

National Water-Quality Assessment Program

Total Mercury, Methylmercury, and Ancillary Water-Quality and Streamflow Data for Selected Streams in Oregon, Wisconsin, and Florida, 2002–06

Data Series 341

Cover: Saint Marys River near MacClenny, Florida, November 17, 2003 (photograph by D.A. Wentz, U.S. Geological Survey).

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By Mark E. Brigham, Joseph W. Duris, Dennis A. Wentz, Daniel T. Button, and
Lia C. Chasar

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

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Foreword

The U.S. Geological Survey (USGS) is committed to providing the Nation with credible scientific information that helps to enhance and protect the overall quality of life and that facilitates effective management of water, biological, energy, and mineral resources (<http://www.usgs.gov/>). Information on the Nation's water resources is critical to ensuring long-term availability of water that is safe for drinking and recreation and is suitable for industry, irrigation, and fish and wildlife. Population growth and increasing demands for water make the availability of that water, now measured in terms of quantity and quality, even more essential to the long-term sustainability of our communities and ecosystems.

The USGS implemented the National Water-Quality Assessment (NAWQA) Program in 1991 to support national, regional, State, and local information needs and decisions related to water-quality management and policy (<http://water.usgs.gov/nawqa>). The NAWQA Program is designed to answer: What is the condition of our Nation's streams and ground water? How are conditions changing over time? How do natural features and human activities affect the quality of streams and ground water, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues and priorities. From 1991–2001, the NAWQA Program completed interdisciplinary assessments and established a baseline understanding of water-quality conditions in 51 of the Nation's river basins and aquifers, referred to as Study Units (<http://water.usgs.gov/nawqa/studyu.html>).

Multiple national and regional assessments are ongoing in the second decade (2001–2012) of the NAWQA Program as 42 of the 51 Study Units are reassessed. These assessments extend the findings in the Study Units by determining status and trends at sites that have been consistently monitored for more than a decade, and filling critical gaps in characterizing the quality of surface water and ground water. For example, increased emphasis has been placed on assessing the quality of source water and finished water associated with many of the Nation's largest community water systems. During the second decade, NAWQA is addressing five national priority topics that build an understanding of how natural features and human activities affect water quality, and establish links between sources of contaminants, the transport of those contaminants through the hydrologic system, and the potential effects of contaminants on humans and aquatic ecosystems. Included are topics on the fate of agricultural chemicals, effects of urbanization on stream ecosystems, bioaccumulation of mercury in stream ecosystems, effects of nutrient enrichment on aquatic ecosystems, and transport of contaminants to public-supply wells. These topical studies are conducted in those Study Units most affected by these issues; they comprise a set of multi-Study-Unit designs for systematic national assessment. In addition, national syntheses of information on pesticides, volatile organic compounds (VOCs), nutrients, selected trace elements, and aquatic ecology are continuing.

The USGS aims to disseminate credible, timely, and relevant science information to address practical and effective water-resource management and strategies that protect and restore water quality. We hope this NAWQA publication will provide you with insights and information to meet your needs, and will foster increased citizen awareness and involvement in the protection and restoration of our Nation's waters.

The USGS recognizes that a national assessment by a single program cannot address all water-resource issues of interest. External coordination at all levels is critical for cost-effective management, regulation, and conservation of our Nation's water resources. The NAWQA Program, therefore, depends on advice and information from other agencies—Federal, State, regional, interstate, Tribal, and local—as well as nongovernmental organizations, industry, academia, and other stakeholder groups. Your assistance and suggestions are greatly appreciated.

Matthew C. Larsen
Associate Director for Water

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Conversion Factors

Multiply	By	To obtain
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
foot (ft)	0.3048	meter (m)
liter (L)	33.82	ounce, fluid (fl. oz)
liter (L)	2.113	pint (pt)
liter (L)	1.057	quart (qt)
liter (L)	0.2642	gallon (gal)
liter (L)	61.02	cubic inch (in ³)
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)
gram (g)	0.03527	ounce, avoirdupois (oz)
micrometer (µm)	3.937 x 10 ⁻⁵	inch
nanometer (nm)	3.937 x 10 ⁻⁸	inch
milligram per liter	1	part per million (ppm)
milliliter (mL)	0.0338	ounce, liquid (US)
nanogram per gram (ng/g)	1	part per billion (ppb)
nanogram per liter (ng/L)	1	part per trillion (ppt)

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

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

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

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L), micrograms per liter (µg/L), or nanograms per liter (ng/L).

Abbreviations and Acronyms

CVAFS	cold vapor atomic fluorescence spectrometry
DOC	dissolved organic carbon
FMeHg	methylmercury in filtered water
FTHg	total mercury in filtered water
HPI	hydrophilic acids
HPOA	hydrophobic acids
MDL	method detection limit
NADP	National Atmospheric Deposition Program
NWIS	National Water Information System
NWQL	National Water Quality Laboratory
PETG	polyethylene terephthalate copolyester, glycol-modified
PMeHg	methylmercury in suspended particulate matter
PTHg	total mercury in suspended particulate matter
RPD	relative percent difference
RSD	relative standard deviation
SD	standard deviation
SUVA	specific ultraviolet absorbance
TPIA	transphilic acids
USGS	U.S. Geological Survey

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By Mark E. Brigham, Joseph W. Duris, Dennis A. Wentz, Daniel T. Button, and Lia C. Chasar

Abstract

Field and analytical methods, mercury and ancillary water-quality data, and associated quality-control data are reported for eight streams in Oregon, Wisconsin, and Florida from 2002 to 2006. The streams were sampled as part of a U.S. Geological Survey National Water-Quality Assessment Program study of mercury cycling, transport, and bioaccumulation in urban and nonurban stream ecosystems that receive mercury predominantly by way of atmospheric deposition.

Introduction

To better understand mercury in stream ecosystems, the U.S. Geological Survey (USGS) National Water-Quality Assessment Program studied mercury in precipitation, stream water, streambed sediment and pore water, and selected biota in stream basins across the United States that receive mercury predominantly by way of atmospheric deposition (Brigham and others, 2003). Eight streams in Oregon, Wisconsin, and Florida were sampled during 2002–06 as part of this study.

Purpose and Scope

This report summarizes field and analytical methods and quality-control data, and provides mercury and ancillary water-quality data in an electronic format for eight streams in Oregon, Wisconsin, and Florida. The streams were sampled from 2002 to 2006 as part of a USGS study to better understand mercury cycling, transport, and bioaccumulation in urban and nonurban stream ecosystems that receive mercury primarily from atmospheric deposition.

Water-quality data presented in this report include total mercury and methylmercury in stream water; dissolved organic carbon (DOC), specific fractions of DOC,

and specific ultraviolet absorbance (SUVA) of DOC; major ions; suspended sediment; nutrients, including total nitrogen, ammonia plus organic nitrogen, particulate nitrogen, ammonia, nitrite, nitrite plus nitrate, and orthophosphate; and other water-quality parameters, including field measurements of water temperature, pH, specific conductance, and dissolved oxygen. This report provides only water-quality data for samples collected as part of the USGS mercury cycling study. Some streams were sampled for other purposes during the period of study; however, those data are not included in this report. The report also provides streamflow data for the study period.

Acknowledgments

We thank the Oregon Water Resources Department for streamflow data for Beaverton Creek, Oregon; the Menominee Indian Tribe of Wisconsin for access and logistical support for the Evergreen River, Wisconsin; and the St. Johns River Water Management District for streamflow data for the Little Wekiva River, Florida. This study also benefited from analyses of particulate forms of mercury, supported by the Toxic Substances Hydrology Program of the USGS.

Study Sites and Environmental Setting

Study sites were selected to represent a broad range of environmental settings. Stream sampling sites were selected across a range of mercury wet deposition rates (as reported by the National Atmospheric Deposition Program (NADP)/Mercury Deposition Network, <http://nadp.sws.uiuc.edu/mdn/>). The stream basins included both urban settings and nonurban settings that consisted mostly of forested or other noncultivated areas. Two sites were selected in Oregon, and three sites were selected in Wisconsin and Florida (fig. 1; table 1). A more thorough explanation of the study sites and basin settings can be found in Bell and Lutz (in press).

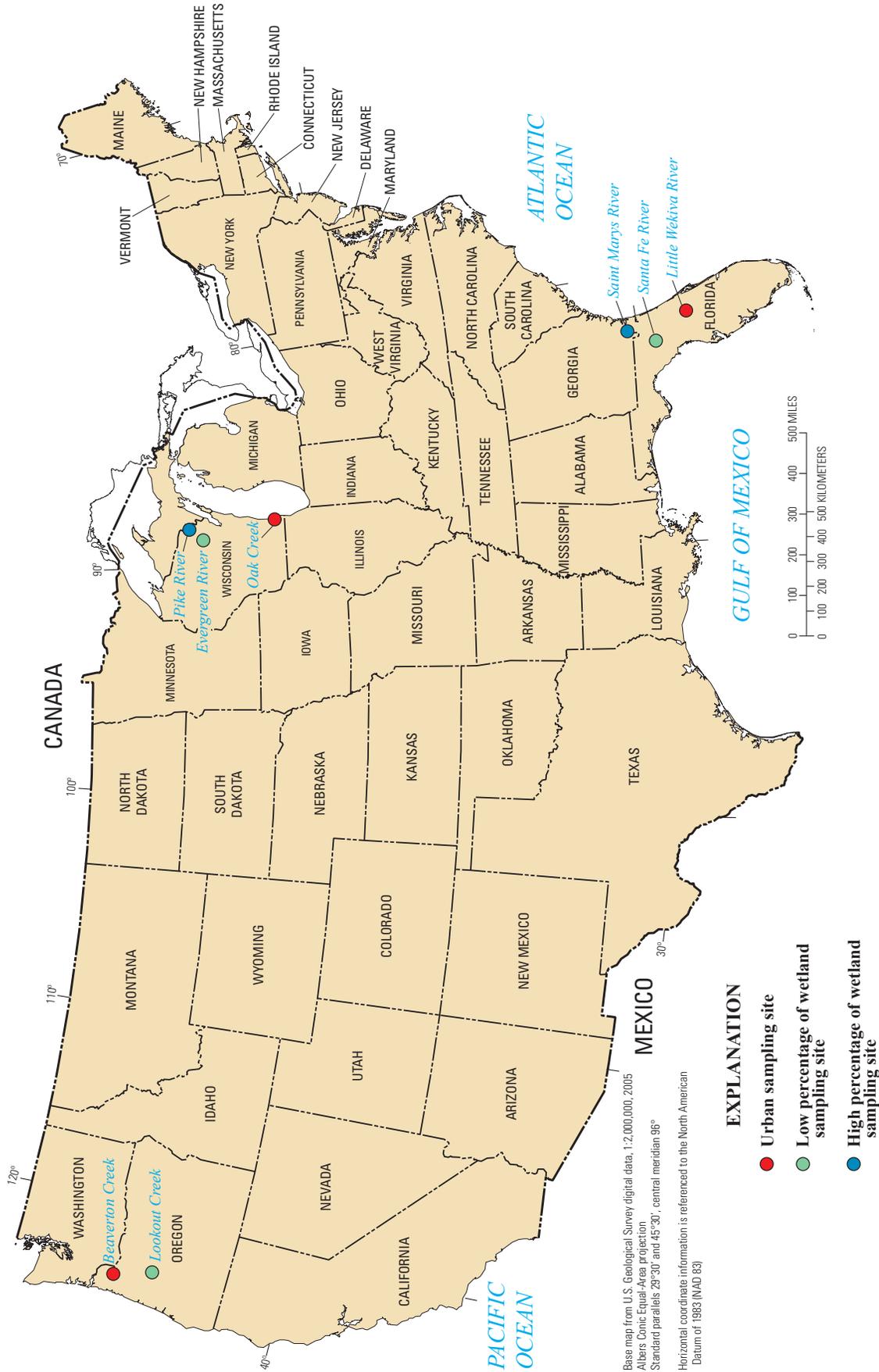


Figure 1. Location of sites sampled for the U.S. Geological Survey mercury study.

Table 1. Selected information for study sites sampled for U.S. Geological Survey mercury study, 2002–06.

[USGS, U.S. Geological Survey. Site latitude (north) and longitude (west) as recorded in USGS National Water Information System database, relative to North American Datum of 1927 (NAD27)]

Stream site	Short site name	USGS site identification number	Latitude	Longitude
Lookout Creek near Blue River, Oregon	Lookout Creek, OR	14161500	44°12'35"	122°15'20"
Beaverton Creek near Orenco, Oregon	Beaverton Creek, OR	14206435	45°31'15"	122°53'54"
Pike River at Amberg, Wisconsin	Pike River, WI	04066500	45°30'00"	88°00'00"
Evergreen River below Evergreen Falls, Wisconsin	Evergreen River, WI	04075365	45°03'57"	88°40'34"
Oak Creek at South Milwaukee, Wisconsin	Oak Creek, WI	04087204	42°55'30"	87°52'12"
St. Marys near MacClenny, Florida	St. Marys River, FL	02231000	30°21'31"	82°04'54"
Santa Fe River at Fort White, Florida	Santa Fe River, FL	02322500	29°50'55"	82°42'55"
Little Wekiva River near Longwood, Florida	Little Wekiva River, FL	02234998	28°42'07"	81°23'32"

Sample Collection, Processing, Analytical Methods, and Quality-Assurance Summary

Samples and streamflow data for this study were collected from 2002 to 2006. An intensive sampling period, during which each site was sampled approximately 12 to 18 times per year, was conducted from October 2002 through September 2004. Most sites were sampled once before this 2-year period, and several of the sites also were sampled after September 2004.

Sample Collection

Wadeable, well-mixed streams typically were sampled by dipping 2-liter (L) media bottles (Nalgene polyethylene terephthalate copolyester, glycol-modified [PETG]) into the approximate centroid of flow or into multiple points along a stream cross section. A new, factory-sealed PETG media bottle was used for each sample. Larger streams were sampled from the bow of a boat moving slowly upstream by dipping a media bottle below the stream surface near the center of the stream.

In some cases, particularly small streams at high flow, sampling was conducted from bridges using a depth-integrating sampler fitted with a 3-liter (L) Teflon® bottle and Teflon® nozzle to regulate the fill rate of the bottle (Wilde and others, 2004). Teflon® bottles and nozzles were cleaned in a 65 degree Celsius (°C) acid bath, rinsed with deionized water, and double bagged in zip-seal bags in a clean laboratory before each use.

Field crews were trained in clean-sampling techniques similar to EPA method 1631 (U.S. Environmental Protection Agency, 2002a; Wilde and others, 2006). Sampling personnel wore clean, disposable, shoulder-length polyethylene gloves and wrist-length nitrile gloves during sample collection and

processing, and took care to fill sample bottles upstream and upwind from potential sources of contamination, such as waders or boats. Sampling for major ions, nutrients, and suspended sediment was done according to Wilde and others (2006).

Sample Processing

Water was filtered and preserved in a field laboratory or in a dedicated water-quality sample processing vehicle. Filtered total mercury (FTHg) and methylmercury (FMeHg) were determined from samples that were vacuum-filtered through a 147-millimeter diameter, 0.7-micrometer nominal pore size, prebaked (550°C) quartz-fiber filter; acidified to approximately 1 percent hydrochloric acid in the field; and stored in the dark until analysis (Lewis and Brigham, 2004). This filtered fraction includes truly dissolved mercury, as well as filter-passing colloidal forms of mercury. Particulate total mercury (PTHg) and methylmercury (PMeHg) were determined from the aforementioned quartz fiber filters, which were placed on dry ice immediately after filtration and were stored frozen until analysis (Lewis and Brigham, 2004). DOC samples were pressure-filtered with baked glass fiber filters into 40-milliliter (mL) amber glass vials (for DOC concentration) and three 1-L amber glass bottles (for carbon fractionation); samples were chilled and stored at 4°C until analysis (Wilde and others, 2004).

Analytical Methods

Mercury analyses were conducted at the USGS Wisconsin Mercury Research Laboratory in Middleton, Wisconsin. DOC analyses were conducted at the National Research Program, Organic Carbon Transformation Laboratory in Boulder, Colorado. Major ions, nutrients, laboratory-measured alkalinity, and laboratory-measured specific conductance were analyzed at the USGS National Water Quality Laboratory

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in Lakewood, Colorado. Suspended sediment concentrations were measured at various regional USGS sediment laboratories. Analytical methods are summarized in the following sections.

Filtered Total Mercury

For analysis of FTHg, filtered water was treated with ultraviolet light, then treated with bromine monochloride (a strong oxidant) and heat, to oxidize all mercury in the sample. Excess bromine monochloride was reduced with hydroxylamine hydrochloride, and mercury subsequently was determined by stannous chloride reduction and cold vapor atomic fluorescence spectrometry (CVAFS) using a Model 2500 CVAFS Mercury Detector from Tekran (Toronto, Ontario) (Olson and DeWild, 1999; U.S. Environmental Protection Agency, 2002a).

Filtered Methylmercury

For analysis of FMeHg, filtered water was treated with copper sulfate and distilled to remove potential matrix interferences. Methylmercury was determined using the standard method of ethylation, gas chromatographic separation, pyrolysis, and CVAFS (DeWild and others, 2002; Horvat and others, 1993).

Particulate Total Mercury

For analysis of PHg, quartz fiber filters were digested in a Teflon® digestion chamber with aqua regia. Samples were then treated with bromine monochloride, then analyzed using a method similar to that for FTHg (Olund and others, 2004).

Particulate Methylmercury

For analysis of PMeHg, quartz fiber filters were treated with potassium bromide, copper sulfate, and methylene chloride, then mixed, allowed to react, and centrifuged. An aliquot of reacted methylene chloride was transferred to water, and the methylene chloride was allowed to evaporate. The sample was then treated similarly to water samples (DeWild and others, 2004). Concentrations of particulate forms of mercury are expressed as mass of mercury per volume of water.

Dissolved Organic Carbon

DOC concentrations were determined by using the platinum catalyzed persulfate wet oxidation method (Aiken, 1992). Measurements were made using an O.I. Analytical (O.I. Corporation, College Station, Texas) Model 700 TOC Analyzer™.

Dissolved Organic Carbon Fractionation

DOC was separated into five fractions: hydrophobic acids (HPOA), hydrophobic neutrals (not reported), transphilic neutrals (not reported), low molecular weight hydrophilic acids (HPI), and transphilic acids (TPIA). Carbon fractions were determined using a modified version of the nonionic macroporous resin (Amberlite™ XAD-8/XAD-4; Rohm and Haas Company) extraction methods used to isolate organic matter from water samples (Aiken and others, 1992).

Specific Ultraviolet Absorbance

SUVA was determined by measuring the UV absorbance at 254 nanometers (nm) and dividing by the total DOC concentration (Weishaar and others, 2003). SUVA serves as a measure of the quality of the DOC by providing an indicator of the degree of aromaticity.

Routine Water-Quality Measurements

Alkalinity, major ions, and nutrients were analyzed by standard USGS procedures at the National Water Quality Laboratory. Alkalinity, chloride, sulfate, and laboratory-measured specific conductance were determined using methods of Fishman and Friedman (1989). Calcium, magnesium, sodium, iron, and all nitrogen and phosphorus nutrient species were determined using methods of Fishman (1993). Potassium concentrations were determined using methods of the American Public Health Association (1998). Suspended sediment concentrations and (for a limited number of samples) percentages of suspended sediment finer than 63 microns were determined at regional USGS sediment laboratories using methods of Guy and Norman (1970). Field-measured alkalinity, pH, dissolved oxygen, specific conductance, and temperature were measured using methods of Wilde (2006).

Quality-Control Summary

Replicate and blank field quality-control samples routinely were collected for most analytes. These samples allowed for an assessment of bias and variability in environmental data that could occur because of sampling methods, preservation techniques, shipping and transportation, and analysis. Over the course of the study, the number of field-submitted quality-control samples (blank and replicate samples) equaled approximately 20 percent of the number of environmental samples. Blank and replicate sample data were aggregated for each constituent before analysis or summary, and data were summarized using a strategy similar to that of Apodaca and others (2006).

Blank Samples

Potential for sample contamination during sampling and analysis was assessed through field-submitted blank samples, which consisted of inorganic- or organic-free water that was passed through all equipment used for collection, processing, shipping, and analyzing stream water samples.

In 11 of 18 blank samples for FTHg, reported concentrations were less than or equal to 0.20 nanogram per liter (ng/L) (mean = 0.11, standard deviation = 0.048). FTHg concentrations in the remaining seven blank samples ranged from 0.25 to 0.77 ng/L (mean = 0.46, standard deviation = 0.17); these higher blank values were collected from December 2003 through April 2004 and were observed at six of the eight streams. A specific cause of the higher FTHg blanks during December 2003 to April 2004 could not be ascertained. Mercury concentrations in laboratory blank water samples during this time were all less than 0.05 ng/L (John DeWild, U.S. Geological Survey, oral commun., 2007); thus, the blank source-water likely was not the source of contamination.

Nearly all PTHg concentrations in blank samples were not detectable; one detected value of 0.20 ng/L was reported. All concentrations of FMeHg, PMeHg, and suspended sediment in blank samples were less than method detection limits (MDLs). The MDL is the minimum concentration of a substance that can be measured and reported with 99-percent confidence that the analyte concentration is greater than zero. It is determined from the analysis of a sample in a given matrix containing the analyte (U.S. Environmental Protection Agency, 2002b). DOC usually was detected in blank samples, but at low concentrations (0.1–0.4 milligram per liter).

The blank data were summarized into a minimum, maximum, and 90th percentile concentrations for select constituents. All blank sample concentrations, including non-detections, were used in the analysis of aggregated blank data. The 90th percentile value and the maximum value for the aggregated blank sets for each analyte were compared to the environmental data set, and a percentage of environmental samples that were less than the 90th percentile and maximum values was calculated (table 2). In addition, the entire blank sample data set is presented in Appendix 1.

Replicate Samples

Precision of the overall sample collection, processing, and analysis process was evaluated by analyzing replicate samples. Replicate samples were obtained by collecting two or more samples simultaneously or in sequence, resulting in samples that should be nearly identical. Replicate data were analyzed by aggregating replicate sets for selected analytes into groups. The range and mean relative standard deviation (Apodaca and others, 2006) were then calculated for each group. Because replicate variability can be determined only when concentrations of both members of a replicate set are greater than the method detection limit, replicate sets containing nondetected values were omitted from the analysis.

Replicate data were summarized for sulfate, DOC, HPOA, ultraviolet absorbance at 254 nm (UVABS), FMeHg, FTHg, PMeHg, PTHg, suspended sediment, and pH (table 3). In addition, the entire replicate data set is also available (Appendix 2).

The mean relative percent difference (RPD) also was calculated for all analytes at or above five times the MDL. FMeHg and FTHg replicate values that exceeded five times the MDL had mean RPDs of 2.2 and 11.3 percent, respectively. PMeHg and PTHg replicate values that exceeded five times the MDL had mean RPDs of 12.4 and 13.8 percent, respectively. Sulfate, DOC, and suspended sediment values that exceeded five times the MDL had mean RPDs of 0.8, 10.6, and 3.1 percent, respectively.

Total Mercury, Methylmercury, and Ancillary Water-Quality Data

Total mercury, methylmercury, and ancillary water-quality data are presented in electronic format in Appendix 3. The data tables for Appendix 3 are available for download in two file formats: Microsoft Excel (.xls) and comma-separated values (.csv) text files. The Excel file is formatted to properly display the data. Users that use software that reads Excel files are encouraged to download the Excel version of the data table. For users that cannot read Excel files, the .csv file also is provided.

Streamflow Data

Streamflow data for six of the eight sites were collected by the USGS using standard stream-gaging procedures (Rantz and others, 1982). Streamflow for Beaverton Creek, Oregon, was measured by the Oregon Water Resources Department using standard USGS procedures. During 2002–03, several high streamflow data at this site were missing because they were beyond the range of the stage-streamflow rating curve for this site. These missing data were estimated by regressing available daily mean streamflow at Beaverton Creek against daily mean streamflow measured by the USGS at Fanno Creek at Durham (an adjacent basin with similar drainage basin size and land use/land cover; USGS station number 14206950) by water year, and using the regressions to estimate missing Beaverton Creek data (this method generates unbiased streamflow estimates, but with lower variance than other methods; Hirsch, 1982). Daily mean streamflows at these two sites were strongly correlated ($r^2=0.862\text{--}0.931$). Streamflow data for the Little Wekiva River, Florida, were collected by St. Johns River Water Management District using standard USGS procedures.

Streamflow data for each stream are presented in Appendixes 4–11. The data tables for Appendixes 4–11 are available for download in two file formats: Microsoft Excel (.xls) and comma-separated values (.csv) text files. The Excel files are

Table 2. Summary of field-submitted blank sample data.

[MDL, method detection limit; mg/L, milligram per liter; USGS, U.S. Geological Survey; NWQL, National Water Quality Laboratory; <, less than; n/a, not applicable; UV, ultraviolet; L*mg C⁻¹*m⁻¹, liter per milligram carbon per meter; NRP, National Research Program; OCTL, Organic Carbon Transformation Laboratory; ng/L, nanogram per liter; nm, nanometers; WMRL, Wisconsin Mercury Research Laboratory]

Analyte	Abbreviation	Unit	Laboratory	MDL	Num-ber of samples	Number of concen-trations greater than MDL	Concentrations			Percent of environmen-tal samples exceeded by maximum concentra-tion	
							Mini-mum	90th percentile	Maxi-mum		
Sulfate	SO4_WTR	mg/L	USGS NWQL	0.18	13	0	<0.18	n/a	<0.18	0	0
Dissolved organic carbon	DOC_WTR	mg/L	USGS NRP OCTL	.2	13	11	.1	0.4	.4	0	0
Specific UV absorbance	SUVA_WTR	L*mg C ⁻¹ *m ⁻¹	USGS NRP OCTL	variable	9	9	.2	1.1	1.7	0	.8
UV absorbance at 254 nm	UVABS_WTR	units/cm	USGS NRP OCTL	.001	12	12	E.0001	.005	.005	0	0
Filtered methylmercury	FMeHG_WTR	ng/L	USGS WMRL	.04	19	0	<.04	n/a	<.04	0	0
Filtered total mercury	FTHG_WTR	ng/L	USGS WMRL	.04	18	18	.06	.51	.77	27.6	43.2
Particulate methylmercury	PMeHG_SUS	ng/L	USGS WMRL	1.01	17	0	<.0084	n/a	<.0394	0	0
Particulate total mercury	PTHG_SUS	ng/L	USGS WMRL	1.059	18	3	<.052	.195	.712	16.0	53.9
Suspended sediment	TOT_SUS	mg/L	USGS Sediment	1	4	0	<1	n/a	<1	0	0

¹MDL is approximate, and depends on suspended particulate concentration.

Table 3. Summary of replicate sample quality-control data.

[MDL, method detection limit; RSD, relative standard deviation; mg/L, milligram per liter; NWQL, National Water Quality Laboratory; USGS, U.S. Geological Survey; WMRL, Wisconsin Mercury Research Laboratory; NRP, National Research Program; OCTL, Organic Carbon Transformations Laboratory; nm, nanometers; cm, centimeter; ng/L, nanogram per liter]

Analyte	Abbreviation	Units	Laboratory	Total number of replicate sets	Samples in each replicate set greater than MDL			Mean concentration of replicate sets	
					Number of replicate sets	Number of samples	Sample range	Mean percent RSD	
Sulfate	SO4_WTR	mg/L	USGS NWQL	15	15	30	0.26–135	0.01	
Dissolved organic carbon	DOC_WTR	mg/L	USGS NRP OCTL	17	17	40	0.9–42	3.41	
Hydrophobic organic acid fraction	HPOA_FRAC	percent	USGS NRP OCTL	16	16	32	40–69	3.13	
UV absorbance at 254 nm	UVABS_WTR	absorbance units per cm	USGS NRP OCTL	12	12	30	0.31–1.866	2.05	
Filtered methylmercury	FMeHG_WTR	ng/L	USGS WMRL	23	12	28	0.05–0.23	7.47	
Filtered total mercury	FTHG_WTR	ng/L	USGS WMRL	23	23	52	0.19–5.21	5.67	
Particulate methylmercury	PMeHG_SUS	ng/L	USGS WMRL	26	13	30	0.012–0.231	20.33	
Particulate total mercury	PTHG_SUS	ng/L	USGS WMRL	23	22	50	0.0916–11.8	13.75	
Suspended sediment	TOT_SUS	mg/L	USGS Sediment	13	12	30	1–247	21.62	
pH	PH_FLD_WTR	pH units	Field measurement	17	17	39	3.35–8.42	.27	

formatted to properly display the data. Users that use software that reads Excel files are encouraged to download the Excel versions of the data tables. For users that cannot read Excel files, the .csv files also are provided.

References Cited

- Aiken, G.R., 1992, Chloride interference in the analysis of dissolved organic carbon by the wet oxidation method: *Environmental Science and Technology*, v. 26, p. 2,435–2,439.
- Aiken, G.R., McKnight, D.M., Thorn, K.A., and Thurman, E.M., 1992, Isolation of hydrophilic organic acids from water using nonionic macroporous resins: *Organic Geochemistry*, v. 18, p. 567–573.
- American Public Health Association, 1998, Standard methods for the examination of water and wastewater (20th ed.): Washington, D.C., American Public Health Association, American Water Works Association, and Water Environment Federation, p. 3-37–3-43.
- Apodaca, L.E., Mueller, D.K., and Koterba, M.T., 2006, Review of trace element blank and replicate data collected in ground and surface water for the National Water-Quality Assessment Program, 1991–2002: U.S. Geological Survey Scientific Investigations Report 2006–5093, 32 p.
- Bell, A. H. and Lutz, M. A., in press, Environmental settings of selected streams sampled for mercury in Oregon, Wisconsin, and Florida, 2002–06, U.S. Geological Survey Open-File Report 2008–1277.
- Brigham, M.E., Krabbenhoft, D.P., and Hamilton, P.A., 2003, Mercury in stream ecosystems—New studies initiated by the U.S. Geological Survey: U.S. Geological Survey Fact Sheet 016–03, 4 p., accessed March 12, 2007, at: <http://pubs.usgs.gov/fs/fs-016-03/>.
- DeWild, J.F., Olson, M.L., and Olund, S.D., 2002, Determination of methyl mercury by aqueous phase ethylation, followed by gas chromatographic separation with cold vapor atomic fluorescence detection: U.S. Geological Survey Open-File Report 01–445, 14 p.
- DeWild, J.F., Olund, S.D., Olson, M.L., Tate, M.T., 2004, Methods for the preparation and analysis of solids and suspended solids for methylmercury: U.S. Geological Survey Techniques and Methods Report 5–A7, 21 p.
- Fishman, M.J., ed., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of inorganic and organic constituents in water and fluvial sediments: U.S. Geological Survey Open-File Report 93–125, 217 p.
- Fishman, M.J., and Friedman, L.C., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p.
- Guy, H.P., and Norman, V.W., 1970, Field methods for measurement of fluvial sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. C2, 59 p.
- Hirsch, R.M., 1982, A comparison of four streamflow record extension techniques: *Water Resources Research*, v. 18, p. 1,081–1,088.
- Horvat, M., Liang, L., and Bloom, N.S., 1993, Comparison of distillation with other current isolation methods for the determination of methyl mercury compounds in low level environmental samples—Part II. *Water: Analytica Chimica Acta*, v. 282, p. 153–168.
- Lewis, M.E. and Brigham, M.E., 2004, Processing of water samples—Low-level mercury: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A5.6.4.B, accessed March 12, 2007, at http://water.usgs.gov/owq/FieldManual/chapter5/pdf/5.6.4.B_v1.0.pdf
- Olson, M.L., and DeWild, J.F., 1999, Techniques for the collection and species-specific analysis of low levels of mercury in water, sediment, and biota: U.S. Geological Survey Water Resources Investigations Report 99–4018–B, 11 p.
- Olund, S.D., DeWild, J.F., Olson, M.L., Tate, M.T., 2004, Methods for the preparation and analysis of solids and suspended solids for total mercury: U.S. Geological Survey Techniques and Methods Report 5–A8, 23 p.
- Rantz, S.E., and others, 1982, Measurement and computation of streamflow—Volume 1. Measurement of stage and discharge and Volume 2. Computation of discharge: U.S. Geological Survey Water-Supply Paper 2175.
- U.S. Environmental Protection Agency, 2002a, Method 1631, Revision E, Hg in water by oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry: U.S. Environmental Protection Agency EPA 821/R–02–019, 38 p.
- U.S. Environmental Protection Agency, 2002b, Guidelines establishing test procedures for the analysis of pollutants (Part 136, Appendix B. Definition and procedure for the determination of the method detection limit—Revision 1.11): U.S. Code of Federal Regulations, Title 40, revised as of July 1, 2002, p. 635–638.
- Weishaar, J.L., Aiken, G.R., Bergamaschi, B.A., Fram, M.S., Fuji, R., and Mopper, K., 2003, Evaluation of specific ultraviolet absorbance as an indicator of the chemical composition and reactivity of dissolved organic carbon: *Environmental Science and Technology*, v. 37, p. 4,702–4,708.

8 Total Mercury, Methylmercury, and Water-Quality and Streamflow Data for Streams in Oregon, Wisconsin, and Florida

Wilde, F.D., ed., 2006, Field measurements: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6, accessed March 14, 2007, at <http://pubs.water.usgs.gov/twri9A6/>.

Wilde, F.D., Radtke, D.B., Gibs, Jacob, and Iwatsubo, R.T., eds., 2004, Processing of water samples (version 2.1): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A5, accessed March 13, 2007, at <http://pubs.water.usgs.gov/twri9A5/>.

Wilde, F.D., Radtke, D.B., Gibs, Jacob, and Iwatsubo, R.T., eds., September 2006, Collection of water samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A4, accessed March 12, 2007, at <http://pubs.water.usgs.gov/twri9A4/>.

Appendixes

Appendix 1. Blank-Sample Quality-Control Data

The Excel spreadsheet [Appendix01_FieldBlankData.xls](#) contains a worksheet (worksheet: Note) that describes the documentation and abbreviations used in Appendix 1. The spreadsheet also contains quality-control data for field-submitted blank water samples during 2002–06 (worksheet: Appendix01_BlankData).

For users that cannot read Excel files, a comma-delimited text file ([Appendix01_Note.csv](#)) is provided that describes the documentation and abbreviations used in Appendix 1. A comma-delimited file ([Appendix01_BlankData.csv](#)) is presented for quality-control data for field-submitted blank water samples during 2002–06.

Appendix 2. Replicate Sample Quality-Control Data

The Excel spreadsheet [Appendix02_ReplicateData.xls](#) contains a worksheet (worksheet: Note) that describes the documentation and abbreviations used in Appendix 2. The spreadsheet also contains quality-control data for field-submitted replicate water samples during 2002–06 (worksheet: Appendix02_ReplicateData).

For users that cannot read Excel files, a comma-delimited text file ([Appendix02_Note.csv](#)) is provided that describes the documentation and abbreviations used in Appendix 2. A comma-delimited file ([Appendix02_ReplicateData.csv](#)) is presented for quality-control data for field-submitted replicate water samples during 2002–06.

Appendix 3. Total Mercury, Methylmercury, and Ancillary Water-Quality Data, 2002–06

The Excel spreadsheet [Appendix03_StreamWaterChemistry.xls](#) contains a worksheet (worksheet: Note) that describes the documentation and abbreviations used in Appendix 3. The spreadsheet also contains total mercury, methylmercury, and ancillary water-quality data for stream samples collected during 2002–06 (worksheet: Appendix03_SWChemistry).

For users that cannot read Excel files, a comma-delimited text file ([Appendix03_Note.csv](#)) is provided that describes the documentation and abbreviations used in Appendix 3. A comma-delimited file ([Appendix03_SWChemistry.csv](#)) is presented for that contains the total mercury, methylmercury, and ancillary water-quality data for stream samples collected during 2002–06.

Appendix 4. Streamflow Data, Lookout Creek, Oregon, 2002–06

The Excel spreadsheet [Appendix04_LookoutCreekOregonFlow.xls](#) contains streamflow data during 2002–06 for Lookout Creek near Blue River, Oregon. For users that cannot read Excel files, a comma-delimited text file ([Appendix04_LookoutCreekOregonFlow.csv](#)) is provided that presents that same data as the Excel file.

Appendix 5. Streamflow Data, Beaverton Creek, Oregon, 2002–05

The Excel spreadsheet [Appendix05_BeavertonCreekOregonFlow.xls](#) contains streamflow data during 2002–05 for Beaverton Creek near Orenco, Oregon. For users that cannot read Excel files, a comma-delimited text file ([Appendix05_BeavertonCreekOregonFlow.csv](#)) is provided that presents that same data as the Excel file.

Appendix 6. Streamflow Data, Pike River, Wisconsin, 2002–06

The Excel spreadsheet [Appendix06_PikeRiverWisconsinFlow.xls](#) contains streamflow data during 2002–06 for Pike River at Amberg, Wisconsin. For users that cannot read Excel files, a comma-delimited text file ([Appendix06_PikeRiverWisconsinFlow.csv](#)) is provided that presents that same data as the Excel file.

Appendix 7. Streamflow Data, Evergreen River, Wisconsin, 2002–06

The Excel spreadsheet [Appendix07_EvergreenRiverWisconsinFlow.xls](#) contains streamflow data during 2002–06 for Evergreen River below Evergreen Falls, near Langlade, Wisconsin. For users that cannot read Excel files, a comma-delimited text file ([Appendix07_EvergreenRiverWisconsinFlow.csv](#)) is provided that presents that same data as the Excel file.

Appendix 8. Streamflow Data, Oak Creek, Wisconsin, 2002–06

The Excel spreadsheet [Appendix08_OakCreekWisconsinFlow.xls](#) contains streamflow data during 2002–06 for Oak Creek at South Milwaukee, Wisconsin. For users that cannot read Excel files, a comma-delimited text file ([Appendix08_OakCreekWisconsinFlow.csv](#)) is provided that presents that same data as the Excel file.

Appendix 9. Streamflow Data, St. Marys River, Florida, 2002–06

The Excel spreadsheet [Appendix09_StMarysRiverFloridaFlow.xls](#) contains streamflow data during 2002–06 for St. Marys River near Macclenny, Florida. For users that cannot read Excel files, a comma-delimited text file ([Appendix09_StMarysRiverFloridaFlow.csv](#)) is provided that presents that same data as the Excel file.

Appendix 10. Streamflow Data, Santa Fe River, Florida, 2002–06

The Excel spreadsheet [Appendix10_SantaFeRiverFloridaFlow.xls](#) contains streamflow data during 2002–06 for Santa Fe River near Fort White, Florida. For users that cannot read Excel files, a comma-delimited text file ([Appendix10_SantaFeRiverFloridaFlow.csv](#)) is provided that presents that same data as the Excel file.

Appendix 11. Streamflow Data, Little Wekiva River, Florida, 2002–06

The Excel spreadsheet [Appendix11_LittleWekivaRiverFloridaFlow.xls](#) contains streamflow data during 2002–06 for Little Wekiva River near Longwood, Florida. For users that cannot read Excel files, a comma-delimited text file ([Appendix11_LittleWekivaRiverFloridaFlow.csv](#)) is provided that presents that same data as the Excel file.

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