of the Onondaga Limestone; the Union Springs, Cherry Valley Limestone, and Oatka Creek Members of the Marcellus Shale; and the Mottville and Delphi Station Members of the Skaneateles Formation. The Mottville shale and sandstone and the Delphi Station shale, which were penetrated in only a few wells, were tentatively identified from characteristic thicknesses and gamma signatures. The Mottville Member is partly exposed in a road cut along State Route 326, about 1 mile (mi) south of Half Acre, N.Y. (fig. 1, outcrop site A).

The Oriskany Sandstone and the Springvale Sandstone of the Tri-States Group in central New York are discontinuously present between the Manlius Formation and Onondaga Limestone (Brett and others, 2000). The Oriskany and Springvale were not present in rock cores from wells nor in exposures at the Oakwood quarry (fig. 1, outcrop site B) or along State Route 5 and U.S. Route 20 near the Finger Lakes Mall (fig. 1, outcrop site C). However, a 3-ft-thick section of the Oriskany Sandstone is present at the Yawgers Woods outcrop (fig. 1, outcrop site D) described by Luther (1910). At the Schooley quarry (fig. 1, outcrop site E), no Oriskany Sandstone is present but a thin discontinuous bed of the Springvale Sandstone with its characteristic phosphate nodules is present. The Oriskany Sandstone and Springvale Sandstone were not identified through the geophysical log analysis, although relatively thin sections of these units may be penetrated by some of the wells. Clasts of reworked phosphate nodules from the Springvale Sandstone are present at the base of the Edgecliff Member of the Onondaga Limestone in many of the rock cores and in exposures at the Oakwood and Schooley quarries and along State Route 5 and U.S. Route 20 near the Finger Lakes Mall. The phosphate nodules produce a characteristic gamma peak that facilitates the identification of the contact between the Onondaga and Manlius Formations, which is a major erosional unconformity. Another significant gamma peak is produced by the Tioga Bentonite, which is a thin volcanic ash deposit at the contact of the Seneca and Moorehouse Members of the Onondaga Limestone (Ver Straeten, 2004).

Repeated stratigraphic sections were identified within the Manlius Formation in well CY–205, the Manlius and Onondaga Formations in well CY–212, and the Onondaga Formation and the Marcellus Shale in wells CY–215 and CY–225. The repeated sections are likely owing to localized thrust faults similar to that described by Conkin and Conkin (1984) and Duskin (1969) west and east of the study area.

Flow-Zone Logs

The flow-zone logs define the distribution and relative hydraulic head of flow zones penetrated by selected wells. The distribution and character of flow zones were determined by the integrated analysis of the caliper, OTV and ATV, fluid-resistivity, temperature, and flow logs. At least one feature within each zone was designated as an hydraulically active fracture or solution feature that contributes to the measured ambient or pumped flows (Paillet, 1998; 2000). Most flow zones were associated with bedding-related permeability including bedding fractures and solution features.

The ambient water levels measured in the open-hole multi-zone wells are composite hydraulic heads that reflect the transmissivity-weighted average of the heads of the penetrated flow zones (Bennett and others, 1982, Williams and Lane, 1998). Heads in inflow zones are higher than the composite water level, and outflow zones are lower than the composite water level.

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Appendix 1. Explanations For Abbreviations Used in Composites of Geophysical, Stratigraphic, and Flow-Zone Logs for Selected Wells, Cayuga County, New York, 2001–2011

The logs are available for display and download in log Ascii standard (LAS), portable document format (PDF), and WellCad (WCL) formats from the USGS geophysical log archive at *http://ny.water.usgs.gov/projects/geologs*. The WellCad Reader program, which may be obtained free of charge through *http://www.alt.lu/downloads.htm*, allows the logs to be displayed, tabulated, and printed at user-specified vertical scales.

Explanation

Depth—Depth, in feet below land surface at specified vertical scale

Form—Stratigraphic formation

Mmb—Stratigraphic member

Gamma—Natural gamma radiation, in counts per second

Mech Cal—Mechanical three-arm caliper, borehole diameter in inches

Acou Cal—Acoustic caliper from travel times collected with acoustic televiewer, borehole diameter in inches

ATV—Acoustic-televiewer image; 360-degree acoustic image of borehole wall; MN indicates log oriented to magnetic north; HS indicates log oriented to high side of borehole wall

OTV—Optical-televiewer image; 360-degree optical image of borehole wall; MN indicates log oriented to magnetic north; HS indicates log oriented to high side of borehole wall

SPR—Single-point resistance, in ohms

Fl Res—Fluid resistivity, in ohms per meter; blue line indicates log collected under ambient conditions; red line indicates log collected under pumped conditions (pmp) ; green line indicates log collected under injection conditions (inj)

Temp—Temperature, in degrees Celsius; blue line indicates log collected under ambient conditions; red line indicates log collected under pumped conditions (pmp) ; green line indicates log collected under injection conditions (inj)

Flow—Borehole flow measured by stationary flowmeter, in gallons per minute; ND indicates log collected without flow diverter; blue disk indicates log collected under ambient conditions; red square indicates log collected under pumped conditions (pmp); green triangle indicates log collected under injection conditions (inj)

Troll—Borehole flow measured by trolling flowmeter; scale adjusted to matched stationary flowmeter measurements; blue line indicates log collected under ambient conditions; red line indicates log collected under pumped conditions (pmp)

Flow zone—Flow zone; blue line indicates ambient composite hydraulic head; yellow line indicates inflow zone with head higher than composite head; red line indicates outflow zone with head lower than composite head; black line designates base of casing

Azi MN—Borehole deviation azimuth from magnetic north, in degrees.

Tilt—Borehole deviation angle from vertical, in degrees

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Eckhardt and others—**Geophysical, Stratigraphic, and Flow-Zone Logs in Cayuga County, NY, 2001–2011**—Open-File Report 2011-1319