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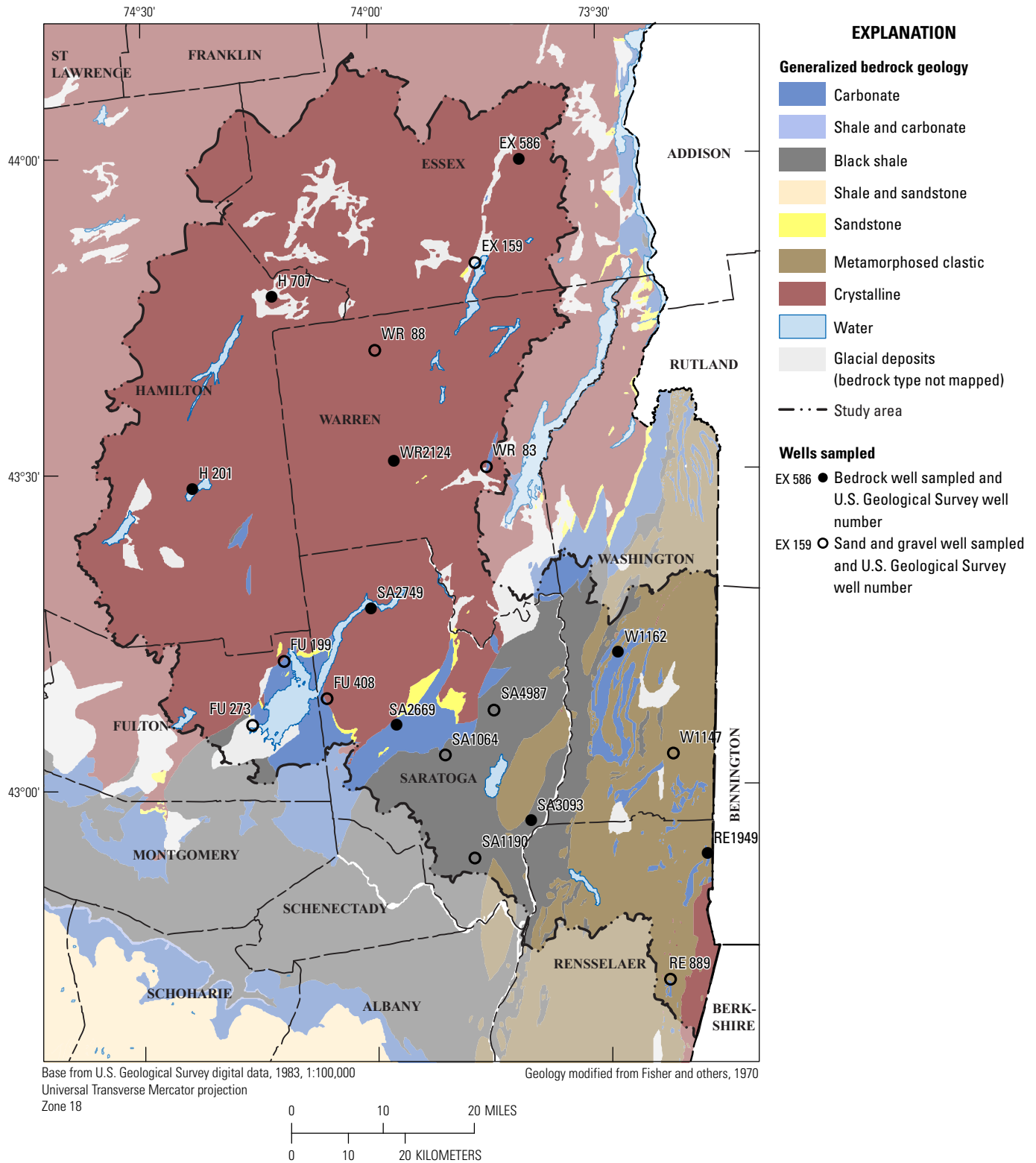







Figure 3. Generalized bedrock geology of the Upper Hudson River Basin, New York, and locations of wells sampled in 2012.

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

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

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

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

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

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

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

## Sampling Methods

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

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

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

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

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

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



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

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

## Analytical Methods

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

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

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

## Quality-Control Samples

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

## Groundwater Quality

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

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

### Physiochemical Properties

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

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

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

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

<sup>1</sup> U.S. Environmental Protection Agency Secondary Drinking Water Standard.











## Wells sampled in 2007 and 2012

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

## Summary

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

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

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

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

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

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

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



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