Arsenic and Uranium Occurrence in Private Wells in Connecticut, 2013–18—A Spatially Weighted and Bedrock Geology Assessment

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

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By Eliza L. Gross and Craig J. Brown

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
Length		
mile (mi)	1.609	kilometer (km)

Datum

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

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

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

Supplemental Information

Concentrations of chemical constituents in water are given in micrograms per liter (µg/L).

Abbreviations

DPH   Connecticut Department of Public Health

EPA   U.S. Environmental Protection Agency

MCL   maximum contaminant level

USGS   U.S. Geological Survey

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Abstract

The U.S. Geological Survey, in cooperation with the Connecticut Department of Public Health, conducted a study to determine the presence of arsenic and uranium in private drinking water wells in Connecticut. Samples were collected during 2013–18 from wells completed in 115 geologic units, with 2,433 samples analyzed for arsenic and 2,191 samples analyzed for uranium. The study concluded four major findings.

- In a spatially weighted analysis of groundwater samples collected from more than 2,000 private wells in bedrock aquifers in Connecticut, 3.9 percent of collected samples contained arsenic concentrations greater than the U.S. Environmental Protection Agency's (EPA) maximum contaminant level (MCL) of 10 micrograms per liter (µg/L), and 4.7 percent of collected samples contained uranium concentrations greater than the EPA MCL of 30 µg/L.

- Of the 2,433 water samples collected and analyzed from bedrock aquifers in Connecticut, 4.2 percent (102) contained arsenic concentrations at greater than 10 µg/L, and of the 2,191 water samples collected and analyzed from bedrock aquifers in Connecticut, 5.4 percent (118) contained uranium concentrations greater than 30 µg/L.

- Uranium concentrations greater than or equal to 1 µg/L are relatively ubiquitous across the State of Connecticut, with these concentrations present in 44.9 percent of the State, according to spatially weighted statewide-scale proportion analysis.

- Of the 115 geologic units studied, 44 had at least one sample with arsenic or uranium concentrations that exceeded the respective constituent's EPA MCL.

Introduction

Arsenic and uranium occurrence in groundwater used for drinking has been a concern owing to the potential health risks that can occur when concentrations of these constituents in drinking water meet or exceed established human health standards. Previous studies in New England (Ayotte and others, 2003, 2006; Montgomery and others, 2003; Colman, 2011; Flanagan and others, 2014) have shown a strong association between geologic setting and arsenic and uranium concentrations in groundwater. A previous study (Flanagan and Brown, 2017) examined arsenic and uranium concentrations in water samples collected from 674 wells completed in 81 of the 156 geologic units in Connecticut and found that 7 percent of samples collected from 19 geologic units contained either arsenic or uranium concentrations exceeding the U.S. Environmental Protection Agency's (EPA) maximum contaminant levels (MCLs) for drinking-water supplies of 10 micrograms per liter (µg/L) for arsenic or 30 µg/L for uranium. This study, completed by the U.S. Geological Survey (USGS) in cooperation with the Connecticut Department of Public Health (DPH) during 2013–18, expands on the 2017 study with the inclusion of additional samples and a focus on areas of the State with few or no samples. Additionally, this study provides a statewide spatially weighted assessment and updated bedrock geology occurrence information for arsenic and uranium across the State and supporting datasets (Gross, 2020).

Arsenic and Uranium Concentration Data Sources

The objective of this study was to analyze new data on arsenic and uranium concentrations of samples collected from private wells throughout areas of Connecticut that have been poorly represented in past studies (Flanagan and Brown, 2017) in order to fill data gaps across the State. Several towns in central Connecticut were omitted from sample collection efforts and the subsequent statewide-scale proportion assessment because these towns were assumed to be serviced primarily by public water supply and would contain no or few actively used domestic wells (fig. 1). Groundwater-quality data that were collected, geo-coded, and compiled by the DPH were used in the assessment. Sample collection methods are described in Flanagan and Brown (2017). In figure 1, well locations were offset by one-fourth mile to maintain the confidentiality of the well owner's identity.

A. Spatial distribution of arsenic concentrations, in micrograms per liter
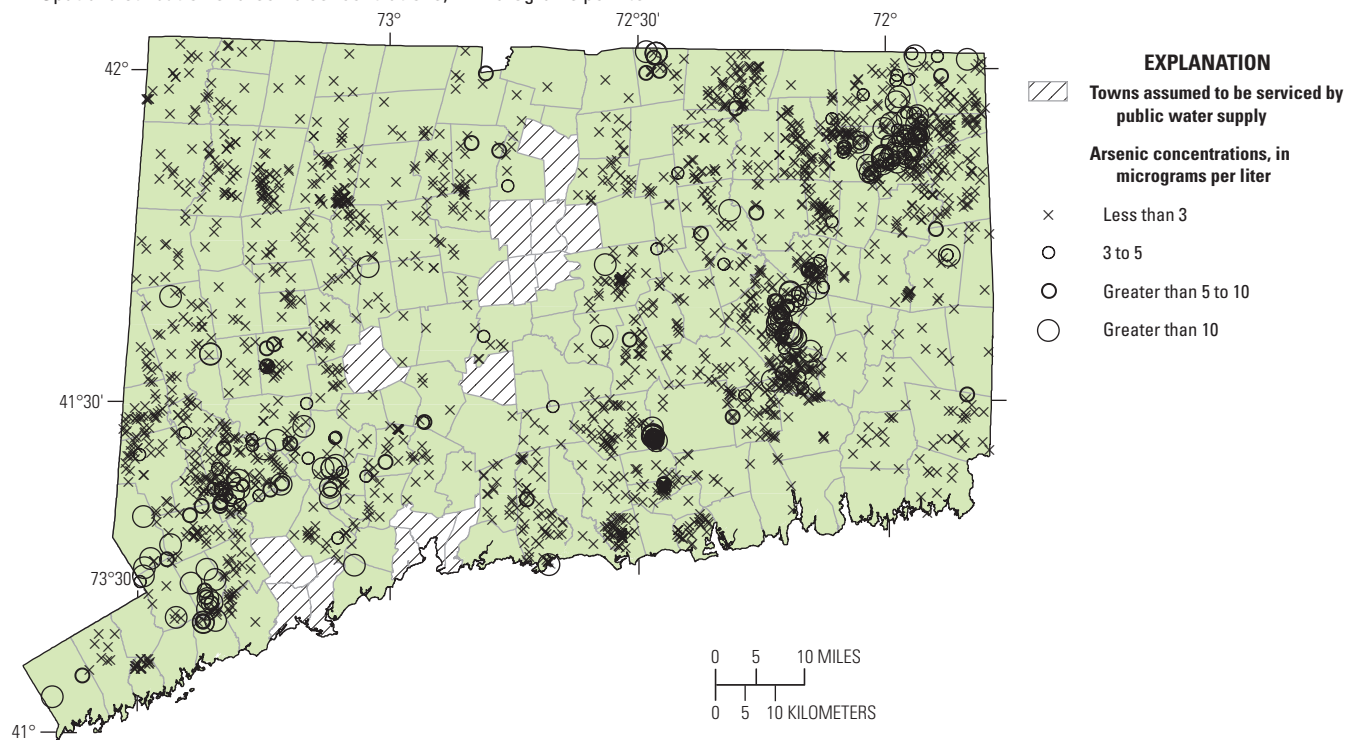
B. Spatial distribution of uranium concentrations, in micrograms per liter
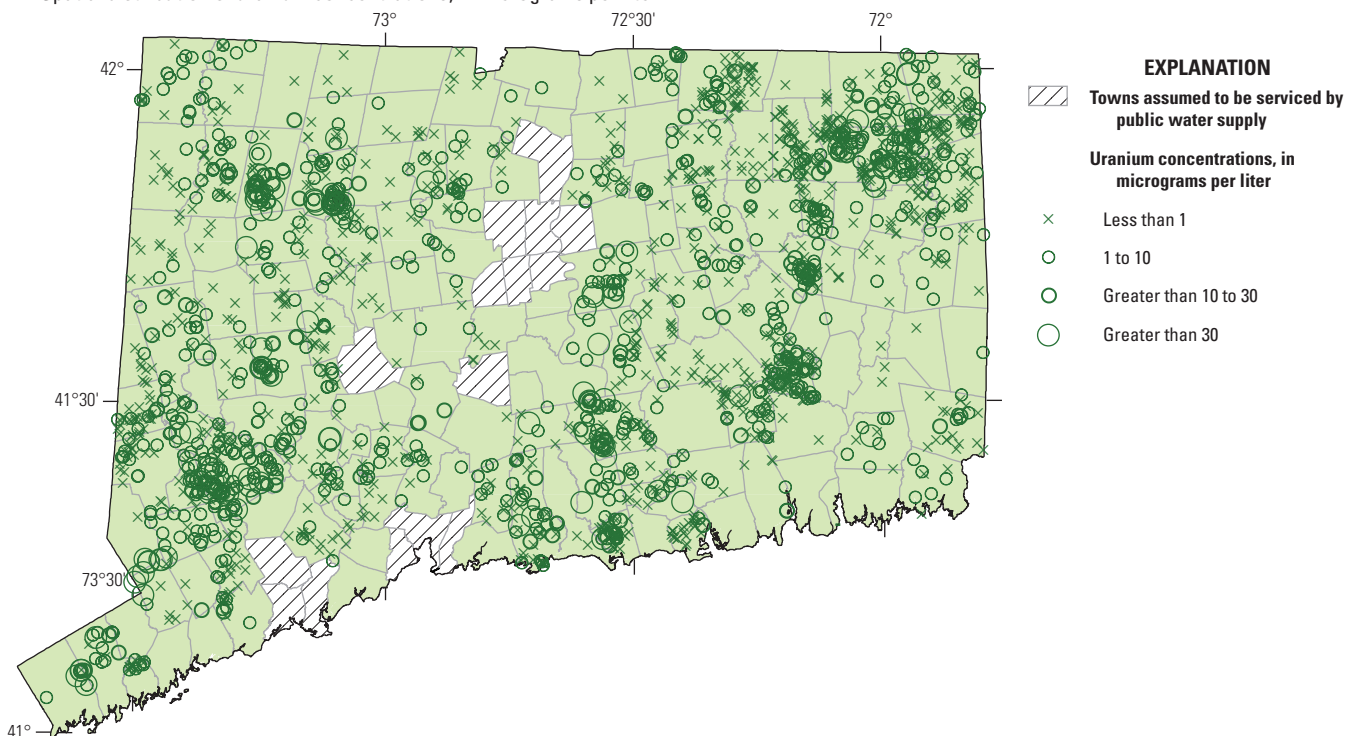
Base from Connecticut Department of Environment Protection, 2005
1:24,000 Lambert Conformal Conic projection: standard parallels 41.20° N and 41.87° N,
central meridian 72.75° W, latitude of origin 40.83°

Figure 1.   Concentrations of A, arsenic in water samples from 2,433 private wells and B, uranium in water samples from 2,191 private wells in Connecticut, 2013-18. Well locations have been offset by one-fourth mile to maintain the confidentiality of the well owner's identity. [<, less than; >, greater than; µg/L, micrograms per liter]

As part of the quality assurance plan for this study, the USGS submitted 11 standard reference samples to the DPH Laboratory with known concentrations of arsenic and uranium spanning the range of expected environmental concentrations. The standard reference samples were supplied by the USGS Branch of Quality Systems in Denver, Colorado, and provided an independent analysis of measurable bias. Results from the analysis of the standard reference samples (table 1) indicated no measurable bias, with all but two relative percent difference values less than 10 percent (Mueller and others, 2015).

Arsenic and Uranium Concentrations in the State

Arsenic concentrations ranged mostly (95th percentile) from less than 3 to 8.3 µg/L (table 2). Uranium concentrations ranged mostly (95th percentile) from less than 1 to 32 µg/L (table 2). Arsenic concentrations at or greater than the minimum reporting level (MRL) of 3 µg/L were measured in 248 (10.2 percent) of 2,433 samples, whereas uranium concentrations at or greater than the MRL of 1 µg/L were measured in 1,016 (46.4 percent) of 2,191 samples (table 2). Without adjustment by spatial weighting, arsenic concentrations equal to or exceeding the MCL of 10 µg/L were measured in 102 (4.2 percent) samples, and uranium concentrations equal to or exceeding the MCL of 30 µg/L were measured in 118 (5.4 percent) samples (table 2).

Arsenic and Uranium Spatially Weighted Assessment

Areas across Connecticut have variable amounts of data representing concentrations of arsenic and uranium in water from private bedrock-aquifer wells (fig. 1). In some parts of the State, there are relatively few sample locations, whereas in other areas, sample locations are clustered (fig. 1). In order to delineate the occurrence and distribution of arsenic and uranium in private wells in an unbiased way, a spatially weighted assessment method was used to represent the proportion of affected areas across the State. The spatially weighted assessment describes the proportion of the State, excluding towns assumed to be served primarily by public water supply, that contains concentrations of a constituent (arsenic or uranium) greater than a specified threshold and is nondimensional and spatially unbiased (Belitz and others, 2015). This statistical approach was based on a set of randomized equal-area grid cells (see fig. 2); one grid was created for arsenic, with 130 grid cells, and one was created for uranium, with 110 grid cells (Scott, 1990). Separate grids were created for arsenic and uranium so that the number of grid cells could be maximized and account for the differing amounts of samples available for each constituent. There are 242 more samples and 20 more grid cells for arsenic than uranium (tables 2 and 3). Each grid cell contains between 1 and 86 wells with sample concentrations for the arsenic set of 130 grid cells and between 1 and 102 wells with sample concentrations for the uranium set of

Table 1.   Inventory of standard reference samples for arsenic and uranium concentrations, 2015–18.

[SRS, standard reference sample; #, number; µg/L, micrograms per liter; MPV, most probable value; DPH, Connecticut Department of Public Health Laboratory in Rocky Hill, Connecticut; RPD, relative percent difference; <, less than; NA, not applicable]

SRS lot #	Submission date	Arsenic concentration, in µg/L			Uranium concentration, in µg/L		
		MPV	DPH	RPD[1]	MPV	DPH	RPD[1]
T-219	6/30/2015	3.51	<3.0	NA	1.58	1.5	5.2
T-201	7/28/2015	24.4	23	5.9	9.22	9.2	0.2
T-201b	8/18/2015	24.4	23	5.9	9.22	9.1	1.3
T-217	8/31/2015	5.99	5.8	3.2	1.78	1.7	4.6
T-217B	9/29/2015	5.99	5.2	14.1	1.78	1.7	4.6
T-201c	9/29/2015	24.4	22	10.3	9.22	9.3	0.9
T-221a	9/3/2017	17.7	17	4.0	1.49	1.4	6.2
T-217a	9/11/2017	5.99	5.7	5.0	1.78	1.7	4.6
T-193a	10/3/2017	3.44	3.2	7.2	1.7	1.7	0
T-201b	10/24/2017	24.4	24	1.7	9.22	9.2	0.2
T-217b	4/30/2018	5.99	5.5	8.5	1.78	1.8	1.1

[1]RPD = [|(Sample 1 – Sample 2)| / Average (Sample 1 + Sample 2)] × 100, where sample 1 is the MPV value and sample 2 is the DPH value.
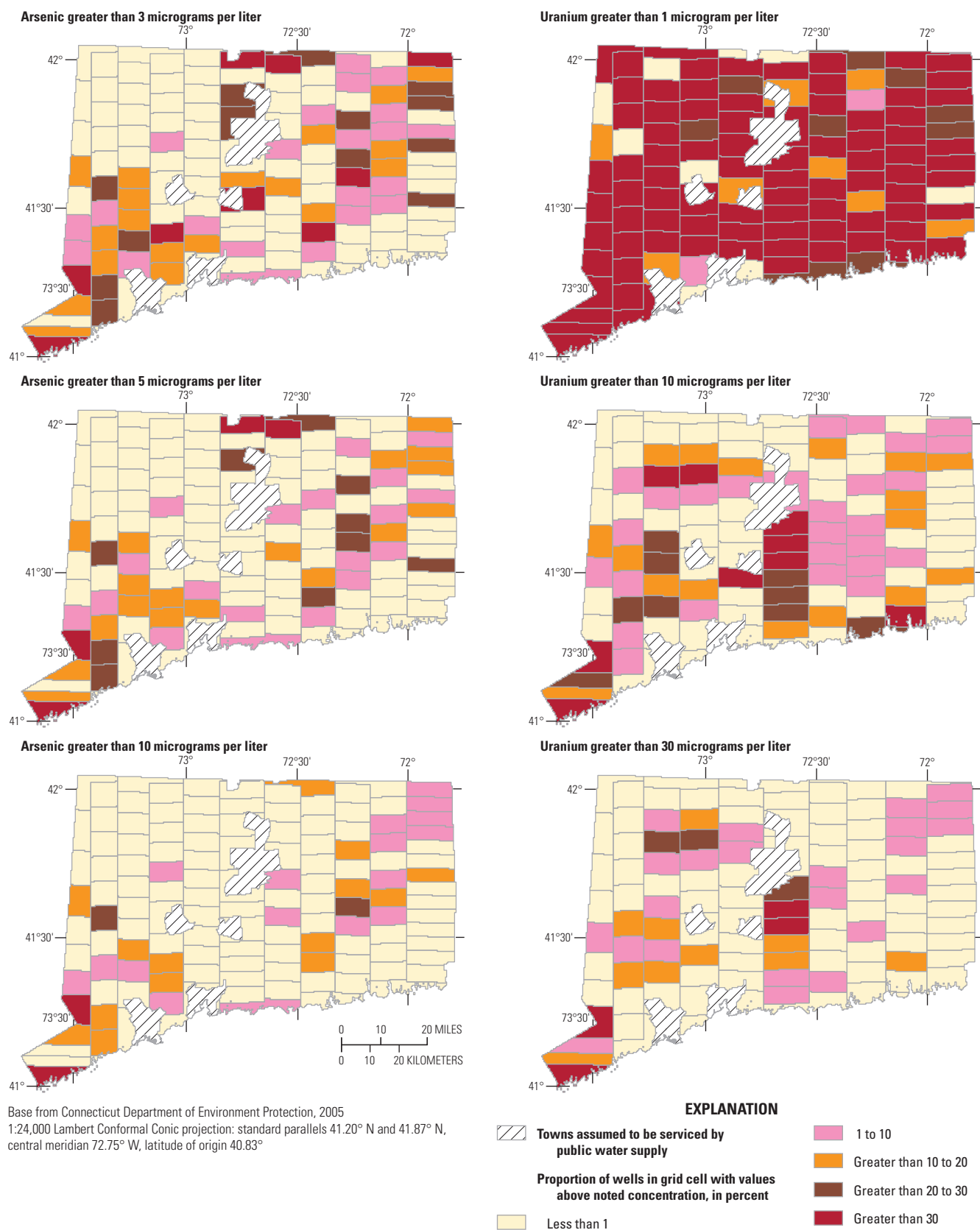
Figure 2.   Spatially weighted statewide-scale proportion of wells within grid cells for arsenic and uranium.

110 grid cells. For each constituent, spatially weighted, cell-wide proportions were determined by computing the proportion of wells with sample concentrations exceeding specific thresholds for each grid cell (Belitz and others, 2010). The specific thresholds include greater than 3 µg/L, greater than 5 µg/L, and greater than 10 µg/L for arsenic and greater than 1 µg/L, greater than 10 µg/L, and greater than 30 µg/L for uranium, representing low, moderate, and high value thresholds, respectively, for each constituent (fig. 2). The calculated cell proportions for low, moderate, and high value thresholds for arsenic and uranium were then averaged across the State to determine one spatially weighted statewide-scale proportion value for each of the three thresholds associated with each constituent (table 3; Belitz and others, 2010).

The spatially distributed, randomized equal-area grid approach yields a view of groundwater quality in which all areas are weighted equally, and regions with a high density of groundwater use or with high density of potential arsenic or uranium in groundwater are not preferentially represented (Belitz and others, 2010; Scott, 1990). Arsenic was present at high concentrations (greater than 10 µg/L) in 3.9 percent of the State of Connecticut, whereas uranium was present at high concentrations (greater than 30 µg/L) in 4.7 percent of the State (table 3). Figure 2 illustrates that low uranium concentrations (greater than 1 µg/L) are relatively ubiquitous across the State of Connecticut, with these concentrations present in 44.9 percent of the State (table 3), and account for greater than 30 percent of the proportion of wells in most grid cells (fig. 2). Low arsenic concentrations (greater than 3 µg/L) were not as common or widespread (fig. 2) as that for uranium concentrations, perhaps in part, owing to the higher reporting level (table 2).

Table 2. Arsenic concentrations in water samples from 2,433 private wells and uranium concentrations in water samples from 2,191 private wells in Connecticut, 2013–18.

[MRL, minimum reporting level; ≥, greater than or equal to; µg/L, micrograms per liter; <, less than; >, greater than; Min., Minimum; Max., Maximum; MCL, maximum contaminant level]

Constituent	Number of samples	MRL, in µg/L	Number of wells with concentration ≥ MRL (percent)	Concentration, in µg/L						MCL, in µg/L	Number of wells with concentration > MCL (percent)
				Percentile							
				Min.	50	75	90	95	Max.		
Arsenic	2,433	3	248 (10.2)	< 3.0	< 3.0	< 3.0	3	8.3	1,650	10	102 (4.2)
Uranium	2,191	1	1,016 (46.4)	< 1.0	< 1.0	3.6	12	32	3,170	30	118 (5.4)

Table 3. Spatially weighted statewide-scale proportions for arsenic and uranium during 2013–18 from the Connecticut Department of Public Health database.

[>, greater than; µg/L, micrograms per liter]

Number of grid cells	Spatially weighted statewide-scale proportion		
	Low values (percent)	Moderate values (percent)	High values (percent)
	Arsenic		
130	>3 µg/L (8.7)	>5 µg/L (6.6)	>10 µg/L (3.9)
	Uranium		
110	>1 µg/L (44.9)	>10 µg/L (10.1)	>30 µg/L (4.7)

West Mountains in West Simsbury, Connecticut. Photo by Tiziana Shea.

Arsenic and Uranium Occurrence in Relation to Bedrock Geology

For this study, it was assumed that each sampled well was drilled and completed in the mapped bedrock geologic unit (referred to as "geologic unit" in this report) represented at the well's location, as identified on the bedrock geological map of Connecticut (Rodgers, 1985; Connecticut Department of Environmental Protection, 2000). Corresponding arsenic and uranium samples were grouped according to the geologic units in which the sampled wells were located (table 4).

Of the 156 geologic units in the State, 115 units (covering 98.1 percent of the land area) were represented by at least one water sample analyzed for arsenic and (or) uranium (table 4). Of the 115 geologic units represented, 21 geologic units had only 1 arsenic sample, 45 geologic units had 2 to 10 arsenic samples, and 49 geologic units had more than 10 arsenic samples. Of the 113 geologic units with uranium samples, 20 geologic units had only 1 uranium sample, 44 geologic units had 2 to 10 uranium samples, and 49 geologic units had more than 10 uranium samples. The 115 geologic units with samples were organized under 11 different major categories of bedrock, which are listed in table 4 and can be viewed in figure 1 of Flanagan and Brown (2017). These major categories of bedrock are based on groups of individual geologic units with similar geochemical and lithological properties (Robinson and Kapo, 2003). The percentage of arsenic and uranium samples from each geologic unit containing concentrations exceeding MCLs was computed, and geologic units were grouped and shaded on the basis of percentage ranges (fig. 3). MCL exceedance percentages computed for geologic units for this study provide new and updated information on arsenic and uranium concentrations in Connecticut groundwater; however, they may not represent the actual hazard for existing and future wells in geologic units. Some of the local geologic maps for New England have been revised since the publication of the Rodgers (1985) geological map compilation and the Robinson and Kapo (2003) lithogeochemical map (M.A. Thomas, Connecticut Geological Survey, written commun., 2019), but these revisions are not reflected in the geological map versions used in this study. In figure 3, well locations are offset by one-fourth mile to maintain the confidentiality of the well owner's identity.

The results show that geologic units had widely differing rates of arsenic and uranium concentrations exceeding MCLs (table 4). Twenty-two of 115 geologic units had at least one sample with arsenic concentrations that exceeded the MCL of 10 µg/L, and 32 of 113 geologic units had at least one sample with uranium concentrations that exceeded the MCL of 30 µg/L. The pelitic rocks category had 7 (out of 28) geologic units with at least one arsenic concentration that exceeded the MCL of 10 µg/L and 8 geologic units with at least one uranium concentration that exceeded the MCL of 30 µg/L. The mafic rocks category contained 10 (out of 25) geologic units with at least one uranium concentration that exceeded the MCL.

Penwood State Park in Simsbury, Connecticut. Photo by Tiziana Shea.

Table 4. Arsenic and uranium concentrations that exceed U.S. Environmental Protection Agency's maximum contaminant levels in samples from private wells in Connecticut, by geologic unit and major bedrock category, 2013–18.

[Geologic unit names are the Connecticut Department of Environmental Protection preferred names as modified from Rodgers (1985). Major categories of bedrock (subheadings) are modified from Robinson and Kapo (2003). Color shadings indicate the percentage of wells with exceedances greater than concentration thresholds in ranges of: ■, no data; ■, less than (<) 1 percent; ■, 1 to 10 percent; ■, greater than (>) 10 to 20 percent; ■, greater than (>) 20 to 30 percent; and ■, greater than (>) 30 percent. MCL, U.S. Environmental Protection Agency maximum contaminant level enforceable for public water supplies; µg/L, micrograms per liter; NA, not available; −, no uranium samples from geologic unit]

| Geologic unit name[1]	Geologic unit code[1]	Number of samples		Percentage of water samples with concentrations exceeding MCL, in µg/L		Percentage of study area underlain by geologic unit[2]
		Arsenic	Uranium	Arsenic >10 µg/L	Uranium >30 µg/L	
Avalon Granites						
"Scituate" Granite Gneiss	Zss	16	16	0	0	0.7
Hope Valley Alaskite Gneiss	Zsh	30	24	3.3	0	2.3
Mamacoke Formation	Zwm	6	6	0	16.7	0.8
Plainfield Formation	Zp	25	24	0	0	1.6
Plainfield Formation, Stony Creek Granite Gneiss and Narragansett Pier Granite undivided	Zp+Zsc+Pn	10	11	10	0	<0.2
Ponaganset Gneiss	Zsp	3	3	0	0	0.3
Porphyritic phase of Potter Hill Granite Gneiss	Zspp	4	5	0	0	<0.2
Potter Hill Granite Gneiss	Zsph	23	21	0	0	1.5
Potter Hill Granite Gneiss and Narragansett Pier Granite undivided	Zsph+Pn	1	1	0	0	<0.2
Rope Ferry Gneiss	Zwr	18	18	0	0	1.2
Stony Creek Granite Gneiss and Narragansett Pier Granite undivided	Zsc+Pn	3	2	0	0	<0.2
Basalt						
Buttress Dolerite	Jb	1	1	0	0	0.2
Hampden Basalt	Jha	3	3	0	33.3	0.3
Holyoke Basalt	Jho	5	5	0	0	1.2
Talcott Basalt	Jta	1	1	0	0	0.2
Calcgranofels						
Fly Pond (Calc-Silicate) Member of Tatnic Hill Formation	Otaf	21	19	0	0	0.5
Hawley Formation (Carbonaceous Schist Facies)	Ohc	3	3	0	0	<0.2
Hebron Gneiss	SOh	290	199	13.4	4.5	5.2
Lower Member of Bigelow Brook Formation	SObl	25	25	0	0	0.7
Southbridge Formation	SOs?	6	6	0	0	0.3
Southbridge Formation	SOs	60	58	0	0	0.8
Carbonate-Bearing Metasedimentary Rocks						
Basal Marble Member of Walloomsac Schist	Owm	11	11	9.1	0	0.6
Stockbridge Marble	OCs	14	13	7.1	0	0.9
Unit a of Stockbridge Marble	Csa	1	1	0	0	<0.2
Unit b of Stockbridge Marble	Csb	9	9	0	0	0.4
Unit c of Stockbridge Marble	Csc	9	9	0	0	0.6
Units e and d of Stockbridge Marble	Ose	2	2	0	0	<0.2

Table 4.   Arsenic and uranium concentrations that exceed U.S. Environmental Protection Agency's maximum contaminant levels in samples from private wells in Connecticut, by geologic unit and major bedrock category, 2013–18.—Continued

[Geologic unit names are the Connecticut Department of Environmental Protection preferred names as modified from Rodgers (1985). Major categories of bedrock (subheadings) are modified from Robinson and Kapo (2003). Color shadings indicate the percentage of wells with exceedances greater than concentration thresholds in ranges of: ▪, no data; ▪, less than (<) 1 percent; ▪, 1 to 10 percent; ▪, greater than (>) 10 to 20 percent; ▪, greater than (>) 20 to 30 percent; and ▪, greater than (>) 30 percent. MCL, U.S. Environmental Protection Agency maximum contaminant level enforceable for public water supplies; µg/L, micrograms per liter; NA, not available; −, no uranium samples from geologic unit]

Geologic unit name[1]	Geologic unit code[1]	Number of samples		Percentage of water samples with concentrations exceeding MCL, in µg/L		Percentage of study area underlain by geologic unit[2]
		Arsenic	Uranium	Arsenic >10 µg/L	Uranium >30 µg/L	
Granite, other						
Canterbury Gneiss	Dc	49	48	0	4.2	1.3
"Eastford Gneiss phase" of Canterbury Gneiss	Dce	27	27	3.7	25.9	0.6
Felsic Gneiss Member of Quinebaug Formation	Oqf	3	3	0	0	<0.2
Glastonbury Gneiss	Ogl	57	41	1.8	14.6	1.8
Maromas Granite Gneiss	Dm	1	1	0	0	<0.2
Nonewaug Granite	Dng	19	19	0	10.5	0.6
Ordovician? Granitic Gneiss	Og	106	86	14.2	25.6	2.3
Porphyritic Member of Southbridge Formation	SOsp	2	2	0	0	<0.2
Trap Falls Formation and Ordovician? Granitic Gneiss undivided	Otf+Og	5	11	0	9.1	1.1
Waterbury Gneiss	Cwb	11	10	0	0	0.9
Waterford Group, Stony Creek Granite Gneiss and Narragansett Pier Granite undivided	Zw+Zsc+Pn	2	2	0	0	<0.2
Grenville Granites						
Augen Gneiss	Yga	4	4	0	0	<0.2
Gneiss of Highlands Masifs	Yg	17	17	0	5.9	0.7
Pink Granitic Gneiss	Ygr	32	33	0	3.0	1.2
Mafic Rocks						
Amphibolite unit in Rutlum Mountain Schist	Ora	2	2	0	0	<0.2
Amphibolite-Bearing unit of Manhattan Schist	Cma	8	8	0	0	0.5
Beardsley Member of Harrison Gneiss	Ohb	9	9	0	0	0.5
Black Hill Member of Quinebaug Formation	Oqb	2	3	0	0	<0.2
Brookfield Gneiss	Ob	78	78	5.1	12.8	1.4
Dioritic phase of Lebanon Gabbro	Dld	9	6	0	0	<0.2
Gneiss (Metavolcanic) Member of Brimfield Schist	Obrg	8	8	0	0	0.3
Harrison Gneiss	Oh	7	15	14.3	46.7	0.9
Hornblende Gneiss and Amphibolite	Ygh	27	27	0	0	0.8
Hornblende Gneiss Member of Collinsville Formation	Ocg	8	8	0	12.5	0.4
Lebanon Gabbro	Dl	15	8	13.3	0	0.3
Litchfield Norite	Ol	1	1	0	100.0	<0.2
Lower Member of Middletown Formation	Oml	5	12	0	25.0	0.2
Massive Mafic Rock in Middletown Formation	Omm	1	1	0	0	<0.2
Middletown Formation	Om	38	45	0	4.4	1.1
Monson Gneiss	Omo	115	94	0	8.5	2.6

Table 4. Arsenic and uranium concentrations that exceed U.S. Environmental Protection Agency's maximum contaminant levels in samples from private wells in Connecticut, by geologic unit and major bedrock category, 2013–18.—Continued

[Geologic unit names are the Connecticut Department of Environmental Protection preferred names as modified from Rodgers (1985). Major categories of bedrock (subheadings) are modified from Robinson and Kapo (2003). Color shadings indicate the percentage of wells with exceedances greater than concentration thresholds in ranges of: ▨, no data; ▨, less than (<) 1 percent; ▨, 1 to 10 percent; ▨, greater than (>) 10 to 20 percent; ▨, greater than (>) 20 to 30 percent; and ▨, greater than (>) 30 percent. MCL, U.S. Environmental Protection Agency maximum contaminant level enforceable for public water supplies; µg/L, micrograms per liter; NA, not available; −, no uranium samples from geologic unit]

Geologic unit name[1]	Geologic unit code[1]	Number of samples		Percentage of water samples with concentrations exceeding MCL, in µg/L		Percentage of study area underlain by geologic unit[2]
		Arsenic	Uranium	Arsenic >10 µg/L	Uranium >30 µg/L	
Mafic Rocks—Continued						
Mylonite along Paleozoic Faults	Pzmy	3	3	0	0	<0.2
Preston Gabbro	Op	1	1	0	0	0.2
Pumpkin Ground Member of Harrison Gneiss	Ohp	4	4	0	0	0.5
Quinebaug Formation	Oq	89	76	1.1	0	2.0
Rowe Schist	OCr?	2	2	0	0	<0.2
Rowe Schist	OCr	54	55	1.9	1.8	1.9
Rowe Schist and Amphibolite unit in Rowe Schist undivided	OCr+OCra	2	2	0	0	<0.2
Sweetheart Mountain Member of Collinsville Formation	Ocs	2	2	0	50.0	<0.2
Waterford Group	Zw	36	30	0	3.3	0.9
Mesozoic Basin Sediments						
East Berlin Formation	Jeb	14	14	0	0	1.3
New Haven Arkose	TRnh	61	59	0	1.7	6.3
Portland Arkose	Jp	57	45	8.8	0	8.0
Shuttle Meadow Formation	Jsm	14	13	0	0	0.5
Metamorphic Rocks, other						
Bristol Gneiss	Obs	3	3	0	0	0.4
Clough Quartzite	Sbc	1	1	0	0	<0.2
Dalton Formation	Cd	13	12	0	8.3	0.7
Fitch Formation	Sbf	1	1	0	0	<0.2
Layered Gneiss	Ygn	36	37	0	0	1.9
New London Gneiss	Zwn	1	1	0	0	0.4
Quartzite unit in Plainfield Formation	Zpq	14	14	0	0	0.6
Pelitic Rocks						
Basal Member of Taine Mountain Formation around Waterbury Dome	Otb	3	3	0	0	0.4
Cobble Mountain Formation	Ocm	1	1	0	0	0.4
Collinsville Formation	Oc	33	32	12.1	3.1	1.1
Everett Schist	Ce	1	1	0	0	0.2
Golden Hill Schist	Ogh	3	3	0	0	0.3
Hoosac Schist	Ch	40	40	0	20.0	1.1
Littleton Formation	Dbl	7	7	0	0	0.4
Manhattan Schist	Cm	37	37	0	8.1	2.0
Mount Pisgah Member of Littleton Formation	Dblm	4	3	0	0	<0.2
Oronoque Schist	Oo	1	1	0	0	0.5

Table 4.   Arsenic and uranium concentrations that exceed U.S. Environmental Protection Agency's maximum contaminant levels in samples from private wells in Connecticut, by geologic unit and major bedrock category, 2013–18.—Continued
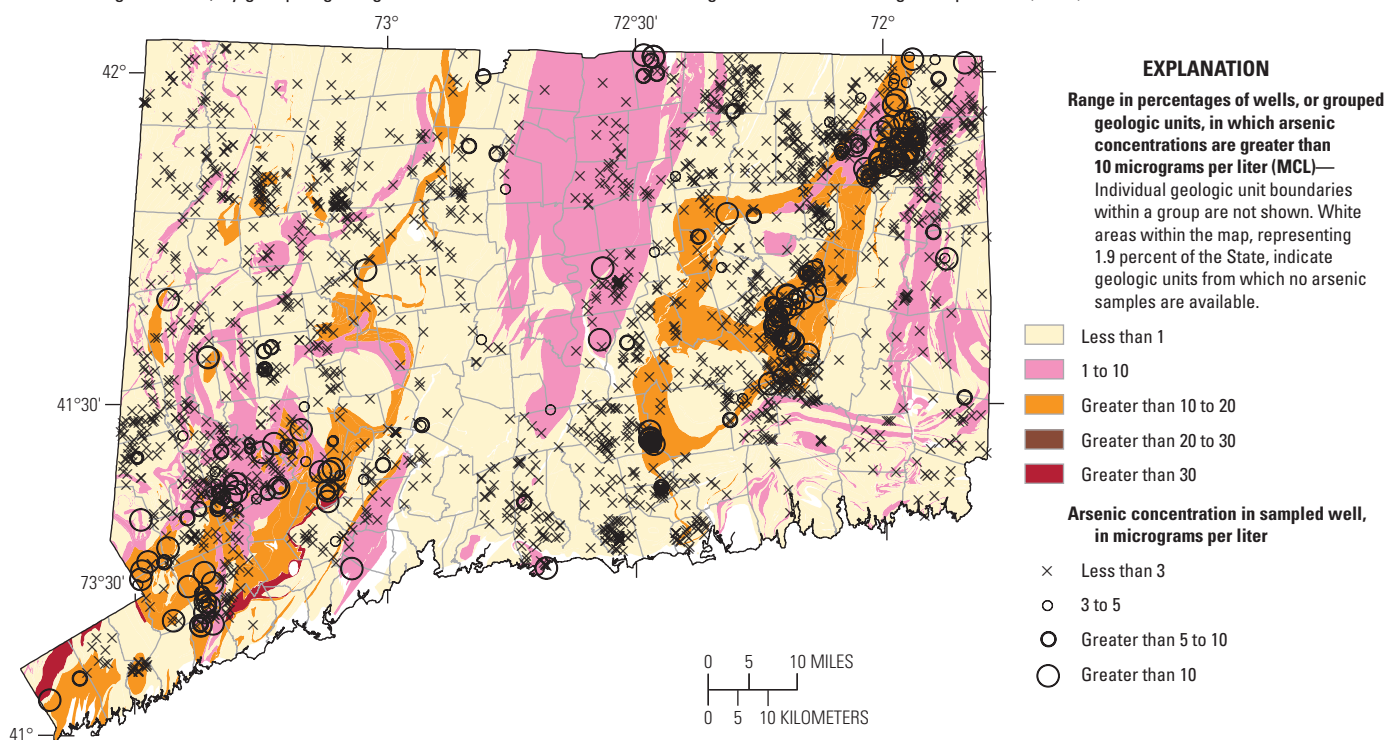
[Geologic unit names are the Connecticut Department of Environmental Protection preferred names as modified from Rodgers (1985). Major categories of bedrock (subheadings) are modified from Robinson and Kapo (2003). Color shadings indicate the percentage of wells with exceedances greater than concentration thresholds in ranges of: ▢, no data; ▢, less than (<) 1 percent; ▢, 1 to 10 percent; ▢, greater than (>) 10 to 20 percent; ▢, greater than (>) 20 to 30 percent; and ▢, greater than (>) 30 percent. MCL, U.S. Environmental Protection Agency maximum contaminant level enforceable for public water supplies; μg/L, micrograms per liter; NA, not available; −, no uranium samples from geologic unit]

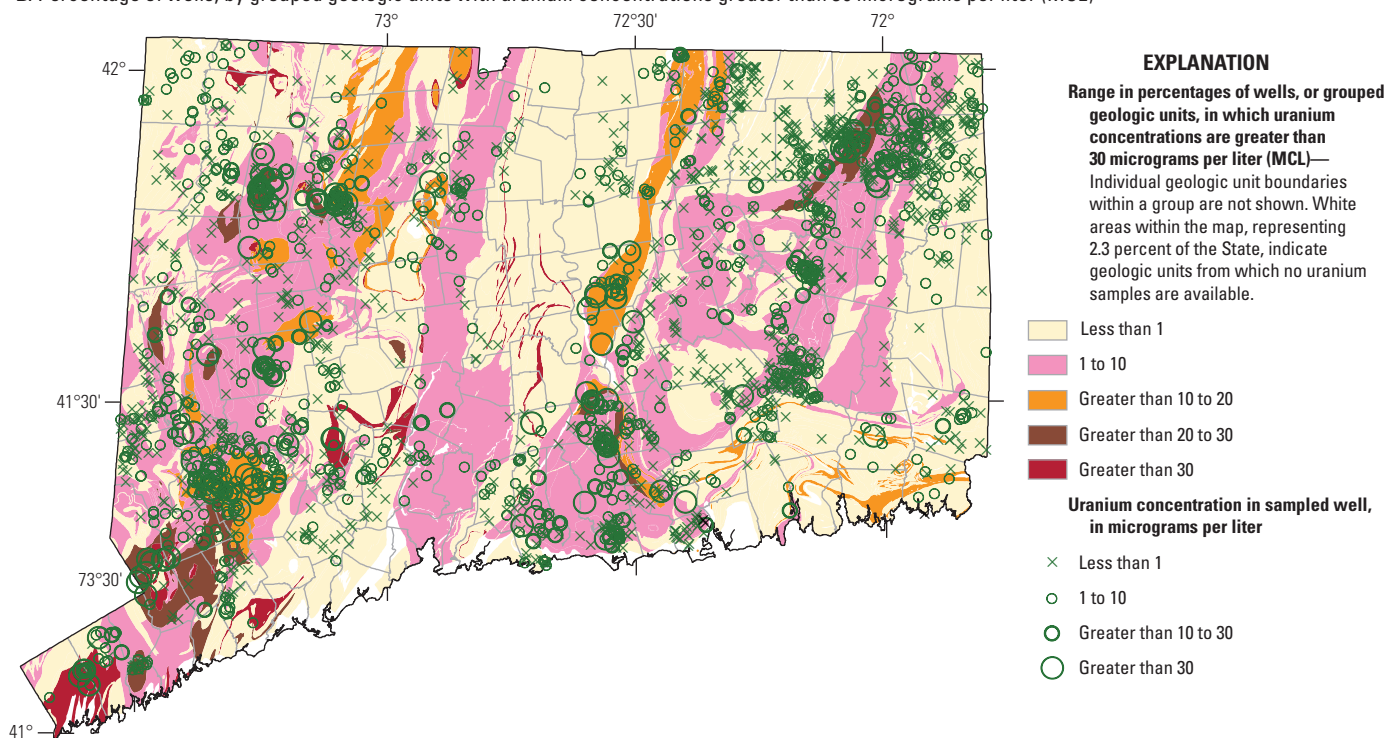| Geologic unit name[1]	Geologic unit code[1]	Number of samples		Percentage of water samples with concentrations exceeding MCL, in μg/L		Percentage of study area underlain by geologic unit[2]
		Arsenic	Uranium	Arsenic >10 μg/L	Uranium >30 μg/L	
Pelitic Rocks—Continued						
Ratlum Mountain Schist	Or?	12	6	8.3	0	0.3
Ratlum Mountain Schist	Or	114	104	0	9.6	4.2
Ratlum Mountain Schist and Amphibolite unit in Rutlum Mountain Schist undivided	Or+Ora	1	1	0	0	<0.2
Schist and Granulite Member of Trap Falls Formation	Otfg	16	13	0	0	0.5
Scotland Schist	DSs	96	87	16.7	1.1	1.0
Scranton Mountain Member of Taine Mountain Formation	Ots	1	1	0	0	<0.2
Shelton (White Gneiss) Member of Trap Falls Formation	Otfs	3	3	0	0	0.3
Southington Mountain Member of The Straits Schist	DSts	3	3	0	0	0.4
Taine Mountain and Collinsville Formation undivided	Ot+Oc	6	6	16.7	33.3	0.3
Taine Mountain Formation	Ot	20	20	5.0	0	0.9
Tatnic Hill Formation	Ota	80	68	0	1.5	3.1
The Straits Schist	DSt	24	24	12.5	0	2.1
Trap Falls Formation	Otf	3	−	0	−	0.3
Upper Member of Middletown Formation	Omu	20	9	0	11.1	0.2
Walloomsac Schist	Ow	11	11	0	0	0.5
Wepawaug Schist	DSw	10	8	10.0	0	0.8
Whigville Member of Taine Mountain Formation	Otwv	1	1	0	0	<0.2
Yantic Member of Tatnic Hill Formation	Otay	40	36	0	0	0.8
Sulfidic Schists						
Basal Member of upper slice of Canaan Mountain Schist	Cmcub	1	1	0	0	<0.2
Brimfield Schist	Obr?	6	6	0	0	<0.2
Brimfield Schist	Obr	113	111	0	0	3.4
Carringtons Pond Member of Trap Falls Formation	Otfc	3	3	33.3	0	0.5
Collins Hill Formation	Och	23	22	0	4.5	0.8
lower slice of Canaan Mountain Schist	Cmcl	1	−	0	−	<0.2
Rusty Mica Schist and Gneiss	Ygs	8	8	0	0	1.0
Upper Member of Bigelow Brook Formation	SObu	9	9	0	0	0.3
upper slice of Canaan Mountain Schist	Cmcu	1	1	0	0	0.4
Unmapped Areas	l	1	1	0	0	1.1
Overall for the Study Area	NA	2,433	2,191	4.4	5.4	98.1

[1]Geologic units from Connecticut Department of Environmental Protection, 2000; names may not conform to usage by the U.S. Geological Survey. Queries indicate uncertainty about geologic unit identification.

[2]About 1.9 percent of the study area (State of Connecticut) was underlain by 41 individual geologic units from which no water samples were collected.

A. Percentage of wells, by grouped geologic units with arsenic concentrations greater than 10 micrograms per liter (MCL)

EXPLANATION

Range in percentages of wells, or grouped geologic units, in which arsenic concentrations are greater than 10 micrograms per liter (MCL)—Individual geologic unit boundaries within a group are not shown. White areas within the map, representing 1.9 percent of the State, indicate geologic units from which no arsenic samples are available.

Less than 1

1 to 10

Greater than 10 to 20

Greater than 20 to 30

Greater than 30

Arsenic concentration in sampled well, in micrograms per liter

×   Less than 3

○   3 to 5

◎   Greater than 5 to 10

◯   Greater than 10

0   5   10 MILES

0   5   10 KILOMETERS

B. Percentage of wells, by grouped geologic units with uranium concentrations greater than 30 micrograms per liter (MCL)

EXPLANATION

Range in percentages of wells, or grouped geologic units, in which uranium concentrations are greater than 30 micrograms per liter (MCL)—Individual geologic unit boundaries within a group are not shown. White areas within the map, representing 2.3 percent of the State, indicate geologic units from which no uranium samples are available.

Less than 1

1 to 10

Greater than 10 to 20

Greater than 20 to 30

Greater than 30

Uranium concentration in sampled well, in micrograms per liter

×   Less than 1

○   1 to 10

◎   Greater than 10 to 30

◯   Greater than 30

Base from Connecticut Department of Environment Protection, 2005
1:24,000 Lambert Conformal Conic projection: standard parallels 41.20° N and 41.87° N, central meridian 72.75° W, latitude of origin 40.83°

Figure 3.   Spatial distribution and range of percentages of private wells in Connecticut, grouped by geologic units, in which A, arsenic concentrations exceeded the maximum concentration level (MCL) of 10 micrograms per liter (µg/L), and B, uranium concentrations exceeded the MCL of 30 µg/L. Well locations have been offset by one-fourth mile to maintain the confidentiality of the well owner's identity. Geologic units are listed in table 4. See Rodgers (1985) for the location and description of individual geologic units.

The Carringtons Pond Member of Trap Falls Formation was the only geologic unit with greater than 30 percent occurrence of arsenic concentrations (1 out of 3 samples) exceeding the MCL of 10 µg/L (table 4). Five geologic units (Hampden Basalt, Harrison Gneiss, Litchfield Norite, Sweetheart Mountain Member of Collinsville Formation, and Taine Mountain and Collinsville Formation undivided) had greater than 30 percent of uranium concentrations (1 of 3, 7 of 15, 1 of 1, 1 of 2, and 2 of 6 samples, respectively) exceeding the MCL of 30 µg/L.

The well containing the highest measured arsenic concentration (1,650 µg/L) in this study is completed in the Basal marble member of Walloomsac Schist geologic unit of the carbonate-bearing metasedimentary rocks bedrock category. Of the 11 samples in this geologic unit, this was the only well containing an arsenic concentration exceeding the MCL of 10 µg/L. Eleven geologic units (table 4) in the State had a higher percentage (greater than 9.1 percent) of samples with arsenic exceeding 10 µg/L than the Basal marble member of Walloomsac Schist geologic unit. The well with the highest uranium concentration (3,170 µg/L) is completed in the Harrison Gneiss geologic unit of the mafic rocks bedrock category.

This geologic unit had 15 samples, and 46.7 percent of the samples had uranium concentrations exceeding the MCL of 30 µg/L. Two other geologic units (table 4) in the State had a higher percentage (greater than 46.7 percent) of samples with uranium exceeding the MCL. These findings demonstrate that wells with arsenic or uranium concentrations exceeding their respective MCLs were not always in the same geologic unit.

The findings of this study also indicate that, for a household in Connecticut relying on a private well for drinking water, the likelihood of the water containing an arsenic or uranium concentration exceeding the constituent's MCL is related to the particular geologic unit in which the household's well is completed. Other factors that can affect arsenic or uranium concentrations are geochemical conditions or residence time for water-rock reactions in the local groundwater flow system. Testing well water is the only way to know whether a contaminant is present. For more information about well testing and treatment guidelines in Connecticut, readers should contact the Connecticut Department of Public Health Private Well Program using the information provided at http://www.ct.gov/dph/privatewells.

Kent Falls State Park in Kent, Connecticut. Photo by Tiziana Shea.
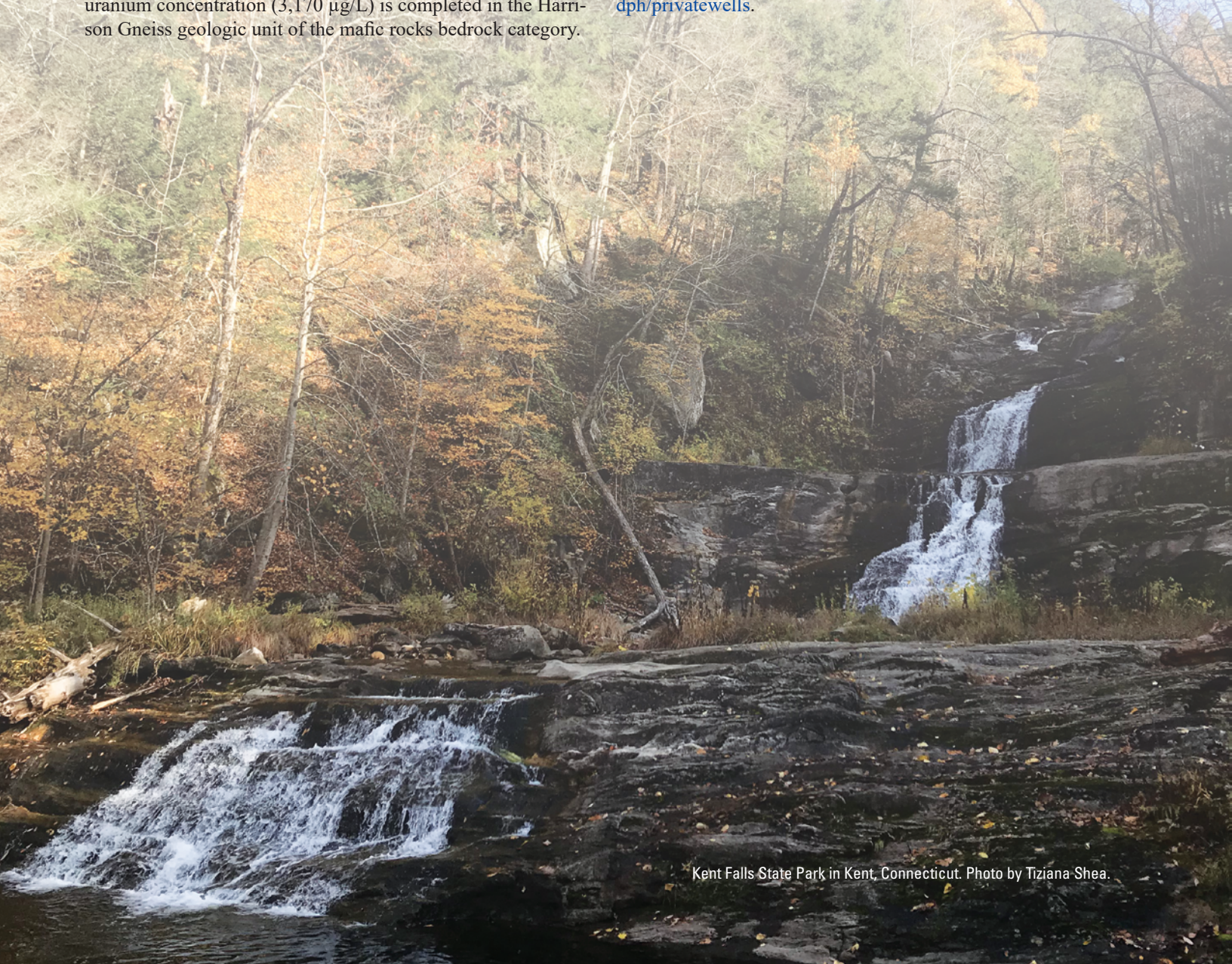
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