

Environmental Health Program

Prepared in cooperation with the Town of Campbell, Wisconsin

**Occurrence of Mixed Organic and Inorganic Chemicals
in Groundwater and Tapwater, Town of Campbell,
Wisconsin, 2021–22**

Open-File Report 2023–1088

Occurrence of Mixed Organic and Inorganic Chemicals in Groundwater and Tapwater, Town of Campbell, Wisconsin, 2021–22

By Kristin M. Romanok, Shannon M. Meppelink, Paul M. Bradley, Sara E. Breitmeyer, Lee Donahue, Mark P. Gaikowski, Randy K. Hines, and Kelly L. Smalling

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U.S. Department of the Interior
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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Volume	
ounce, fluid (fl. oz)	0.02957	liter (L)

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

$$^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32.$$

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

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8.$$

Datum

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

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

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

Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius ($\mu\text{S}/\text{cm}$ at 25°C), pH is given in standard units and water temperature in degrees Celsius (degrees C).

Concentrations of chemical constituents in water are given in either milligrams per liter (mg/L, equivalent to parts per million [ppm]), micrograms per liter ($\mu\text{g}/\text{L}$, equivalent to parts per billion [ppb]) or nanograms per liter (ng/L, equivalent to parts per trillion [ppt]).

Abbreviations

6:2 FTS	1H,1H,2H,2H-Perfluorohexane sulfonate (6:2)
ASTM	American Society for Testing and Materials
CFU/100 mL	colony forming units per 100 milliliters
DBP	disinfection byproduct
DQCALC	detection and quantitation estimation and data assessment utilizing software
E	estimated value
<i>E. coli</i>	<i>Escherichia coli</i>
EPA	U.S. Environmental Protection Agency
EPHML	Environmental and Public Health Microbiology Laboratory
FBSA	perfluorobutane sulfonamide
FOSA	perfluoro-1-octanesulfonamide
HAL	health advisory levels
HPC	heterotrophic plate count
HPLC-MS/MS	high performance liquid chromatography-tandem mass spectrometry
IRL	interim reporting limit
LOD	limit of detection
MCL	maximum contaminant level
MDL	method detection limit
MRL	minimum reporting level
nd	not detected above reporting limit
NLS	Northern Lake Service, Inc.
NPDWR	National Primary Drinking Water Regulations
NWQL	National Water Quality Laboratory
PFAS	per- and polyfluoroalkyl substances
PFBA	perfluorobutyrate
PFNA	perfluoro-n-nonanoate
PFBS	perfluoro-1-butanefulfonate
PFOA	perfluoro-n-octanoate
PFOS	perfluorooctanesulfonate
post-6h	post-6 hour
PTFE	polytetrafluoroethylene
RCL	Redox Chemistry Laboratory
RLDQC	reporting limit determined by DQCALC
SGS AXYS	Standard Global Services, Analytical Services Inc.

SPE	solid-phase extraction
SVOC	semi-volatile organic compounds
TTAL	treatment technique action level
UMESC	Upper Midwest Environmental Sciences Center
USGS	U.S. Geological Survey
VOC	volatile organic compounds
WSLH	Wisconsin State Laboratory of Hygiene

Occurrence of Mixed Organic and Inorganic Chemicals in Groundwater and Tapwater, Town of Campbell, Wisconsin, 2021–22

By Kristin M. Romanok,¹ Shannon M. Meppelink,¹ Paul M. Bradley,¹ Sara E. Breitmeyer,¹ Lee Donahue,² Mark P. Gaikowski,¹ Randy K. Hines,¹ and Kelly L. Smalling¹

Abstract

In response to previous reports of per- and polyfluoroalkyl substances (PFAS) contamination in French Island's (located in the Mississippi River within the town of Campbell, Wisconsin) primary source of drinking water, 11 locations were sampled by the U.S. Geological Survey (USGS) in October 2021 to assess the potential presence of contaminant mixtures, including PFAS, in tapwater. Three locations were assessed seven times each over the course of three days. These samples were chosen to evaluate the water quality of the deeper Mount Simon bedrock aquifer and the water quality of the shallower sand and gravel (alluvial) aquifer at two locations. The other eight sample locations were spatially distributed within Campbell and were sampled once each. For each of these 11 sites, tapwater samples were analyzed for disinfection byproducts (DBP), pesticides, PFAS, pharmaceuticals, semi-volatile organic compounds (SVOC), volatile organic compounds (VOC), cations, anions, trace elements, alkalinity, microbial indicators, as well as measurements of water temperature, specific conductance, and pH. Of the 506 organic compounds analyzed in each water-quality sample, 74 (14 percent) were detected at least one time in any of the samples collected. Of the 14 percent, detected analytes included 27 pesticides (5 percent), 14 PFAS (3 percent), 6 pharmaceuticals (1 percent), 7 SVOC (1 percent), and 20 VOC (4 percent). No DBP were detected. The total number of organic compounds detected per sample ranged from 0–20 (median of 10), with the sum of concentrations ranging from not detected (nd)–2.53 micrograms per liter ($\mu\text{g/L}$; median of 0.333 $\mu\text{g/L}$). Of the inorganic constituents measured, eight were not detected above their reporting limit in any of the samples. The inorganic constituents that were not detected were antimony, arsenic, beryllium, cadmium, cobalt, molybdenum, selenium, and vanadium.

Along with the 11 sites sampled throughout Campbell, Wisconsin, beginning in October 2021, four more wells were sampled on the Upper Midwest Environmental Sciences

Center (UMESC) campus for PFAS. Three of these sites withdraw water from the shallow alluvial aquifer (the same source water for tapwater site 002) and one from the Mount Simon aquifer (the same source of water for tapwater site 001). This sampling is ongoing with results from samples through December 2022 summarized in this report. Of the 33 PFAS analyzed in samples from the four UMESC locations, 15 individual PFAS were detected at least one time in any of the samples analyzed with the sum of PFAS concentrations ranging from nd–1.49 $\mu\text{g/L}$ (median of 0.309 $\mu\text{g/L}$).

Introduction

Due to human influences on water resources and quality, the U.S. Geological Survey (USGS) Environmental Health Program (EHP) has been conducting tapwater exposure studies assessing potential human exposures to contaminant mixtures in point-of-use (point-of-exposure) drinking water around the nation since 2016. To date, eight studies assessing co-occurring organic and inorganic chemical constituents, microbial indicators, and in-vitro bioactivities have been completed at the point-of-use in public supply and private-well tapwater as well as bottled water (Bradley and others, 2018, 2020, 2021a, 2021b, 2022, 2023a, 2023b and Smalling and others, 2023). These samplings were conducted at 243 locations, including 159 public-supply (source water, pre-distribution drinking water, and point-of-use tapwater), 53 private-groundwater locations, as well as samples from 31 bottled water brands, and additional studies are on-going. The current collaborative study, while building on the broader tapwater portfolio, was conducted in Campbell, Wisconsin in 2021 to support ongoing efforts to address community drinking-water concerns arising from per- and polyfluoroalkyl substances (PFAS) contamination within the shallow alluvial aquifer, which is utilized by the residents of Campbell for their drinking water (Schultz, 2021).

While working in conjunction with the USGS Upper Midwest Environmental Sciences Center (UMESC) and the town of Campbell (located on French Island in the middle

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²Town of Campbell, La Crosse, Wisc.

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of the Mississippi River in Wisconsin), the USGS collected samples from 11 sites (8 tapwater and 3 groundwater wells, [fig. 1](#)). All samples were collected from private residential- or community-groundwater well locations. The groundwater source for 10 of the sampling locations was the shallow, unconsolidated alluvial aquifer composed of sand and gravel (referred to as the alluvial aquifer in this report) discussed in Hunt and others (2003) that currently serves as the primary drinking-water source for the 4,462 residents of Campbell (U.S. Census Bureau, 2023). The groundwater source for the remaining sample location was the deeper Mount Simon aquifer that is composed mostly of sandstone and dolomite bedrock (Olcott, 1992; Hunt and others, 2003). This groundwater source underlies the alluvial aquifer and is under consideration as an alternative drinking-water source for Campbell. To gain a broader perspective of potential human exposures to drinking-water contaminants (in addition to PFAS), all 11 of the point-of-use and groundwater water samples were analyzed for 506 organic compounds (disinfection byproducts [DBP], pesticides, PFAS, pharmaceuticals, semi-volatile organic compounds [SVOC], and volatile organic compounds [VOC]), 34 inorganic constituents (cations, anions, trace elements, and alkalinity), 3 microbial indicator groups, and 3 field parameters (pH, water temperature, and specific conductance). All samples were collected by USGS personnel, and all analyses were completed at USGS laboratories. A full list of compounds analyzed, and results are available in Romanok and others (2023a) and are summarized herein.

Additional PFAS samples were collected quarterly, beginning in 2021, by USGS UMESC personnel from four wells located on UMESC property and analyzed by private and public laboratory facilities. Data from 2021 to 2022 are summarized herein and a full list of compounds that were analyzed, as well as their results, can be found in Romanok and others (2023b). Users can download the files from these data releases for site information and compound-specific results.

Purpose and Scope

The purpose of this report is to present a summary of the site selection, sampling and analytical methods, and organic, inorganic, and microbiological results for water-quality samples collected from 11 groundwater well locations in Campbell, Wisconsin from October 18–20, 2021. These wells were selected to provide spatial and depth representation of the current and potential drinking-water supplies. Three of those locations were selected for further temporal evaluation of the occurrence of water contaminants, specifically, the area around the La Crosse Regional Airport, a previously documented source of PFAS to the alluvial aquifer (Schultz, 2021). The sampling design and sample collection were developed and conducted by USGS in collaboration with the town of Campbell. An additional four groundwater wells in the shallow alluvial and Mount Simon aquifers were sampled on a quarterly basis beginning in 2021 to assess

PFAS. These 4 wells also serve as the source water for the 11 locations sampled from October 18–20, 2021. U.S. Environmental Protection Agency National Primary Drinking Water Regulations (EPA NPDWR) are applicable only to public-supply drinking water sources (sites 001 and WR972) and are provided herein for reference in relation to private wells (sites 002–011).

Methods

Innovative sampling and analytical approaches and methods were utilized in this study to assess the temporal and spatial occurrence of inorganic and organic constituents in groundwater.

Site Selection

Water-quality samples were collected from two taps within the UMESC facility, three residential tapwater locations, three community tapwater locations, two community parks, and one fire department pump station ([fig. 1](#) and [table 1](#)). Sample locations were selected from available public community buildings, residential volunteer participants, and UMESC locations to provide broad spatial coverage of Campbell, part of French Island, Wisconsin, specifically focusing on the area that borders the La Crosse Regional Airport, which is part of the City of La Crosse, Wisconsin. Samples were collected from October 18–20, 2021. All but one sample (taken at site 001) were collected from groundwater wells withdrawing water from the shallow alluvial aquifer. Samples from site 001 were collected from a groundwater well that withdrew water from the deeper Mount Simon aquifer. Due to agency-mandated pandemic physical-distancing policies in place at the time of sampling, residential building tapwater samples were collected from exterior, non-potable taps (spigots).

Three sites (sites 001, 002, and 003) were selected to be sampled over the course of three days to evaluate potential short-term temporal changes in drinking-water contaminant exposures. These sites were chosen due to their depth profiles and proximity to the airport, a suspected source of PFAS (Schultz, 2021). The precise depths of the wells are unknown.

Four groundwater wells (sampled for only PFAS) located on the UMESC property were sampled by UMESC personnel. Three of these wells (Wisconsin unique well numbers BG122, BG123, and BG124) were drilled in 1973 to 22.3–22.9 meters below land surface (Wisconsin Department of Natural Resources website, undated). These wells pump water from the shallow alluvial aquifer and are the source of water for site 002. The fourth well (Wisconsin unique well number WR972) was drilled in 2011 to 62.2 meters below land surface and cased to 52.1 meters below land surface. WR972 pumps water from the deeper Mount Simon aquifer and is located approximately 320 meters from the airport boundaries. This well is the source of water for site 001.

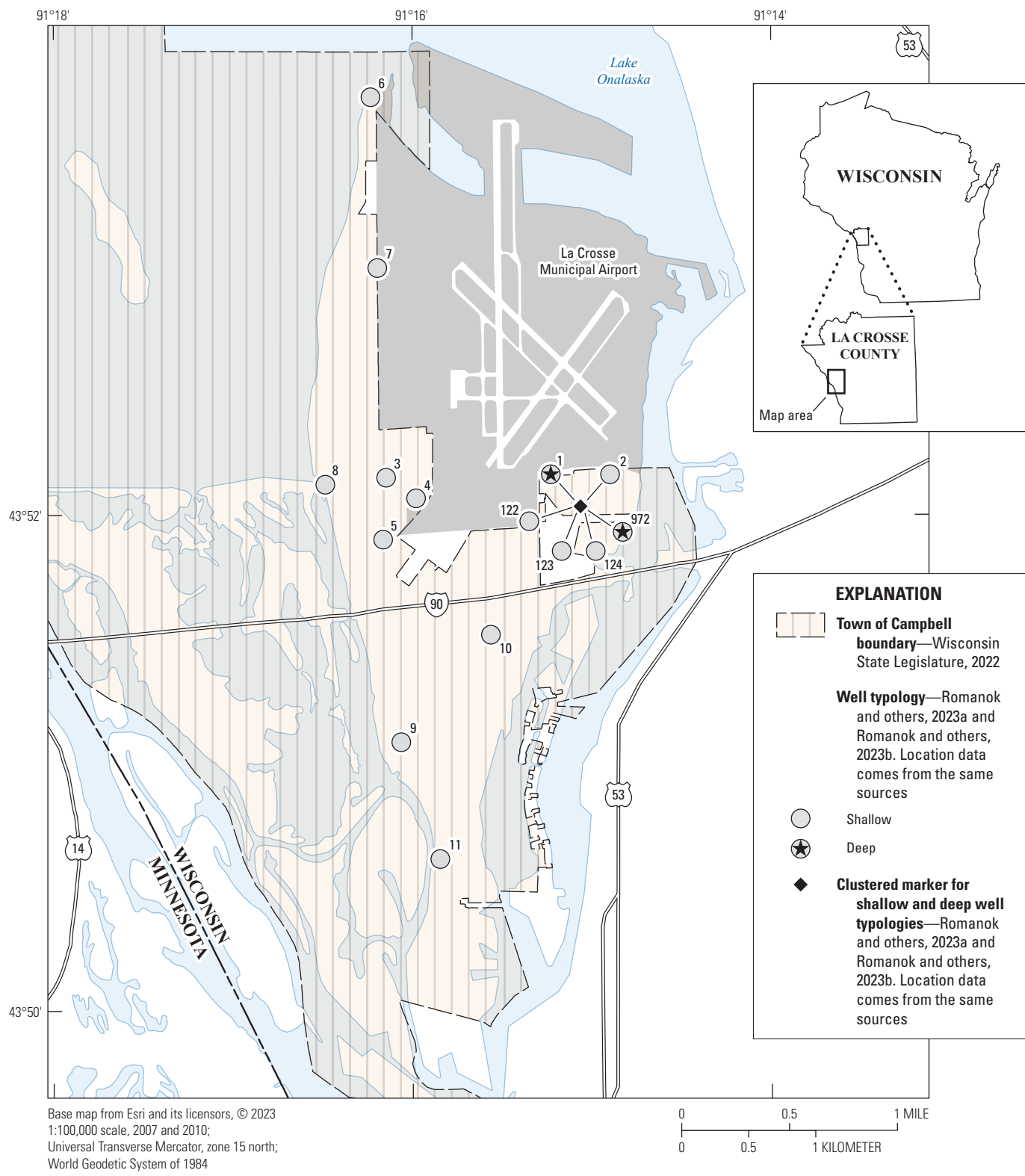


Figure 1. Map of site locations for the French Island Tapwater Exposure Study, town of Campbell, Wisconsin, 2021–22.

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Table 1. Site information for locations sampled for the French Island Tapwater Exposure Study, town of Campbell, Wisconsin, 2021–22.

Station name	Site code	Type of sample	Type of samples collected
Mount Simon aquifer			
WITW2021 001	001	Temporal	All analytes
WR972	972	Temporal	PFAS only
Shallow alluvial aquifer			
WITW2021 002	002	Temporal	All analytes
WITW2021 003	003	Temporal	All analytes
WITW2021 004	004	Spatial	All analytes
WITW2021 005	005	Spatial	All analytes
WITW2021 006	006	Spatial	All analytes
WITW2021 007	007	Spatial	All analytes
WITW2021 008	008	Spatial	All analytes
WITW2021 009	009	Spatial	All analytes
WITW2021 010	010	Spatial	All analytes
WITW2021 011	011	Spatial	All analytes
BG122	122	Temporal	PFAS only
BG123	123	Temporal	PFAS only
BG124	124	Temporal	PFAS only

Analytical Methods

For the October 18–20, 2021 sampling event, a total of 32 samples (including 3 quality-assurance field blanks) were analyzed for 506 organic compounds, 34 ions and trace elements, and 3 microbial indicator groups. Water temperature, specific conductance, and pH were measured at the time of sample collection using a multi-parameter sonde. Refer to [table 2](#) for sample handling, volume, and container information. For complete lists of all chemical compounds analyzed, refer to Romanok and others (2023a and 2023b).

USGS National Water Quality Laboratory (NWQL), Denver, Colorado

Tapwater samples were analyzed at the NWQL for 212 pesticides, 32 PFAS, 111 pharmaceuticals, 53 SVOC, and 76 VOC.

Pesticide samples (10 milliliters [mL]) were filtered in the field using a 0.7-micrometer (μm) nominal pore-size glass-fiber syringe filter and analyzed using direct aqueous injection-high performance liquid chromatography and tandem mass spectrometry (DAI HPLC-MS/MS) as detailed in Sandstrom and others (2015). Method detection limits (MDL) are determined using EPA procedures that are outlined in U.S. Environmental Protection Agency (2005). Reporting limits, reported as laboratory reporting limits, were set to twice the MDL (Childress and other, 1999). Concentration results are reported in nanograms per liter (ng/L).

Whole-water samples were analyzed by DAI HPLC-MS/MS for PFAS as described in Kolpin and others (2021). MDL were determined using American Society for Testing and Materials (ASTM) detection and quantitation-estimation and data assessment-utilizing software (DQCALC; ASTM International, 2016). Interim reporting limits (IRL) were set at twice the MDL. Concentration results are reported in ng/L.

Pharmaceutical samples (10 mL) were filtered in the field using a 0.7- μm nominal pore-size glass-fiber syringe filter and analyzed using DAI LC-MS/MS, which is further detailed in Furlong and others (2014). MDL are determined using EPA procedures outlined in U.S. Environmental Protection Agency (2005). IRL were determined as described in Oblinger Childress and others (1999) and allow for quantitation below the corresponding MDL. Concentration results are reported in ng/L.

Whole-water samples were analyzed for SVOC (base/neutral and acid extractable compounds). A 1-liter (L) water sample was extracted prior to analysis by gas chromatography/mass spectrometry (Fishman, 1993). Minimum reporting levels (MRL) were determined by the DQCALC procedure to get the reporting limit detected by DQCALC (RLDQC). The RLDQC is referred to in U.S. Geological Survey (2015) which is further described in ASTM International (2016). Concentration results are reported in $\mu\text{g/L}$.

Two different whole-water analytical methods were used to determine VOC concentrations in sample water. While both methods utilized electron impact ionization mass spectrometry, 37 heat-purgeable VOC were analyzed in simultaneous full scan/selected ion monitoring mode and 49 ambient purgeable VOC were analyzed in full scan mode (Rose and others, 2016). Reporting limits were determined using the RLDQC method, except for 2-Ethyl-1-hexanol, chloromethane, methylene chloride, and toluene, which were blank-limited and are reported using MRL as described in Oblinger Childress and others (1999). Concentration results are reported in $\mu\text{g/L}$.

USGS Organic Chemical Research Laboratory (OCRL), Sacramento, California

Whole-water samples were measured for 22 DBP as detailed in Hladik and others (2014). Samples were extracted using an Oasis HLB (hydrophilic and lipophilic balance) solid-phase extraction (SPE) cartridge (Waters Corporation, Milford, MA), and then were analyzed by gas chromatography/mass spectrometry. MDL were determined using methods described in U.S. Environmental Protection Agency, 2005. Concentration results are reported in $\mu\text{g/L}$.

USGS Redox Chemistry Laboratory (RCL) and Analytical Trace Element Chemistry Laboratory (ATECL), Boulder, Colorado

Filtered (0.45 μm pore-size nylon filter) water samples were analyzed for anions, and whole-water samples were analyzed for major cations and trace elements at the RCL.

Table 2. Summary of chemical groups analyzed and handling requirements, in order of collection, in the town of Campbell, Wisconsin, 2021.

[RCL, Redox Chemistry Laboratory, Boulder, Colorado; ATECL, Analytical Trace Element Chemistry Laboratory, Boulder, Colorado; EPHML, Environmental and Public Health Microbiology Laboratory, St. Petersburg, Florida; NWQL, National Water Quality Laboratory, Denver, Colorado; OGRL, Organic Geochemistry Research Laboratory, Lawrence, Kansas; OCRL, Organic Chemistry Research Laboratory, Sacramento, California; PFAS, per- and polyfluoroalkyl substances; SVOC, semi-volatile organic compounds; DBP, disinfection byproducts; VOC, volatile organic compounds; mL, milliliter; L, liter; HDPE, high density polyethylene; AA, ascorbic acid; PETG, polyethylene terephthalate; μ L, microliter; HNO₃, nitric acid; HCl, hydrochloric acid; μ m, micrometer; NLS, Northern Lake Service, Inc., Crandon, Wisconsin; WSHL, Wisconsin State Laboratory of Hygiene, University of Wisconsin-Madison, Madison, Wisconsin; SGS AXYS, Standard Global Services, Inc., British Columbia, Canada]

Analyzing laboratory	Analysis method	Number of bottles	Type of bottle	Field rinse required	Preservation
Unfiltered tapwater samples					
RCL/ATECL	Cations/metals	1	30 mL HDPE	Yes	300 μ L HNO ₃ , chill on ice
EPHML	Microbiology	1	1 L PETG	No	Chill on ice
NWQL	PFAS	3	2 mL centrifuge tube	Yes	Chill on ice
NWQL	SVOC	1	1 L, amber, glass (AA)	No	Chill on ice
OGRL	Microcystins	1	125 mL PETG	No	Chill on ice
OCRL	DBP	2	40 mL, amber, glass, vial	No	Chill on ice
NWQL	VOC	6	40 mL, amber, glass, vial	No	3 drops HCl, chill on ice
Filtered tapwater samples (0.7 μ m syringe filter)					
NWQL	Pesticides	1	20 mL, amber, glass vial (AA, 10 mL sample)	No	Chill on ice
NWQL	Human-use pharmaceuticals	1	20 mL, amber, glass vial (AA, 10 mL sample)	No	Chill on ice
Filtered tapwater samples (0.45 μ m syringe filter)					
RCL	Alkalinity/anions	1	60 mL HDPE	Yes	Chill on ice
RCL	Hexavalent chromium	2	2 mL centrifuge tube	No	SPE (air purge), 10 μ L HNO ₃ , chill on ice
RCL	Total chromium	2	2 mL centrifuge tube	No	10 μ L HNO ₃ , chill on ice
Unfiltered UMESC groundwater samples					
NLS	PFAS	2	250 mL HDPE	Yes	Chill on ice
WSLH	PFAS	2	250 mL Polypropylene	Yes	Frozen
SGS AXYS	PFAS	2	60 mL, 250 mL HDPE	Yes	Chill on ice

Lead, arsenic, hexavalent chromium, and total chromium were analyzed by graphite-furnace, atomic-absorption spectrometry, and results are reported in μ g/L (Ball and McCleskey, 2003; McCleskey and others, 2003; Hergenreder, 2011). Anions (bromide, chloride, fluoride, nitrate as nitrogen, and sulfate) were analyzed by ion chromatography (U.S. Environmental Protection Agency, 1993; Brinton and others, 1996). Results are reported in milligrams per liter (mg/L). Major cations (calcium, magnesium, potassium, silica, and sodium), phosphorus, and trace elements (aluminum, antimony, barium, beryllium, boron, cadmium, cobalt, copper, iron, lithium, manganese, molybdenum, nickel, selenium, strontium, vanadium, and zinc) were analyzed by inductively coupled plasma-optical emission spectrometry (U.S. Environmental Protection Agency, 2014). Results are reported in mg/L for major ions and μ g/L for trace elements (table 1.1). Uranium was analyzed at the ATECL by inductively coupled plasma-mass spectrometry (McCleskey and others, 2019). Uranium results are reported in μ g/L.

SGS AXYS Laboratory, British Columbia, Canada

The SGS AXYS analytical method used for PFAS was MLA-110 REV. 02 VER. 11, dated January 13, 2021, and is available upon request from SGS AXYS (Sean Campbell, Environment, Health, and Safety project manager, written commun., 2021). Samples were stored in high-density polyethylene containers that were frozen for up to 90 days. After spiking with isotopically labeled surrogate standards, samples were extracted and cleaned by SPE. Analysis of the sample extract was performed by ultra-high performance liquid chromatography and tandem mass spectrometry (UHPLC-MS/MS) and reversed phase C18 column (18 carbon chains) using a solvent gradient. The column was coupled to a triple-quadrupole mass spectrometer run at unit-mass resolution in the Multiple Reaction Monitoring in negative-electrospray ionization mode. Target compounds were quantified using the isotope dilution/internal standard method, comparing the area of the primary (quantifying)

transition product ion of the target compound to the carbon-13-labeled (or deuterium-labeled) standard and correcting for response factors. Results are reported in ng/L.

Northern Lakes Service Inc., Crandon, Wisconsin

The Northern Lakes Service (NLS) utilizes EPA Method 537.1 to analyze for 33 PFAS (U.S. Environmental Protection Agency, 2020). After the addition of isotopically labeled standards, samples were passed through SPE and analyzed using UHPLC-MS/MS. Additional method details are available upon request from NLS (Steve Hefter, laboratory manager, written commun., 2021). MDL (National Archives, 2023) and results are reported in ng/L.

Wisconsin State Laboratory of Hygiene, Environmental Health Division, University of Wisconsin-Madison, Madison, Wisconsin

The Wisconsin State Laboratory of Hygiene (WSLH) utilizes their “PFAS in Water” method, developed at WSLH based on both EPA Method 537.1 and ISO/DIS 21675, to analyze for 33 PFAS (International Organization of Standardization, 2019; U.S. Environmental Protection Agency, 2020). Samples are stored chilled to 6°C for no more than 28 days before SPE. Prior to SPE, isotopically labeled standards are added. Samples are analyzed using HPLC-MS/MS in negative ion electrospray ionization mode. Additional method details are available upon request from WSLH (Alex Schwartz, Environmental Health Division, written commun., 2021). According to the WSLH standard operating procedures, MRL are set at 1 ng/L, or by multiplying the MDL by 2 and rounding up to the nearest calibration standard, whichever value is higher. Values between the MDL and MRL are reported as estimates. Results are reported in ng/L.

USGS Environmental and Public Health Microbiology Laboratory, St. Petersburg, Florida

The tapwater samples were analyzed for total coliforms, *Escherichia coli* (*E. coli*), and heterotrophic plate counts (HPC) by the USGS Environmental and Public Health Microbiology Laboratory (EPHML). Total coliforms were measured using Standard Method 9222B (Lipps and others, 2022b), membrane filtration with Endo Media. *E. coli* was measured using modified membrane-thermotolerant *E. coli* agar as described in EPA method 1603 (U.S. Environmental Protection Agency, 2014). HPC was measured using membrane filtration as described in Standard Methods 9215D (Lipps and others, 2022a). Results for all methods are reported in colony-forming units per 100 milliliters (CFU/100 mL).

USGS Organic Geochemical Research Laboratory, Lawrence, Kansas

Three 1-liter (L) baked glass-amber bottles filled with unfiltered water were collected at each site (labelled *A*, *B*, and *C* bottles) and extracted and concentrated to a total final volume of 300 microliters (μL). These extracted samples are archived at the OGRL.

The sample masses were calculated from the mass of the bottle before and after extraction. Each 1 L sample was extracted using a 24-port vacuum rack with Teflon tubing attached to 6 mL SPE cartridge adapters. The 200-milligram HLB SPE cartridges (Waters Corp., Milford, Massachusetts) were conditioned with 8 mL of methanol followed by 8 mL of water. The samples were loaded into the cartridges at a flow rate of about 10 mL per minute (min), the bottle and cartridge were rinsed with 8 mL of water, and air was passed through the cartridge for at least 20 minutes. A 24-port vacuum rack equipped with disposable polytetrafluoroethylene (PTFE) liners was used to elute the cartridges with two aliquots of 4 mL of methanol into 15 mL glass conical-bottom centrifuge tubes, and elution colors were recorded. The samples were evaporated to approximately 1 mL at 40°C, and the extracts from the B and C bottles were washed into the A bottle centrifuge tube with two aliquots of 1 mL of methanol. This combined extract was evaporated to 10 μL and then brought to a final volume of 300 μL with liquid chromatography/mass spectrometry (LC-MS)-grade methanol. The sample was transferred to a 12 by 32-millimeter plastic vial with an amber glass 0.1 mL insert and aluminum seal with PTFE/silicone liner lids. Extracts are archived at -20°C.

Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) for the 11 temporal and spatial sites sampled from October 18–20, 2021 included field blanks, laboratory blanks and spikes, and stable isotope surrogates. Low-level detections (nitrate, chloride, and sulfate ranging from 0.01 to 0.2 mg/L) in inorganic field blanks did not result in any blank-correction procedures for chloride and sulfate, but nitrate was censored to the reporting level. There were single detections of four compounds in the organic field blanks (butyl benzyl phthalate [0.8 μg/L], di-n-butyl phthalate [0.17 μg/L], diethyl phthalate [0.1 μg/L], and ethyl acetate [0.05 μg/L]). All four compounds were blank censored to two times the value detected in the blank. The median isotopic-surrogate percent recovery for the VOC, pharmaceutical, and pesticide compounds was 102 percent (ranging from 11.8–369 percent, 25th and 75th percentiles are 93.5 and 116 percent, respectively).

QA/QC for the UMESC PFAS samples included 1 laboratory blank (SGS AXYS), 20 field blanks (NLS), and 4 matrix spike samples (SGS AXYS). There were no PFAS detections in the laboratory blank or field blanks. The median matrix spike percent recovery was 92.5 percent (ranging from 57.8–137 percent, 25th and 75th percentiles are

82 and 97.6 percent, respectively). Two compounds (perfluoro-1-hexanesulfonate [PFHxS] and perfluoro-n-octanoate [PFOA]) from the June 6, 2021, sample were not reported due to quality-assurance issues at the laboratory. Additional laboratory QA/QC information can be requested from the participating laboratories.

Sampling Methods

Samples for the 11 sites were collected according to tapwater-sampling protocols described in Romanok and others (2018). Prior to sampling, a clean area was created by laying out a large plastic bag near the sampling point. After putting on clean gloves, an additional clean glove was placed on the cold-water handle, and 22 sample bottles and associated supplies were laid out on the clean surface. Gloves were replaced as necessary to maintain cleanliness.

Consistent with prior USGS tapwater studies (Bradley and others, 2020, 2022), sample collection began immediately after the spigot was turned on, in the order listed in [table 2](#). [Table 2](#) also details the bottle type and preservation for each chemical group. Field rinses, where specified, were done in triplicate; the bottles were filled with a small aliquot of water and then were capped, shaken, and emptied prior to final bottle filling. The total amount of water being flushed during the approximate 20 minutes of sampling was about 10 liters. After all (22) of the sample containers were filled, properly preserved where applicable, and capped, the sample containers were placed in resealable bags on ice for overnight shipment to the analytical laboratories. Field parameters (water temperature [degrees C], specific conductance [$\mu\text{S}/\text{cm}$], and pH [standard units]) were collected after bottle filling. These efforts to maintain the same analytical methods and the containers, as well as the same sampling team, allow for cross-study comparisons.

Samples for the 3-day temporal assessment were collected at three locations. On the first day, three tapwater samples were collected: an initial sample that has not been used for 6-plus hours (stagnant first-flush) sample, a sample 30 minutes after the start of the initial sample collection (post-flush), and a sample collected 6 hours (post-6h) after the initial sample. For the next two days, only stagnant first-flush and post-6h samples were collected. Due to COVID-19 pandemic restrictions, two of these locations had not been used for several days prior to sampling. Sampling points were not cleaned, and aeration screens (if present) were not removed from the tap prior to sampling. There were no point-of-use filtration systems on any of the sampled locations. All sample locations identified in figures have been anonymized for privacy, so exact locations are not identified.

Samples for the UMESC groundwater PFAS study were collected quarterly beginning in February 2021. Samples from February 4, 2021, were analyzed at SGS AXYS laboratory. Samples from June 30, 2021, were analyzed at the WSLH. The remaining samples (beginning in January 2022) were analyzed at NLS. Samples for sites BG122, BG123, and

BG124 were collected from individual well-pump spigots inside the pump house, and samples for site WR972 were collected from a spigot inside the public building prior to the on-site water softener. There were no aeration filters or screens installed on taps. See [table 2](#) for details on sample collection.

Results

Organic and inorganic chemical constituent concentration and microbiological results of this report are available from Romanok and others (2023a) and Romanok and others (2023b) and are summarized herein. Authors encourage users to download these files for site information and compound-specific results. To sum organic concentrations, units have been converted from ng/L (equivalent to parts per trillion [ppt]) to $\mu\text{g}/\text{L}$ (equivalent to parts per billion [ppb]) when necessary.

Level of Occurrence

Three field parameters (water temperature, specific conductance, and pH) were measured on site. Samples were analyzed for 34 inorganic constituents (nine anions and cations, along with alkalinity, nitrate [as nitrogen], and phosphorus), including 22 trace elements ([tables 1.1](#) and [1.2](#)). Of the inorganic constituents measured, eight were not detected in any of the samples in this study (antimony, arsenic, beryllium, cadmium, cobalt, molybdenum, selenium, and vanadium).

Ten inorganic constituents have U.S. Environmental Protection Agency National Primary Drinking Water Regulations (EPA NPDWR) maximum contaminant levels (MCL): antimony (6 $\mu\text{g}/\text{L}$), arsenic (10 $\mu\text{g}/\text{L}$), barium (2,000 $\mu\text{g}/\text{L}$), beryllium (4 $\mu\text{g}/\text{L}$), cadmium (5 $\mu\text{g}/\text{L}$), chromium (100 $\mu\text{g}/\text{L}$), fluoride (4,000 $\mu\text{g}/\text{L}$), nitrate (10 mg/L), selenium (50 $\mu\text{g}/\text{L}$), and uranium (30 $\mu\text{g}/\text{L}$; U.S. Environmental Protection Agency, 2008). Two constituents have treatment technique action levels (TTAL) established for public-supply drinking water to protect the public health (U.S. Environmental Protection Agency, 2009): copper (1,300 $\mu\text{g}/\text{L}$) and lead (15 $\mu\text{g}/\text{L}$). EPA NPDWR are applicable only to public-supply drinking-water sources and are presented here for reference only for private wells. No inorganic constituent exceeded the respective MCL or TTAL in this study.

Of the 506 unique organic compounds analyzed for the spatially and temporally (October 18–20, 2021) collected water-quality samples, 74 (14 percent of total unique organic analytes) were detected at least one time in any sample ([tables 1.3](#) and [1.4](#)). Detected organic compounds include 27 pesticides (5 percent of total unique organic analytes), 14 PFAS (3 percent), 5 pharmaceuticals (1 percent), 7 SVOC (1 percent), and 21 VOC (4 percent). Three additional PFAS were detected in the quarterly UMESC sampling, which were

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not detected in the October 18–20, 2021, spatial or temporal sampling; however, the concentration results were below the reporting level for the October 18–20, 2021, samples analyzed at the NWQL. Almost half of all detected organic compounds analyzed at the NWQL had maximum concentrations near or below the reporting limits. Reported values above the limit of detection (LOD), but below the reporting levels, were considered “detections”. There were no detections of DBP in any sample in this study.

Eight organic compounds detected in this study have established EPA NPDWR MCL: 1,4-dichlorobenzene (75 µg/L), benzene (5 µg/L), chlorobenzene (100 µg/L), m-xylene plus p-xylene (10,000 µg/L), styrene (100 µg/L), tetrachloroethene (5 µg/L), bis(2-ethylhexyl) phthalate (6 µg/L), and simazine (4 µg/L) (U.S. Environmental Protection Agency, 2009). EPA NPDWR are applicable only to public-supply drinking-water sources and are for reference for private wells. None of these compounds were detected at concentrations that exceeded their respective MCL.

In June 2022, the EPA published non-regulatory Lifetime Drinking Water health advisory levels (HAL) for four PFAS. The EPA interim PFAS HAL are: perfluoro-n-octanoate (PFOA), 0.004 ng/L (0.000004 µg/L) and perfluorooctanesulfonate (PFOS), 0.02 ng/L (0.00002 µg/L). The EPA final HAL for hexafluoropropylene oxide dimer acid (HFPO-DA; commonly referred to as “GenX”) and perfluorobutane sulfonate (PFBS) are 10 ng/L (0.01 µg/L) and 2,000 ng/L (2 µg/L), respectively. More information can be found in the Federal Registry at U.S. Environmental Protection Agency, 2022.

Subsequently, in March 2023, the EPA released a proposed NPDWR (as MCL) for PFOA and PFOS: 4 ng/L (0.004 µg/L) for each; however, until the respective MCL are finalized and promulgated, the interim HAL remains in effect (U.S. Environmental Protection Agency, 2022 and U.S. Environmental Protection Agency, 2023). In addition to PFOA and PFOS, a hazard index (HI) for PFHxS, HFPO-DA (“GenX”), PFNA, and PFBS has been proposed—the calculated HI is not to exceed one. The interim HAL, as well as the proposed MCL for PFOA, was exceeded at sites 002, 003, 004, and 005, and PFOS was exceeded in samples from sites 002, 003, 004, 005, and 007. Additionally, the 3 shallow UMESC groundwater wells (BG122, BG123, and BG124) exceeded the interim HAL and proposed MCL for PFOA and PFOS. The proposed HI was exceeded at tapwater site 002, as well as sites BG122, BG123, and BG124, which are the sources of water for tapwater site 002.

The tapwater samples were analyzed for total coliforms, *E. coli*, and HPC at all sites in this study (table 6 in Romanok and others, 2023a). There were no detections of *E. coli* at any site. HPC results at all three temporal sites decreased over the course of the three days of sampling. At site 001, the maximum HPC concentration of 1,620 CFU/100 mL was detected on day 1, and HPC was not detected in the post-6h sample on day 3. At site 002, the HPC had colony growth greater than 20,000 CFU/100 mL in multiple samples during the first two days of sampling; however, by the

post-6h sample on day 3, HPC was not detected. At site 003, the maximum HPC concentration was 4,170 CFU/100 mL in the stagnant first-flush sample on day 1, and although HPC remained at similar levels the following day, by the post-6h sample on day 3, the HPC level was 4 CFU/100 mL. For the temporal samples, total coliforms were present in one sample from site 001 (day 1, post-6h; 100 CFU/100 mL) and in one sample at site 002 (day 1, 30 min; 2 CFU/100 mL). In the remaining samples, total coliforms were present in two locations: sites 004 and 009, and HPC ranged from 311–28,000 CFU/100 mL. No MCL exists for HPC; however, there is a TTAL for public-supply water from groundwater sources influenced by surface water (U.S. Environmental Protection Agency, 2009) which states, among other details, that HPC should not exceed 500 bacterial colonies per milliliter. The Revised Total Coliform Rule established by the EPA requires a repeat sampling for *E. Coli* and total coliforms for any public supply water after a positive detection for *E. Coli* and (or) total coliforms (U.S. Environmental Protection Agency, 2013), and violations would be based upon those subsequent results.

Spatial Occurrence

Result concentrations in groundwater samples at the 11 locations were used to assess the spatial occurrence of inorganic constituents and organic compounds. Comparison of the deeper Mount Simon aquifer to the alluvial aquifer (currently used for drinking water) was accomplished by comparing concentrations in groundwater from site 001 sourced by the Mount Simon aquifer to the groundwater in the remaining alluvial aquifer sites. The spatial distribution of inorganic constituents and organic compounds in groundwater were assessed by comparing median concentrations for the 3-day temporally sampled sites (001, 002, and 003) along with the one-time sample at the remaining sites.

Inorganic Constituents

When considering the spatial distribution and aquifer comparison of inorganic constituents, little variation is apparent between most sites, but there are two notable exceptions: site 006 (the community-park drinking-water fountain at the northern, upstream tip of the island) and site 001 (UMESC tapwater sourced from the deeper Mount Simon aquifer; table 3 in Romanok and others, 2023a). The tapwater sample from site 006 had some of the highest concentrations of trace elements, including lead (8.5 µg/L), iron (8,600 µg/L), and manganese (104 µg/L). The tapwater sample from site 001 had some of the lowest concentrations of many inorganic constituents, including aluminum, barium, calcium, chloride, magnesium, manganese, nitrate, potassium, strontium, uranium, and iron. Trace elements, such as barium, strontium, and uranium are commonly an order of magnitude lower at site 001 when compared to other sites. The median concentration of barium and strontium from the 10 locations

drawing from the alluvial aquifer were 54.5 µg/L (interquartile range=39.5–70.5 µg/L) and 86.5 µg/L (interquartile range=67.2–104 µg/L), respectively, but neither barium nor strontium were detected at site 001 (table 1.5). Similar results are reported for uranium. The median concentration of uranium in samples from the shallow aquifer locations was 0.255 µg/L (interquartile range=0.16–0.562 µg/L), and the median from site 001 was 0.002 µg/L (table 1.5).

Organic Compounds

Of the 74 organic compounds detected (table 1.4), the 4 most frequently detected compounds were didealkylatrazine, metolachlor SA, PFBA, and PFBS, with detections in at least half of the sites (table 1.4). The total number of compounds detected in each sample ranged from 0 to 20 (median number of compounds detected per site of 11), and the sum of concentrations ranged from nd to 2.53 µg/L (median sum of concentrations per site of 0.342 µg/L; fig 2 and table 1.6).

Pesticides were detected in samples from all sites, but the median of the sum of pesticide concentrations from the seven samples collected at site 001 was below the detection limit. The sum of pesticide concentrations per sample ranged from nd to 1.26 µg/L (median per site of 0.086 µg/L; table 1.6). Among the most frequently detected pesticides were metabolites of both metolachlor (metolachlor SA) and atrazine (didealkylatrazine; table 1.4). PFAS were detected at 7 of the 11 locations, with the total number of detections per sample ranging from 0–14 (median per site of 1; table 1.6). The sum of PFAS concentrations per sample ranged from nd to 0.661 µg/L (median sum of concentrations per site of 0.014 µg/L). Sites 002 and 004 had the most PFAS detections per sample with 14 (median of 13) and 7, respectively, and concentration sums of 0.609 (median) and 0.164 µg/L, respectively (fig. 3 and table 1.6). Concentrations of PFOA and PFOS exceeded both the EPA interim HAL and the proposed MCL at sites 002, 003, 004, and 005. Site 007 exceeded the EPA interim HAL for PFOS only.

Pharmaceuticals were detected at 5 of the 11 sites, with total detections per sample ranging from 0–1 (median per site of 0), and the sum of pharmaceutical concentrations per sample ranged from nd–0.036 µg/L (median per site of nd). SVOC were detected in 5 of the 11 sites, with the total number of detected compounds per sample ranging from 0–6 (median per site of 0), and the sum of concentrations per sample ranging from nd–2.2 µg/L (median per site of nd). Sites 004, 007, and 010 had a single SVOC detection at each location; however, site 006 had 6 detected SVOC (table 1.6). VOC were detected in 9 of the 11 sites; however, the median concentration of the 7 samples collected at site 001 was below the detection limit (nd). The total number of VOC detected in all samples ranged from 0–11 (median per site of 1), and the sum of concentrations per sample ranged from nd to 1.9 µg/L (median per site of 0.113 µg/L; table 1.6).

At site 006, VOC and SVOC were the most frequently detected compound groups (11 and 6 compounds detected, respectively) comprising 85 percent of detections. There were no PFAS detected in the sample (table 1.6). Sites 002 and

006 had the most organic compounds detected with 20 each. Residential tapwater sites 007 and 008 on the western edge of the island (fig. 1) had 19 and 13 organic compound detections, respectively. Sites 009, 010, and 011 had 4 or fewer detections of any organic compounds, and no PFAS were detected at any of these locations (table 1.6 and figs. 2 and 3). Site 001, the well that withdraws water from the Mount Simon aquifer, had the fewest number of detected organic compounds and the lowest sum of organic concentrations (tables 1.5 and 1.6).

Temporal Occurrence

Short-term temporal variability was assessed for 3 days (October 18–20, 2021) at 3 tapwater site locations. Sites 002 and 003 withdraw water from the alluvial aquifer and site 001 withdraws water from the Mount Simon aquifer. Long-term temporal variability was also assessed for PFAS in samples collected from 4 groundwater wells, which supply water to sites 001 and 002.

Inorganic Constituents

Overall, there was little variation in inorganic concentrations in any of the three sites evaluated temporally during October 18–20, 2021. At site 001, water temperatures ranged from 17–22.1°C (median of 18.6°C), specific conductance ranged from 509–519 µS/cm (median of 512 µS/cm), and pH ranged from 7.1–7.8 (median of 7.4; table 1.2). Seventeen inorganic constituents were detected, with 5 (aluminum, chromium, hexavalent chromium, manganese, and phosphorus) only detected in the stagnant first-flush sample on day 1. Iron was only detected in the first-flush (37 µg/L) and post-6h (4 µg/L) samples on day 1 (table 3 in Romanok and others, 2023a). The maximum value for boron occurred during the first-flush sample on day 1 (84 µg/L), with the remaining concentrations for this site ranging from 13–20 µg/L (median for all boron samples at site 001 was 15 µg/L; table 1.2).

At site 002, water temperature ranged from 19.5–25.4°C (median of 24°C), specific conductance ranged from 420–428 µS/cm (median of 426 µS/cm), and pH ranged from 7–7.5 (median of 7.2; table 1.2). Of the 21 inorganic constituents detected, chromium, fluoride, hexavalent chromium, iron, and lead were only detected in the samples collected on the first day at this site and were generally at or near the analytical reporting level. With a few exceptions, all other inorganics were detected at concentrations that remained stable throughout the sampling. For example, boron was detected in every sample with concentrations ranging from 17–18 µg/L (table 1.2). One exception was manganese, with a concentration of 189 µg/L, which was the maximum detected concentration and occurred in the post-flush sample on day 2 (table 3 in Romanok and others, 2023a).

At site 003, water temperature ranged from 17.2–18.1°C (median of 17.8 °C), specific conductance ranged from 728 to 731 µS/cm (median of 729 µS/cm), and pH ranged from 7.5–7.8 (median of 7.6; table 1.2). Twenty-four inorganic

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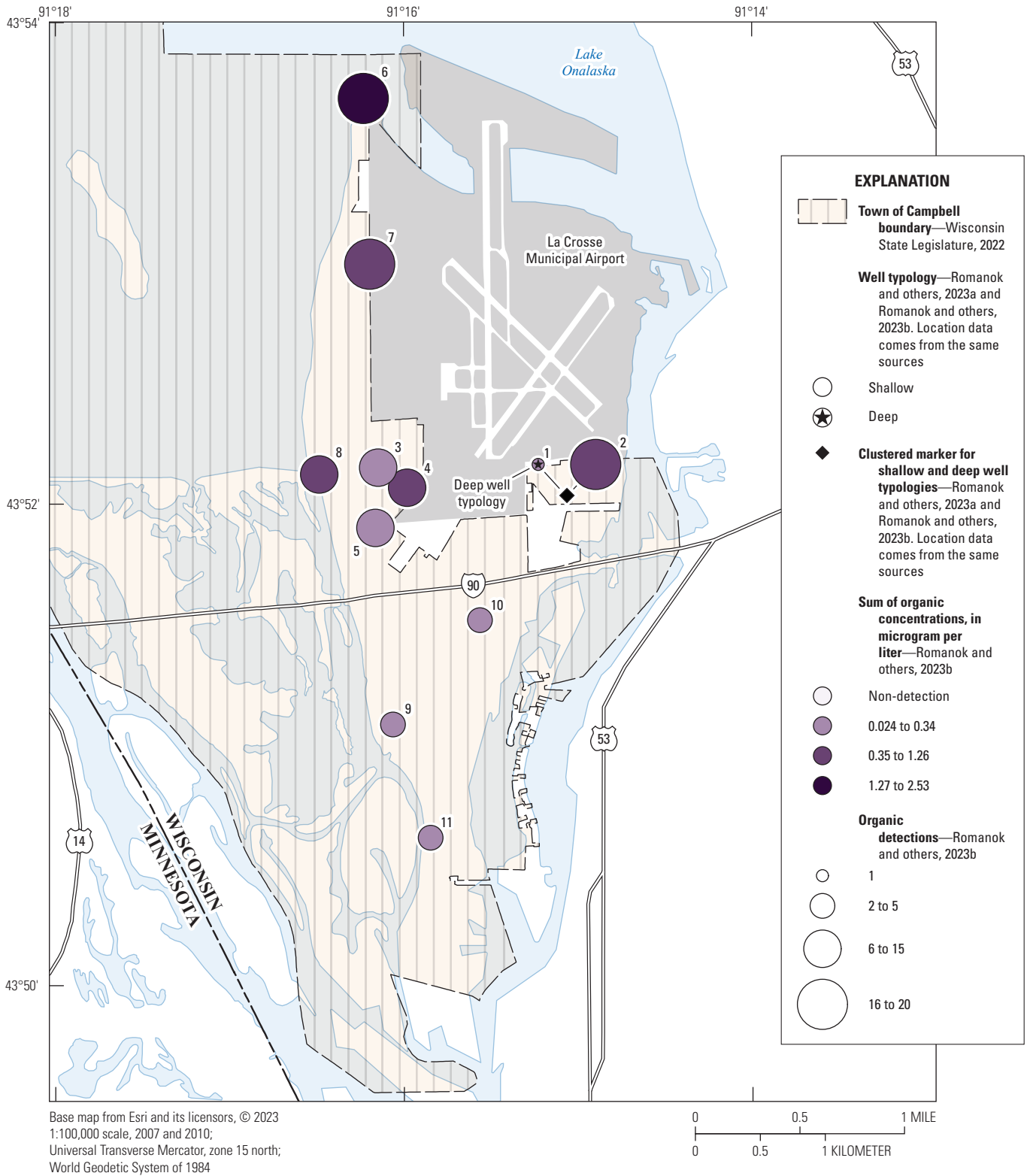


Figure 2. Map showing the sum of total organic compounds for the French Island Tapwater Exposure Study, town of Campbell, Wisconsin, 2021. [Median sum of concentrations used for sites 001, 002, and 003.]

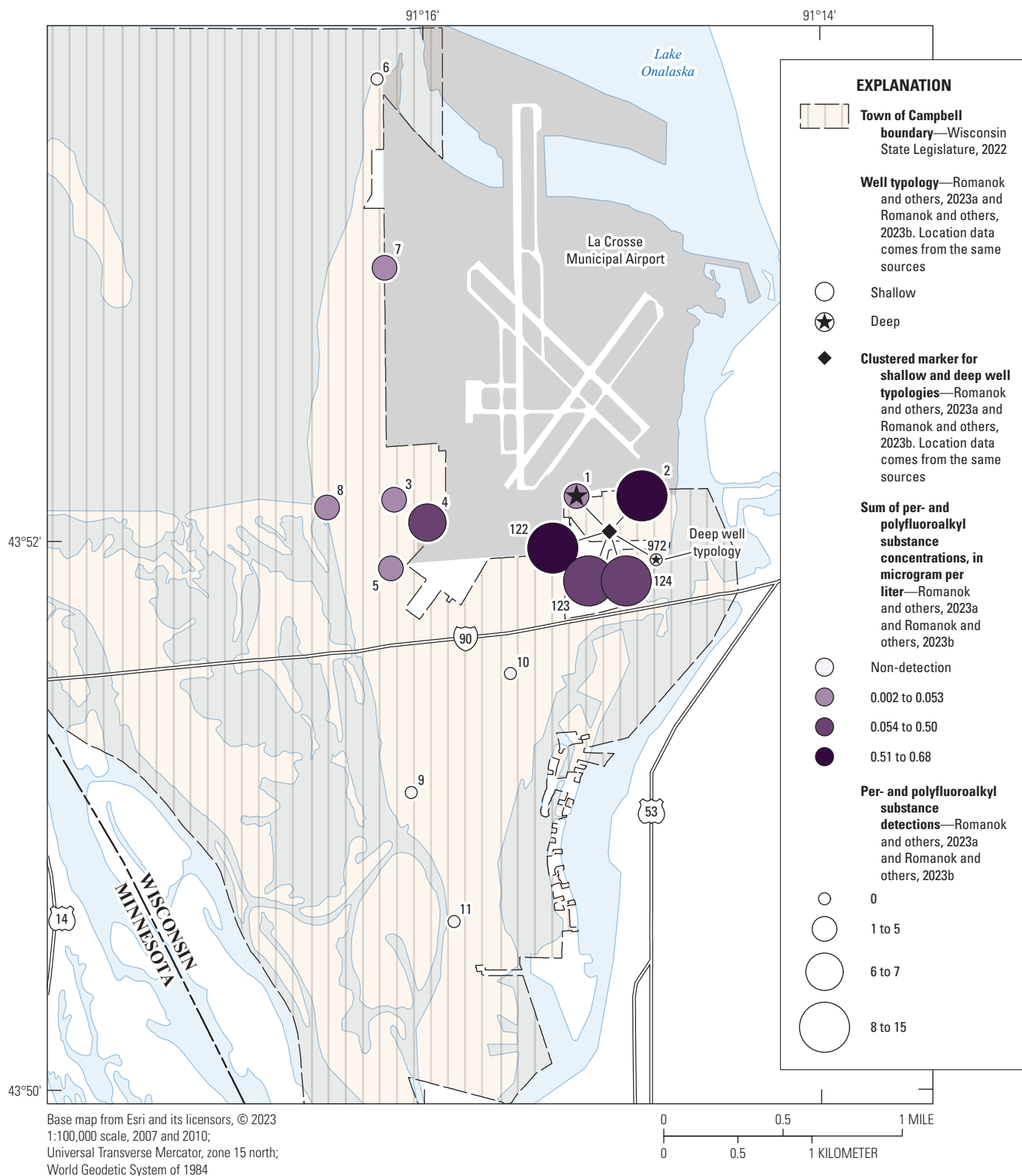


Figure 3. Map showing the sum of total per- and polyfluoroalkyl substances (PFAS) for the French Island Tapwater Exposure Study, town of Campbell, Wisconsin, 2021–22. [Median sum of PFAS concentrations used for sites 001, 002, 003, BG122, BG123, BG124, and WR972.]

compounds were detected at site 003. Median concentrations were generally higher at site 003 than at any other site in the study and concentrations were stable throughout the three days of sampling with a few exceptions. For example, chloride was detected in every sample, with concentrations ranging from 75.8–77.4 mg/L (median of 76.3 mg/L; [table 1.2](#)).

One exception was between the first-flush and post-flush samples on day 1 for copper and iron, as the concentration in the first-flush sample for copper was 617 µg/L (the maximum detected concentration), and the post-flush was 30 µg/L (the minimum detected concentration). Concentrations generally remained stable throughout the rest of the samples (concentration range was 332–517 µg/L; [table 3](#) in Romanok and others, 2023a). The iron concentration in the first-flush sample on day 1 was 13 µg/L (the minimum detected concentration), while in the post-flush sample on day 1 the concentration was 108 µg/L (the maximum detected concentration), which also remained stable for the rest of the sampling period (concentration range is 48–73 µg/L; [table 3](#) in Romanok and others, 2023a).

Organic Compounds

Six organic compounds were detected at least once in the seven samples collected at site 001 during October 18–20, 2021: 1 pesticide, 1 PFAS, 2 pharmaceuticals, and 2 VOC ([table 1.3](#)). On the first day, 2–3 organic compounds were detected from the 3 samplings, with the sum of concentrations per sample ranging from 0.024–1.92 µg/L (median of 0.024 µg/L; [table 1.6](#)). These findings included one detection each of isopropyl alcohol (1.9 µg/L in the stagnant first-flush sample), flubendiamide (0.0005 µg/L), and caffeine (E [estimated] 0.005 µg/L) in the post-flush sample, and dehydronifedipine (E0.036 µg/L) in the post-6h sample ([table 3](#) in Romanok and others, 2023a). Perfluorobutyrate (PFBA) was the only compound detected consistently on the first day, with concentrations ranging from nd–E0.025 µg/L ([table 1.3](#)). On the following days, only PFBA was detected on day 2 (stagnant first-flush sample), and only methyl acetate was detected on day 3 (post-6h sample). No SVOC were detected at site 001 ([table 1.5](#)).

At site 002, there was little variability over the course of the three days of sampling. Twenty-six total compounds were detected at least once in the seven samples. These included 9 pesticides, 14 PFAS, 1 pharmaceutical, and 2 VOC ([table 1.3](#)). On the first day, 18–20 compounds (median of 20) were detected in all three samplings; similar results were observed on the second (17 and 20 compounds detected) and third (16 and 20 compounds detected) days ([table 1.6](#)). The sum of concentrations per sample ranged from 0.931–1.28 µg/L (median of 1.08 µg/L; [table 1.6](#)). In each sample, 2–5 pesticides were detected, with the sum of concentrations per sample ranging from 0.029–0.302 µg/L (median concentration sum was 0.132 µg/L; [table 1.6](#)). The most frequently detected pesticides were metabolites of metolachlor, alachlor, and atrazine. No SVOC were detected

at this site. Methylbenzotriazole and 1,1-difluoroethane were detected in every sample collected at site 002 ([table 1.3](#)), with concentrations ranging from E0.1–E0.141 µg/L (median of E0.123 µg/L) and from 0.208–0.262 µg/L (median of 0.238 µg/L), respectively ([table 1.3](#)).

Of the 32 PFAS analyzed, 12–14 (median of 13) were consistently detected at site 002 during the October 18–20, 2021 sampling period: PFBA, PFBS, PFHxS, PFOA, PFOS, perfluoro-*n*-pentanoate (PFPeA), perfluoro-1-pentanesulfonate (PFPeS), perfluoro-1-hexanesulfonamide (FHx-SA), perfluoro-*n*-heptanoate (PFHpA), perfluoro-1-heptanesulfonate (PFHpS), perfluoro-*n*-hexanoate (PFHxA), perfluorobutane sulfonamide (FBSA), 1H,1H,2H,2H-perfluorohexane sulfonate (6:2) (6:2 FTS), and perfluoro-*n*-nonanoate (PFNA; [table 1.6](#) and [table 1.3](#)). This site had the most PFAS detections with the highest individual concentrations for those compounds compared to other locations ([table 1.6](#)). Eleven of the 14 PFAS were detected in all of the samples at this location; FBSA, 6:2 FTS, and PFNA were detected in 85.7, 71.4, and 57.1 percent of the samples, respectively ([table 1.3](#)). Of the detected PFAS, PFHxS and PFOS had the highest median concentrations with 0.158 µg/L and 0.156 µg/L, respectively ([table 1.6](#)). The sum of PFAS concentrations per sample ranged from 0.527–0.661 µg/L (median sum of concentration was 0.609 µg/L) ([table 1.6](#)).

Site 003 also showed little variability over the three days of sampling. Of the 19 total compounds detected at this site (6 pesticides, 5 PFAS, 2 pharmaceuticals, 2 SVOC, and 4 VOC, [table 1.3](#)), 9–12 compounds were detected at each sampling (median of 9), with the sum of concentrations per sample ranging from 0.165–2.46 µg/L (median sum of concentration was 0.226 µg/L; [table 1.6](#)). Of the six detected pesticide compounds, metabolites of metolachlor and atrazine were the most frequently detected ([table 1.3](#)). Bis (2-ethylhexyl) phthalate was only detected in the stagnant first-flush sample on day 1 (E2.2 µg/L). Four VOC were detected frequently: 1-Chloro-1,1-difluoroethane (HCFC-142b), 1,4-dichlorobenzene, butanal, and butane. 1,4-dichlorobenzene was detected consistently throughout the three days of sampling, with concentrations per sample ranging from 0.039–0.175 µg/L (median of 0.058 µg/L; [table 1.3](#)). Butane was detected in all samples on day 1. Butanal was only detected in the stagnant first-flush sample on each day and in the post-6h sample on day 1. HCFC-142b was not detected on day 1 but was consistently detected on subsequent days ([table 3](#) in Romanok and others, 2023a).

Five PFAS were detected at site 003: PFBA, PFBS, PFHxS (sum of linear and branched isomers), PFOA, and PFOS (sum of linear and branched isomers). PFBS, PFHxS, and PFOA (except for one sample) were detected consistently over the course of three days ([table 3](#) in Romanok and others, 2023a). PFBS concentrations ranged from 0.012–0.014 µg/L (median of 0.012 µg/L), PFHxS ranged from 0.002–0.004 µg/L (median of 0.003 µg/L), and PFOA ranged from nd–E0.005 µg/L (median of 0.005; [table 1.3](#)). PFBA and PFOS were each detected in 57 percent of the samples. PFBA ranged from

nd–E0.013 µg/L (median of 0.012 µg/L) and PFOS concentrations ranged from nd–0.005 µg/L (median of 0.003 µg/L; [table 1.3](#)). The sum of all PFAS concentrations per sample ranged from 0.017–0.039 µg/L (median sum of concentrations was 0.033 µg/L; [table 1.6](#)).

For the long-term PFAS sampling at UMESC, 15 of the 33 PFAS were detected at least one time in any sample ([table 1.7](#)). Only PFBS (0.0006 µg/L) and FOSA (perfluoro-1-octanesulfonamide; 0.0005 µg/L) were detected (one time each) in the deep well (WR972) at concentrations near the method LOD and below the method quantitation limit ([table 3](#) in Romanok and others, 2023b). The median number of detections ranged from 11.5–12 for the 3 wells in the shallow alluvial aquifer (BG122, BG123, and BG124), with the median sum of concentrations per sample ranging from 0.276–0.676 µg/L ([table 1.7](#)). With one exception (PFHpS was only detected in 87.5 percent of samples at site BG123), 10 PFAS were detected in every sample collected from these three wells ([table 1.7](#)). These results are consistent with the results collected at sites 001 and 002 in the 3-day temporal sampling during October 18–20, 2021.

Summary

Eleven sites were sampled in Campbell, Wisconsin in October 2021. All samples were collected from groundwater sources, eight of which were collected from private or community tapwater locations. The sites were spatially distributed within Campbell and 3 of the sites were selected to be sampled for short-term temporal variability over a 3-day period. These three sites were selected to include both the shallow sand and gravel (alluvial) aquifer and the deeper sandstone and dolomite of the Mount Simon aquifer. Each of these samples were analyzed for 506 unique organic compounds, 34 cations, anions, trace elements, 3 microbial indicators, and 3 field parameters (pH, specific conductance, and water temperature). Additionally, groundwater wells BG122, BG123, and BG124 that supply water to tapwater site 002 and one well (site WR972) that supplies water to tapwater site 001 were sampled for only PFAS (per- and polyfluoroalkyl substances) to assess long-term variability.

Of the 32 inorganic constituents (cations, anions, and trace elements) analyzed from October 18–20, 2021, eight were not detected in any sample, and none were reported at concentrations that would have exceeded an MCL (maximum contaminant load) or TTAL (treatment technique action level). U.S. Environmental Protection Agency National Primary Drinking Water Regulations (EPA NPDWR) are applicable only to public-supply drinking water sources (site 001) and are for reference only for private wells (sites 002–011). For the sites that were evaluated temporally, concentration ranges, with few exceptions, showed little variability over the three days. This lack of variability is also demonstrated in the spatially distributed samples, with one exception: site 006 (the northernmost site). Site 001, the well withdrawing

water from the deeper Mount Simon aquifer, had the lowest concentrations for some ions and trace elements, for example, nitrate, strontium, and uranium, compared to the other 10 locations.

Of the 506 organic compounds analyzed from October 18–20, 2021, 74 were detected at least one time in any sample. These organic compounds included 27 pesticides, 14 PFAS, 5 pharmaceuticals, 7 SVOC (semi-volatile organic compounds), and 21 VOC (volatile organic compounds). No DBP (disinfection byproducts) were detected in any sample. None of the compounds detected exceeded their respective MCL (provided for reference only), but the interim HAL (health advisory levels) and recently proposed MCL for select PFAS were exceeded in samples from 4 sites for PFOA (perfluoro-n-octanoate) and 5 sites for PFOS (perfluorooctanesulfonate). Additionally, the proposed EPA HI calculated for perfluoro-1-hexanesulfonate HFPO-DA (commonly referred to as “GenX”, which was not detected at any site), PFNA (perfluoro-n-nonanoate), and PFBS (perfluoro-1-butanesulfonate) was exceeded at site 002.

Four sites were sampled quarterly, beginning in 2021, to assess long-term PFAS temporal variability as part of the UMESC PFAS groundwater study. Fifteen of the 33 PFAS were detected at least one time in any sample. Eleven of the 15 PFAS were detected in almost every sample from the three groundwater wells sourced from the alluvial aquifer. Concentrations of PFOA and PFOS exceeded both the EPA interim HAL and proposed MCL (provided for reference) in each of the 23 samples where they were detected. The proposed EPA HI calculated for PFHxS, HFPO-DA (“GenX”, which was not detected at any site), PFNA, and PFBS was exceeded at sites BG122, BG123, and BG124. There were only two detections of PFAS (PFBS and perfluoro-1-octanesulfonamide [FOSA]) in samples taken from well (WR972) in the deeper Mount Simon aquifer and both detections were at the method LOD and below the method quantitation limit.

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Appendix 1. Summary Data Tables for the Occurrence of Mixed Organic and Inorganic Chemicals in Groundwater and Tapwater, Town of Campbell, Wisconsin, 2021–22

Data collected during the 2021 effort are available from Romanok and others (2023a). Data collected at UMESC in 2022 are available from Romanok and others (2023b).

Table 1.1. Frequency of detection (in percent for all samples) and concentrations ranges (in units listed), for detected inorganic constituents, and field parameters, collected at 11 spatially distributed sites (eight sampled one time each; median concentration ranges used for sites 001, 002, and 003 for minimum, median and maximum value presented in table) and analyzed at the U.S. Geological Survey Redox Chemistry Laboratory (RCL) and Analytical Trace Element Chemistry Laboratory in Boulder, Colorado, for the French Island Tapwater Exposure study, Campbell, Wisconsin, 2021.

[Water temperature, specific conductance and pH were measured in the field at time of sample collection. Antimony, arsenic, beryllium, cadmium, cobalt, molybdenum, selenium, and vanadium were not detected in any sample. n, number of samples; —, not applicable; °C, degrees Celsius; nd, not detected above reporting limit; µS/cm, microsiemens per centimeter; <, less than; mg/L, milligrams per liter; CaCO₃, calcium carbonate; µg/L, micrograms per liter; ^, value reflects median for each of the seven samples collected at sites 001, 002, or 003]

Parameter name	Reporting limit	Units of measurement	Frequency of detection (percent, n=29)	Concentration ranges (in units listed, n=11)		
				Minimum	Median	Maximum
Temperature, water	—	°C	—	12.4	16.5	24
Specific conductance	—	µS/cm at 25°C	—	333	508	748
pH	—	standard units	—	7.2	7.9	8.2
Alkalinity	<2.	mg/L CaCO ₃	—	121	164	294
Bromide	<0.01	mg/L	9.1	nd	nd	0.08
Calcium	<0.1	mg/L	90.9	nd	52	93.2
Chloride	<0.1	mg/L	100	6.6	39	99.1
Fluoride	<0.01	mg/L	81.8	nd	0.06	0.1
Magnesium	<0.01	mg/L	100	0.03	16.4	20.3
Nitrate, Nitrogen	<0.01	mg/L	81.8	nd	2.48	7.81
Potassium	<0.08	mg/L	100	0.08	1.27	4.13
Silica	<0.05	mg/L	100	13.5	20.8	23.5
Sodium	<0.05	mg/L	100	9.2	21.8	127
Sulfate	<0.1	mg/L	100	2.4	17.2	54.6
Aluminum	<2	µg/L	100	nd^	5	11
Barium	<0.5	µg/L	90.9	nd	51	145
Boron	<5	µg/L	100	15	20	33
Chromium	<0.2	µg/L	45.4	nd	nd	0.7
Copper	<2	µg/L	81.8	nd	11	457
Hexavalent chromium	<0.2	µg/L	45.4	nd	nd	0.6
Iron	<2	µg/L	90.9	nd	14	8,600
Lead	<0.5	µg/L	72.7	nd	1.1	8.5
Lithium	<0.5	µg/L	36.4	nd	nd	2
Manganese	<1	µg/L	90.9	nd	19	203
Nickel	<4	µg/L	18.2	nd	nd	8
Phosphorus	<50	µg/L	27.3	nd	nd	60
Strontium	<0.5	µg/L	90.9	nd	82	230
Uranium	<0.0002	µg/L	100	0.002	0.25	0.82
Zinc	<1.	µg/L	100	21	146	1,050

Table 1.2. Frequency of detection (in percent) and concentrations ranges (in units listed), for detected inorganic constituents, and field parameters, collected at three sites sampled temporally (sampled seven times over three days) and analyzed at the U.S. Geological Survey Redox Chemistry Laboratory and Analytical Trace Element Chemistry Laboratory in Boulder, Colorado, for the French Island Tapwater Exposure study, Campbell, Wisconsin, 2021.

[Water temperature, specific conductance and pH were measured in the field at time of sample collection. Antimony, arsenic, beryllium, cadmium, cobalt, molybdenum, selenium, and vanadium were not detected in any sample. n, number of samples; —, not applicable; °C, degrees Celsius; nd, not detected above reporting limit; <, less than; mg/L, milligrams per liter; µg/L, micrograms per liter; µS, microsiemens; CaCO₃, calcium carbonate]

Parameter name	Reporting limit	Units of measurement	Frequency of detection (percent)	Concentration ranges (in units listed, n=11)		
				Minimum	Median	Maximum
Site 001 (n=7)						
Temperature, water	—	°C	—	17	18.6	22.1
Specific conductance	—	µS/cm at 25°C	—	509	512	519
pH	—	standard units	—	7.1	7.4	7.8
Alkalinity	<2	mg/L CaCO ₃	—	249	253	255
Chloride	<0.1	mg/L	100	6.3	6.6	7.8
Fluoride	<0.01	mg/L	57.1	nd	0.05	0.31
Magnesium	<0.01	mg/L	100	0.03	0.03	0.06
Potassium	<0.08	mg/L	100	0.07	0.08	0.12
Silica	<0.05	mg/L	100	11	13.5	57.5
Sodium	<0.05	mg/L	100	121	127	162
Sulfate	<0.1	mg/L	100	13.7	17.6	19.2
Aluminum	<2	µg/L	14.3	nd	nd	19
Boron	<5	µg/L	100	13	15	84
Chromium	<0.2	µg/L	14.3	nd	nd	0.3
Copper	<2	µg/L	100	10	44	74
Hexavalent chromium	<0.2	µg/L	14.3	nd	nd	0.3
Iron	<2	µg/L	28.6	nd	nd	37
Manganese	<1	µg/L	14.3	nd	nd	1
Phosphorus	<50	µg/L	14.3	nd	nd	110
Uranium	<0.0002	µg/L	100	0.0004	0.002	0.003
Zinc	<1	µg/L	100	8	55	104
Site 002 (n=7)						
Temperature, water	—	°C	—	19.5	24	25.4
Specific conductance	—	µS/cm at 25°C	—	420	426	428
pH	—	standard units	—	7	7.2	7.5
Alkalinity	<2	mg/L CaCO ₃	—	139	139	143
Calcium	<0.1	mg/L	100	46	47.1	47.8
Chloride	<0.1	mg/L	100	23.7	23.8	24
Fluoride	<0.01	mg/L	42.9	nd	nd	0.05
Magnesium	<0.01	mg/L	100	14.5	14.8	15
Nitrate, Nitrogen	<0.01	mg/L	100	7.52	7.81	7.97
Potassium	<0.08	mg/L	100	1.3	1.3	1.32
Silica	<0.05	mg/L	100	14.2	16.5	18.1
Sodium	<0.05	mg/L	100	11.1	11.4	12.9
Sulfate	<0.1	mg/L	100	9	9	9.1
Aluminum	<2	µg/L	100	4	5	7
Barium	<0.5	µg/L	100	63	74	77
Boron	<5	µg/L	100	17	17	18
Chromium	<0.2	µg/L	28.6	nd	nd	0.4
Copper	<2	µg/L	85.7	nd	8	17

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Table 1.2. Frequency of detection (in percent) and concentrations ranges (in units listed), for detected inorganic constituents, and field parameters, collected at three sites sampled temporally (sampled seven times over three days) and analyzed at the U.S. Geological Survey Redox Chemistry Laboratory and Analytical Trace Element Chemistry Laboratory in Boulder, Colorado, for the French Island Tapwater Exposure study, Campbell, Wisconsin, 2021.—Continued

[Water temperature, specific conductance and pH were measured in the field at time of sample collection. Antimony, arsenic, beryllium, cadmium, cobalt, molybdenum, selenium, and vanadium were not detected in any sample. n, number of samples; —, not applicable; °C, degrees Celsius; nd, not detected above reporting limit; <, less than; mg/L, milligrams per liter; µg/L, micrograms per liter; µS, microsiemens; CaCO₃, calcium carbonate]

Parameter name	Reporting limit	Units of measurement	Frequency of detection (percent)	Concentration ranges (in units listed, n=11)		
				Minimum	Median	Maximum
Site 002 (n=7)—Continued						
Hexavalent chromium	<0.2	µg/L	28.6	nd	nd	0.4
Iron	<2	µg/L	28.6	nd	nd	10
Lead	<0.5	µg/L	14.3	nd	nd	0.6
Lithium	<0.5	µg/L	0	nd	nd	nd
Manganese	<1	µg/L	100	9	26	189
Nickel	<4	µg/L	0	nd	nd	nd
Phosphorus	<50	µg/L	0	nd	nd	nd
Strontium	<0.5	µg/L	100	62	62	63
Uranium	<0.0002	µg/L	100	0.24	0.26	0.3
Zinc	<1	µg/L	100	557	1,050	1,280
Site 003 (n=7)						
Temperature, water	—	°C	—	17.2	17.8	18.1
Specific conductance	—	µS/cm at 25°C	—	728	729	731
pH	—	standard units	—	7.5	7.6	7.8
Alkalinity	<2	mg/L CaCO ₃	—	226	229	233
Bromide	<0.01	mg/L	0	nd	nd	nd
Calcium	<0.1	mg/L	100	58.2	58.7	59.1
Chloride	<0.1	mg/L	100	75.8	76.3	77.4
Fluoride	<0.01	mg/L	28.6	nd	nd	0.05
Magnesium	<0.01	mg/L	100	17.1	17.2	17.5
Nitrate, nitrogen	<0.01	mg/L	100	6.19	6.48	6.68
Potassium	<0.08	mg/L	100	1.28	1.31	1.32
Silica	<0.05	mg/L	100	21.4	22.8	23.6
Sodium	<0.05	mg/L	100	63.9	64.3	65
Sulfate	<0.1	mg/L	100	12.7	12.8	12.9
Aluminum	<2	µg/L	100	5	6	6
Barium	<0.5	µg/L	100	59	60	60
Boron	<5	µg/L	100	25	25	26
Chromium	<0.2	µg/L	100	0.6	0.7	0.8
Copper	<2	µg/L	100	30	457	617
Hexavalent chromium	<0.2	µg/L	100	0.5	0.6	0.7
Iron	<2	µg/L	100	13	60	108
Lead	<0.5	µg/L	100	1.4	2.8	4.3
Lithium	<0.5	µg/L	100	2	2	2
Manganese	<1	µg/L	100	1	2	3
Nickel	<4	µg/L	71.4	nd	8	15
Phosphorus	<50	µg/L	14.3	nd	nd	70
Strontium	<0.5	µg/L	100	105	105	106
Uranium	<0.0002	µg/L	100	0.59	0.61	0.63
Zinc	<1	µg/L	100	741	1,000	1,290

Table 1.3. Frequency of detection (in percent) and concentrations ranges (in micrograms per liter) for detected organic compounds collected at three sites sampled temporally (each site was sampled seven times over three days) and analyzed at the U.S. Geological Survey National Water Quality Laboratory, Denver, Colorado, for the French Island Tapwater Exposure Study, Campbell, Wisconsin, 2021–22.

[PFHxS and PFOS represent the sum of the branched and linear isotopes. Reporting limit for PFHxS branched was <0.009 µg/L, and for PFOS branched was <0.040 µg/L. µg/L, micrograms per liter; n, number of samples; <, less than; nd, not detected above reporting limit; E, estimated value]

Parameter name	Reporting limit (µg/L)	Frequency of detection (percent)	Concentration ranges (µg/L, n=11)		
			Minimum	Median	Maximum
Site 001 (n=7)					
Caffeine	<0.091	14.3	nd	nd	E0.005
Dehydronifedipine	<0.02	14.3	nd	nd	E0.036
Flubendiamide	<0.004	14.3	nd	nd	0.0005
Isopropyl alcohol	<1.8	14.3	nd	nd	1.9
Methyl acetate	<0.14	14.3	nd	nd	0.21
Perfluorobutyrate (PFBA)	<0.007–0.01	57.1	nd	E0.014	E0.025
Site 002 (n=7)					
1,1-Difluoroethane	<0.025	100	0.208	0.238	0.262
1H,1H,2H,2H-Perfluorohexane sulfonate (6:2 FTS)	<0.01	71.4	nd	0.01	0.011
Alachlor oxanilic acid (OA)	<0.06	71.4	nd	0.013	0.022
Alachlor sulfonic acid (SA)	<0.84	57.1	nd	0.093	E0.25
Bromacil	<0.006	28.6	nd	nd	0.007
Caffeine	<0.091	14.3	nd	nd	E0.005
Deethylatrazine (CIAT)	<0.011	28.6	nd	nd	0.012
Didealkylatrazine (CAAT)	<0.025	28.6	nd	nd	0.015
Flubendiamide	<0.004	14.3	nd	nd	0.0005
Methylbenzotriazole	<0.08	100	E0.1	0.123	E0.141
Metolachlor oxanilic acid (OA)	<0.149	14.3	nd	nd	E0.011
Metolachlor sulfonic acid (SA)	<0.068	85.7	nd	0.024	0.027
Perfluoro-1-butanesulfonate (PFBS)	<0.002–0.004	100	0.021	0.023	0.025
Perfluoro-1-heptanesulfonate (PFHpS)	<0.01	100	E0.006	0.006	E0.006
Perfluoro-1-hexanesulfonamide (FHx-SA)	<0.05	100	E0.04	0.043	0.047
Perfluoro-1-hexanesulfonate (PFHxS)	<0.004	100	0.151	0.158	0.178
Perfluoro-1-pentanesulfonate (PFPeS)	<0.005	100	E0.026	0.027	E0.028
Perfluorobutane sulfonamide (FBSA)	<0.05	85.7	nd	0.041	0.045
Perfluorobutyrate (PFBA)	<0.007–0.01	100	E0.054	0.067	E0.07
Perfluoro-n-heptanoate (PFHpA)	<0.005	100	E0.007	0.01	E0.011
Perfluoro-n-hexanoate (PFHxA)	<0.005–0.01	100	0.024	0.028	0.032
Perfluoro-n-nonanoate (PFNA)	<0.002	57.1	nd	0.001	0.002
Perfluoro-n-octanoate (PFOA)	<0.002	100	E0.012	0.017	0.02
Perfluoro-n-pentanoate (PFPeA)	<0.002–0.005	100	E0.021	0.027	E0.031
Perfluorooctanesulfonate (PFOS)	<0.007	100	0.147	0.156	0.177
Tebuthiuron	<0.003	14.3	nd	nd	0.002
Site 003 (n=7)					
1,4-Dichlorobenzene	<0.026	100	0.039	0.058	0.175
2,4-Dichlorophenol	<0.1	42.9	nd	nd	0.04
Bis(2-ethylhexyl) phthalate	<2.8	14.3	nd	nd	E2.2
Butanal	<0.38	57.1	nd	0.04	0.06
Butane	<0.08	42.9	nd	nd	0.044
Caffeine	<0.091	14.3	nd	nd	E0.01
Deethylatrazine (CIAT)	<0.011	28.6	nd	nd	0.018

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Table 1.3. Frequency of detection (in percent) and concentrations ranges (in micrograms per liter) for detected organic compounds collected at three sites sampled temporally (each site was sampled seven times over three days) and analyzed at the U.S. Geological Survey National Water Quality Laboratory, Denver, Colorado, for the French Island Tapwater Exposure Study, Campbell, Wisconsin, 2021–22.—Continued

[PFHxS and PFOS represent the sum of the branched and linear isotopes. Reporting limit for PFHxS branched was <0.009 µg/L, and for PFOS branched was <0.040 µg/L. µg/L, micrograms per liter; n, number of samples; <, less than; nd, not detected above reporting limit; E, estimated value]

Parameter name	Reporting limit (µg/L)	Frequency of detection (percent)	Concentration ranges (µg/L, n=11)		
			Minimum	Median	Maximum
Site 003 (n=7)—Continued					
Didealkylatrazine (CAAT)	<0.025	85.7	nd	0.039	0.049
1-Chloro-1,1-difluoroethane (HCFC-142b)	<0.08	57.1	nd	0.017	E0.034
Metolachlor sulfonic acid (SA)	<0.068	71.4	nd	0.015	0.02
Nicotine	<0.08	14.3	nd	nd	E0.035
Perfluoro-1-butanedisulfonate (PFBS)	<0.002–0.004	100	0.012	0.012	0.014
Perfluoro-1-hexanesulfonate (PFHxS)	<0.004	100	0.002	0.003	0.004
Perfluorobutyrate (PFBA)	<0.007–0.01	57.1	nd	E0.012	E0.013
Perfluoro-n-octanoate (PFOA)	<0.002	85.7	nd	E0.005	E0.005
Perfluorooctanesulfonate (PFOS)	<0.007	57.1	nd	0.003	0.005
Simazine	<0.007	14.3	nd	nd	0.003
Sulfentrazone	<0.018	14.3	nd	nd	0.003
Tebuthiuron	<0.003	14.3	nd	nd	0.001

Table 1.4. Frequency of detection (in percent for all samples) and concentrations ranges (in micrograms per liter) of detected organic compounds collected at eleven spatially distributed sites (eight sampled one time each; median concentration ranges used for sites 001, 002, and 003 for minimum, median, and maximum value presented in table) and analyzed at the U.S. Geological Survey National Water Quality Laboratory, Denver, Colorado, for the French Island Tapwater Exposure Study, Campbell, Wisconsin, 2021–22.

[PFHxS and PFOS represent the sum of the branched and linear isotopes. Reporting limit for PFHxS branched was <0.009 µg/L, and for PFOS branched was <0.040 µg/L. µg/L, micrograms per liter; n, number; nd, not detected above reporting limit; <, less than; E, estimated value; ^, maximum value reported for sites 001, 002, or 003, but median value is nd]

Parameter name	Reporting limit (µg/L)	Frequency of detection (percent, n=29)	Concentration ranges (µg/L, n=11)		
			Minimum	Median	Maximum
Pesticides					
2-Hydroxy-4-isopropylamino-6-amino-s-triazine (OIAT)	<0.004	9.09	nd	nd	0.001
2-Hydroxyatrazine (OIET)	<0.008	18.2	nd	nd	0.075
Acetochlor oxanilic acid (OA)	<0.065	18.2	nd	nd	E0.211
Acetochlor sulfonic acid (SA)	<0.32	9.09	nd	nd	E0.212
Alachlor oxanilic acid (OA)	<0.06	27.3	nd	nd	0.037
Alachlor sulfonic acid (SA)	<0.84	9.09	nd	nd	E0.093
Bentazon	<0.009	18.2	nd	nd	0.002
Bromacil	<0.006	18.2	nd	nd	0.176
Dechlorometolachlor	<0.002	18.2	nd	nd	0.027
Deethylatrazine (CIAT)	<0.011	18.2	nd	nd	0.018^
Didealkylatrazine (CAAT)	<0.025	63.6	nd	0.009	0.061
Dimethenamid OA	<0.085	9.09	nd	nd	0.008
Fipronil	<0.004	9.09	nd	nd	0.004
Fipronil amide	<0.009	9.09	nd	nd	0.04
Fipronil sulfone	<0.006	9.09	nd	nd	0.008
Flubendiamide	<0.004	18.2	nd	nd	0.001^
Imazethapyr	<0.008	9.09	nd	nd	0.004

Table 1.4. Frequency of detection (in percent for all samples) and concentrations ranges (in micrograms per liter) of detected organic compounds collected at eleven spatially distributed sites (eight sampled one time each; median concentration ranges used for sites 001, 002, and 003 for minimum, median, and maximum value presented in table) and analyzed at the U.S. Geological Survey National Water Quality Laboratory, Denver, Colorado, for the French Island Tapwater Exposure Study, Campbell, Wisconsin, 2021–22.—Continued

[PFHxS and PFOS represent the sum of the branched and linear isotopes. Reporting limit for PFHxS branched was <0.009 µg/L, and for PFOS branched was <0.040 µg/L. µg/L, micrograms per liter; n, number; nd, not detected above reporting limit; <, less than; E, estimated value; ^, maximum value reported for sites 001, 002, or 003, but median value is nd]

Parameter name	Reporting limit (µg/L)	Frequency of detection (percent, n=29)	Concentration ranges (µg/L, n=11)		
			Minimum	Median	Maximum
Pesticides—Continued					
Methoxyfenozide	<0.002	9.09	nd	nd	0.002
Metolachlor	<0.003	9.09	nd	nd	0.004
Metolachlor oxanilic acid (OA)	<0.149	36.4	nd	nd	E0.192
Metolachlor sulfonic acid (SA)	<0.068	54.5	nd	0.015	0.454
Phorate oxon sulfone	<0.02	9.09	nd	nd	0.004
Prometon	<0.004	18.2	nd	nd	0.026
Simazine	<0.007	9.09	nd	nd	0.003^
Sulfentrazone	<0.018	18.2	nd	nd	E0.034
Tebufenozide	<0.002	9.09	nd	nd	0.004
Tebuthiuron	<0.003	27.3	nd	nd	0.008
Per- and polyfluoroalkyl substances (PFAS)					
1H,1H,2H,2H-Perfluorohexane sulfonate (6:2 FTS)	<0.01	9.09	nd	nd	0.01
Perfluoro-1-butanedisulfonate (PFBS)	<0.002	54.5	nd	0.002	0.023
Perfluoro-1-heptanesulfonate (PFHpS)	<0.005–0.01	9.09	nd	nd	0.006
Perfluoro-1-hexanesulfonamide (FHx-SA)	<0.05	9.09	nd	nd	0.043
Perfluoro-1-hexanesulfonate (PFHxS)	<0.004	45.4	nd	nd	0.158
Perfluoro-1-pentanesulfonate (PFPeS)	<0.005	18.2	nd	nd	E0.027
Perfluorobutane sulfonamide (FBSA)	<0.005	9.09	nd	nd	0.041
Perfluorobutyrate (PFBA)	<0.005–0.01	54.5	nd	0.012	E0.102
Perfluoro-n-heptanoate (PFHpA)	<0.005	9.09	nd	nd	E0.01
Perfluoro-n-hexanoate (PFHxA)	<0.005–0.01	9.09	nd	nd	0.028
Perfluoro-n-nonanoate (PFNA)	<0.002	9.09	nd	nd	0.001
Perfluoro-n-octanoate (PFOA)	<0.002	45.4	nd	nd	0.033
Perfluoro-n-pentanoate (PFPeA)	<0.002–0.005	18.2	nd	nd	E0.027
Perfluorooctanesulfonate (PFOS)	<0.007	45.4	nd	nd	0.156
Pharmaceuticals					
Caffeine	<0.091	27.3	nd	nd	E0.01^
Carbamazepine	<0.011	9.09	nd	nd	0.004
Dehydronifedipine	<0.02	9.09	nd	nd	E0.036^
Fenofibrate	<0.02	9.09	nd	nd	E0.0002
Nicotine	<0.08	9.09	nd	nd	E0.035^
Semi-volatile organic compounds (SVOC)					
2,4-Dichlorophenol	<0.1	18.2	nd	nd	E0.02
2,4,6-Trichlorophenol	<0.1	9.09	nd	nd	0.11
Anthracene	<0.1	9.09	nd	nd	0.01
Benzo[b]fluoranthene	<0.1	9.09	nd	nd	E0.01
Bis(2-ethylhexyl) phthalate	<2.8	27.3	nd	nd	0.3^
N-Nitrosodiphenylamine	<0.28	18.2	nd	nd	E0.18
Pyrene	<0.1	9.09	nd	nd	0.01
Volatile organic compounds (VOC)					
1,1-Dichloroethane	<0.044	9.09	nd	nd	0.02
1,1-Difluoroethane	<0.025	18.2	nd	nd	0.238
1,2,4-Trimethylbenzene	<0.032	9.09	nd	nd	0.068
1,4-Dichlorobenzene	<0.026	9.09	nd	nd	0.058

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Table 1.4. Frequency of detection (in percent for all samples) and concentrations ranges (in micrograms per liter) of detected organic compounds collected at eleven spatially distributed sites (eight sampled one time each; median concentration ranges used for sites 001, 002, and 003 for minimum, median, and maximum value presented in table) and analyzed at the U.S. Geological Survey National Water Quality Laboratory, Denver, Colorado, for the French Island Tapwater Exposure Study, Campbell, Wisconsin, 2021–22.—Continued

[PFHxS and PFOS represent the sum of the branched and linear isotopes. Reporting limit for PFHxS branched was <0.009 µg/L, and for PFOS branched was <0.040 µg/L. µg/L, micrograms per liter; n, number; nd, not detected above reporting limit; <, less than; E, estimated value; ^, maximum value reported for sites 001, 002, or 003, but median value is nd]

Parameter name	Reporting limit (µg/L)	Frequency of detection (percent, n=29)	Concentration ranges (µg/L, n=11)		
			Minimum	Median	Maximum
Volatile organic compounds (VOC)—Continued					
1-Chloro-1,1-difluoroethane (HCFC-142b)	<0.08	36.4	nd	nd	E0.098
Benzene	<0.026	9.09	nd	nd	0.014
Butanal	<0.38	27.3	nd	nd	0.06
Butane	<0.08	27.3	nd	nd	0.257
Carbon disulfide	<0.1	9.09	nd	nd	E0.8
Chlorobenzene	<0.026	9.09	nd	nd	0.037
Hexane	<0.068	9.09	nd	nd	E0.087
Isopropyl alcohol	<1.8	9.09	nd	nd	1.9^
Methyl acetate	<0.14	9.09	nd	nd	0.21^
Methylbenzotriazole	<0.08	9.09	nd	nd	0.123
m-Xylene plus p-xylene	<0.08	9.09	nd	nd	0.08
n-Pentane	<0.066	18.2	nd	nd	0.169
Styrene	<0.042	9.09	nd	nd	0.042
tert-Butyl alcohol	<0.24	9.09	nd	nd	0.28
tert-Butyl methyl ether (MTBE)	<0.01	9.09	nd	nd	0.05
Tetrachloroethene	<0.058	9.09	nd	nd	0.016
Trichloromethane	<0.03	27.3	nd	nd	0.05

Table 1.5. Summary statistics for detected inorganic constituents and grouped organic concentration results (in units listed) for the ten spatially distributed samples collected from the shallow sand and gravel (alluvial) aquifer (median results used for sites 002 and 003), as well as the median concentration results from site 001, finished in the sandstone and dolomite of the Mount Simon aquifer, analyzed by the U.S. Geological Survey Redox Chemistry Laboratory and Analytical Trace Element Chemistry Laboratory in Boulder, Colorado, and the National Water Quality Laboratory in Denver, Colorado, for the French Island Tapwater Exposure Study, Campbell, Wisconsin, 2021–22.

[Antimony, arsenic, beryllium, cadmium, cobalt, molybdenum, selenium, and vanadium were not detected in any sample. Disinfection byproducts (DBP) were not detected in any sample. n, number of samples; °C, degrees Celsius; µS/cm, microsiemens per centimeter; µg/L, micrograms per liter; mg/L, milligrams per liter; —, not applicable; <, less than; nd, not detected above reporting limit; CaCO₃, calcium carbonate; PHARM, pharmaceuticals; VOC, volatile organic compounds; SVOC, semi-volatile organic compounds; PEST, pesticides; PFAS, per- and polyfluoroalkyl substances]

Parameter name	Reporting limit	Units of measurement	Alluvial aquifer (n=10 sites)			Mount Simon aquifer (site 001, n=7 samples)
			25th percentile	Median	75th percentile	Median
Temperature	—	°C	13.6	16.2	17.5	18.6
Specific conductance	—	µS/cm at 25°C	428	486	663	512
pH	—	standard units	7.6	8	8	7.4
Alkalinity	<2	mg/L CaCO ₃	143	162	198	253
Bromide	<0.01	mg/L	nd	nd	nd	nd
Calcium	<0.1	mg/L	48	55.2	60.1	nd
Chloride	<0.1	mg/L	21.9	39.9	71.5	6.6

Table 1.5. Summary statistics for detected inorganic constituents and grouped organic concentration results (in units listed) for the ten spatially distributed samples collected from the shallow sand and gravel (alluvial) aquifer (median results used for sites 002 and 003), as well as the median concentration results from site 001, finished in the sandstone and dolomite of the Mount Simon aquifer, analyzed by the U.S. Geological Survey Redox Chemistry Laboratory and Analytical Trace Element Chemistry Laboratory in Boulder, Colorado, and the National Water Quality Laboratory in Denver, Colorado, for the French Island Tapwater Exposure Study, Campbell, Wisconsin, 2021–22.—Continued

[Antimony, arsenic, beryllium, cadmium, cobalt, molybdenum, selenium, and vanadium were not detected in any sample. Disinfection byproducts (DBP) were not detected in any sample. n, number of samples; °C, degrees Celsius; µS/cm, microsiemens per centimeter; µg/L, micrograms per liter; mg/L, milligrams per liter; —, not applicable; <, less than; nd, not detected above reporting limit; CaCO₃, calcium carbonate; PHARM, pharmaceuticals; VOC, volatile organic compounds; SVOC, semi-volatile organic compounds; PEST, pesticides; PFAS, per- and polyfluoroalkyl substances]

Parameter name	Reporting limit	Units of measurement	Alluvial aquifer (n=10 sites)			Mount Simon aquifer (site 001, n=7 samples)
			25th percentile	Median	75th percentile	Median
Fluoride	<0.01	mg/L	nd	0.06	0.078	0.05
Magnesium	<0.01	mg/L	14.9	16.8	18.4	0.03
Nitrate, Nitrogen	<0.01	mg/L	0.318	2.83	4.38	nd
Potassium	<0.08	mg/L	1.14	1.28	1.36	0.08
Silica	<0.05	mg/L	17.7	21	22.4	13.5
Sodium	<0.05	mg/L	11.2	17.8	32.7	127
Sulfate	<0.1	mg/L	12.6	16.4	20.2	17.6
Aluminum	<2	µg/L	5	5.5	6	2
Barium	<0.5	µg/L	39.5	54.5	70.5	nd
Boron	<5	µg/L	17.5	22	27.2	15
Chromium	<0.2	µg/L	nd	nd	0.5	nd
Copper	<2	µg/L	5	9.5	54	44
Hexavalent chromium	<0.2	µg/L	nd	nd	0.425	nd
Iron	<2	µg/L	9.25	37	100	nd
Lead	<0.5	µg/L	nd	1.2	2.78	nd
Lithium	<0.5	µg/L	nd	nd	2	nd
Manganese	<1	µg/L	3.25	22.5	70.2	nd
Nickel	<4	µg/L	nd	nd	nd	nd
Phosphorus	<50	µg/L	nd	nd	nd	nd
Strontium	<0.5	µg/L	67.2	86.5	104	nd
Uranium	<0.0002	µg/L	0.16	0.255	0.562	0.002
Zinc	<1	µg/L	86.2	176	645	55
Organic compound group summaries						
Total organic detections	—	count	5.25	12	18.5	1
Sum of organic concentrations	—	µg/L	0.246	0.448	0.986	0.024
Total detections PHARMS	—	count	0	0	0	0
Sum of concentrations PHARMS	—	µg/L	nd	nd	nd	nd
Total detections VOC	—	count	1.25	2.5	3	0
Sum of concentrations VOC	—	µg/L	0.023	0.12	0.2	nd
Total detections SVOC	—	count	0	0.5	1	0
Sum of concentrations SVOC	—	µg/L	nd	0.005	0.07	nd
Total detections PEST	—	count	2	3	5.5	0
Sum of concentrations PEST	—	µg/L	0.053	0.109	0.184	nd
Total detections PFAS	—	count	0	2.5	4.75	1
Sum of concentrations PFAS	—	µg/L	nd	0.013	0.048	0.014

26 Occurrence of Mixed Organic and Inorganic Chemicals in Groundwater and Tapwater

Table 1.6. Summary information, total number of detections, sum of concentrations (in micrograms per liter) and medians for organic compounds, detected at least one time in any sample (by group), analyzed at the U.S. Geological Survey National Water Quality Laboratory for the French Island Tapwater Exposure Study, Campbell, Wisconsin, 2021.

[Disinfection byproducts (DBP) were not detected in any sample. First-flush; initial 6-plus hour overnight (stagnant first-flush) sample; post-flush, sample collected 30 minutes after the start of the initial sample collection; post-6h, sample collected 6 hours after the initial. yyyyymmdd, year month day; HHMM, hour minute; µg/L, micrograms per liter; PHARM, pharmaceuticals; VOC, volatile organic compounds; SVOC, semi-volatile organic compounds; PEST, pesticides; PFAS, per- and polyfluoroalkyl substances; —, not applicable]

Site code	Sampling date (yyyyymmdd)	Sampling time (HHMM)	Sample type	Total detections (count)	Sum of concentrations (µg/L)	Total detections PEST (count)	Sum of concentrations PEST (µg/L)
Temporal							
Site 001	20211018	0800	first-flush	2	1.92	0	nd
Site 001	20211018	0830	post-flush	3	0.024	1	0.0005
Site 001	20211018	1440	post-6h	2	0.05	0	nd
Site 001	20211019	0730	first-flush	1	0.015	0	nd
Site 001	20211019	1500	post-6h	0	nd	0	nd
Site 001	20211020	0730	first-flush	0	nd	0	nd
Site 001	20211020	1450	post-6h	1	0.21	0	nd
Site 002	20211018	0900	first-flush	20	1.08	4	0.132
Site 002	20211018	0930	post-flush	18	1.03	2	0.036
Site 002	20211018	1500	post-6h	20	1.2	4	0.244
Site 002	20211019	0750	first-flush	17	0.931	2	0.029
Site 002	20211019	1520	post-6h	20	1.28	5	0.302
Site 002	20211020	0750	first-flush	16	1.06	2	0.032
Site 002	20211020	1500	post-6h	20	1.19	5	0.23
Site 003	20211018	1000	first-flush	12	2.46	2	0.064
Site 003	20211018	1030	post-flush	8	0.165	1	0.047
Site 003	20211018	1630	post-6h	11	0.333	3	0.049
Site 003	20211019	0820	first-flush	9	0.209	2	0.05
Site 003	20211019	1550	post-6h	10	0.232	3	0.056
Site 003	20211020	0820	first-flush	9	0.226	3	0.081
Site 003	20211020	1530	post-6h	9	0.215	2	0.018
Spatial							
Site 004	20211018	1100	—	17	0.554	6	0.187
Site 005	20211018	1140	—	11	0.304	2	0.086
Site 006	20211018	1220	—	20	2.53	2	0.012
Site 007	20211018	1250	—	19	0.696	10	0.447
Site 008	20211019	0900	—	13	1.26	12	1.26
Site 009	20211019	0940	—	4	0.06	4	0.06
Site 010	20211019	1020	—	4	0.342	1	0.009
Site 011	20211019	1050	—	2	0.196	1	0.176
Medians							
Site 001	—	—	—	1	0.024	0	nd
Site 002	—	—	—	20	1.08	4	0.132
Site 003	—	—	—	9	0.226	2	0.05
Spatial ¹	—	—	—	12	0.448	3	0.131
All sites ²	—	—	—	11	0.342	2	0.086
All samples ³	—	—	—	10	0.333	2	0.049

Table 1.6. Summary information, total number of detections, sum of concentrations (in micrograms per liter) and medians for organic compounds, detected at least one time in any sample (by group), analyzed at the U.S. Geological Survey National Water Quality Laboratory for the French Island Tapwater Exposure Study, Campbell, Wisconsin, 2021. —Continued

[Disinfection byproducts (DBP) were not detected in any sample. First-flush; initial 6+ hour overnight (stagnant first-flush) sample; post-flush, sample collected 30 minutes after the start of the initial sample collection; post-6h, sample collected 6 hours after the initial. yyymmdd, year month day; HHMM, hour minute; PHARM, pharmaceuticals; VOC, volatile organic compounds; SVOC, semi-volatile organic compounds; PEST, pesticides; PFAS, per- and polyfluoroalkyl substances]

Total detections PFAS (count)	Sum of concentrations PFAS (µg/L)	Total detections PHARM (count)	Sum of concentrations PHARM (µg/L)	Total detections SVOC (count)	Sum of concentrations SVOC (µg/L)	Total detections VOC (count)	Sum of concentrations VOC (µg/L)
Temporal							
1	0.025	0	nd	0	nd	1	1.9
1	0.019	1	0.005	0	nd	0	nd
1	0.014	1	0.036	0	nd	0	nd
1	0.015	0	nd	0	nd	0	nd
0	nd	0	nd	0	nd	0	nd
0	nd	0	nd	0	nd	0	nd
0	nd	0	nd	0	nd	1	0.21
14	0.609	0	nd	0	nd	2	0.342
14	0.607	0	nd	0	nd	2	0.388
14	0.575	0	nd	0	nd	2	0.377
12	0.527	1	0.005	0	nd	2	0.37
13	0.65	0	nd	0	nd	2	0.333
12	0.661	0	nd	0	nd	2	0.371
13	0.65	0	nd	0	nd	2	0.309
5	0.039	1	0.01	1	2.2	3	0.148
5	0.036	0	nd	0	nd	2	0.083
5	0.035	0	nd	0	nd	3	0.249
4	0.033	0	nd	0	nd	3	0.126
3	0.021	1	0.035	1	0.02	2	0.101
2	0.017	0	nd	1	0.01	3	0.119
4	0.025	0	nd	1	0.04	2	0.132
Spatial							
7	0.164	0	nd	1	0.09	3	0.113
5	0.053	0	nd	0	nd	4	0.166
0	nd	1	0.0002	6	0.63	11	1.88
4	0.023	1	0.004	1	0.01	3	0.212
1	0.002	0	nd	0	nd	0	nd
0	nd	0	nd	0	nd	0	nd
0	nd	0	nd	1	0.3	2	0.033
0	nd	0	nd	0	nd	1	0.02
Medians							
1	0.014	0	nd	0	nd	0	nd
13	0.609	0	nd	0	nd	2	0.37
4	0.033	0	nd	1	0.01	3	0.126
0.5	0.001	0	nd	0.5	0.005	2.5	0.073
1	0.014	0	nd	0	nd	2	0.113
4	0.025	0	nd	0	nd	2	0.132

¹Combined; n=8.

²Medians used for sites 001, 002, and 003; n=11.

³n=29.

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Table 1.7. Frequency of detection (in percent) and concentrations ranges (in micrograms per liter) for detected per- and polyfluoroalkyl substances (PFAS) collected at four sites (sampled 7 or 8 times each beginning in 2021) and analyzed by SGS AXYS, British Columbia, Northern Lake Service, Inc., Crandon, Wisconsin, and Wisconsin State Laboratory of Hygiene, Madison, Wisconsin, for the Upper Midwest Environmental Sciences Center study, Campbell, Wisconsin, 2021–22.

[See Romanok and others (2023b) for a full list of PFAS analyzed. n, number of samples; *, value not reported due to laboratory quality assurance issues, therefore n=7; nd, not detected above reporting limit; µg/L, micrograms per liter; —, not applicable]

Parameter name	Frequency of detection (percent)	Concentration ranges (µg/L, n=11)		
		Minimum	Median	Maximum
BG122 (n=8)				
Perfluoro-1-butanefulfonate (PFBS)	100	0.013	0.028	0.054
Perfluorobutyrate (PFBA)	100	0.03	0.08	0.088
Perfluoro-n-heptanoate (PFHpA)	100	0.004	0.012	0.021
Perfluoro-n-hexanoate (PFHxA)	100	0.021	0.042	0.088
Perfluoro-n-octanoate (PFOA)	100	0.019	0.033	0.045
Perfluoro-n-pentanoate (PFPeA)	100	0.018	0.033	0.1
Perfluoro-1-pentanesulfonate (PFPeS)	100	0.014	0.034	0.07
Perfluoro-1-heptanesulfonate (PFHpS)	100	0.003	0.009	0.018
Perfluoro-1-hexanesulfonate (PFHxS)	100*	0.131	0.281	0.564
Perfluorooctanesulfonate (PFOS)	100*	0.074	0.269	0.466
1H,1H,2H,2H-Perfluorohexane sulfonate (6:2 FTS)	75	nd	0.012	0.047
Perfluoro-n-nonanoate (PFNA)	50	nd	0.0002	0.003
1H,1H,2H,2H-Perfluorohexane sulfonate (8:2 FTSA)	37.5	nd	nd	0.003
Perfluoro-1-octanesulfonamide (FOSA)	12.5	nd	nd	0.0006
Perfluoro-n-decanoate (PFDA)	12.5	nd	nd	0.0004
Sum of PFAS	—	0.189	0.676	1.5
Total number of PFAS detections	—	10	11.5	15
BG123 (n=8)				
Perfluoro-1-butanefulfonate (PFBS)	100	0.011	0.02	0.04
Perfluorobutyrate (PFBA)	100	0.033	0.054	0.068
Perfluoro-n-heptanoate (PFHpA)	100	0.005	0.01	0.026
Perfluoro-n-hexanoate (PFHxA)	100	0.015	0.032	0.051
Perfluoro-n-octanoate (PFOA)	100	0.011	0.03	0.044
Perfluoro-n-pentanoate (PFPeA)	100	0.015	0.028	0.053
Perfluoro-1-pentanesulfonate (PFPeS)	100	0.013	0.022	0.045
Perfluoro-1-heptanesulfonate (PFHpS)	87.5	nd	0.005	0.012
Perfluoro-1-hexanesulfonate (PFHxS)	100*	0.059	0.153	0.306
Perfluorooctanesulfonate (PFOS)	100*	0.061	0.153	0.36
1H,1H,2H,2H-Perfluorohexane sulfonate (6:2 FTS)	87.5	nd	0.006	0.033
Perfluoro-n-nonanoate (PFNA)	50	nd	0.0002	0.004
1H,1H,2H,2H-Perfluorohexane sulfonate (8:2 FTSA)	0	nd	nd	nd
Perfluoro-1-octanesulfonamide (FOSA)	12.5	nd	nd	0.0004
Perfluoro-n-decanoate (PFDA)	0	nd	nd	nd
Sum of PFAS	—	0.18	0.495	0.878
Total number of PFAS detections	—	10	11	13
BG124 (n=7)				
Perfluoro-1-butanefulfonate (PFBS)	100	0.008	0.012	0.025
Perfluorobutyrate (PFBA)	100	0.02	0.028	0.078

Table 1.7. Frequency of detection (in percent) and concentrations ranges (in micrograms per liter) for detected per- and polyfluoroalkyl substances (PFAS) collected at four sites (sampled 7 or 8 times each beginning in 2021) and analyzed by SGS AXYS, British Columbia, Northern Lake Service, Inc., Crandon, Wisconsin, and Wisconsin State Laboratory of Hygiene, Madison, Wisconsin, for the Upper Midwest Environmental Sciences Center study, Campbell, Wisconsin, 2021–22.—Continued

[See Romanok and others (2023b) for a full list of PFAS analyzed. n, number of samples; *, value not reported due to laboratory quality assurance issues, therefore n=7; nd, not detected above reporting limit; µg/L, micrograms per liter; —, not applicable]

Parameter name	Frequency of detection (percent)	Concentration ranges (µg/L, n=11)		
		Minimum	Median	Maximum
BG124 (n=7)—Continued				
Perfluoro-n-heptanoate (PFHpA)	100	0.009	0.011	0.02
Perfluoro-n-hexanoate (PFHxA)	100	0.024	0.033	0.046
Perfluoro-n-octanoate (PFOA)	100	0.018	0.034	0.047
Perfluoro-n-pentanoate (PFPeA)	100	0.022	0.03	0.043
Perfluoro-1-pentanesulfonate (PFPeS)	100	0.007	0.009	0.032
Perfluoro-1-heptanesulfonate (PFHpS)	100	0.001	0.002	0.007
Perfluoro-1-hexanesulfonate (PFHxS)	100	0.043	0.047	0.155
Perfluorooctanesulfonate (PFOS)	100	0.056	0.067	0.199
1H,1H,2H,2H-Perfluorohexane sulfonate (6:2 FTS)	85.7	nd	0.011	0.015
Perfluoro-n-nonanoate (PFNA)	57.1	nd	0.0005	0.002
1H,1H,2H,2H-Perfluorohexane sulfonate (8:2 FTSA)	14.3	nd	nd	0.0008
Perfluoro-1-octanesulfonamide (FOSA)	0	nd	nd	nd
Perfluoro-n-decanoate (PFDA)	0	nd	nd	nd
Sum of PFAS	—	0.24	0.276	0.607
Total number of PFAS detections	—	12	12	13
WR972 (n=8)				
Perfluoro-1-butanefulfonate (PFBS)	12.5	nd	nd	0.0006
Perfluorobutyrate (PFBA)	0	nd	nd	nd
Perfluoro-n-heptanoate (PFHpA)	0	nd	nd	nd
Perfluoro-n-hexanoate (PFHxA)	0	nd	nd	nd
Perfluoro-n-octanoate (PFOA)	0	nd	nd	nd
Perfluoro-n-pentanoate (PFPeA)	0	nd	nd	nd
Perfluoro-1-pentanesulfonate (PFPeS)	0	nd	nd	nd
Perfluoro-1-heptanesulfonate (PFHpS)	0	nd	nd	nd
Perfluoro-1-hexanesulfonate (PFHxS)	0	nd	nd	nd
Perfluorooctanesulfonate (PFOS)	0	nd	nd	nd
1H,1H,2H,2H-Perfluorohexane sulfonate (6:2 FTS)	0	nd	nd	nd
Perfluoro-n-nonanoate (PFNA)	0	nd	nd	nd
1H,1H,2H,2H-Perfluorohexane sulfonate (8:2 FTSA)	0	nd	nd	nd
Perfluoro-1-octanesulfonamide (FOSA)	12.5	nd	nd	0.0005
Perfluoro-n-decanoate (PFDA)	0	nd	nd	nd
Sum of PFAS	—	nd	nd	0.0006
Total number of PFAS detections	—	0	0	1

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