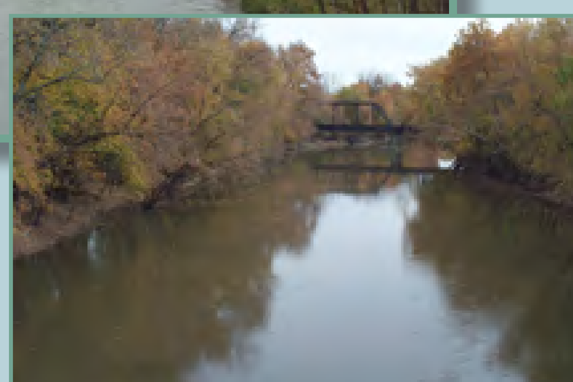
Prepared in cooperation with the Indiana Department of Environmental Management

Total Mercury and Methylmercury in Indiana Streams, August 2004–September 2006



Scientific Investigations Report 2008–5176

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

Upper left—East Fork Whitewater River at Brooksville, Indiana, USGS site 03276000. (Photogaph by Martin R. Risch, USGS)

Lower right—Maumee River at New Haven, Indiana, USGS site 04183000. (Photogaph by Amanda L. Ulberg, USGS)

Total Mercury and Methylmercury in Indiana Streams, August 2004–September 2006

By Amanda L. Ulberg and Martin R. Risch

In cooperation with the Indiana Department of Environmental Management

Scientific Investigations Report 2008–5176

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

U.S. Department of the Interior
DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia: 2008

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment, visit http://www.usgs.gov or call 1–888–ASK–USGS

For an overview of USGS information products, including maps, imagery, and publications, visit http://www.usgs.gov/pubprod

To order this and other USGS information products, visit http://store.usgs.gov

Suggested citation:
Ulberg, Amanda L., and Risch, Martin R., 2008, Total mercury and methylmercury in Indiana streams, August 2004–September 2006: U.S. Geological Survey Scientific Investigations Report 2008–5176, 76 p.

ISBN 978-1-4113-2290-5

Contents

Figures

Tables

Conversion Factors

Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
foot (ft)	.3048	meter (m)
mile (mi)	1.609	kilometer (km)
acre	4,047	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
foot per second (ft/s)	.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	.02832	cubic meter per second (m^3/s)
milliliter (mL)	.03382	ounce, fluid (fl.oz)
liter (L)	33.81	ounce, fluid (fl. oz)
gram (g)	.03527	ounce, avoirdupois (oz)

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

$$°F=(1.8\times°C)+32$$

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

$$°C=(°F-32)/1.8$$

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

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

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

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

A kilogram is 1,000 grams.
A milligram is 0.001 gram and 1,000 milligrams equal 1 gram.
A microgram is 0.001 milligram and 1,000 micrograms equal 1 milligram.
A nanogram is 0.001 microgram and 1,000 nanograms equal 1 microgram.

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

Turbidity is given in nephelometric turbidity ratio units (ntru).

Total Mercury and Methylmercury in Indiana Streams, August 2004–September 2006

By Amanda L. Ulberg and Martin R. Risch

Abstract

Total mercury and methylmercury were determined by use of low (subnanogram per liter) level analytical methods in 225 representative water samples collected following ultraclean protocols at 25 Indiana monitoring stations in a statewide network, on a seasonal schedule, August 2004–September 2006. The highest unfiltered total mercury concentrations were at six monitoring stations—five that are downstream from urban and industrial wastewater discharges and that have upstream drainage areas more than 1,960 square miles and one that is downstream from active and abandoned mine lands and that has an upstream drainage area of 602 square miles.

Total mercury concentrations in unfiltered samples ranged from 0.24 to 26.9 nanograms per liter (ng/L), with a median of 2.35 ng/L. The highest concentrations of total mercury, those in the 90th percentile and above, were more than 9.05 ng/L, and most were in samples collected during winter and spring 2006 during changing streamflow hydrograph conditions. Seasonal medians for unfiltered total mercury were highest during winter and spring. Instantaneous streamflow and turbidity at the time of sample collection also were highest in winter and spring and potentially indicate conditions for the most particulate mercury transport.

Samples with the highest total mercury concentrations were from water that had the highest turbidity at the time of sample collection. Unfiltered total mercury concentrations were significantly lower in samples collected at five stations downstream from dams. Values for particulate total mercury and streamflow also were significantly lower at these five stations.

Total mercury concentrations equaled or exceeded the 2007 Indiana chronic aquatic criterion of 12 ng/L in 5.8 percent of samples and at 10 monitoring stations. Most of the total mercury in these 13 samples was estimated to be particulate. Most of the samples with mercury concentrations that equaled or exceeded the 12 ng/L criterion were collected during winter and spring 2006 during changing streamflow hydrograph conditions and in streamflow that was high for 2004–2006.

Methylmercury was detected in 83 percent of unfiltered samples; reported concentrations ranged from 0.04 to 0.57 ng/L, with a median of 0.09 ng/L. The highest concentrations of methylmercury, those in the 90th percentile and above, were more than 0.25 ng/L, and most were in samples collected during spring and summer. Methylation efficiency in most samples was less than 5.8 percent, but was as much as 24.6 percent. Seasonal medians for methylmercury were highest during spring and summer. Seasonal medians for water temperatures at the time of sample collection were highest during these seasons and potentially indicate conditions for the most formation of methylmercury. The low streamflow statistical category had the significantly highest methylation efficiency.

Introduction

A monitoring program for mercury in Indiana streams was operated by the U.S. Geological Survey (USGS) in cooperation with the Indiana Department of Environmental Management (IDEM). The data from the monitoring program support assessments of the efficacy of mercury regulations and provide information for policymakers and resource managers who make decisions about mercury that could affect aquatic ecosystems in Indiana. Mercury concentrations measured through this monitoring program required subnanogram-per-liter level analytical techniques at a USGS laboratory designed for mercury research. In addition, specialized equipment and ultraclean protocols were used to obtain and process representative stream-water samples for the low-level mercury analysis.

Purpose and Scope

This report presents total mercury and methylmercury concentrations in 225 water samples collected from streams in Indiana at 25 stations in a statewide monitoring network, August 2004–September 2006. The report summarizes data from 88 quality-control samples and streamflow and water-quality characteristics at the time of sample collection. Methods of study are described. Mercury concentrations are compared with Indiana water-quality standards, selected water-quality characteristics, and streamflow. Mercury concentrations are displayed in maps, tables, and graphs, with regard to monitoring locations, upstream drainage areas, and seasons. Estimates of mercury loads and statistical evaluations of factors affecting mercury concentrations are outside the scope of this report.

Description of the Study Area

Indiana is 35,887 mi^2 in size, 38th in geographic area in the Nation. The State population estimate in 2006 was 6.3 million, 15th in the Nation; population density was 176 individuals per mi^2. Children represent one-fourth of the total Indiana population (Indiana Business Research Center, 2007)[1]. Indiana has 35,673 mi of rivers, 575 publicly owned lakes and reservoirs that total 106,205 acres, 813,000 acres of wetlands, and 59 mi of Lake Michigan shoreline (Indiana Department of Environmental Management, 2006).

The climate of Indiana is continental, influenced mainly by eastward-moving cold polar and warm gulf-air masses. The low-pressure centers formed by the interaction of these air masses are the major sources of precipitation in Indiana. Spring and early summer are normally the wettest periods of the year, as storm systems tap moisture from the Gulf of Mexico and travel across Indiana. Early fall is generally the driest period. Seasonal precipitation patterns vary statewide, particularly in the summer when isolated thunderstorms are common and during the winter when lake-effect snows fall in northern Indiana. Mean annual temperature in Indiana is approximately 52°F and ranges from 49.6°F in the north to more than 54.8°F in the south (Purdue Applied Meteorology Group, 2005).

The statewide mean annual precipitation is 42 in. and ranges from 37 in. for northern Indiana to nearly 47 in. for southern Indiana. Snowfall (as liquid) accounts for 2 to 7 in. of the mean annual precipitation, and the greatest amounts of snow fall in northern Indiana (Morlock and others, 2004; Purdue Applied Meteorology Group, 2005). According to Clark (1980), approximately 68 percent of the mean annual precipitation in Indiana returns to the atmosphere through evapotranspiration, 24 percent enters streams and lakes through surface runoff, and 8 percent recharges ground water. Generally, runoff is greatest in areas with steep slopes and relatively impermeable soils, which are characteristic of much of the southern one-third of Indiana.

Mercury in the Environment

Mercury is a metallic element that occurs in the environment from natural and anthropogenic sources. It poses risks as an environmental contaminant, and it has been linked to adverse health effects in humans and wildlife. Naturally occurring mercury is found as mercuric sulfide, or cinnabar, in rock and soil. Mercury can be released into the environment during volcanic eruptions and forest fires. Anthropogenic sources of mercury include emissions to the atmosphere from fossil fuel combustion, waste incineration, and industrial processes. Aquatic ecosystems receive mercury from atmospheric deposition (National Research Council, 2000) and through wastewater discharge, including discharge from household, medical, and dental sources (U.S. Environmental Protection Agency, 2008). The State of Indiana has designated mercury as a “bioaccumulative chemical of concern” (Indiana Administrative Code, 2007a).

Low concentrations of inorganic mercury in aquatic ecosystems can be converted to organic methylmercury by microorganisms. Methylmercury is highly absorbable and concentrations accumulate and magnify in food chains. Concentrations of methylmercury in water have been strongly correlated with bioaccumulation of mercury in fish (Brumbaugh and others, 2001). The greatest concentrations are present in fish and in fish-eating mammals and birds at the top of the food chain. Methylmercury is a potent neurotoxin and potential endocrine disruptor that can slow nervous-system and cognitive development in humans and wildlife. Methylmercury can interfere with reproduction in vertebrates (Klaper and others, 2006), and it has been linked to congenital birth defects, increased risk of heart attack, renal damage, and blood pressure dysfunction (National Research Council, 2000).

The U.S. Environmental Protection Agency (2001a) freshwater criterion for mercury is based on a level for mercury in fish tissue of 0.3 micrograms per kilogram (µg/kg). The Indiana Water-Quality Standards list three criteria for mercury expressed as total mercury concentration. Statewide, the chronic aquatic criterion for mercury is 12 nanograms per liter (ng/L) to protect aquatic life from chronic toxic effects (Indiana Administrative Code, 2007a). The State of Indiana lists two criteria for water in the Great Lakes System, which includes “all the streams, rivers, lakes, and other waters of the state within the drainage basin of the Great Lakes (Lake Michigan and Lake Erie) within Indiana” (Indiana Administrative Code, 2007b). For water in the Great Lakes System, Indiana’s water-quality criterion for mercury, including methylmercury, is 1.8 ng/L, and it is intended to protect human health from possible noncancerous effects resulting from consumption of aquatic organisms (Indiana Administrative Code, 2007b). An additional water-quality criterion for mercury, including methylmercury, of 1.3 ng/L for water in Indiana in the Great Lakes System is intended to protect avian and mammalian wildlife populations from adverse effects that may result from consumption of aquatic organisms (Indiana Administrative Code, 2007b).

Wastewater dischargers in Indiana are required to meet the applicable surface-water standards for mercury or obtain a permit variance. One justification for the availability of a permit variance for mercury is that ambient mercury concentrations in some streams are expected to exceed the standard.

[1] According to the Indiana Business Research Center (2007), children less than 4 years in age (0.43 million) plus children 5 to 17 years in age (1.15 million) total 1.6 million of the 6.3 million total Indiana population (25.4 percent).

In part, ambient mercury concentrations in Indiana streams are thought to be influenced by nonpoint-source contributions, primarily runoff and direct input from atmospheric deposition. Concentrations of mercury in precipitation in Indiana, 2001–2003, were greater than the 12 ng/L Indiana chronic aquatic criterion in 47 percent of 517 samples; nearly all precipitation samples exceeded the most conservative Indiana water-quality criterion of 1.3 ng/L (Risch, 2007).

Mercury has been detected in nearly all fish-tissue samples collected in Indiana since 1983 (Stahl, 1997). Concentrations of mercury in some tissue samples have prompted State health officials to issue advisories warning about human consumption of fish (Indiana State Department of Health, 2008). The Indiana annual fish consumption advisories are based on the U.S. Environmental Protection Agency Reference Dose[2] and measured concentrations of mercury in fish-tissue samples collected throughout the state. These advisories recognize a greater risk to some members of the population. The advisories can be summarized generally with the following statements. If safety is unknown, women who are pregnant, breast-feeding, or planning pregnancy and children less than 15 years of age may assume that one meal of Indiana sport fish per month is safe. Women and children in this group should not eat any large carp, flathead catfish, walleye, sauger, or striped bass. Adult men and women not in the previous group may assume that one meal of Indiana sport fish per week is safe; however, some Indiana rivers and streams have “do not eat” advisories for all fish (Indiana State Department of Health, 2008).

As of 2006, fish-consumption advisories for mercury applied to fish caught in 3,113 mi or 9 percent of streams, 40,628 acres or 38 percent of lakes, and all 59 mi of Great Lakes shoreline in Indiana (Indiana Department of Environmental Management, 2006). According to the IDEM, 524 Indiana stream segments were classified as having impaired beneficial use because of fish-consumption advisories for mercury. Each year, some 833,000 resident anglers 16 years and older spend 15.5 million person-days and $469 million fishing. An estimated 286,000 more resident anglers were 6 to 15 years old (U.S. Department of the Interior, 2003). Based on these numbers, fish-consumption advisories could affect approximately 1 of 6 Indiana residents.[3]

Particulate and filtered total mercury and methylmercury in water have been monitored in many ecosystems as explained by Mason and others (2005), and changes in concentrations are expected to be an indicator of response to changes in atmospheric mercury deposition. It is noted, however, that interpreting the response of mercury concentrations in water to changes in atmospheric mercury input may be difficult. Mercury concentrations in water can be influenced by factors unrelated to mercury inputs, such as the variation in organic carbon and particulate matter. Some studies have shown a reasonable correlation between methylmercury in water and in fish that reflects changes at the base of the food chain, and one study includes a prediction that reductions in mercury emissions will rapidly decrease methylmercury concentrations in fish (Harris and others, 2007). In addition, recent studies in the northeastern United States (Evers, 2005) demonstrated that mercury exposure can be related to populationwide effects in fish and wildlife.

Four previous studies of total mercury and methylmercury in streams in the U.S. have involved different sizes of study areas—nationwide, multistate, and single state (table 1). A nationwide study from June through October 1998 analyzed mercury in stream-water samples from 106 locations in 21 river basins (Krabbenhoft and others, 1999). Total mercury concentrations were a maximum of 1,107 ng/L, with a median of 2.3 ng/L; methylmercury concentrations were a maximum of 1.48 ng/L, with a median of 0.06 ng/L. Methylation efficiency (methylmercury concentration as a percentage of total mercury concentration), computed from their published data for water, was a maximum 47.2 percent, with a median of 2.7 percent.

A multistate study in 1998–2001 analyzed mercury in stream-water samples from 25 locations in the 12,700-mi^2 Delaware River Basin in Pennsylvania, New Jersey, and New York (Brightbill and others, 2004). Total mercury concentrations were a maximum of 22 ng/L, with a median of 1.3 ng/L; methylmercury concentrations were a maximum of 0.28 ng/L, with a median of 0.04 ng/L. Methylation efficiency computed from their published data was a maximum of 8.6 percent, with a median of 3.6 percent.

A statewide study in Wisconsin in 1993–94, analyzed mercury in nine monthly stream-water samples from locations on seven rivers (Babiarz and others, 1998). Total mercury concentrations were a maximum of 45.9 ng/L, with a median 2.60 ng/L; methylmercury concentrations were a maximum of 1.8 ng/L, with a median of 0.11 ng/L (concentrations less than the reporting limit were omitted). The authors reported that the maximum total mercury concentrations were associated with storm events. They also observed methylmercury detections at all locations only during summer. As reported by Babiarz and others, methylation efficiencies rarely exceeded 6 percent. Methylation efficiency computed from their published data was a maximum of 51.2 percent, with a median of 4.8 percent.

A previous study of total mercury in streams in the Midwest included two drainage basins in Indiana—the Indiana Harbor Canal and the St. Joseph River (table 1). This study in 1994 analyzed mercury in stream-water samples from 11 tributaries of Lake Michigan in 3 states (Hurley and others, 1998). Total mercury concentrations were a maximum

[2] The U.S. Environmental Protection Agency Reference Dose is 0.1 μg mercury per kg of body weight per day of exposure for women of childbearing years, nursing mothers, and all children under age 15. The Reference Dose is 0.3 μg mercury per kg of body weight per day of exposure for women beyond their childbearing years and adult men (Indiana State Department of Health, 2006).

[3] The sum of 833,000 Indiana resident anglers over 16 years in age and an estimated 286,000 resident anglers 6 to 15 years in age is approximately 1 million Indiana anglers out of 6.3 million Indiana residents (Indiana Business Research Center, 2007).

Table 1. Summary of some previous studies of total mercury and methylmercury in streams of the United States.

[ng/L, nanograms per liter; NR, not reported]

Scale of study	Number of sample locations	Unfiltered total mercury concentration (ng/L)		Unfiltered methylmercury concentration (ng/L)		Methylation efficiency (percent)	
		Maximum	Median	Maximum	Median	Maximum	Median
Nationwide[1]	106	1,107	2.3	1.48	0.06	47.2	2.7
Multistate[2]	25	22	1.3	.28	.04	8.61	3.61
Statewide[3]	7	46	2.6	1.8	.11	51.2	4.8
Regional[4]	11	182	NR	NR	NR	NR	NR
Indiana small river basin[5]	15	19	4.6	.18	.02	6.2	.6
Indiana large river basin[6]	8	7.6	2.1	.38	.15	15.3	9.1
Indiana multiple river basins[7]	24	28	2.2	.66	.17	15	3.6

[1]Krabbenhoft and others (1998); methylation efficiency computed from published data.

[2]Brightbill and others (2004); methylation efficiency computed from published data.

[3]Babiarz and others (1998); methylation efficiency computed from published data.

[4]Hurley and others (1998).

[5]Stewart and others (2001) and Risch (2005).

[6]Brigham and others (2003).

[7]Indiana Department of Environmental Management, Assessment Information Management System database, unpublished data (2005).

of 182 ng/L, with a mean of 9.02 ng/L. Total mercury concentrations in the Indiana Harbor Canal in Indiana were a maximum of 15.9 ng/L, with a median of 8.56 ng/L. Total mercury concentrations at the mouth of the St. Joseph River in Michigan were a maximum of 14.8 ng/L, with a median of 5.34 ng/L. Particulate total mercury concentrations increased during spring snowmelt and other high streamflow conditions and coincided with high concentrations of suspended particulate matter.

Monitoring of Mercury in Indiana Streams

Previous studies have analyzed mercury in stream-water samples from a small river basin in northwestern Indiana, from a large river basin in central-southern Indiana, and from multiple river basins statewide (table 1). Samples collected in Indiana prior to 1999 have been excluded from this discussion unless they were analyzed with methods capable of detecting mercury and methylmercury at subnanogram per liter concentrations, and collected with ultraclean protocols. For this discussion, particulate and filtered mercury concentrations are combined and are considered to be equivalent to unfiltered mercury concentrations summarized for other previous studies.

Mercury was analyzed in stream-water samples from as many as 15 locations on the Grand Calumet River/Indiana Harbor Canal in a small river basin in Lake County in northwestern Indiana in July 1999 (Stewart and others, 2001) and in August 2001 and May 2002 (Risch, 2005). Samples were collected during warm, dry-weather conditions and during cool, wet-weather conditions. Total mercury concentrations were a maximum of 19 ng/L, with a median of 4.6 ng/L; methylmercury concentrations were a maximum of 0.18 ng/L, with a median of 0.02 ng/L. Methylation efficiency was a maximum of 6.2 percent, with a median of 0.4 percent. Nearly all of the mercury transported in the Grand Calumet River was particulate mercury.

Mercury was analyzed in stream-water samples at eight locations on the White River, in a large river basin in central and southern Indiana, in summer 2002, as part of the USGS National Water Quality Assessment program study of mercury in selected river basins nationwide (Brigham and others, 2003). Total mercury concentrations were a maximum of 7.61 ng/L, with a median of 2.11 ng/L; methylmercury concentrations were a maximum of 0.38 ng/L, with a median of 0.15 ng/L. Methylation efficiency computed from published data was a maximum of 15 percent, with a median of 9.1 percent.

The IDEM initiated a statewide reconnaissance of concentrations of trace metals, including mercury, in Indiana streams during 2002–2004 (Steve Boswell, Indiana Department of Environmental Management, written commun., 2001). This reconnaissance utilized a network of 24 monitoring stations at USGS streamflow-gaging stations and involved collection of grab samples of water 3 to 4 times per year. These samples were analyzed for total mercury and methylmercury (Indiana Department of Environmental Management Assessment Information Management System database, unpub. data, 2005). Unfiltered total mercury concentrations in 185 samples were a maximum of 28.2 ng/L, with a median of 2.23 ng/L; unfiltered methylmercury concentrations in 65 samples were a maximum of 0.66 ng/L, with a median of 0.17 ng/L. Methylation efficiency was a maximum of 64.8 percent, with a median of 3.6 percent. Filtered total mercury concentrations in 162 samples were a maximum of 5.86 ng/L, with a median of 0.56 ng/L (23 percent of the median unfiltered total mercury for these samples). Filtered methylmercury concentrations in 13 samples were a maximum of 0.68 ng/L, with a median concentration of 0.12 ng/L. Unfiltered total mercury in 4.9 percent of the IDEM samples, or 9 of 185 samples, exceeded the 12 ng/L Indiana chronic aquatic criterion for mercury. Median unfiltered total mercury concentrations were higher during spring and winter (3.6 and 2.9 ng/L) than summer and fall (1.8 and 1.0 ng/L).

Data on ambient concentrations of mercury and methylmercury in Indiana streams have been used by the IDEM as a measure of progress toward achieving statewide water-quality standards. In addition, these mercury data can be used to interpret the relation of mercury in streams to mercury in fish and atmospheric mercury deposition in Indiana. During summer 2004, the USGS, in cooperation with the IDEM, implemented a monitoring program that utilized 23 of the 24 stations in the IDEM network. Two new monitoring stations were included in the USGS network to replace a discontinued station, for a total of 25 stations. In 2004–2006, stream-water samples were collected once each season by use of stream-width and streamflow-integrating techniques. The results presented in this report are from 9 sets of 25 seasonal samples collected by the USGS during summer 2004 through summer 2006.

Methods

Total mercury and methylmercury were determined for water samples collected from a statewide stream-monitoring network in Indiana. Samples were collected on a seasonal schedule, following ultraclean protocols, with equipment and techniques for obtaining representative samples, consistent with USGS practices nationwide. Samples were filtered and preserved under cleanroom conditions at the trace metals laboratory at the USGS Indianapolis office. Unfiltered and filtered water samples were analyzed for total mercury and methylmercury. Analyses were completed at the USGS Mercury Research Laboratory in Middleton, Wis. by use of low-level methods. Instantaneous streamflow was obtained from, or estimated with, data from the nearby USGS streamflow-gaging stations.

Monitoring Station Selection

The USGS network of monitoring stations for mercury in Indiana streams (table 2, fig. 1) consisted of 25 locations representing 78 percent of the land area in the State[4]. The locations are identified by a station number (1 through 25) in this report. The locations of 23 monitoring stations in the USGS network were selected by the IDEM in 2002 to represent major watersheds, reservoirs, sources of water supply, urban wastewater discharges, special habitats, and areas with active and abandoned mine lands (Steve Boswell, Indiana Department of Environmental Management, written commun., 2001). Stations 15 and 25 were added by the USGS in 2004. Most monitoring stations were at bridges where USGS streamflow-gaging stations also are located. Five monitoring stations (stations 5, 12, 17, 18, and 25) were at bridges upstream or downstream from USGS streamflow-gaging stations. Station 6 was a tailwater pool below the Cagles Mill Lake dam, upstream from the USGS streamflow-gaging station.

The drainage areas upstream from the 25 monitoring stations (fig. 2) ranged from 59 mi^2 for station 22 to 13,800 mi^2 for station 25. The 25 monitoring stations represent 6 major hydrologic systems—the Wabash River, White River, Illinois River, Ohio River, Lake Michigan, and Lake Erie Systems. White River is physically part of the Wabash River basin; however, it is treated as an independent hydrologic system in this report. The 25 monitoring stations also represent 11 IDEM water management basins—the Upper Wabash River, Middle Wabash River, Lower Wabash River, West Fork White River, East Fork White River, Maumee River, St. Joseph River, Kankakee River, Patoka River, Whitewater River, and Lake Michigan Basins (table 2).

The monitoring stations represent different land-use settings primarily identified by the IDEM (table 3). Some stations represent more than one land-use setting. Five stations (6, 10, 17, 18, and 23) are within 2.7 mi downstream from a dam impounding a reservoir. Five stations are upstream from public water-supply intakes (1, 8, 12, 18, and 23). At least seven stations are downstream from urban and industrial wastewater discharges (5, 7, 8, 15, 19, 22, and 25); station 23 is downstream from urbanized and developed land use. Two stations—stations 13 and 20—represent special habitats. Station 13 is on a stream designated by IDEM for “exceptional use” for reasons of exceptional natural beauty or character or support of unique assemblages of aquatic organisms (Indiana Administrative Code, 2007c). Station 20 is on a stream that supports three endangered species of mussels (Sparks and others, 1999). Stations 14 and 16 are in watersheds with active and abandoned mine lands. Sixteen stations are downstream from rural and agricultural land uses (1, 2, 3, 4, 6, 9, 10, 11, 12, 13, 14, 17, 18, 20, 21, and 24).

[4] The total land area of Indiana is 35,887 mi^2 and the sum of the unique drainage areas upstream from the 25 stations in the USGS stream-monitoring network, less any area outside the Indiana border, is 27,968 mi^2.

Table 2. Characteristics of monitoring stations for mercury in Indiana streams, August 2004–September 2006.

[ddmmss, degrees minutes seconds; mi^2, square mile; NGVD29, National Geodetic Vertical Datum of 1929; IDEM, Indiana Department of Environmental Management]

Monitoring station number	Station name	Latitude (ddmmss)	Longitude (ddmmss)	National Water Information System station identifier	USGS streamflow gaging station number	Upstream drainage area (mi^2)	Altitude NGVD29 (feet)	IDEM water management basin	Major hydrologic system	Hydrologic unit code
1	Fall Creek near Fortville, Ind.	395717	855203	03351500	03351500	173	787.4	West Fork White River	White	5120201
2	Eel River near Logansport, Ind.	404655	861550	03328500	03328500	789	621.5	Upper Wabash River	Wabash	5120104
3	Tippecanoe River at Winamac, Ind.	410259	863557	03331753	03331753	941	674.2	Upper Wabash River	Wabash	5120106
4	Wildcat Creek near Lafayette, Ind.	402626	864945	03335000	03335000	794	527.7	Upper Wabash River	Wabash	5120107
5	Wabash River at U.S. Highway 40 at Terre Haute, Ind.	392801	872513	392801087251301	03341500	12,300	445.8	Middle Wabash River	Wabash	5120111
6	Mill Creek at tailwater pool near Manhattan, Ind.	392911	865508	392911086550701	03359000	293	650.0	West Fork White River	White	5120203
7	White River near Centerton, Ind.	392951	862402	03354000	03354000	2,440	595.4	West Fork White River	White	5120201
8	White River near Nora, Ind.	395438	860620	03351000	03351000	1,220	710.9	West Fork White River	White	5120201
9	Sugar Creek at New Palestine, Ind.	394251	855308	03361650	03361650	94	786.0	East Fork White River	White	5120204
10	East Fork Whitewater River at Brookville, Ind.	392602	850012	03276000	03276000	381	621.8	Whitewater River	Ohio	5080003
11	Vernon Fork Muscatatuck River at Vernon, Ind.	385835	853711	03369500	03369500	198	585.0	East Fork White River	White	5120207
12	White River at State Road 258 near Seymour, Ind.	385823	855546	385823085554501	03365500	2,340	560.0	East Fork White River	White	5120206
13	Blue River at Fredericksburg, Ind.	382602	861130	03302800	03302800	283	590.0	Ohio River	Ohio	5140104
14	Patoka River at Winslow, Ind.	382249	871300	03376300	03376300	602	400.0	Patoka River	Wabash	5120209

Table 2. Characteristics of monitoring stations for mercury in Indiana streams, August 2004–September 2006.—Continued

[ddmmss, degrees minutes seconds; mi^2, square mile; NGVD29, National Geodetic Vertical Datum of 1929; IDEM, Indiana Department of Environmental Management]

Monitoring station number	Station name	Latitude (ddmmss)	Longitude (ddmmss)	National Water Information System station identifier	USGS streamflow gaging station number	Upstream drainage area (mi^2)	Altitude NGVD29 (feet)	IDEM water management basin	Major hydrologic system	Hydrologic unit code
15	White River at Petersburg, Ind.	383039	871722	03374000	03374000	11,100	400.0	West Fork White River	White	5120202
16	Busseron Creek near Carlisle, Ind.	385827	872533	03342500	03342500	228	425.4	Lower Wabash River	Wabash	5120111
17	Mississinewa River at County Road 275 East near Peoria, Ind.	404330	855909	404330085590901	03327000	808	660.0	Upper Wabash River	Wabash	5120103
18	Wabash River at County Road 200 West near Huntington, Ind.	405112	852923	405112085292301	03323500	766	700.0	Upper Wabash River	Wabash	5120101
19	Maumee River at New Haven, Ind.	410506	850120	04183000	04183000	1,960	724.5	Maumee River	Great Lakes (Lake Erie)	4100005
20	Fish Creek near Artic, Ind.	412754	844851	04177810	04177810	96	833.0	Maumee River	Great Lakes (Lake Erie)	4100003
21	St. Joseph River at Elkhart, Ind.	414130	855830	04101000	04101000	3,380	700.0	St. Joseph River	Great Lakes (Lake Michigan)	4050001
22	Trail Creek at Michigan City Harbor, Ind.	414322	865415	04095380	04095380	59	575.0	Lake Michigan	Great Lakes (Lake Michigan)	4040001
23	Deep River at Lake George outlet at Hobart, Ind.	413210	871525	04093000	04093000	124	588.2	Lake Michigan	Great Lakes (Lake Michigan)	4040001
24	Kankakee River at Shelby, Ind.	411058	872025	05518000	05518000	1,780	628.1	Kankakee River	Illinois	7120001
25	Wabash River at Vigo Street at Vincennes, Ind.	384053	873207	384156087310701	03343000	13,800	394.4	Lower Wabash River	Wabash	5120111

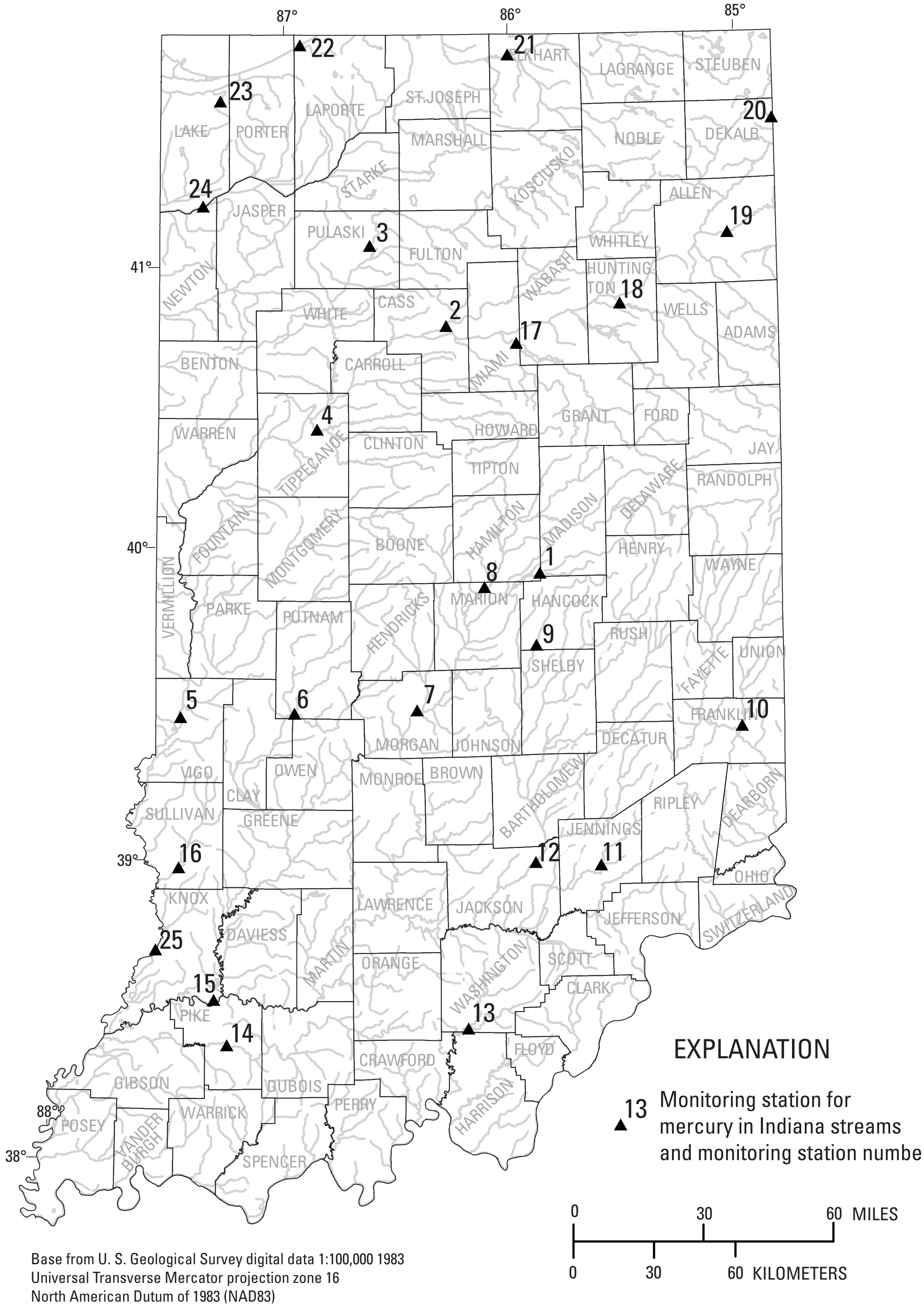


Figure 1. Locations of monitoring stations for mercury in Indiana streams, August 2004–September 2006.

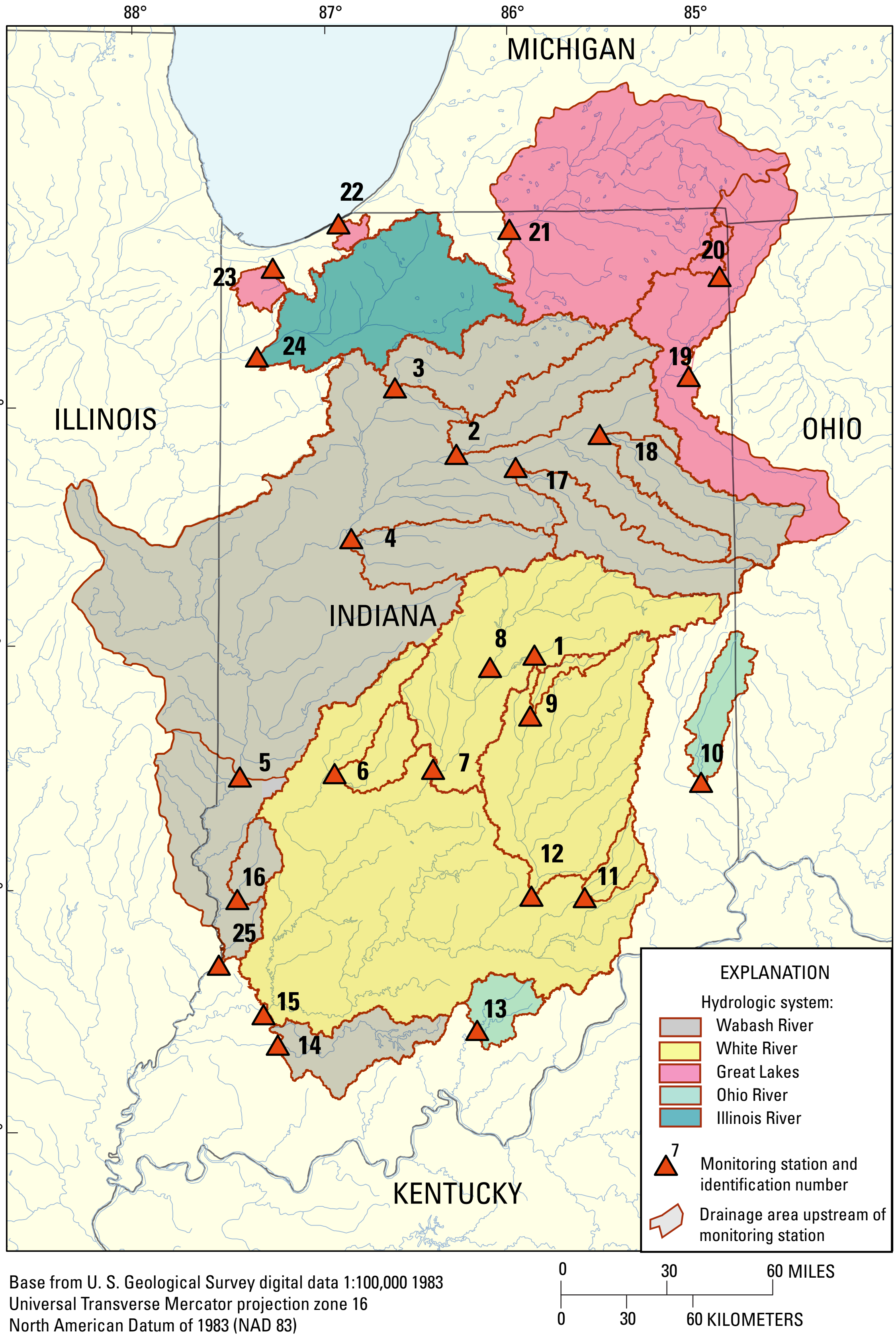


Figure 2. Locations of monitoring stations for mercury in Indiana streams, August 2004–September 2006, and upstream drainage areas and hydrologic systems.

Table 3. Land–use settings of monitoring stations for mercury in Indiana streams, August 2004–September 2006.

Monitoring station number	Station name	Land–use setting or location of monitoring station
1	Fall Creek near Fortville, Ind.	Downstream from rural and agricultural land use; upstream from public water–supply intake.
2	Eel River near Logansport, Ind.	Downstream from rural and agricultural land use.
3	Tippecanoe River at Winamac, Ind.	Downstream from rural and agricultural land use.
4	Wildcat Creek near Lafayette, Ind.	Downstream from rural and agricultural land use.
5	Wabash River at U.S. Highway 40 at Terre Haute, Ind.	Downstream from urban and industrial wastewater discharges.
6	Mill Creek at tailwater pool near Manhattan, Ind.	Downstream from reservoir; downstream from rural and agricultural land use.
7	White River near Centerton, Ind.	Downstream from urban and industrial wastewater discharges.
8	White River near Nora, Ind.	Downstream from urban wastewater discharges; upstream from public water–supply intake.
9	Sugar Creek at New Palestine, Ind.	Downstream from rural and agricultural land use.
10	East Fork Whitewater River at Brookville, Ind.	Downstream from reservoir; downstream from rural and agricultural land use.
11	Vernon Fork Muscatatuck River at Vernon, Ind.	Downstream from rural and agricultural land use and forest.
12	White River at State Road 258 near Seymour, Ind.	Downstream from rural and agricultural land use; upstream from public water–supply intake.
13	Blue River at Fredericksburg, Ind.	Special habitat: "exceptional use" stream; downstream from rural and agricultural land use and forest.
14	Patoka River at Winslow, Ind.	Downstream from active and abandoned mine lands; downstream from rural and agricultural land use and forest.
15	White River at Petersburg, Ind.	Downstream from urban and industrial wastewater discharges.
16	Busseron Creek near Carlisle, Ind.	Downstream from active and abandoned mine lands.
17	Mississinewa River at County Road 275 East near Peoria, Ind.	Downstream from reservoir; downstream from rural and agricultural land use.
18	Wabash River at County Road 200 West, near Huntington, Ind.	Downstream from reservoir; upstream from public water–supply intake; downstream from rural and agricultural land use.
19	Maumee River at New Haven, Ind.	Downstream from urban and industrial wastewater discharges.
20	Fish Creek near Artic, Ind.	Special habitat: endangered mussel species; downstream from rural and agricultural land use.
21	St. Joseph River at Elkhart, Ind.	Downstream from rural and agricultural land use.
22	Trail Creek at Michigan City Harbor, Ind.	Downstream from urban and industrial wastewater discharges.
23	Deep River at Lake George outlet at Hobart, Ind.	Downstream from reservoir; upstream from public water–supply; downstream from urbanized and developed land use.
24	Kankakee River at Shelby, Ind.	Downstream from rural and agricultural land use.
25	Wabash River at Vigo Street at Vincennes, Ind.	Downstream from urban and industrial wastewater discharges.

Daily mean streamflow and daily mean precipitation for August 2004 through August 2006 are shown for six selected monitoring stations for mercury in Indiana streams (fig. 3). Streamflow data are from nearby USGS gaging stations and precipitation data are from nearby National Weather Service cooperative observer stations. These six monitoring stations represent a range of upstream drainage area sizes, land-use settings, and regions of Indiana. The ranges of mean daily streamflow vary with the upstream drainage area, and higher streamflow is shown for larger upstream drainage areas. Station 5, with an upstream drainage area larger than 10,000 mi^2, had maximum streamflow of approximately 120,000 ft^3/s. Station 7, with an upstream drainage area larger than 1,000 mi^2, had maximum streamflow of approximately 50,000 ft^3/s. Station 9, with an upstream drainage area smaller than 100 mi^2, had maximum streamflow of approximately 2,500 ft^3/s. Station 6, unlike stations 5, 7, and 9 for example, is downstream from a dam that controls streamflow. The hydrograph for station 6 was computed with daily stream stage and has multiday time segments with unchanging streamflow. Regionally, station 19 is in northern Indiana, station 14 is in southern Indiana, and station 7 is in central Indiana. Bar graphs of precipitation near these stations show that daily maximums did not exceed 3.5 inches. Precipitation was recorded year round in all regions, but amounts were smallest in northern Indiana. In a few of the graphs, high precipitation corresponds with high streamflow, such as for station 14 in early 2006, and for stations 5, 7, and 9 in early 2005; more often, however, the increases in mean daily streamflow do not appear to be a direct response to nearby precipitation.

Sample Collection and Processing

Water samples were collected from a bridge, or while wading, or from a boat. (An inflatable, rubberized boat with a wooden floor and minimal amounts of metal was used primarily at station 6.) Samples were collected from a bridge by use of a US D-95 or US DH-95 sampler suspended from a cable reel on a portable bridge crane (fig. 4). Samples were collected while wading or from a boat by use of a US DH-81 sampler on a wading rod, with extensions as necessary (fig. 5). Materials for the samplers that contacted the water were of plastic construction or were plastic coated. Each sampler consisted of a 1-L Teflon bottle with a Teflon sampler cap and nozzle. The 1-L bottle had been cleaned in a heated acid bath according to procedures for low-level mercury in the USGS National Field Manual (Wilde and Radtke, 1998)[5] and transported in new, doubled zip-seal plastic bags.

Representative samples were collected according to USGS procedures in Wilde and Radtke (1998) that are intended to composite water collected across the full width and depth of the stream, thus accounting for differences in velocity and water chemistry. Prior to sample collection at a monitoring station, stream velocity at the swiftest point was measured by using a stopwatch to repeatedly time the passage of a float along a known distance. If stream velocity was greater than 1.5 ft/s, samples were obtained by use of a depth-integrating isokinetic sampler with a 1/4-in. Teflon nozzle (fig. 6). The nozzle accumulates water in the sample bottle at the stream velocity to assure a representative sample. If stream velocity was less than 1.5 ft/s, samples were collected as depth-integrated samples at multiple verticals, without a nozzle. In addition, prior to sample collection, the stream width was measured and divided into 10 to 15 equal-width increments so that samples could be collected in the center of each increment. Increments were marked on bridge rails or on a tagline stretched across the stream for wading or boat samples. In addition, the maximum depth of the stream was measured with a sounding weight so that a uniform transit rate for the sampler could be determined.

Water-sample collection and processing for total mercury and methylmercury analysis followed ultraclean protocols for low-level mercury in Wilde and Radtke (1998)[6], which are comparable to the trace metals sample-collection methods in EPA Method 1669 (U.S. Environmental Protection Agency, 1996) and the USGS Inorganic Protocol (Horowitz and others, 1994). Ultraclean protocols are designed to avoid the unintentional introduction of mercury or other contaminants into a sample. A minimum of two USGS personnel collected samples. To protect sample integrity, Tyvek lab coats and powder-free disposable nitrile gloves were used (fig. 5). Sampling procedures followed a “clean hands-dirty hands” outline. For example, one person (clean hands) handled sample bottles and inner bags of double-bagged supplies; the other person (dirty hands) handled sampling equipment and the outer bag of double-bagged supplies. All water for analysis of mercury was dispensed into Teflon bottles that had been cleaned in a heated acid bath according to procedures in Wilde and Radtke (1998)[6] and transported in new, doubled zip-seal plastic bags. Each sample bottle contained 20 mL of 1-percent high-purity hydrochloric acid, which was emptied from the bottle before it was triple rinsed and filled with sample water.

The sampler was lowered and raised through the water column one or more times in the center of each equal-width increment to obtain a minimum 4 L total sample volume from

[5, 6] USGS National Field Manual for Collection of Water-Quality Data, chapter 5, section 5.6.4B, Low-Level Mercury, version 1.0, 10/2004, *http://water.usgs.gov/owq/FieldManual/chapter5/pdf/5.6.4.B_v1.0.pdf*

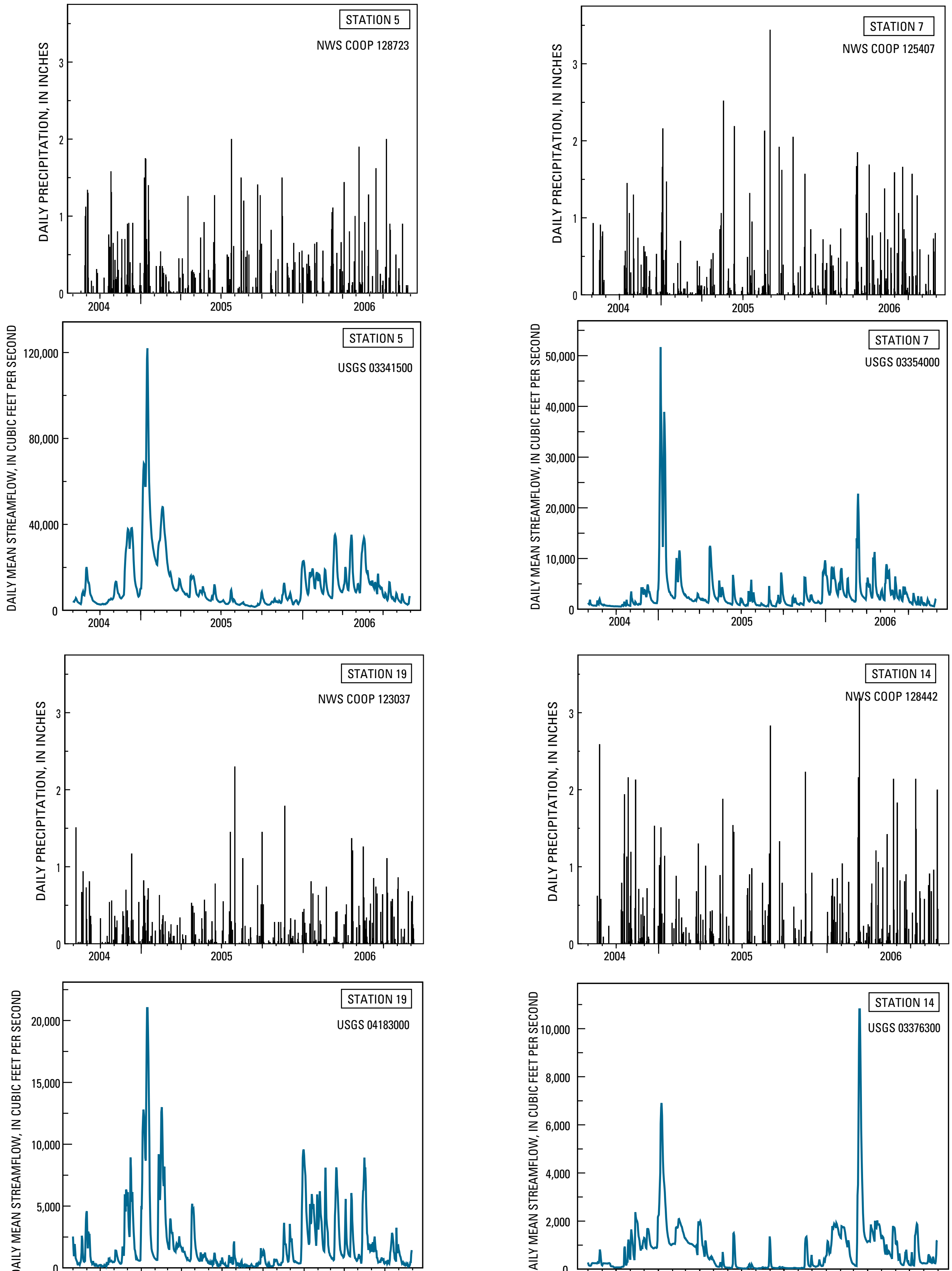


Figure 3. Daily mean streamflow and daily precipitation at six selected monitoring stations for mercury in Indiana streams, August 2004–August 2006.

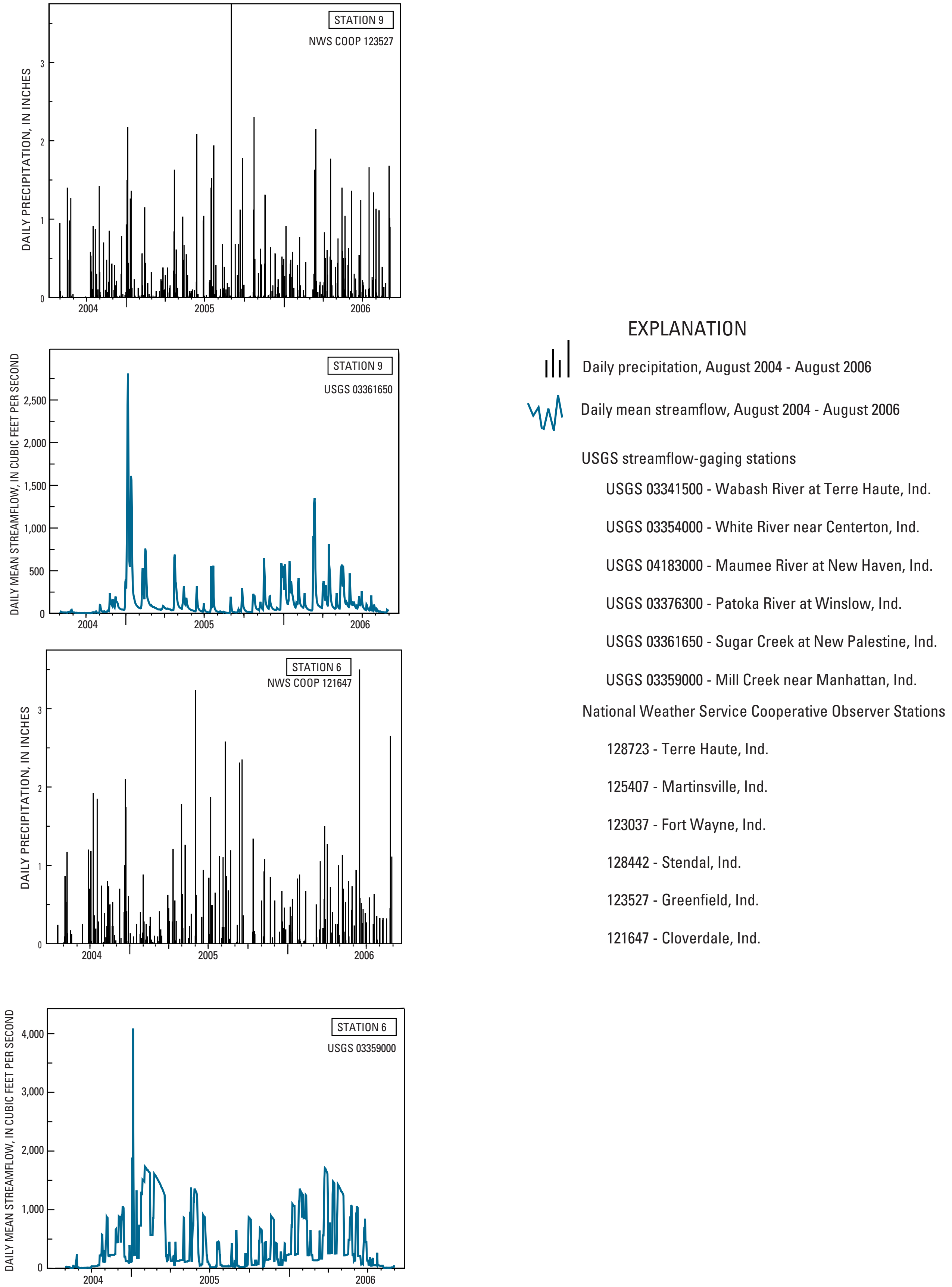


Figure 3. Daily mean streamflow and daily precipitation at six selected monitoring stations for mercury in Indiana streams, August 2004–August 2006.—Continued

Figure 4. Method used on a bridge to collect water samples for analysis of mercury in Indiana streams by use of a US DH-95 sampler suspended from a cable reel on a portable bridge crane.

Figure 5. Method used while wading to collect water samples for analysis of mercury in Indiana streams by use of a US DH-81 sampler on a wading rod.

Figure 6. Isokinetic sampler (US D-95) with a nozzle used to collect water samples for analysis of mercury in Indiana streams. The nozzle was used to obtain a representative sample when the stream velocity was greater than 1.5 ft/s. A typical USGS streamflow-gaging station can be seen on the shoreline.

all increments sufficient for processing and analysis. A 14-L Teflon churn was used to thoroughly mix the composite of samples from all the increments. The churn has an internal perforated disc attached to a handle. Water was mixed by moving the disc up and down with the handle. The churn, sampler cap, and nozzle were cleaned prior to sampling with a sequential process of detergent solution scrub and deionized water rinse, 5-percent hydrochloric acid rinse, and ultrapure deionized water rinse; the deionized water had a specific conductance of less than 1.0 µS/cm. The clean churn was transported and operated inside new, doubled plastic bags.

While it was mixed in the churn, water for analysis of unfiltered mercury and unfiltered methylmercury was dispensed into clean 500-mL and 250-mL Teflon bottles. The composited sample water to be filtered was dispensed into the 1-L Teflon bottle used to collect the sample. Unfiltered, unpreserved samples were stored in coolers, which were transported or shipped overnight to the USGS Indianapolis office.

Within 24 hours of collection, samples were filtered and preserved in a Class 100, laminar-flow, high-efficiency particulate-air filter work station (fig. 7) in the trace metals laboratory at the USGS Indianapolis office. Filtered samples were pumped with a peristaltic pump from the 1-L bottle of unfiltered, mixed, composite sample. Samples were pumped through Teflon tubing, a short piece of c-flex pump-head tubing, and a 0.7-µm nominal pore-size quartz-fiber filter in a Teflon holder. The tubing and filter holder had been cleaned in a heated acid bath according to procedures in Wilde and Radtke (1998)[6] and transported in new, doubled zip-seal plastic bags. Water for analysis of filtered mercury and filtered methylmercury was dispensed into clean 500-mL and 250-mL Teflon bottles. All samples for mercury analysis were preserved with 50-percent high-purity hydrochloric acid at the rate of 5 mL of acid per 250 mL of sample. After filtering and preservation, and within 2 weeks of sample collection, samples were shipped by overnight freight to the USGS Mercury Research Laboratory for analysis.

Sample Analysis

Water samples were analyzed for mercury and water-quality constituents were determined by measurement in the field (table 4). Water samples were analyzed for mercury at the USGS Mercury Research Laboratory in Middleton, Wis. (table 4). Total mercury was analyzed by oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry (Olson and DeWild, 1997), equivalent to EPA Method 1631 (U.S. Environmental Protection Agency, 1999). Methylmercury samples were prepared by distillation and analyzed by aqueous phase ethylation and gas chromatography separation with cold vapor atomic fluorescence detection (DeWild and others, 2002), equivalent to EPA Method 1630 (U.S. Environmental Protection Agency, 1998). All total mercury and methylmercury determinations were made on multiple aliquots from each sample. Mercury concentrations in this report are the mean of the multiple-aliquot analyses.

The USGS Mercury Research Laboratory utilizes equipment to minimize potential mercury contamination including: high-efficiency particulate-air filters, mercury-free Class 100 laminar flow hoods, gold-coated cloth filters at the intakes of the laminar flow hoods, a vinyl curtain at the main doorway, and tacky mats (fig. 8). Water purification systems provide ultrapure reagent grade water. The laboratory follows a written

Figure 7. Class 100, laminar-flow, high-efficiency particulate-air filter work station and apparatus used to filter water samples for analysis of mercury in Indiana streams.

Table 4. Constituents and water quality characteristics reported in samples from Indiana streams, August 2004–September 2006.

[ng/L nanograms per liter; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; °C, degree Celsius; ntru, nephelometric turbidity ratio unit]

Constituent	Analysis	Reporting limit
Unfiltered total mercury	Oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry	0.04 ng/L
Filtered total mercury	Oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry	0.04 ng/L
Unfiltered methylmercury	Aqueous phase ethylation and gas chromatography separation with cold vapor atomic fluorescence	0.04 ng/L
Filtered methylmercury	Aqueous phase ethylation and gas chromatography separation with cold vapor atomic fluorescence	0.04 ng/L
pH	In–stream measurement with multiparameter instrument	±0.01 standard unit
Specific conductance	In–stream measurement with multiparameter instrument	±1 µS/cm
Dissolved oxygen	In–stream measurement with multiparameter instrument	±0.01 mg/L
Water temperature	In–stream measurement with multiparameter instrument	±0.1 °C
Turbidity	Field measurement of composite sample with portable turbidimeter	±0.1 ntru

Figure 8. U.S. Geological Survey Mercury Research Laboratory facilities used for analysis of mercury in water samples from Indiana streams.

quality-assurance plan (U.S. Geological Survey, 2007) that details procedures for reagents, containers, instrument calibration and maintenance, quality control, record keeping, and quality-assurance reports.

Additional Measurements

A multiparameter instrument was used to measure pH, specific conductance, dissolved oxygen, and water temperature in the field. The meter was calibrated each day prior to its use, following procedures outlined in Wilde and Radtke (1998). Water-quality characteristics were measured at the center of the equal-width increments where the water samples were collected. Summary values for the stream at the time of sampling were recorded as the median pH, mean specific conductance, mean dissolved oxygen, and mean water temperature. A portable turbidimeter (Hach model 2100p) was used to measure turbidity in three aliquots drawn from the churn used to mix the composite water samples. A mean of the turbidity values in the three aliquots was reported as the summary turbidity value for each sample. The turbidimeter was checked with secondary standards each day prior to its use, and it was calibrated annually.

Instantaneous streamflow was determined with data obtained from the USGS streamflow-gaging station at or nearest each monitoring station, with the exception of station 16. Hereafter in this report, “streamflow” refers to instantaneous streamflow. The hourly streamflow value closest to the time of sample collection was obtained for 19 monitoring stations. The hourly gage-height value closest to the time of sample collection (from USGS streamflow-gaging stations that provided only stage) was obtained for five monitoring stations. Streamflow was estimated for these five stations with the stream stage (gage height) and the most current stage-streamflow rating curve. Station 16 was discontinued as a USGS streamflow-gaging station after December 2, 2003 (prior to the USGS sampling); streamflow measurements were therefore required at this station. For the first sample at station 16, during summer 2004, streamflow was computed as a product of stream velocity measured by use of a float and stopwatch, incremental depth, and stream width at the time of sampling. For the next eight samples at station 16, streamflow was measured with a handheld acoustic doppler velocimeter.

Streamflow measurements followed USGS methods in Rantz and others (1982).

Data Analysis

Bioaccumulation of mercury in fish is driven by many factors including total mercury load, methylation efficiency, fish size, and food chain dynamics in a given water body (Brumbaugh, 2001, 1999; Kidd and others, 1995). For this report, methylation efficiency was computed as the methylmercury concentration as a percentage of the total mercury concentration, following the method in Krabbenhoft and others (1999). Methylation efficiency was computed for 187 samples in which both methylmercury and mercury concentrations were greater than the reporting limit.

Particulate mercury was not measured directly in the 225 water samples collected during August 2004–September 2006. Particulate mercury concentrations were estimated by subtracting the filtered concentration from the unfiltered concentration (appendix 6). The fraction of unfiltered mercury that was estimated to be particulate mercury was expressed as a percentage. Particulate mercury concentrations were computed for samples in which unfiltered mercury concentrations were greater than the reporting limit. For samples with filtered mercury concentrations less than the reporting limit, all of the mercury was estimated to be particulate.

Mercury concentration data in this report do not have a normal distribution; therefore nonparametric statistics are most appropriate for their analysis (Helsel and Hirsch, 1995). Nonparametric tests are completed on data ranks rather than the data values, thus minimizing the effects of outliers. Concentrations reported as less than the reporting limit of 0.04 ng/L were set equal to one-half of the reporting limit for ranking in the statistical tests and graphical presentations of data.

A confidence level of 95 percent (significance level $\alpha=0.05$) was used for all statistical tests. A p-value is reported for the statistical tests and compared to the significance level. If the p-value for a test is greater than 0.05, it indicates a statistically significant difference between two or more groups. The p-value is the "attained significance level" or the probability of incorrect reporting of a difference among groups or failure to report a statistically significant difference.

Three nonparametric tests are used in data analysis for this report. The Wilcoxon rank-sum test is a nonparametric test for determination of whether two groups of data come from the same population (Helsel and Hirsch, 1995). For comparisons involving three or more groups, the Kruskal-Wallis test was computed. The Kruskal-Wallis test is a nonparametric one-way analysis of variance used to accept or reject the null hypothesis that the groups of data have the same distributions. The alternate hypothesis is that at least one group differs in its distribution (Helsel and Hirsch, 1995). If the Kruskal-Wallis test rejects the null hypothesis, which indicates a difference among the groups, Tukey's test was computed to determine which groups are statistically different. Tukey's test is a multiple-stage test, computed on ranked data, which compares the medians of the distributions from each group (Helsel and Hirsch, 1995).

Concentration data are summarized graphically in standard boxplots and a scatterplot. Boxplots provide visual summaries and comparisons of median, distribution, skewness, and presence of outliers among data sets (Helsel and Hirsch, 1995). Upper and lower limits of the central boxes are defined by quartiles.

Quality Assurance and Quality Control

A Quality Assurance Program Plan (QAPP) was prepared prior to the beginning of sample collection. The QAPP described the project approach to achieving quality assurance objectives of precision, accuracy, completeness, representativeness, and comparability. In addition, the QAPP outlined procedures for analytical calibration, quality-control checks, performance audits, and data validation.

Field quality-control samples included field-blank and field-duplicate samples. For each set of 25 stream-water samples, 6 field-blank samples (4 equipment blanks and 2 source solution/bottle blanks) were prepared to evaluate cleaning of the sampling equipment. Blank water for mercury analysis was provided by the USGS Mercury Research Laboratory. Equipment-blank samples were collected by pouring blank water into the 1-L sample bottle, then through the sampler cap with nozzle into the churn; the sample was then mixed and dispensed into a 1-L bottle. In the Class 100, laminar-flow, high-efficiency particulate-air filter work station in the trace metals laboratory at the USGS Indianapolis office, the sample was pumped through the Teflon tubing, pump-head tubing, and a filter into a sample bottle. Source-solution/bottle-blank samples were collected by pouring blank water into a sample bottle. Field-blank samples were preserved in a manner identical to the stream-water samples. Field-blank samples were filtered and preserved in a manner identical to the stream-water samples. Field-blank samples were analyzed for filtered total mercury. Source-solution/bottle-blank samples were analyzed for unfiltered total mercury.

For each set of 25 stream-water samples, field-duplicate samples were collected at 3 or 4 different monitoring stations. Split-duplicate samples were prepared by sequentially filling a second set of sample bottles from the same churn. Concurrent-duplicate samples were collected simultaneously in two churns. Duplicate samples were filtered, preserved, and analyzed in a manner identical to the stream-water samples. Field-duplicate samples were analyzed for unfiltered and filtered total mercury and methylmercury. A total of 35 duplicate samples were collected, consisting of 19 split- and 16 concurrent-duplicates, for the 225 stream-water samples.

Laboratory quality-control samples included 71 matrix-spike and spike-duplicate samples that were analyzed for unfiltered and filtered total mercury and unfiltered methylmercury. For a matrix-spike sample, a known concentration of mercury or methylmercury was added to a sample of stream water. The purpose of the matrix-spike samples was to quantify interference with determination of a mercury concentration due to the sampling matrix. Matrix-spike duplicate samples were used to evaluate the precision of the matrix-spike analyses.

The following discussion summarizes the data from 89 field quality-control samples and 71 laboratory quality-control samples associated with mercury analyses for this study. Quality-control data for the mercury concentrations from this study indicated there were few, if any, biases caused by artifacts from sampling and processing or by interference from the sampling matrix and that precision of the reported concentrations was not substantially affected by natural variability or variability from sampling and processing.

The 54 field-blank samples (appendix 1) consisted of 18 bottle-blank samples to evaluate the blank water, sample bottles, and acid preservatives and 36 equipment-blank samples to evaluate the sampling and processing equipment. These field-blank data were evaluated with procedures for EPA Method 1631 (U.S. Environmental Protection Agency, 2001b). Unfiltered total mercury concentrations greater than or equal to the 0.04 ng/L reporting limit were 0.04 and 0.06 ng/L in two source-solution/bottle-blank samples from two different sets of seasonal samples. Filtered total mercury was not detected in the equipment blanks associated with these samples and the average field-blank mercury concentration for each set of samples was less than the 0.04 ng/L reporting limit. Filtered total mercury concentrations greater than the 0.04 ng/L reporting limit were 0.05, 0.05, and 0.09 ng/L for three equipment-blank samples from two different sets of seasonal samples. Unfiltered total mercury was not detected in the source-solution/bottle-blank samples associated with these equipment-blank samples. The mean equipment-blank mercury concentration for these two sets of samples was less than or equal to one-fifth the filtered total mercury concentration in the associated environmental samples. On the basis of the field-blank evaluations, it was determined that no substantial mercury artifacts were introduced during sampling and processing of the samples that would bias the accuracy of reported concentrations.

Field-duplicate samples were a measure of the natural variability of mercury concentrations in the stream water and the variability associated with sample collection and processing, rather than a measure of analytical precision. Analytical precision in the determination of mercury concentrations was quality assured by the laboratory, through analysis of duplicate or triplicate aliquots of water from the same sample bottle until a control limit for a percentage difference of less than 10 percent was attained. Each of the 35 field-duplicate samples was paired with the water sample (called "environmental sample" in this discussion) collected at the same station and date. Total mercury concentrations in the field-duplicate samples were compared with the mercury concentrations in the environmental samples by computing the relative percent difference[7] (RPD) (appendix 2). Relative percent difference of methylmercury concentrations in the field-duplicate and environmental sample pairs were also computed (appendix 3). The median RPD's were 8.2 and 9.8 for unfiltered and filtered total mercury. The median RPD's of 13.3 and 15.4 for unfiltered and filtered methylmercury were higher than those for total mercury, although the median numerical differences between methylmercury concentrations of 0.01 ng/L were smaller compared with numerical differences of 0.22 ng/L and 0.06 ng/L for unfiltered and filtered methylmercury. These field-duplicate data indicate that most of the mercury concentrations in this report were not substantially affected by natural variability or variability from sampling and processing.

The laboratory quality-control data (appendix 4) for 60 matrix-spike and 11 spike duplicates for samples collected in Indiana had median percent recovery[8] of 98 for unfiltered total mercury, 98 for filtered total mercury, and 99 for unfiltered methylmercury. No matrix-spike samples were performed for filtered methylmercury. These data indicate that the mercury concentrations were not biased by interference from the sample matrix. The laboratory quality-control data for 11 matrix-spike-duplicate samples had a median RPD of 7.0 percent. These data indicate good agreement of the matrix-spike concentrations.

Total Mercury and Methylmercury in Indiana Streams

Concentrations of unfiltered and filtered total mercury and methylmercury (appendix 5) were analyzed and reported for 225 water samples collected from Indiana streams, August 2004–September 2006. These samples represent the major hydrologic systems in Indiana, multiple seasons, and a range of streamflow conditions statewide. This section describes total mercury and methylmercury in the samples with regard to the highest concentrations, concentrations exceeding an Indiana Water Quality Standard, and estimated particulate mercury (appendix 6). Mercury data are discussed with regard to the locations, upstream drainage areas, and seasonal observation. Streamflow and water-quality characteristics (appendix 7) at the time of sampling are summarized and compared to mercury concentrations.

[7] Relative percent difference is the nonnegative difference of the duplicate and environmental sample concentrations divided by the average of the concentrations, expressed as a percentage.

[8] Percent recovery was computed as the mercury concentration in the matrix-spike sample divided by the sum of the mercury concentration in the sample and the mercury concentration in the spike solution, expressed as a percentage.

Table 5. Water samples collected from streams in Indiana and analyzed for mercury, August –September 2006, grouped by hydrologic system, season, and streamflow.

Hydrologic system		Season		Streamflow [1]			
Name	Number of samples	Name	Number of samples	Hydrograph condition[2]	Number of samples	Statistical category[3]	Number of samples
Wabash River	81	Spring	50	Stable normal	39	Low flow	43
White River	72	Summer	73	Stable low	75	Medium flow	89
Ohio River	18	Fall	52	Stable high	3	High flow	58
Great Lakes	45	Winter	50	Peak stage	2	Event flow	26
Illinois River	9			Rising stage	31	Not determined	9
				Falling stage	66		
				Not determined	9		

[1] Streamflow was not classified for samples collected at station 16, due to discontinuation of USGS streamflow–gaging station.

[2] Streamflow hydrograph condition classified from several days of streamflow data around the time of sample collection.

[3] Streamflow statistical category (October 1, 2003, through September 30, 2006): low (less than or equal to the 10th percentile), medium (greater than the 10th percentile to equal to the median), high (greater than the median to equal to the 90th percentile), and event (greater than the 90th percentile).

Sample Characteristics

The monitoring network was designed to provide data from the major hydrologic systems in Indiana (table 5). Of the 225 samples, 36 percent were from the Wabash River System; 32 percent from the White River System; 20 percent from the Great Lakes Systems, combining Lake Michigan and Lake Erie; 8 percent from the Ohio River System; and 4 percent from the Illinois River System.

The schedule for sample collection was intended to include the variety of weather and streamflow conditions of the four seasons[9] in Indiana. Two sets of water samples were collected at the 25 monitoring stations during winter (2005 and 2006), spring (2005 and 2006), and fall (2004 and 2005); three sets of samples were collected during summer (2004, 2005, and 2006). Streamflow hydrograph conditions at the time of sample collection were classified by an examination of several days of data from the nearby USGS streamflow-gaging station. The classifications (appendix 5) were stable (normal, low, high) and changing (peak, rising, falling). Slightly more than one-half of the samples, or 117 of 225, were collected during stable hydrograph conditions (table 5), including 3 from a high stage. The 99 samples collected during changing hydrograph conditions included 2 at peak stage. Streamflow hydrograph conditions were not determined for the nine samples collected at station 16, because the streamflow-gaging station had been discontinued.

Streamflow statistical category, for purposes of this report, was based on the daily mean streamflow record from the USGS streamflow-gaging station near each monitoring station, for water years 2004–2006 (October 1, 2003, through September 30, 2006). For five stations, the gage height record was used instead of streamflow. Statistical categories were based on the rank ordered streamflow (or gage-height) data for a monitoring station, and are defined as low (less than or equal to the 10th percentile), medium (greater than the 10th percentile to equal to the median), high (greater than the median to equal to the 90th percentile), and event (greater than the 90th percentile). Instantaneous streamflow at the time of sample collection was placed in one of these four statistical categories (appendix 5). Samples collected at Station 16 were not assigned a streamflow statistical category because data were not available.

[9] Temperate seasons for the northern hemisphere are used in this report, and the changes are at dates of solstices and equinoxes: winter is from December 22 to March 19; spring is from March 20 to June 21; summer is from June 22 to September 22; and fall is from September 23 to December 21.

Table 6. Summary statistics for total mercury and methylmercury concentrations, estimated particulate mercury and methylmercury, and methylation efficiency in water samples from the monitoring network in Indiana, August 2004–September 2006.

[ng/L, nanograms per liter; <, less than; R.L., reporting limit of 0.04 ng/L]

Summary statistic	Unfiltered total mercury (ng/L)	Filtered total mercury (ng/L)	Unfiltered methyl–mercury (ng/L)	Filtered methyl–mercury (ng/L)	Particulate total mercury (ng/L)	Particulate methyl–mercury (ng/L)	Methylation efficiency (percent)
Maximum	26.9	6.14	0.57	0.42	21.7	0.37	24.6
90th percentile	9.05	2.35	.25	.09	7	.21	10.3
75th percentile	4.60	1.21	.15	.06	3.43	.14	6.2
50th percentile (median)	2.35	.63	.09	.04	1.43	.07	3.7
25th percentile	1.31	.40	.05	<.04	.69	.03	2.2
Minimum	.24	.06	<.04	<.04	.03	0	.4
Number of reported concentrations	225	225	187	116	225	116	187
Number of concentrations < R.L.	0	0	38	109	0	109	38
Total number of samples	225	225	225	225	225	225	225

Overall variability in the values of the water-quality characteristics (water temperature, specific conductance, and dissolved oxygen) at each sampling interval at a station were used to classify the stream conditions at the time of sample collection as well mixed or poorly mixed. Differences of less than 1 ºC for water temperature, 5 µS/cm for specific conductance, and 3 mg/L for dissolved oxygen were used to classify stream conditions as well mixed. If differences were greater than these values, stream conditions were classified as poorly mixed. Stream conditions for 94 samples (42 percent) were classified as well mixed and 130 samples (58 percent) were classified as poorly mixed. Stream conditions for one sample were not classified because water-quality characteristics were not measured. Poorly-mixed streams were most susceptible to bias in the mercury concentration. This bias was minimized by the use of depth-integrating isokinetic, equal-width increment, and depth-integrating, multiple-vertical sampling techniques.

Total Mercury and Methylmercury Concentrations

In the following discussions, total and methylmercury concentrations are summarized, along with estimated particulate total mercury and methylmercury and methylation efficiency (table 6 shows all monitoring stations, table 7 shows each monitoring station). The highest concentrations and concentrations equal to or exceeding an Indiana Water Quality Standard are described with respect to location and time. Concentrations of total mercury and methylmercury, along with estimated particulate mercury, are compared according to upstream drainage areas, land uses, seasons, water-quality characteristics, and streamflow.

The 2.35 ng/L median unfiltered total mercury in 225 samples, August 2004–September 2006 (table 6), was similar to median unfiltered total mercury in 187 samples collected at 23 of these stations by the IDEM, 2002–2004 (2.23 ng/L). The range of concentrations (table 6) also was similar between August 2004–September 2006 (0.24 to 26.9 ng/L) and 2002–2004 (0.19 to 28.1 ng/L). Median unfiltered total mercury between August 2004–September 2006 (2.35 ng/L, table 6) was similar to the median of 2.3 ng/L for the Krabbenhoft and others (1999) nationwide study in 1998 and slightly less than the median of 2.6 ng/L from the Babiarz and others (1998) statewide study in Wisconsin, 1993–1994. Median unfiltered methylmercury in August 2004–September 2006 (0.9 ng/L, table 6) was about half the median unfiltered methylmercury in 65 samples collected by the IDEM, 2002–2004 (0.17 ng/L). Median unfiltered methylmercury between August 2004–September 2006 was slightly higher than the median for the nationwide study in 1998 (0.06 ng/L) and slightly less than the median from the statewide study in Wisconsin, 1993–1994 (0.11 ng/L). Median methylation efficiency (table 6) was similar between August 2004–September 2006 (3.7 percent, n=187) and 2002–2004 (3.6 percent, n=65) and was approximately nine times higher than the Risch (2005) Grand Calumet River/Indiana Harbor Canal study in Indiana in 2001–2002 (0.4 percent, n=18).

Table 7. Ranges and medians of total mercury and methylmercury concentrations, estimated particulate mercury and methylmercury, and methylation efficiency in water samples from 25 monitoring stations in Indiana, August 2004–September 2006.

[ng/L, nanograms per liter; <, less than]

Monitoring station number	Unfiltered total mercury (ng/L)		Filtered total mercury (ng/L)		Unfiltered methylmercury (ng/L)		Filtered methylmercury (ng/L)		Particulate total mercury (ng/L)		Particulate methylmercury (ng/L)		Methylation efficiency (percent)	
	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median
1	0.39–21.2	1.28	0.22–4.17	0.43	<0.04–0.29	0.07	<0.04–0.06	<0.04	0.14–17.0	1.05	0.04–0.24	0.07	1.4 – 11.6	4.7
2	0.28–14.7	0.88	0.18–3.99	0.54	<0.04–0.27	0.06	<0.04–0.11	0.06	0.10–10.7	0.39	0–0.18	0.06	1.8 – 17.9	5.4
3	0.59–7.42	1.21	0.23–1.35	0.42	<0.04–0.19	0.06	<0.04–0.08	<0.04	0.27–6.19	0.72	0.05–0.14	0.09	1.8 – 7.2	4.6
4	0.34–8.33	1.39	0.26–1.11	0.48	<0.04–0.33	0.08	<0.04–0.13	<0.04	0.08–7.22	0.53	0.04–0.2	0.10	1.9 – 14.7	4.5
5	2.14–11.6	4.32	0.30–1.86	0.78	0.06–0.42	0.12	<0.04–0.05	<0.04	1.77–10.7	2.66	0.06–0.37	0.12	1.3 – 17.6	2.5
6	1.17–3.26	1.67	0.31–2.45	0.90	<0.04–0.57	0.12	<0.04–0.42	<0.04	0.15–1.25	0.85	0.06–0.26	0.14	3.1 – 24.6	12.5
7	2.90–17.8	6.34	0.54–1.53	0.80	0.07–0.29	0.12	<0.04–0.12	0.07	2.05–16.3	5.42	0–0.22	0.08	1.1 – 4.4	2.4
8	0.88–11.3	2.55	0.06–2.35	0.53	<0.04–0.26	0.09	<0.04–0.07	0.06	0.82–9.86	1.99	0.01–0.21	0.05	0.8 – 10.2	4.5
9	0.43–4.76	1.10	0.18–1.95	0.41	<0.04–0.12	0.04	<0.04–0.06	<0.04	0.25–2.81	0.45	0–0.08	0.04	2.5 – 9.3	7.1
10	0.24–1.85	0.54	0.17–1.21	0.40	<0.04–0.04	<0.04	<0.04–<0.04	<0.04	0.04–0.64	0.14	0.04–0.04	0.04	15.4–15.4	15.4
11	1.08–16.2	2.32	0.90–6.14	1.11	<0.04–0.20	0.08	<0.04–0.13	0.07	0.18–10.1	1.11	0–0.14	0.04	1.2 – 6.0	3.6
12	0.73–20.1	1.67	0.16–4.45	0.35	0.05–0.44	0.10	<0.04–0.08	0.04	0.5–15.7	1.3	0.05–0.36	0.06	1.2 – 9.8	4.4
13	0.83–2.96	1.98	0.43–1.90	0.67	<0.04–0.20	0.08	<0.04–0.13	<0.04	0.4–1.74	1.06	0–0.1	0.07	1.9 – 10.8	4.0
14	1.78– 16.0	3.97	0.30–4.40	0.95	0.05–0.32	0.07	<0.04–0.14	<0.04	1.26–11.7	2.75	0–0.18	0.07	0.4 – 4.8	2.5
15	3.42– 12.0	5.63	0.46–2.58	0.80	0.06–0.41	0.20	<0.04–0.10	<0.04	2.8–9.42	4.66	0.06–0.36	0.13	1.6 – 9.9	2.7
16	1.37–6.24	2.49	0.10–2.44	0.49	0.05–0.18	0.12	<0.04–0.13	0.05	0.03–4.05	2.07	0–0.13	0.07	1.9 – 6.5	4.5
17	1.12–3.39	2.31	0.32–2.16	0.99	0.05–0.18	0.06	<0.04–0.10	<0.04	0.44–1.99	1.09	0.01–0.16	0.06	1.5 – 16.1	2.9
18	1.24–15.0	2.67	0.35–5.85	1.68	0.04–0.40	0.12	<0.04–0.17	<0.04	0.89–9.15	1.91	0.04–0.23	0.08	0.7 – 15.4	2.4
19	3.45–26.9	9.28	0.46–5.97	1.00	0.07–0.43	0.23	<0.04–0.09	0.06	2.71–21.7	7.89	0.01–0.36	0.17	0.7 – 7.0	2.2
20	0.76–8.66	2.20	0.43–4.79	0.77	0.06–0.21	0.09	<0.04–0.10	0.06	0.25–6.33	1.35	0.01–0.21	0.06	1.0 – 10.3	7.9

Table 7. Ranges and medians of total mercury and methylmercury concentrations, estimated particulate mercury and methylmercury, and methylation efficiency in water samples from 25 monitoring stations in Indiana, August 2004–September 2006.—Continued

[ng/L, nanograms per liter; <, less than]

Monitoring station number	Unfiltered total mercury (ng/L)		Filtered total mercury (ng/L)		Unfiltered methylmercury (ng/L)		Filtered methylmercury (ng/L)		Particulate total mercury (ng/L)		Particulate methylmercury (ng/L)		Methylation efficiency (percent)	
	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median
21	0.39–9.05	1.77	0.25–2.28	0.48	<0.04–0.12	0.08	<0.04–0.12	0.05	0.14–6.77	1.15	0–0.1	0.02	1.1 – 12.5	4.5
22	0.55–7.15	1.42	0.17–3.31	0.40	<0.04–0.39	0.08	<0.04–0.23	0.05	0.38–3.84	0.68	0.01–0.16	0.03	1.3 – 6.3	5.3
23	1.37–6.89	1.85	0.55–3.17	0.80	<0.04–0.15	0.05	<0.04–0.11	<0.04	0.57–3.72	1.03	0–0.12	0.05	0.7 – 6.3	3.6
24	0.75–12.2	3.23	0.16–3.49	0.46	<0.04–0.13	0.07	<0.04–0.06	0.04	0.4–8.71	2.71	0–0.07	0.07	0.8 – 4.2	1.9
25	1.95–9.73	4.11	0.16–2.00	0.53	<0.04–0.42	0.16	<0.04–0.08	<0.04	1.79–8.04	3.19	0.08–0.34	0.15	1.6 – 16.5	2.3

Highest Concentrations

Total mercury concentrations were greater than the 0.04 ng/L reporting limit in all 225 unfiltered and filtered samples (appendix 5). Unfiltered total mercury ranged from 0.24 to 26.9 ng/L, and filtered total mercury ranged from 0.06 to 6.14 ng/L (table 6). Median unfiltered total mercury was 2.35 ng/L and median filtered total mercury was 0.63 ng/L. The highest concentrations of unfiltered total mercury (in the 90th percentile)[10] ranged from 9.05 to 26.9 ng/L, and 13 of these 23 samples were collected during winter and spring, including 8 in March 2006 and 4 in May 2006. The highest concentrations of unfiltered total mercury were detected in 10 samples from the White River System, 6 samples from the Wabash River System, 6 samples from the Great Lakes System, and 1 sample from the Illinois River System. Station 19 (Maumee River at New Haven) was the location with the most (5 of 23) unfiltered total mercury concentrations in the 90th percentile, three of these during changing streamflow hydrograph conditions. The majority of the highest unfiltered total mercury concentrations, 21 of 23, were collected during high or event streamflow.

Methylmercury concentrations were greater than the 0.04 ng/L reporting limit in 83 percent (187 of 225) of unfiltered samples and 52 percent (116 of 225) of filtered samples. Concentrations less than the 0.04 ng/L reporting limit were included in the calculation of medians and summary statistics in this report. Unfiltered methylmercury concentrations ranged from <0.04 to 0.57 ng/L, and filtered methylmercury concentrations ranged from <0.04 to 0.42 ng/L (table 6). Median unfiltered methylmercury (including 38 censored values <0.04 ng/L) was 0.09 ng/L, and median filtered methylmercury (including 109 censored values <0.04 ng/L) was 0.04 ng/L. The highest concentrations of unfiltered methylmercury (in the 90th percentile) ranged from 0.25 to 0.57 ng/L, and 19 of these 23 concentrations were measured during the spring and summer seasons. The highest unfiltered methylmercury concentrations were detected in 11 samples from the White River System, 8 samples from the Wabash River System, and 4 samples from the Great Lakes System. Locations with the most unfiltered methylmercury concentrations in the 90th percentile were station 19 (Maumee River at New Haven) and station 15 (White River at Petersburg) with three samples each. A majority (16 of 23) of the highest unfiltered methylmercury concentrations were collected during changing streamflow hydrograph conditions.

The two highest methylation efficiencies (appendix 6) were 24.6 percent and 23.5 percent, in samples from station 6 (Mill Creek at tailwater pool near Manhattan), which also had the most values higher than 9.9 percent (the 90th percentile). Most of the methylation efficiencies in the 90th percentile were in samples from low and medium flow. Methylation efficiency was less than 5 percent in 63 percent of the 187 samples.

[10] The 90th percentile is the top one-tenth of a group of values that are rank ordered from highest to lowest.

Table 8. Monitoring stations with unfiltered total mercury concentrations that equaled or exceeded the Indiana chronic aquatic criterion for mercury, August 2004–September 2006.

[Indiana chronic aquatic criterion for mercury is 12 ng/L; ng/L, nanograms per liter]

Monitoring station number	Station name	Date of sample collection (month/day/year)	Unfiltered total mercury (ng/L)	Streamflow hydrograph condition	Streamflow statistical category	Hydrologic system	Season
1	Fall Creek near Fortville	03/10/2006	21.2	Rising	Event flow	White River	Winter.
2	Eel River near Logansport	08/30/2004	14.7	Falling	Event flow	Wabash River	Summer.
7	White River near Centerton	05/16/2006	17.8	Falling	Event flow	White River	Spring.
11	Vernon Fork Muscatatuck River at Vernon	03/09/2006	16.2	Rising	Event flow	White River	Winter.
12	White River at State Road 258 near Seymour	03/09/2006	20.1	Rising	High flow	White River	Winter.
12	White River at State Road 258 near Seymour	05/11/2006	17.9	Rising	High flow	White River	Spring.
14	Patoka River at Winslow	10/28/2004	16.0	Falling	High flow	Wabash River	Fall.
15	White River at Petersburg	10/28/2004	12.0	Falling	Low flow	White River	Fall.
18	Wabash River at County Road 200 West near Huntington	03/13/2006	15.0	Stable high	High flow	Wabash River	Winter.
19	Maumee River at New Haven	03/14/2006	26.9	Rising	Event flow	Great Lakes	Winter.
19	Maumee River at New Haven	05/23/2006	23.6	Rising	High flow	Great Lakes	Spring.
19	Maumee River at New Haven	08/29/2006	12.5	Falling	High flow	Great Lakes	Summer.
24	Kankakee River at Shelby	03/16/2006	12.2	Rising	Event flow	Illinois River	Winter.

Concentrations That Exceeded a Standard

Unfiltered total mercury concentrations equaled or exceeded the 12 ng/L Indiana chronic aquatic criterion in 5.8 percent of samples (13 of 225) and at 10 of the 25 monitoring stations (table 8, fig. 9). A majority (9 of 13) of the samples with concentrations that equaled or exceeded the 12 ng/L criterion were collected during winter and spring (March 2006 and May 2006). These 13 samples were divided among stations in the White River System (6), Wabash River System (3), Great Lakes System (3), and Illinois River System (1). All but one of these samples was collected during changing streamflow hydrograph conditions; one was collected during stable, high streamflow. Most of the samples (12 of 13) with concentrations that equaled or exceeded the 12 ng/L criterion were collected during high or event streamflow. Unfiltered total mercury concentrations were less than or equal to 12 ng/L in all 43 samples collected during low streamflow. Of the 10 monitoring stations where mercury concentrations equaled or exceeded the 12 ng/L criterion, five were downstream from rural and agricultural land use and five were downstream from urban and industrial wastewater discharges. The proportion of samples in which total mercury equaled or exceeded the 12 ng/L criterion was slightly higher between August 2004–September 2006 (5.8 percent) than in samples collected at most of these stations by the IDEM during 2002–2004, (4.9 percent).

Unfiltered total mercury concentrations equaled or exceeded the most conservative Indiana water-quality criterion of 1.3 ng/L in 73 percent of samples, or 170 of 225. Of the 170 samples with concentrations that equaled or exceeded 1.3 ng/L, 102 were collected during spring and summer and 68 were collected during fall and winter. All nine samples collected August 2004–September 2006 at eight stations (figs. 1 and 2) equaled or exceeded 1.3 ng/L—stations 5, 14, 16, and 25 in the Wabash River System, stations 7 and 15 in the White River System, and stations 19 and 23 in the Great Lakes System (where 1.3 ng/L is the applicable water-quality criterion). Five of these stations are downstream from urban and industrial wastewater discharges; stations 14 and 16 are downstream from active and abandoned mine lands, and station 23 is downstream from urbanized land use (table 3).

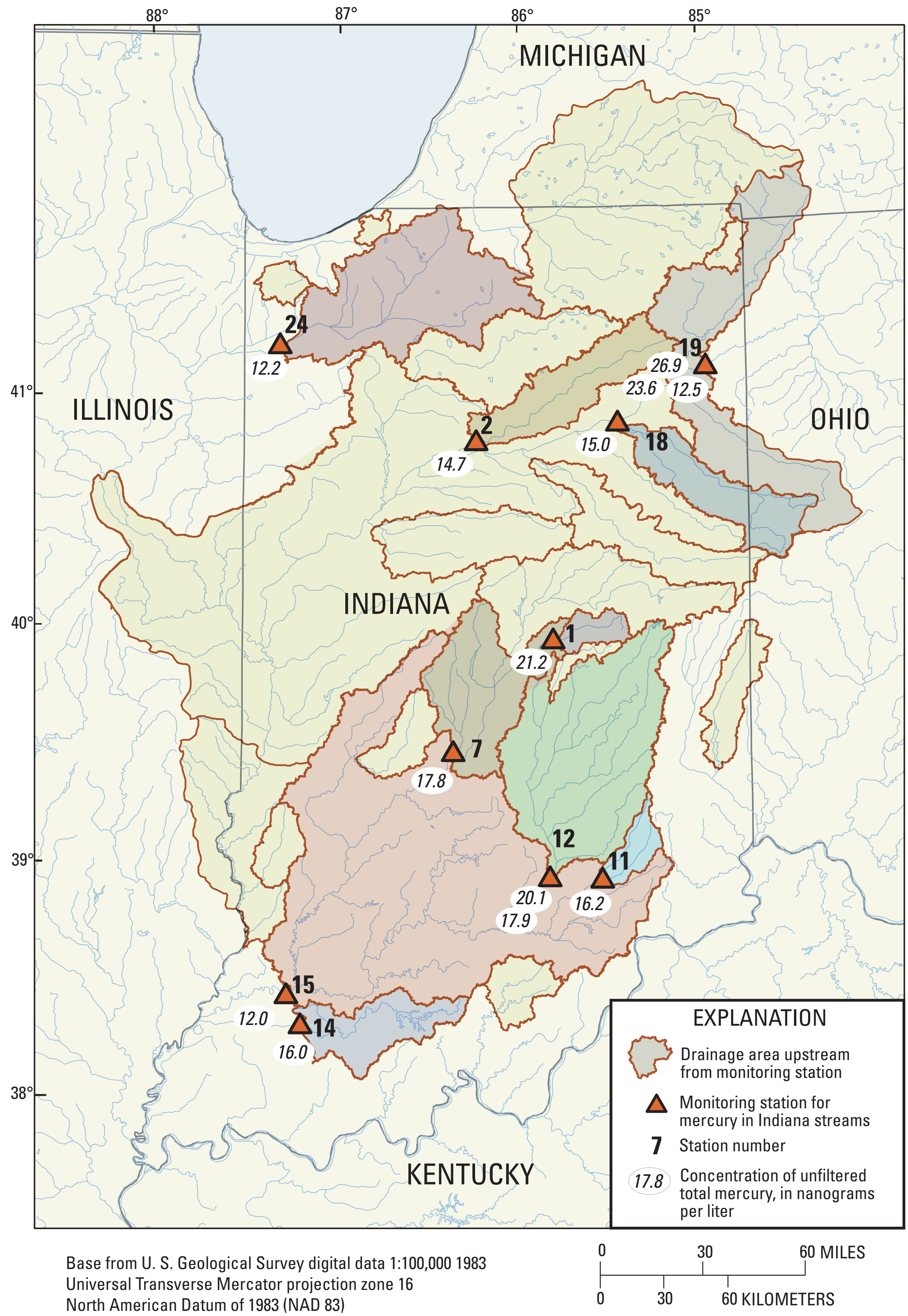


Figure 9. Locations of monitoring stations with unfiltered total mercury concentrations that equaled or exceeded the Indiana chronic aquatic criterion for mercury, August 2004–September 2006.

The monitoring station with mercury concentrations that exceeded the 12 ng/L and 1.3 ng/L standards most frequently was station 19, Maumee River at New Haven, (figs. 1 and 2) in the Great Lakes System, including the two highest concentrations measured August 2004–September 2006 of 26.9 and 23.6 ng/L. Five samples were collected during stable conditions; four samples were collected during changing streamflow hydrograph conditions, including samples with the three highest concentrations. Station 19 is downstream from urban and industrial wastewater discharges (table 3).

Particulate Mercury

Unfiltered mercury is a combination of mercury adsorbed to and entrained in suspended particles (“particulate mercury”) and mercury dissolved in the water. With the methods used in this study, mercury dissolved in the water is measured in water passed through a 0.7-µm nominal pore-size filter. Therefore, in this report, particulate mercury is adsorbed to and entrained in particles larger than 0.7 µm, which includes nearly all sand, silt, and clay suspended sediment particles because only very fine clay is smaller than 0.7 µm (Horowitz, 1991).

Generally, most of the total mercury in the August 2004–September 2006 samples was estimated to be particulate. The median particulate fraction was 78 percent for samples with total mercury concentrations that equaled or exceeded the 12 ng/L Indiana chronic aquatic criterion and 73 percent for samples with total mercury concentrations that equaled or exceeded the 1.3 ng/L Indiana criterion. Among the 225 samples, 84 samples had more than 75 percent particulate total mercury and 15 samples had more than 90 percent. Particulate methylmercury was estimated in 172 of the 225 samples. Of these, 87 samples had more than 75 percent particulate methylmercury and 71 samples had 100 percent particulate methylmercury.

Generally, the fraction of unfiltered total mercury that was estimated to be particulate mercury increased as the turbidity in the water at the time of sample collection increased, as shown in the scatter plot in figure 10. The turbidity of the water samples was classified by range, and the estimated particulate total mercury concentrations were graphed as boxplots for these ranges (fig. 10). The median estimated particulate total mercury in ranges of turbidity more than 20 nephelometric turbidity ratio units (ntru) was higher than the 1.43 ng/L median estimated particulate total mercury in all samples at the 25 stations. In addition, the highest estimated particulate total mercury of more than 12 ng/L, the Indiana chronic aquatic criterion, was in samples with the highest turbidity.

Estimated particulate total mercury and turbidity were significantly higher when streamflow at the time of sample collection was in the high or event statistical category[11] rather than the low or medium statistical category (Kruskal-Wallis test, $p < 0.0001$ and Tukey’s test). Median estimated particulate total mercury was 1.90 ng/L for high streamflow and 3.85 ng/L for event streamflow (fig. 11), exceeding the most conservative Indiana water-quality criterion of 1.3 ng/L. Median turbidity at the time of sample collection was 21 ntru for high streamflow and 48 ntru for event streamflow (fig. 11).

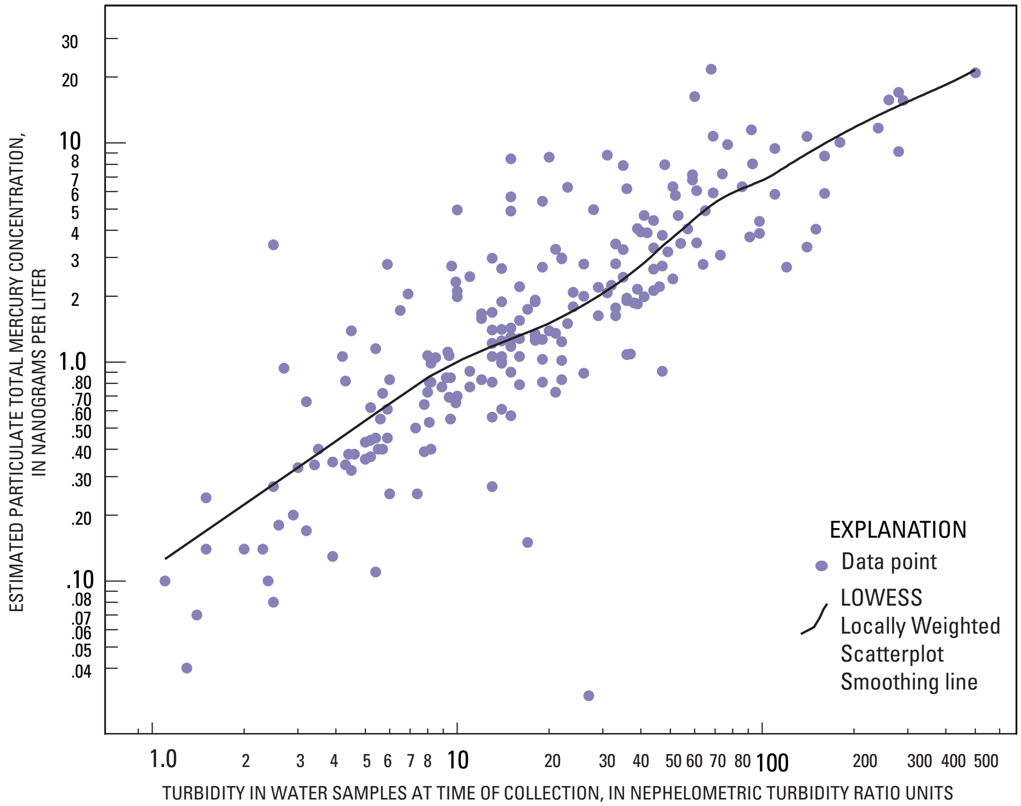
Dams impede streamflow, causing suspended particles to settle and turbidity to decrease. Mercury concentrations were examined in a group of five monitoring stations (6, 10, 17, 18, and 23, figs. 1 and 2, table 3) located within 2.7 miles downstream from dams. The unfiltered total mercury, particulate mercury, and the unfiltered and filtered methylmercury concentrations in 45 samples at monitoring stations downstream from dams were significantly lower[12] than those in 171 samples from stations not downstream from dams[13]. For example, the median unfiltered total mercury was 1.74 ng/L and 50 percent particulate in samples at stations downstream from dams, compared with 2.61 ng/L and 72 percent particulate in the samples from the stations not downstream from dams. Streamflow for samples at stations downstream from dams had a median of 141 ft^3/s and was significantly lower[13] than the streamflow for samples not downstream from dams, where the median was 621 ft^3/s.

---

[11] Streamflow statistical category, for purposes of this report, was based on the daily mean streamflow record from the USGS streamflow-gaging station near each monitoring station, for water years 2004–2006 (October 1, 2003 through September 30, 2006). For five stations, the gage height record was used instead of streamflow. Statistical categories were based on the rank ordered streamflow (or gage-height) data for a monitoring station, and are defined as low (less than or equal to the 10th percentile), medium (greater than the 10th percentile to equal to the median), high (greater than the median to equal to the 90th percentile), and event (greater than the 90th percentile). Instantaneous streamflow at the time of sample collection was placed in one of these four statistical categories. Station 16 was not assigned a streamflow statistical category because data were not available.

[12] The Wilcoxon rank-sum test was computed to examine differences in mercury and methylmercury concentrations and streamflow from stations downstream and not downstream from dams (unfiltered total mercury, $p = 0.003$; unfiltered methylmercury, $p = 0.001$; filtered total mercury, $p=0.284$; filtered methylmercury, $p <0.001$; percent particulate total mercury, $p<0.001$; particulate total mercury, $p<0.001$, and streamflow, $p<0.001$).

[13] Station 22 was frequently affected by flow stagnation and flow reversals influenced by conditions in nearby Lake Michigan, and was excluded from this analysis



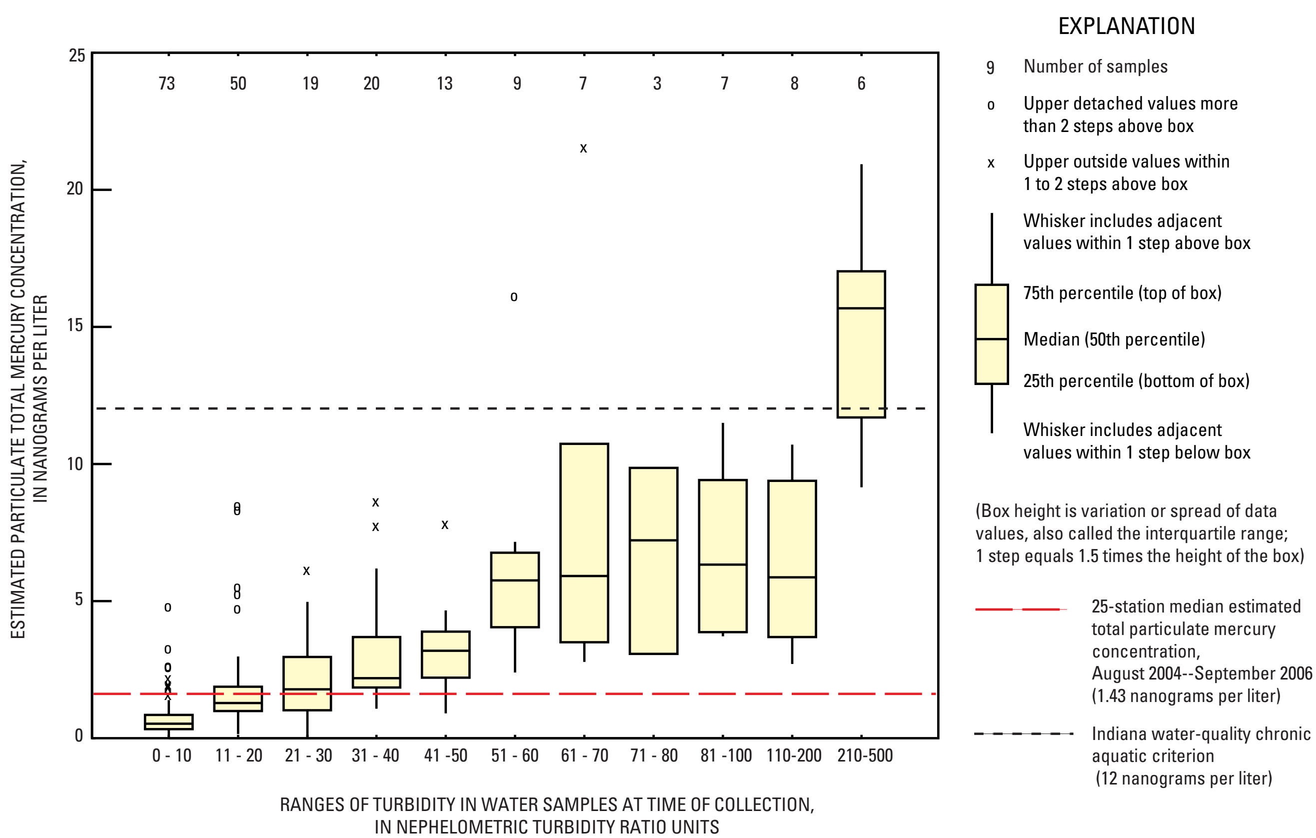


Figure 10. Estimated total particulate mercury and turbidity in water at the time of sample collection at 25 monitoring stations in Indiana, August 2004–September 2006.

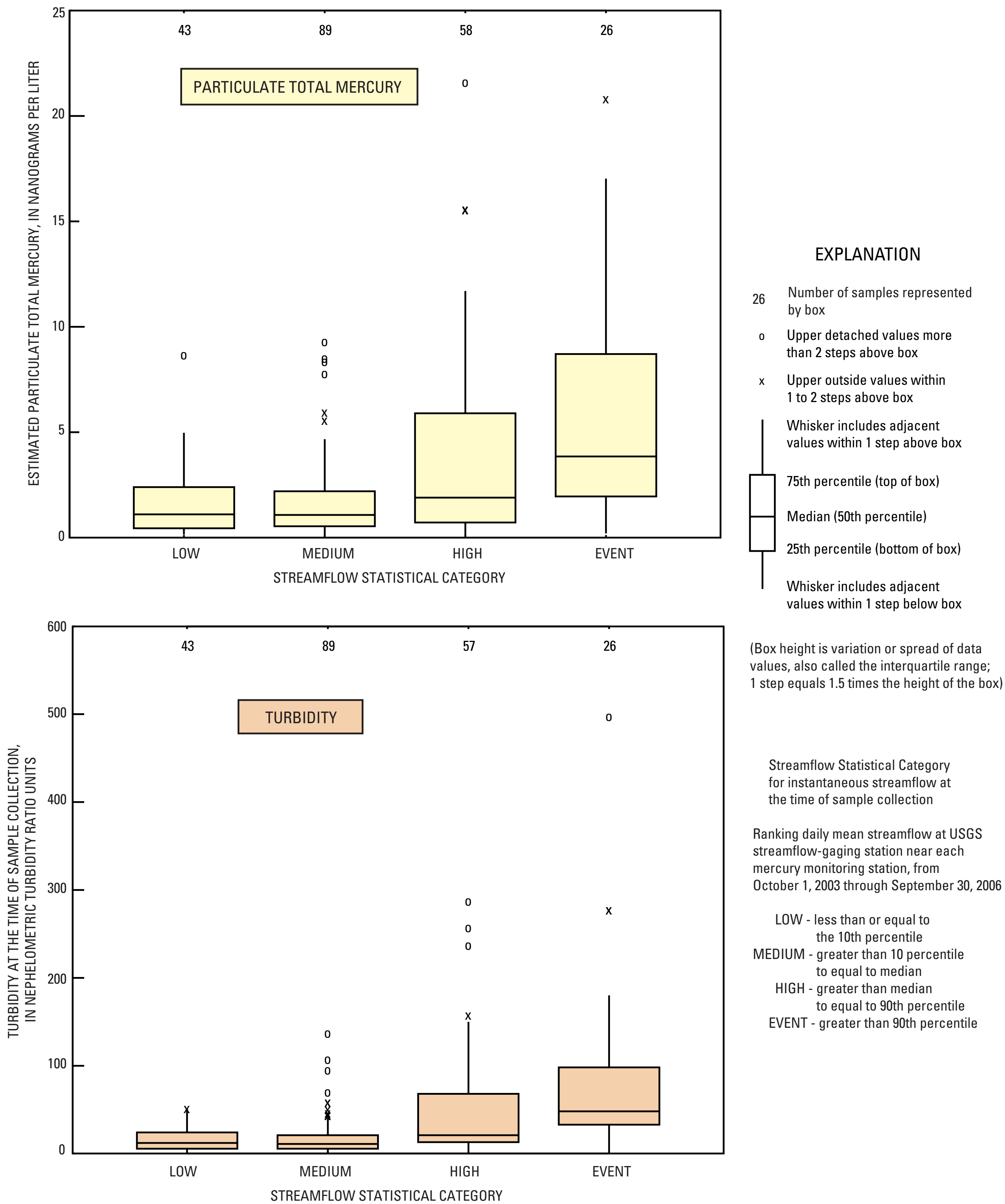


Figure 11. Estimated total particulate mercury and turbidity in water at the time of sample collection by streamflow statistical category for 24 monitoring stations on Indiana streams, August 2004–September 2006.

The observation in this study that higher total mercury and estimated particulate mercury concentrations correspond to higher streamflow and turbidity (representing suspended particles) is similar to observations in previous investigations. The correlations of particulate mercury, streamflow, and suspended particles were reported in a study of Lake Michigan tributaries from 1994 (Hurley and others, 1998), a study of a watershed in Vermont from 2000 (Shanley and others, 2002), and a study of the Grand Calumet River in Indiana, 2001–2002 (Risch, 2005).

Concentrations in Relation to Sampling Locations and Upstream Drainage Areas

Distributions of unfiltered total mercury and unfiltered methylmercury concentrations in the nine samples at each monitoring station during August 2004–September 2006 are displayed in box plots (fig. 12). The plots in fig. 12 show six stations (5, 7, 14, 15, 19, and 25) had the highest distribution of total mercury concentrations, and the 25th percentile for those stations and at least seven of the nine samples were higher than the 2.35 ng/L median for all stations. All 54 unfiltered total mercury concentrations at these 6 stations were higher than the most conservative Indiana water-quality criterion (1.3 ng/L), and 6 concentrations were higher than the 12 ng/L Indiana chronic aquatic criterion. The plots in fig. 12 show five stations (8, 15, 16, 19, and 25) had the highest distribution of methylmercury concentrations[14], and the 25th percentile at those stations and at least seven of the nine samples were higher than or equal to the 0.09 ng/L median for all stations. Station 25 had the most methylmercury concentrations (nine of nine) higher than the 0.09 ng/L median. It should be noted that stations 5, 6, 7, 12, and 18 had five or six concentrations higher than the statewide median and had medians, 75th percentiles, and maximums that were higher than station 8. On the basis of having at least 7 of 9 unfiltered total mercury and unfiltered methylmercury concentrations higher than the statewide median, three stations had the highest distributions (15, 19, and 25, figs. 1 and 2), but stations 5 and 7 could be included in this group too when their overall methylmercury concentrations were considered. By either rating, it can be observed that these three or five stations were downstream from urban and industrial wastewater discharges (table 3).

For descriptive purposes, samples were grouped by the size of their drainage areas (table 2) upstream from the 25 monitoring stations—large (more than 10,000 mi^2), medium (1,000 to 10,000 mi^2), and small (less than 1,000 mi^2). The unfiltered mercury concentrations (table 9) were compared for each group. It was observed that the median unfiltered total mercury and methylmercury concentrations and median streamflow were highest in the samples from the large drainage areas. All of the total mercury concentrations from samples in the large drainage areas equaled or exceeded the most conservative Indiana water-quality criterion, 1.3 ng/L. The medium drainage areas had the highest proportion (13 percent) of the samples with total mercury concentrations that equaled or exceeded the 12 ng/L standard, compared with 3.7 percent from the large drainage areas and 3.4 percent from the small drainage areas.

[14] Concentrations less than the 0.04 ng/L reporting limit were set to one-half of the reporting limit for the plots in figure 12.

Seasonal Variations in Concentrations

The 225 water samples from Indiana streams were collected from summer 2004 through summer 2006. Distributions of unfiltered total mercury and unfiltered methylmercury concentrations in these samples during the four temperate seasons (winter, spring, summer, and fall) were displayed in box plots (fig. 13) and examined statistically. A Kruskal-Wallis test was computed to examine differences among the distributions of unfiltered total mercury and methylmercury concentrations measured during each season. These comparisons indicate that unfiltered total mercury concentrations were significantly higher during spring than fall[15]. For example, the median spring unfiltered total mercury concentration was 2.56 ng/L compared with a 1.36 ng/L median for fall. Most of the concentrations that equaled or exceeded the 12 ng/L Indiana chronic aquatic criterion were collected during winter and spring. The highest mercury concentrations correspond to high median streamflow and highest turbidity during spring (table 10), which potentially could contribute to more transport of particulate mercury. Graphical (fig. 13) and statistical comparisons also indicate that unfiltered methylmercury concentrations were higher during spring and summer than winter and fall[16]. For example, the median spring and summer unfiltered methylmercury concentrations were 0.13 and 0.11 ng/L, compared with 0.07 and 0.05 ng/L for winter and fall. The highest methylmercury concentrations correspond to the highest median water temperatures during spring and summer (table 10), which potentially could contribute to more microbially mediated formation of methylmercury.

[15] The Kruskal-Wallis test confirmed statistically significant differences among seasons for unfiltered total mercury ($p = 0.008$). Tukey's test indicated unfiltered total mercury was higher in spring than fall. Median values were compared to identify which season had higher values when they were statistically different.

[16] The Kruskal-Wallis test confirmed the presence of statistically significant differences among seasons for unfiltered methylmercury ($p < 0.001$). Tukey's test indicated unfiltered methylmercury was higher in spring and summer than winter.

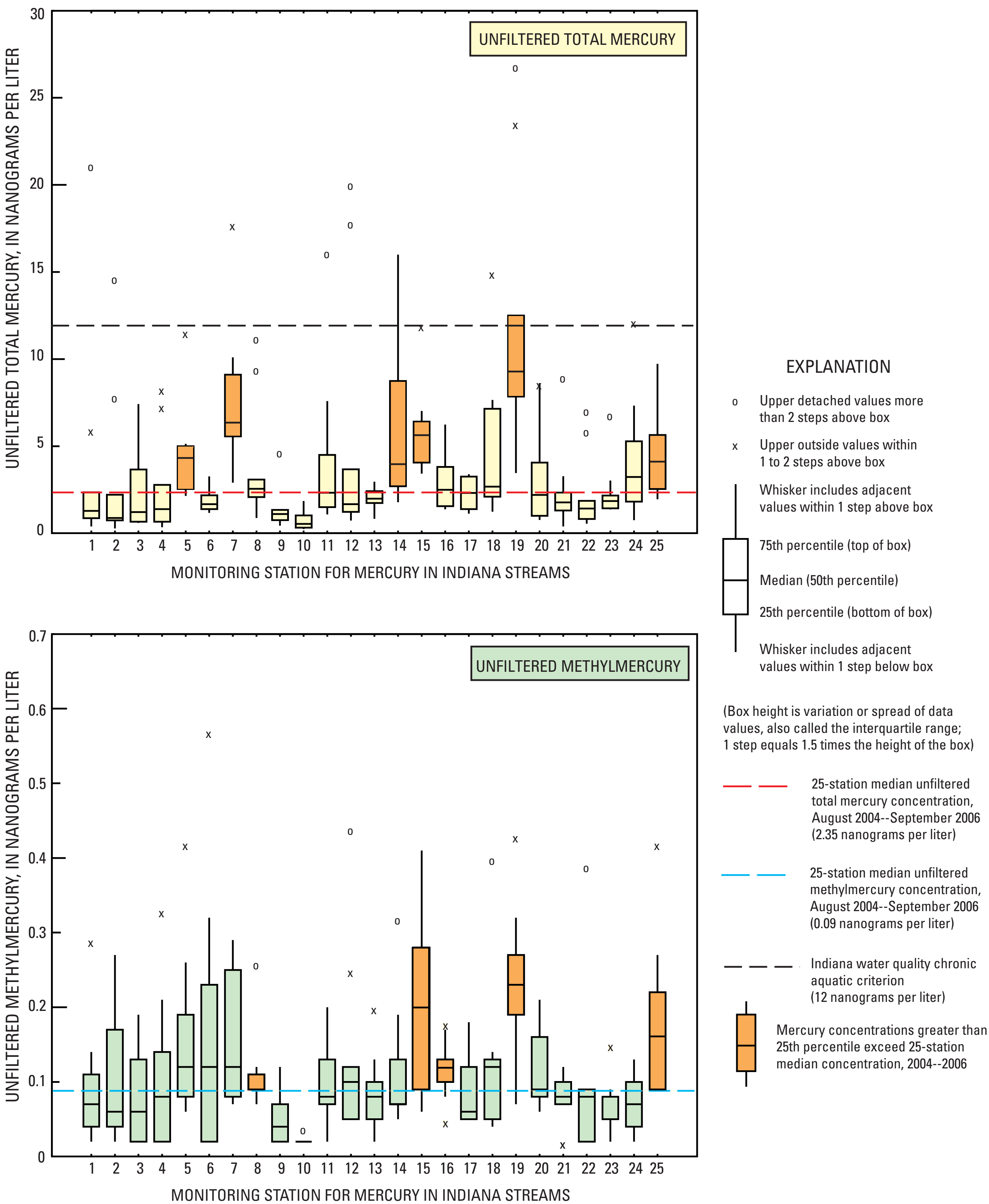


Figure 12. Distributions of concentrations of unfiltered total mercury and unfiltered methylmercury in water samples at 25 monitoring stations in Indiana, August 2004–September 2006.

Table 9. Mercury concentrations and instantaneous streamflow for samples from Indiana streams, August 2004–September 2006, grouped by drainage area upstream from monitoring station.

[mi^2, square mile; ng/L, nanograms per liter; ft^3/s, cubic foot per second; ≥, greater than or equal to; IWQC, Indiana water–quality criterion; NA, not applicable; RL, reporting limit; —, no data]

Drainage area upstream from monitoring station (mi^2)	Number of samples	Descriptive statistic	Unfiltered total mercury (ng/L)	Unfiltered methylmercury (ng/L)	Instantaneous streamflow[1] (ft^3/s)
Large—more than 10,000	27	Median	4.32	0.16	7,220
		Minimum	1.95	.06	1,780
		Maximum	12.0	.42	35,200
		Number ≥12 ng/L IWQC	1	NA	—
		Number ≥1.3 ng/L IWQC	27	NA	—
		Number <0.04 ng/L RL	0	0	—
Medium—1,000 to 10,000	54	Median	3.28	.10	1,270
		Minimum	.39	<.04	106
		Maximum	26.9	.44	8,140
		Number ≥12 ng/L IWQC	7	NA	—
		Number ≥1.3 ng/L IWQC	46	NA	—
		Number <0.04 ng/L RL	0	5	—
Small—Less than 1,000	144	Median	1.74	.08	151
		Minimum	.24	<.04	49
		Maximum	21.0	.57	3,730
		Number ≥12 ng/L IWQC	5	NA	—
		Number ≥1.3 ng/L IWQC	97	NA	—
		Number <0.04 ng/L RL	0	33	—

[1]Small drainage area does not include streamflow from station 22, which was affected by flow reversals and flow stagnation.

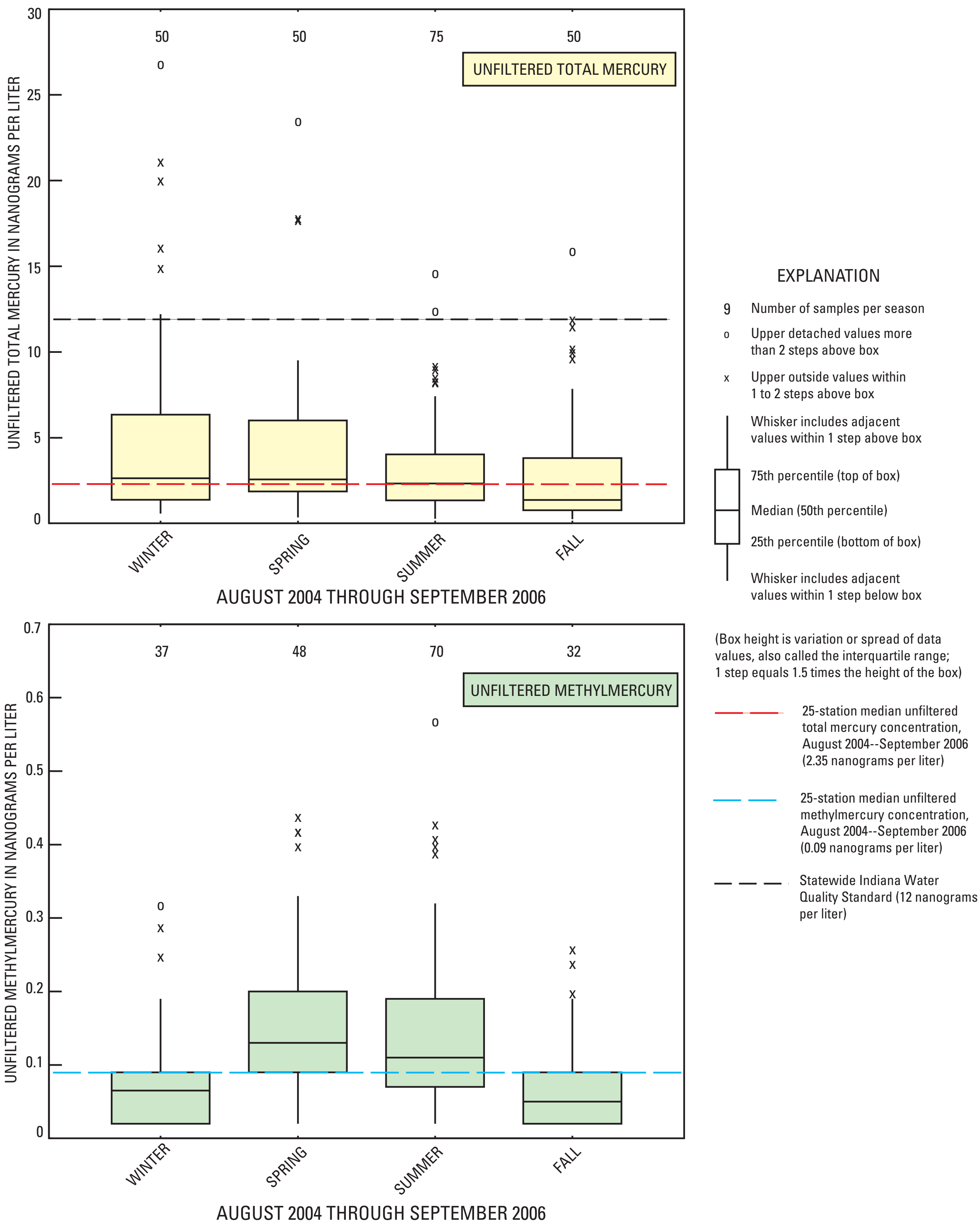


Figure 13. Distributions of concentrations of unfiltered total mercury and unfiltered methylmercury in water samples during four seasons in Indiana, August 2004–September 2006.

Concentrations in Relation to Water-Quality Characteristics and Streamflow

Water-quality characteristics were measured at the time of sample collection (table 11 shows all monitoring stations, table 12 shows each monitoring station). In the following discussion, pH, specific conductance, and turbidity are summarized and compared with mercury concentrations.

Values of pH indicated neutral to alkaline waters and ranged from 7.0 to 8.7 standard units, with a median value of 7.8 (table 11). Some differences in mercury concentrations were noted for groups of samples that had the lowest pH values (in the 10th percentile, less than or equal to 7.4 standard units) and the highest pH values (in the 90th percentile, more than or equal to 8.2 standard units). Station 14, Patoka River at Winslow (figs. 1 and 2), is downstream from active and abandoned mine lands and had the lowest median pH (7.2

Table 10. Median concentrations of mercury in water samples and median streamflow and median water–quality characteristics at the time of sample collection during four seasons in Indiana, August 2004–September 2006.

[ng/L, nanograms per liter; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; ^{o}C, degree Celsius; ntru, nephelometric turbidity ratio unit]

Parameter	Winter	Spring	Summer	Fall
Unfiltered total mercury (ng/L)	2.63	2.56	2.32	1.36
Unfiltered methylmercury (ng/L)	.07	.13	.11	.05
Instantaneous streamflow[1] (ft^3/s)	1,340	553	172	361
pH (standard unit)	7.8	7.9	7.9	7.8
Specific conductance (µS/cm)	550	593	599	661
Water temperature (^{o}C)	5.34	19.0	22.6	9.40
Turbidity (ntru)	17	20	15	9.6

[1] Station 22 was frequently affected by flow stagnation and flow reversals influenced by conditions in nearby Lake Michigan; station 22 was therefore excluded from the statistics for streamflow.

Table 11. Summary statistics for water–quality characteristics and streamflow in water samples from 25 monitoring stations in Indiana, August 2004–September 2006.

[µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; C, Celsius; ntru, nephelometric turbidity ratio unit]

Summary statistic	pH (standard units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Water temperature (degrees C)	Turbidity (ntru)	Streamflow[1] (ft^3)s)
Maximum	8.7	1,280	14.5	30.7	500	35,200
90th percentile	8.2	856	13.0	24.7	74	5,730
75th percentile	8.0	704	11.6	22.5	39	1800
50th percentile (median)	7.8	605	9.4	16.2	16	438
25th percentile	7.7	491	7.7	6.7	8	99
Minimum	7.0	180	4.4	–.3	1	4.9

[1] Station 22 was frequently affected by flow stagnation and flow reversals influenced by conditions in nearby Lake Michigan; station 22 was therefore excluded from the statistics for streamflow.

Table 12. Ranges and medians of water–quality characteristics and streamflow from 25 monitoring stations in Indiana, August 2004–September 2006.

[µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; ºC, Celsius; ntru, nephelometric turbidity ratio unit; ft³/s. cubic foot per second]

Monitoring station number	pH (standard units)		Specific conductance (µS/cm)		Dissolved oxygen (mg/L)		Temperature (ºC)		Turbidity (ntru)		Streamflow (ft³/s)	
	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median
1	7.4–8.1	7.8	368–832	746	6.4–13.0	8.4	1.4–23.3	11.9	2.3–280	13	28–1,660	78
2	7.5–8.3	7.9	365–804	684	6.5–14.1	10.9	–0.2–22.6	13.6	1.5–140	5.7	115–3,730	378
3	7.5–8.2	8.0	511–657	606	6.9–14.1	8.8	3.8–23.8	18.6	2.5–36	5.7	172–2,430	597
4	7.6–8.3	8.0	607–866	681	7.8–13.3	9.6	–0.3–22.8	12.8	2.5–74	8.1	67–2,470	409
5	7.8–8.7	8.0	508–663	597	5.5–13.8	11.2	5.3–30.7	19.3	32–73	39	2,130–26,700	7,220
6	7.1–7.9	7.4	287–445	310	6.8–14.5	9.1	4.5–25.1	16.4	8.2–17	13	12–632	113
7	7.4–8.2	7.8	561–1,280	999	7.2–11.7	9.7	4.1–26.4	17.9	6.9–60	15	570–7,480	975
8	7.7–8.2	7.8	472–969	865	6.6–13.8	9.2	1.3–26.9	14.8	4.3–77	12	227–5,010	516
9	7.7–8.2	7.9	508–728	632	7.1–14.0	9.6	0.6–25.7	12.9	4.3–33	6.0	9.3–346	21
10	7.6–8.3	7.8	418–503	472	7.7–13.8	10.2	3.9–21.8	13.4	1.1–14	2.9	50–2,010	307
11	7.4–8.4	7.9	180–729	385	6.5–13.9	8.9	1.8–26.7	14.3	2.5–180	9.3	4.9–2,030	65
12	7.7–8.3	7.9	334–709	640	7.5–13.3	9.4	3.2–27.5	16.2	5.2–290	9.9	362–6,740	1,090
13	7.4–7.9	7.7	332–520	435	6.2–13.2	8.2	3.4–24.3	15.8	3.5–18	14	10–351	33
14	7.1–7.5	7.2	235–626	350	5.2–12.7	7.5	4.4–25.9	17.1	15–240	48	47–1,240	311
15	7.6–8.2	8.0	460–831	545	6.9–14.5	9.9	5.5–28.7	18.6	22–110	47	1,780–15,100	7,650
16	7.2–8.0	7.6	603–1,280	863	5.4–12.2	7.3	3.2–24.1	17.0	14–57	27	14–244	84
17	7.4–8.0	7.8	458–575	511	4.5–13.2	9.7	3.4–24.5	14.0	5.2–41	21	89–2,020	248
18	7.5–8.2	7.9	478–708	591	7.5–13.5	10.1	0.6–28.1	15.7	26–280	46	25–2,290	133
19	7.4–7.8	7.7	384–905	580	4.4–12.5	9.3	–0.1–24.5	14.5	22–500	68	106–8,140	1,300
20	7.0–8.2	7.9	373–692	619	6.6–12.3	8.4	–0.2–20.9	14.0	4.4–98	21	6.4–592	59
21	7.4–8.2	7.9	496–668	586	7.1–13.3	9.7	0.0–23.5	16.1	2.0–59	4.5	1,060–6,030	1,920

Table 12. Ranges and medians of water-quality characteristics and streamflow from 25 monitoring stations in Indiana, August 2004–September 2006.—Continued

[μS/cm, microsiemens per centimeter; mg/L, milligrams per liter; °C, Celsius; ntru, nephelometric turbidity ratio unit; ft^3/s. cubic foot per second]

Monitoring station number	pH (standard units)		Specific conductance (μS/cm)		Dissolved oxygen (mg/L)		Temperature (°C)		Turbidity (ntru)		Streamflow (ft^3/s)	
	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median
22	7.5–8.2	7.8	610–854	757	7.5–13.7	9.4	2.1–21.7	14.0	4.1–45	9.9	−282[1]–583	49
23	7.3–8.5	7.9	520–939	666	6.0–12.2	9.9	1.5–24	18.4	12–91	18	15–417	36
24	7.7–8.0	7.8	522–766	662	7.4–12.7	8.7	−0.3–22.9	16.7	5.9–160	19	629–3,440	1,590
25	7.6–8.6	8.2	487–629	597	7.7–14.5	11.6	4.4–28	18.8	24–98	49	2,340–35,200	6,050

[1]Instantaneous streamflow from station 22 includes positive values indicating a flow direction downstream toward nearby Lake Michigan and negative values indicating a flow direction upstream from Lake Michigan that were influenced by water levels in Lake Michigan.

standard units) and had eight pH values among the lowest pH of all samples. Median unfiltered total mercury in these eight samples at station 14 was 4.29 ng/L, higher than the median of 2.35 ng/L for all samples and the median of 3.29 ng/L for samples with the lowest pH. In contrast, median unfiltered total mercury was 1.49 ng/L in the samples with the highest pH values.

Values of specific conductance ranged from 180 to 1,280 μS/cm, with a median of 605 μS/cm (table 11). Median specific conductance was highest during fall, 661 μS/cm, and lowest during winter, 550 μS/cm (table 10). Most of the samples that had the highest specific conductance (in the 90th percentile, more than or equal to 857 μS/cm) were at station 7, White River at Centerton (seven samples), station 8, White River near Nora (six samples), and station 16, Busseron Creek near Carlisle (six samples). These three stations (figs. 1 and 2) also had the highest median specific conductance for August 2004–September 2006; median specific conductance was 999 μS/cm at station 7, 865 μS/cm at station 8, and 863 μS/cm at station 16. The median unfiltered total mercury at station 7 was 6.34 ng/L, which is higher than the median unfiltered total mercury of 2.55 ng/L at station 8 and 2.49 ng/L at station 16. Station 7 is downstream from urban and industrial wastewater discharges (table 3), which potentially could contribute to its high specific conductance and unfiltered total mercury. Most of the samples with the lowest specific conductance (in the 10th percentile, less than 377 μS/cm) were at station 6, Mill Creek at tailwater pool near Manhattan, and station 14, Patoka River at Winslow.

Values of turbidity ranged from 1.1 to 500 ntru, with a 16 ntru median (table 11). Median turbidity differed substantially among seasons (table 10), and it was highest during spring (20 ntru). As noted previously, the median fraction of total mercury that was estimated to be particulate increased in ranges of turbidity greater than 20 ntru, where turbidity potentially could indicate more transport of particulate mercury (fig. 11). The samples with the highest turbidity (in the 90th percentile, greater than or equal to 74 ntru) include most of the highest unfiltered total mercury concentrations. Stated in another way, 15 of the 23 highest unfiltered total mercury concentrations were in samples with the highest turbidity values (table 13). Station 19, Maumee River at New Haven, had the most samples with high turbidity.

Streamflow[17] ranged from 4.9 to 35,200 ft^3/s, with a median of 438 ft^3/s. Median streamflow differed substantially among seasons (table 10), and it was highest during winter. Median mercury concentrations and methylation efficiency were related to streamflow statistical category (table 14), as described in the following discussion.

[17] Station 22, Trail Creek at Michigan City Harbor was frequently affected by flow stagnation and flow reversal influenced by conditions in nearby Lake Michigan and was therefore excluded from summary statistics for streamflow.

Table 13. Highest unfiltered total mercury concentrations in water samples from Indiana streams, August 2004–September 2006, and turbidity at the time of sample collection.

[ng/L, nanograms per liter; ntru, nephelometric turbidity ratio unit]

Monitoring station number	Station name	Date of sample collection (month/day/year)	Unfiltered total mercury (ng/L)	Turbidity (ntru)	Turbidity in 90th percentile
19	Maumee River at New Haven	03/14/2006	26.9	500	Yes.
19	Maumee River at New Haven	05/23/2006	23.6	68	No.
1	Fall Creek near Fortville	03/10/2006	21.2	280	Yes.
12	White River at State Road 258 near Seymour	03/09/2006	20.1	290	Yes.
12	White River at State Road 258 near Seymour	05/11/2006	17.9	260	Yes.
7	White River near Centerton	05/16/2006	17.8	60	No.
11	Vernon Fork Muscatatuck River at Vernon	03/09/2006	16.2	180	Yes.
14	Patoka River at Winslow	10/28/2004	16.0	240	Yes.
18	Wabash River at County Road 200 West near Huntington	03/13/2006	15.0	280	Yes.
2	Eel River near Logansport	08/30/2004	14.7	140	Yes.
19	Maumee River at New Haven	08/29/2006	12.5	92	Yes.
24	Kankakee River at Shelby	03/16/2006	12.2	160	Yes.
15	White River at Petersburg	10/28/2004	12.0	110	Yes.
5	Wabash River at U.S. Highway 40 at Terre Haute	11/03/2004	11.6	69	No.
8	White River near Nora	03/10/2006	11.3	77	Yes.
14	Patoka River at Winslow	11/30/2005	10.3	160	Yes.
7	White River near Centerton	10/14/2004	10.1	20	No.
25	Wabash River at Vigo Street at Vincennes	11/04/2004	9.73	93	Yes.
19	Maumee River at New Haven	03/08/2005	9.64	110	Yes.
8	White River near Nora	05/15/2006	9.51	59	No.
19	Maumee River at New Haven	08/30/2005	9.28	31	No.
7	White River near Centerton	08/24/2004	9.10	15	No.
21	St. Joseph River at Elkhart	03/15/2006	9.05	59	No.

Table 14. Median mercury concentrations and methylation efficiency in water samples from Indiana streams, August 2004–September 2006, by streamflow statistical category.

[Streamflow statistical category for 216 samples, excluding 9 samples from station 16; ng/L, nanograms per liter]

Streamflow statistical category	Median unfiltered total mercury (ng/L)	Median unfiltered methylmercury (ng/L)	Median estimated particulate total mercury (ng/L)	Median estimated particulate methylmercury (ng/L)	Median methylation efficiency (percent)
Low flow	1.56	0.10	1.11	0.06	6.0
Medium flow	1.82	.09	1.08	.05	4.7
High flow	3.29	.09	1.90	.09	2.4
Event flow	7.02	.14	3.85	.08	2.0

Unfiltered total mercury was significantly higher when streamflow at the time of sample collection was in the high or event statistical category[18] rather than the low or medium statistical category (Kruskal-Wallis test, $p < 0.001$ and Tukey's test). Median unfiltered total mercury was 3.29 ng/L for high streamflow and 7.02 ng/L for event streamflow (fig. 14). Unfiltered total mercury concentrations that exceeded the Indiana water-quality chronic aquatic criterion of 12 ng/L were all from samples collected during high or event streamflow. Unfiltered methylmercury was not significantly different among the streamflow statistical categories (Kruskal-Wallis test, $p = 0.15$). However, methylation efficiency was significantly higher if streamflow at the time of sample collection was in the low or medium statistical category rather than the high or event statistical category (Kruskal-Wallis test, $p < 0.001$ and Tukey's test). Median methylation efficiency was 6 percent for low streamflow and 4.7 percent for medium streamflow (fig. 14). As noted previously, the median fraction of total mercury that was estimated to be particulate mercury was highest during high and event streamflow, when streamflow potentially could contribute to more transport of particulate mercury (fig. 11).

[18] Streamflow statistical category, for purposes of this report, was based on the daily mean streamflow record from the USGS streamflow-gaging station near each monitoring station, for water years 2004–2006 (October 1, 2003 through September 30, 2006). For five stations, the gage height record was used instead of streamflow. Statistical categories were based on the rank ordered streamflow (or gage-height) data for a monitoring station, and are defined as low (less than or equal to the 10th percentile), medium (greater than the 10th percentile to equal to the median), high (greater than the median to equal to the 90th percentile), and event (greater than the 90th percentile). Instantaneous streamflow at the time of sample collection was placed in one of these four statistical categories. Station 16 was not assigned a streamflow statistical category because data were not available.

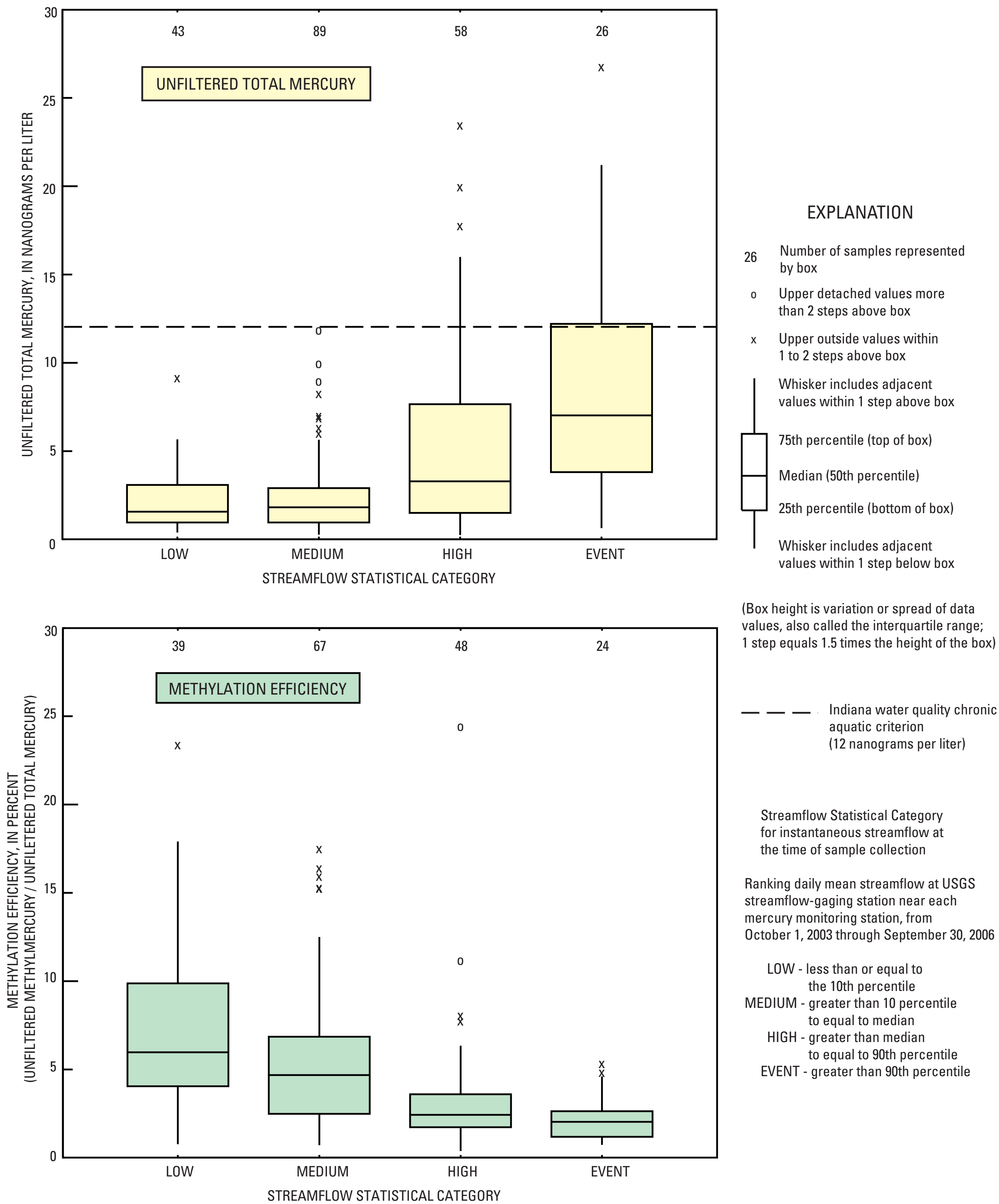


Figure 14. Unfiltered total mercury and methylation efficiency by streamflow statistical category, for 24 monitoring stations on Indiana streams, August 2004–September 2006.

Summary

A monitoring program for mercury in Indiana streams was operated by the U.S. Geological Survey (USGS) in cooperation with the Indiana Department of Environmental Management (IDEM). Total mercury and methylmercury concentrations were determined by use of low (subnanogram per liter) level analytical methods in 225 representative water samples collected following ultraclean protocols at 25 stations in a statewide monitoring network, August 2004–September 2006. These samples represent the major hydrologic systems in Indiana and were collected during multiple seasons and a range of streamflow conditions. Data from 89 quality-control samples indicated there were few, if any, biases in the mercury concentrations caused by artifacts from sampling and processing or interference from the sampling matrix and that precision of the reported concentrations was not substantially affected by natural variability or variability from sampling and processing.

Unfiltered total mercury ranged from 0.24 to 26.9 ng/L, with a median of 2.35 ng/L. The highest concentrations (in the 90th percentile) of unfiltered total mercury were more than 9.05 ng/L, and the majority of these concentrations were from samples collected during winter and spring 2006 during changing streamflow hydrograph conditions. Samples with 15 of the 23 highest unfiltered total mercury concentrations had the highest turbidity values, greater than or equal to 74 ntru, at the time of sample collection. Streamflow at the time of sample collection for most of the highest concentrations was in the high or event statistical category.

Unfiltered methylmercury was detected in 83 percent of samples, and reported concentrations ranged from 0.04 to 0.57 ng/L, with a median of 0.09 ng/L. The highest concentrations of methylmercury were more than 0.25 ng/L, and most of these samples were collected during spring and summer during changing streamflow hydrograph conditions.

Unfiltered total mercury concentrations equaled or exceeded the Indiana chronic aquatic criterion of 12 ng/L in 5.8 percent of the samples and at 10 of the 25 monitoring stations. Of the 13 samples with concentrations that equaled or exceeded this criterion, most were collected during winter and spring 2006 during changing streamflow hydrograph conditions. Of the 10 monitoring stations where mercury concentrations equaled or exceeded the 12 ng/L criterion, 5 were downstream from urban and industrial wastewater discharges and 5 were downstream from rural and agricultural land use. Unfiltered total mercury concentrations equaled or exceeded the most conservative Indiana water-quality criterion of 1.3 ng/L in 73 percent of samples.

Particulate mercury concentrations were estimated in these samples by subtracting the filtered concentration from the unfiltered concentration. Generally, most of the total mercury that equaled or exceeded the 12 ng/L Indiana chronic aquatic criterion and the 1.3 ng/L Indiana water-quality criterion was particulate, which is defined as greater than 0.7 µm in diameter, the size of very fine clay. The median fraction of unfiltered mercury that was particulate was highest in samples in which turbidity was more than 20 ntru and when streamflow at the time of sample collection was in the high or event statistical category.

Methylation efficiencies were computed for 187 samples with reported concentrations of both unfiltered total and unfiltered methylmercury. Methylation efficiencies ranged from 0.4 to 24.6 percent, with a median of 3.7 percent. Methylation efficiency was less than 5.0 percent in 63 percent of samples. Four of the highest methylation efficiency values, including the two highest values (23.5 and 24.6 percent), were from samples collected at station 6—Mill Creek at tailwater pool near Manhattan. The highest methylation efficiencies (21 of 23) were in samples collected when streamflow was in the low and medium statistical categories.

Samples from six stations had the highest distribution of total mercury concentrations—at least seven of the nine samples for these stations were greater than the 2.35 ng/L median for all stations. These stations were station 5, Wabash River at U.S. Highway 40 at Terre Haute; 7, White River near Centerton; 14, Patoka River at Winslow; 15, White River at Petersburg; 19, Maumee River at New Haven; and 25, Wabash River at Vigo Street at Vincennes. With the exception of station 14, all of these stations were downstream from urban and industrial wastewater discharges in upstream drainage areas of more than 1,960 mi^2. Station 14 is downstream from active and abandoned mine lands in an upstream drainage area of 602 mi^2.

The monitoring station with mercury concentrations that exceeded the 12 ng/L and 1.3 ng/L Indiana water-quality criterion most frequently was station 19, Maumee River at New Haven, and the two highest unfiltered total mercury concentrations, 26.9 and 23.6 ng/L, were in samples from this station. Station 19 had the most methylmercury concentrations greater than the 0.09 ng/L median for all samples, the most samples with the highest turbidity (more than or equal to 74 ntru), and the sample with the highest turbidity (500 ntru). Station 19 is downstream from urban and industrial wastewater discharges. Samples at station 7, White River near Centerton, had a median of 6.34 ng/L total mercury, the highest median specific conductance of 999 µS/cm, and seven of the highest specific conductance values for all samples. Station 7 also is downstream from urban and industrial wastewater discharges.

Unfiltered total mercury concentrations were statistically higher during spring than fall. High median instantaneous streamflow and turbidity potentially indicate conditions for the most transport of particulate mercury. Methylmercury concentrations were statistically higher during spring and summer than during winter. High median water temperatures in these seasons potentially indicate conditions for the most microbially mediated formation of methylmercury.

At five monitoring stations located within 2.7 miles downstream from dams, concentrations of unfiltered total mercury, particulate mercury, and the unfiltered and filtered methylmercury were significantly lower than at stations not downstream from dams. Streamflow for samples at stations downstream from dams was significantly lower as well.

The results from monitoring of total mercury and methylmercury in Indiana streams, August 2004–September 2006, are presented with results from previous studies in the following comparisons. In general, the results from August 2004–September 2006 do not differ substantially from results of studies in Indiana and other states during 1994–2004.

- The median concentration of unfiltered total mercury of 2.35 ng/L in 225 samples, August 2004–September 2006, was similar to median unfiltered total mercury of 2.23 ng/L in 187 samples collected by the IDEM, 2002–2004. The range of concentrations of 0.24 to 26.9 ng/L during August 2004–September 2006 and 0.19 to 28.1 ng/L during 2002–2004 also was similar. Median total mercury, August 2004–September 2006, was similar to the median for the nationwide study in 1998 of 2.3 ng/L and slightly less than the median of 2.6 ng/L from the statewide study in Wisconsin, 1993–1994.

- The proportion of samples from Indiana streams in which total mercury equaled or exceeded the 12 ng/L chronic aquatic criterion was 5.8 percent and was slightly higher in August 2004–September 2006 than in samples collected by the IDEM, 2002–2004, 4.9 percent.

- The median concentration of unfiltered methylmercury in 187 samples, August 2004–September 2006, was 0.09 ng/L, which was nearly one-half the median methylmercury of 0.17 ng/L in 65 samples collected by the IDEM, 2002–2004. Median methylmercury, August 2004–September 2006, was slightly higher than the median of 0.06 ng/L for the nationwide study in 1998 and slightly less than the median of 0.11 ng/L from the statewide study in Wisconsin, 1993–1994.

- Median methylation efficiencies of 3.7 percent between August 2004–September 2006 and 3.6 percent in 2002–2004 were similar, but both medians were higher than the median of 0.6 percent for the Grand Calumet River/Indiana Harbor Canal in Indiana in 2001–2002.

- In this study from August 2004 through September 2006, it was observed that higher total mercury and particulate mercury concentrations correspond to higher instantaneous streamflow and turbidity (representing suspended particles). This observation is similar to the correlations of particulate mercury, streamflow, and suspended particles reported in a study of Lake Michigan tributaries from 1994, and a study of the Grand Calumet River in Indiana, 2001–2002.

Acknowledgments

The authors acknowledge the capable assistance and technical support of Tim Beckman of the IDEM Office of Water Management, who participated in most of the field activities of the monitoring. Art Garceau, Dennis Clark, and Steve Boswell of the IDEM Office of Water Management designed the monitoring network. Mark Olson and John DeWild of the USGS Mercury Research Laboratory provided extensive technical support regarding sample preparation and data management. Richard Duwelius, Tim Willoughby, Bret Robinson, and Lee Watson of the USGS Indiana Water Science Center were key to the scientific techniques, safety, and logistics used in the monitoring. The authors are most grateful to Scott Lowe, Cheryl Silcox, Kathleen Fowler and Don Leer of the USGS Indiana Water Science Center, who helped collect and process the more than 300 water samples and quality-control samples described in this report.

References Cited

Babiarz, C.L., Hurley, J.P., Benoit, J.M., Shafer, M.M., Andren, A.W., and Webb, D.A., 1998, Seasonal influences on partitioning and transport of total and methylmercury in rivers from contrasting watersheds: Biogeochemistry, v. 41, no. 3, p. 237–257.

Brightbill, R.A., Riva-Murray, K., Bilger, M.D., and Byrnes, J.D., 2004, Total mercury and methylmercury in fish fillets, water, and bed sediments from selected streams in the Delaware River Basin, New Jersey, New York, and Pennsylvania, 1998–2001: U.S. Geological Survey Water-Resources Investigations Report 03–4183, 30 p.

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.

Brumbaugh, W.G., Krabbenhoft, D.P., Helsel, D.R., Wiener, J.G., and Echols, K.R., 2001, A national pilot study of mercury contamination of aquatic ecosystems along multiple gradients— Bioaccumulation in fish: U.S. Geological Survey, Biological Science Report 2001–009, 28 p.

Clark, G.D., ed., 1980, The Indiana water resource—Availability, uses, and needs: Indianapolis, Ind., Department of Natural Resources, 1,508 p.

DeWild, J.F., Olson, M.L., and Olund, S.D., 2002, Determination of methylmercury by aqueous phase ethylation, followed by gas chromatographic separation with cold vapor atomic fluorescence detection: U.S. Geological Survey Open-File Report 01–445, 19 p.

Evers, D.C., 2005, Mercury connections: the extent and effects of mercury pollution in northeastern North America: Biodiversity Research Institute, Gorham, Maine, 29 p.

Harris, R.C., Rudd, J.W.M., Amyot, M., Babiarz, C.L., Beaty, K.G., Blanchfield, P.J., Bodaly, R.A., Branfireun, B.A., Gilmour, C.C., Graydon, J.A., Heyes, A., Hintelmann, H., Hurley, J.P., Kelly, C.A., Krabbenhoft, D.P., Lindberg, S.E., Mason, R.P., Paterson, M.J., Podemski, C.L., Robinson, A., Sandilands, K.A., Southworth, G.R., St. Louis, V.L., and Tate M.T., 2007, Whole-ecosystem study shows rapid fish-mercury response to changes in mercury deposition: Proceedings of the National Academy of Science of the United States of America, v. 104, no. 42, p. 16,586–16,591.

Helsel, D.R., and Hirsch, R.M., 1995, Statistical methods in water resources (2d printing): Amsterdam, Elsevier Science Publishers, 529 p.

Horowitz, A.J., 1991, A primer on sediment-trace element chemistry: Chelsea, Mich., Lewis Publishers, 136 p.

Horowitz, A.J., Demas, C.R., Fitzgerald, K.K., Miller, T.L., and Rickert, D.A., 1994, U.S. Geological Survey protocol for the collection and processing of surface-water samples for the subsequent determination of inorganic constituents: U.S. Geological Survey Open-File Report 94–539, 57 p.

Hurley, J.P., Cowell, S.E., Shafer, M.M. and Hughes, P.E., 1998, Tributary loading of mercury to Lake Michigan: Importance of seasonal events and phase partitioning: Science of the Total Environment, v. 213, p. 129–137.

Indiana Administrative Code, 2007a, Title 327, Article 2, Rule 1, Minimum surface water quality standards, Section 6 (a)(3), Table 6–1, Surface water quality criteria for specific substances:, accessed August 9, 2007, at URL *http://www.in.gov/legislative/iac/T03270/A00020.PDF*

Indiana Administrative Code, 2007b, Title 327, Article 2, Rule 1.5, Water quality standards applicable to all state waters within the Great Lakes system, Section 8, Minimum surface water quality criteria, Table 8–3 Water-quality criteria for protection of human health, and Table 8–4, Water-quality criteria for protection of wildlife: accessed August 9, 2007, at URL *http://www.in.gov/legislative/iac/T03270/A00020.PDF*

Indiana Administrative Code, 2007c, Title 327, Article 2, Rule 1, Section 11 (b)(9), Limited and exceptional use; designated waters: accessed August 9, 2007, at URL *http://www.in.gov/legislative/iac/T03270/A00020.PDF*

Indiana Business Research Center, 2007, STATS Indiana: Indiana University Kelley School of Business, accessed August 23, 2007, at URL *http://www.stats.indiana.edu*

Indiana Department of Environmental Management, 2006, Indiana integrated water quality monitoring and assessment report: accessed August 23, 2007, at URL *http://www.in.gov/idem/programs/water/305b/2006integrept/ir_narrative.doc*

Indiana State Department of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources, 2006, Indiana fish consumption advisory: 24 p.

Indiana State Department of Health, 2008, Indiana fish consumption advisory: accessed July 7, 2008, at URL *http://www.in.gov/isdh/files/2008_FCA_Booklet.pdf*

Kidd, K.A., Heelein, R.H., Fudge, R.J.P., and Hallard, K.A., 1995, The influence of trophic level as measured by $\delta^{15}N$ on mercury concentrations in freshwater organisms: Water, Air, and Soil Pollution, v. 80, p. 1,011–1,015.

Klaper, R., Rees, C.B., Drevnick, P., Weber, D., Sandheinrich, M., and Carvan, M.J., 2006, Gene expression changes related to endocrine function and decline in reproduction in fathead minnow (*Pimephales promelas*) after dietary methylmercury exposure: Environmental Health Perspectives, v. 114, no. 9, p. 1,337–1,343.

Krabbenhoft, D.P., Wiener, J.G., Brumbaugh, W.G., Olson, M.L., DeWild, J.F., and Sabin, T.J., 1999, A national pilot study of mercury contamination of aquatic ecosystems along multiple gradients, *in* Morganwalp, D.W., and Buxton, H.T., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the Technical Meeting, Charleston, S.C., March 8–12, 1999, v. 2, Contamination of hydrologic systems and related ecosystems: U.S. Geological Survey Water-Resources Investigations Report 99–4018B, p. 147–160.

Mason, R.P., Abbott, M.L., Bodaly, R.A., Bullock, O.R., Driscoll, C.T., Evers, D., Lindberg, S.E., Murray, M., Swain, E.B., 2005, Monitoring the response to changing mercury deposition: Environmental Science and Technology, January 1, 2005, p. 14A–22A

Morlock, S.E., Nguyen, H.T., and Majors, D.K., 2004, Water resources data Indiana, Water Year 2003: U.S. Geological Survey Water-Data Report IN–03–1, 610 p.

National Research Council, 2000, Toxicological effects of methylmercury: Washington, D.C., National Academy Press, 344 p.

Olson, M.L., and DeWild, J.F., 1997, Determination of total mercury in water by oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry: U.S. Geological Survey National Mercury Laboratory Standard Operating Procedure SOP001: accessed August 20, 2007, at URL *http://infotrek.er.usgs.gov/doc/mercury/sop_1_port.htm*

Purdue Applied Meteorology Group, 2005, Indiana Climate Page: Department of Agronomy, Plant, and Soils Lab, accessed August 20, 2007, at URL *http://agmetx.agry.purdue.edu/sc.norm-geog.html*

Rantz, S.E., and others, 1982, Measurement and computation of streamflow–v. 1, Measurement of stage and discharge: U.S. Geological Survey Water-Supply Paper 2175, 284 p.

Risch, M.R., 2005, Mercury in the Grand Calumet River/Indiana Harbor Canal and Lake Michigan, Lake County, Indiana, August 2001 and May 2002: U.S. Geological Survey Water-Resources Investigations Report 2005–5034, 46 p.

Risch, M.R., 2007, Mercury in precipitation in Indiana, January 2001–December 2003: U.S. Geological Survey Scientific Investigations Report 2007–5063, 86 p.

Shanley, J.B., Schuster, P.F., Reddy, M.M., Roth, D.A., Taylor, H.E., and Aiken, G.R., 2002, Mercury on the move during snowmelt in Vermont: EOS, American Geophysical Union Transactions, v. 83, no. 5, p. 45–48.

Sparks, D., Chaffee, C., and Sobiech, S.,1999, Fish Creek preservation and restoration: United States Fish and Wildlife Service, Endangered Species Bulletin, v. 24. no. 1, accessed August 9, 2007, at URL *http://www.fws.gov/endangered/ESB/99/01-02/12-13.pdf*

Stahl, J.R., 1997, A preliminary appraisal of the biological integrity of Indiana streams in the West Fork White River watershed using fish tissue contamination assessment: Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Biological Studies Section, IDEM/32/03/005/1997, 86 p.

Stewart, J.A., Keeton, C.R., Hammil, L.E., Nguyen, H.T., and Majors, D.K., 2001, Water resources data, Indiana, Water Year 2000: U.S. Geological Survey Data Report IN–00–1, 452 p.

U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau, 2003, 2001 National survey of fishing, hunting, and wildlife-associated recreation in Indiana: 86 p.

U.S. Environmental Protection Agency, 1996, Method 1669: Sampling ambient water for trace metals at EPA water quality criteria levels: U.S. Environmental Protection Agency Office of Water Report EPA 821–R–96–008, 36 p.

U.S. Environmental Protection Agency, 1998, Method 1630, Methyl mercury in water by distillation, aqueous ethylation, purge and trap, and cold vapor atomic fluorescence spectrometry: U.S. Environmental Protection Agency Office of Water, accessed August 23, 2007, at URL *http://www.epa.gov/waterscience/methods/method/mercury/1630.pdf*

U.S. Environmental Protection Agency, 1999, Method 1631, Revision E—Mercury in water by oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry: U.S. Environmental Protection Agency Office of Water Report EPA–821–R–99–005, 40 p.

U.S. Environmental Protection Agency, 2001a, Water quality criterion for the protection of human health—Methylmercury: U.S. Environmental Protection Agency Office of Water Report EPA–823–F–01–001, accessed August 23, 2007, at URL *http://www.epa.gov/waterscience/standards/methylmercury*

U.S. Environmental Protection Agency, 2001b, Guidance for implementation and use of EPA Method 1631 for the determination of low-level mercury (40 CFR pt. 136): U.S. Environmental Protection Agency Office of Water Report EPA 821–R–01–023, 78 p.

U.S. Environmental Protection Agency, 2008, Health Services Industry Detailed Study—Dental Amalgam: U.S. Environmental Protection Agency Report EPA–821–R–08–014, accessed October 6, 2008, at URL *http://www.epa.gov/guide/304m/2008/hsi-dental-200809.pdf*

U.S. Geological Survey, 2007, Quality assurance plan for U.S. Geological Survey Mercury Research Laboratory: accessed August 23, 2007 at URL *http://infotrek.er.usgs.gov/mercury/qa.html*

Wilde, F.D., Radtke, D.B., eds., 1998, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, variously paginated.

Appendixes 1–7

Appendix 1. Total mercury concentrations in quality-control field-blank samples from mercury monitoring in Indiana streams, August 2004–September 2006.

[Monitoring station number not assigned to field blanks; ng/L, nanograms per liter; NA, not analyzed; <, less than reporting limit listed]

Type of field blank	Description of field blank	Sample date (month/day/year)	Mercury concentrations	
			Unfiltered total mercury (ng/L)	Filtered total mercury[1] (ng/L)
Equipment blank	Sampling and processing equipment	08/23/2004	NA	<0.04
Equipment blank	Sampling and processing equipment	08/30/2004	NA	<.02
Equipment blank	Sampling and processing equipment	09/01/2004	NA	<.03
Equipment blank	Sampling and processing equipment	09/14/2004	NA	<.04
Bottle blank	Blank water, sample bottle, preservative	08/23/2004	<.04	NA
Bottle blank	Blank water, sample bottle, preservative	09/14/2004	<.04	NA
Equipment blank	Sampling and processing equipment	10/12/2004	NA	<.01
Equipment blank	Sampling and processing equipment	11/04/2004	NA	<.04
Equipment blank	Sampling and processing equipment	10/22/2004	NA	<.04
Equipment blank	Sampling and processing equipment	10/18/2004	NA	<.04
Bottle blank	Blank water, sample bottle, preservative	10/12/2004	<.04	NA
Bottle blank	Blank water, sample bottle, preservative	11/04/2004	<.04	NA
Equipment blank	Sampling and processing equipment	02/22/2005	NA	<.04
Equipment blank	Sampling and processing equipment	03/01/2005	NA	<.04
Equipment blank	Sampling and processing equipment	03/07/2005	NA	<.04
Equipment blank	Sampling and processing equipment	03/17/2005	NA	<.04
Bottle blank	Blank water, sample bottle, preservative	02/22/2005	<.04	NA
Bottle blank	Blank water, sample bottle, preservative	03/17/2005	<.04	NA
Equipment blank	Sampling and processing equipment	06/07/2005	NA	.09
Equipment blank	Sampling and processing equipment	06/14/2005	NA	<.04
Equipment blank	Sampling and processing equipment	06/23/2005	NA	<.04
Equipment blank	Sampling and processing equipment	06/30/2005	NA	<.04
Bottle blank	Blank water, sample bottle, preservative	06/07/2005	<.04	NA
Bottle blank	Blank water, sample bottle, preservative	06/30/2005	<.04	NA
Equipment blank	Sampling and processing equipment	08/29/2005	NA	<.04
Equipment blank	Sampling and processing equipment	09/08/2005	NA	<.04
Equipment blank	Sampling and processing equipment	09/14/2005	NA	.01
Equipment blank	Sampling and processing equipment	09/19/2005	NA	.02

Appendix 1. Total mercury concentrations in quality-control field-blank samples from mercury monitoring in Indiana streams, August 2004–September 2006.—Continued

[Monitoring station number not assigned to field blanks; ng/L, nanograms per liter; NA, not analyzed; <, less than reporting limit listed]

Type of field blank	Description of field blank	Sample date (month/day/year)	Mercury concentrations	
			Unfiltered total mercury (ng/L)	Filtered total mercury[1] (ng/L)
Bottle blank	Blank water, sample bottle, preservative	08/29/2005	0.06	NA
Bottle blank	Blank water, sample bottle, preservative	09/19/2005	<.04	NA
Equipment blank	Sampling and processing equipment	11/28/2005	NA	<.04
Equipment blank	Sampling and processing equipment	12/06/2005	NA	<.04
Equipment blank	Sampling and processing equipment	12/19/2005	NA	<.04
Equipment blank	Sampling and processing equipment	12/16/2005	NA	<.04
Bottle blank	Blank water, sample bottle, preservative	11/28/2005	<.04	NA
Bottle blank	Blank water, sample bottle, preservative	12/16/2005	<.04	NA
Equipment blank	Sampling and processing equipment	02/27/2006	NA	<.04
Equipment blank	Sampling and processing equipment	03/07/2006	NA	<.04
Equipment blank	Sampling and processing equipment	03/13/2006	NA	<.04
Equipment blank	Sampling and processing equipment	03/17/2006	NA	<.04
Bottle blank	Blank water, sample bottle, preservative	02/27/2006	<.04	NA
Bottle blank	Blank water, sample bottle, preservative	03/17/2006	<.04	NA
Equipment blank	Sampling and processing equipment	05/08/2006	NA	<.04
Equipment blank	Sampling and processing equipment	05/12/2006	NA	<.04
Equipment blank	Sampling and processing equipment	05/18/2006	NA	<.04
Equipment blank	Sampling and processing equipment	05/25/2006	NA	<.04
Bottle blank	Blank water, sample bottle, preservative	05/08/2006	<.04	NA
Bottle blank	Blank water, sample bottle, preservative	05/25/2006	.04	NA
Equipment blank	Sampling and processing equipment	08/21/2006	NA	<.04
Equipment blank	Sampling and processing equipment	08/29/2006	NA	<.04
Equipment blank	Sampling and processing equipment	09/05/2006	NA	.05
Equipment blank	Sampling and processing equipment	09/08/2006	NA	.05
Bottle blank	Blank water, sample bottle, preservative	08/21/2006	<.04	NA
Bottle blank	Blank water, sample bottle, preservative	09/08/2006	<.04	NA

[1]Filtered concentration determined from water sample processed through a 0.7 micrometer nominal pore-size quartz-fiber filter.

Appendix 2. Total mercury concentrations in environmental and field-duplicate samples from mercury monitoring in Indiana streams, August 2004–September 2006.

[Locations of stations shown on figure 1; station names shown in table 1; ng/L, nanograms per liter]

Type of field-duplicate sample	Monitoring station number	Sample date (month/day/year)	Unfiltered total mercury (ng/L)			Filtered[1] total mercury (ng/L)		
			Environmental sample	Field-duplicate sample	Relative percent difference	Environmental sample	Field-duplicate sample	Relative percent difference[2]
Split	19	08/27/2004	8.39	7.79	7.4	0.5	0.6	18.2
Split	16	08/31/2004	4.02	3.80	5.6	.56	.62	10.2
Split	14	09/01/2004	3.97	4.21	5.9	1.22	1.09	11.3
Split	6	10/13/2004	1.17	1.13	3.5	.32	.29	9.8
Split	13	10/18/2004	2.96	3.18	7.2	1.9	1.78	6.5
Split	10	10/22/2004	1.02	.94	8.2	.41	.38	7.6
Split	21	10/27/2004	1.3	1.08	18.5	.36	.30	18.2
Split	9	02/23/2005	1.1	1.39	23.3	.4	.51	24.2
Split	5	02/28/2005	4.52	4.26	5.9	1.86	1.82	2.2
Split	20	03/08/2005	4.05	4.60	12.7	2.09	2.54	19.4
Split	3	03/17/2005	1.21	1.08	11.4	.49	.52	5.9
Split	25	06/08/2005	2.54	2.41	5.3	.34	.34	0.0
Split	4	06/13/2005	2.78	2.38	15.5	.9	.65	32.3
Split	22	06/22/2005	1.43	1.23	15.0	.3	.33	9.5
Split	7	06/28/2005	6.47	7.28	11.8	.8	.61	27.0
Split	17	08/29/2005	1.19	1.26	5.7	.38	.34	11.1
Split	15	09/08/2005	7.02	6.77	3.6	.96	.85	12.2
Split	2	09/13/2005	.67	.79	16.4	.33	.43	26.3
Split	1	09/15/2005	.86	.95	9.9	.59	.53	10.7
Concurrent	14	11/30/2005	1.3	10.8	4.7	4.4	3.51	22.5
Concurrent	24	12/08/2005	.75	.68	9.8	.35	.36	2.8
Concurrent	4	12/12/2005	.34	.38	11.1	.26	.31	17.5
Concurrent	8	12/16/2005	.88	.90	2.2	.06	.08	28.6
Concurrent	9	03/08/2006	1.34	1.20	11.0	.57	.72	23.3
Concurrent	1	03/10/2006	21.2	22.0	3.7	4.17	4.18	.2
Concurrent	18	03/13/2006	15.0	15.0	0.0	5.85	4.88	18.1
Concurrent	23	03/16/2006	6.89	6.66	3.4	3.17	3.38	6.4
Concurrent	12	05/11/2006	17.9	18.1	1.1	2.2	2.24	1.8
Concurrent	11	05/12/2006	7.59	7.64	.7	4.8	4.57	4.9
Concurrent	7	05/16/2006	17.8	16.2	9.4	1.53	1.40	8.9
Concurrent	19	05/23/2006	23.6	21.2	10.7	1.89	1.91	1.1
Concurrent	5	08/21/2006	2.14	2.4	11.5	.37	.37	0.0
Concurrent	13	08/24/2006	2.03	1.97	3.0	.48	.49	2.1
Concurrent	21	08/30/2006	3.27	2.69	19.5	.48	.46	4.3
Concurrent	2	09/07/2006	.94	1.16	21.0	.54	.52	3.8

[1]Filtered concentration determined from water sample processed through a 0.7 micrometer nominal pore-size quartz-fiber filter.

[2]Relative percent difference is the nonnegative difference of the duplicate and environmental sample concentrations divided by the average of the concentrations, expressed as a percentage.

Appendix 3. Methylmercury concentrations in environmental and field-duplicate samples from mercury monitoring in Indiana streams, August 2004–September 2006.

[Locations of stations shown on figure 1; station names shown in table 1; ng/L, nanograms per liter; <, less than; —, not computed]

			Unfiltered methylmercury (ng/L)			Filtered[1] methylmercury (ng/L)		
Type of field-duplicate sample	Monitoring station number	Sample date (month/day/year)	Environmental sample	Field-duplicate sample	Relative percent difference[2]	Environmental sample	Field-duplicate sample	Relative percent difference[2]
Split	19	08/27/2004	0.22	0.23	4.4	0.05	0.06	18.2
Split	16	08/31/2004	.18	.16	11.8	.08	.07	13.3
Split	14	09/01/2004	.05	.05	.0	<.04	.04	—
Split	6	10/13/2004	.12	.10	18.2	<.04	<.04	—
Split	13	10/18/2004	.1	.09	1.5	<.04	<.04	—
Split	10	10/22/2004	<.04	<.04	—	<.04	<.04	—
Split	21	10/27/2004	<.04	.05	—	<.04	<.04	—
Split	9	02/23/2005	<.04	.06	—	<.04	<.04	—
Split	5	02/28/2005	.06	.08	28.6	<.04	.05	—
Split	20	03/08/2005	.09	.11	20.0	.05	.06	18.2
Split	3	03/17/2005	.06	.07	15.4	<.04	<.04	—
Split	25	06/08/2005	.42	.35	18.2	.08	.08	0.0
Split	4	06/13/2005	.33	.32	3.1	.13	.16	20.7
Split	22	06/22/2005	.08	.07	13.3	.05	.05	0.0
Split	7	06/28/2005	.07	.06	15.4	.07	.06	15.4
Split	17	08/29/2005	.12	.10	18.2	<.04	.06	—
Split	15	09/08/2005	.2	.17	16.2	.07	.06	15.4
Split	2	09/13/2005	.12	.12	0.0	.06	.08	28.6
Split	1	09/15/2005	.1	.08	22.2	.05	.05	0.0
Concurrent	14	11/30/2005	.19	.15	23.5	.06	.06	0.0
Concurrent	24	12/08/2005	<.04	<.04	—	<.04	<.04	—
Concurrent	4	12/12/2005	<.04	<.04	—	<.04	<.04	—
Concurrent	8	12/16/2005	.09	.08	11.8	.06	<.04	—
Concurrent	9	03/08/2006	<.04	<.04	—	<.04	<.04	—
Concurrent	1	03/10/2006	.29	.29	0.0	.05	.06	18.2
Concurrent	18	03/13/2006	.14	.13	7.4	.05	.05	.0
Concurrent	23	03/16/2006	.05	.06	18.2	.08	.06	28.6
Concurrent	12	05/11/2006	.44	.46	4.4	.08	.08	.0
Concurrent	11	05/12/2006	.2	.19	5.1	.13	.11	16.7
Concurrent	7	05/16/2006	.26	.24	8.0	.04	<.04	—
Concurrent	19	05/23/2006	.23	.23	.0	.06	.07	15.4
Concurrent	5	08/21/2006	.16	.14	13.3	<.04	<.04	—
Concurrent	13	08/24/2006	.08	.06	28.6	<.04	<.04	—
Concurrent	21	08/30/2006	.07	.06	15.4	.06	.05	18.2
Concurrent	2	09/07/2006	.06	.07	15.4	.06	.06	.0

[1]Filtered concentration determined from water sample processed through a 0.7 micrometer nominal pore-size quartz-fiber filter.

[2]Relative percent difference is the nonnegative difference of the duplicate and environmental sample concentrations divided by the average of the concentrations, expressed as a percentage.

Appendix 4. Matrix-spike and spike-duplicate sample quality-control data from mercury monitoring in Indiana streams, August 2004–September 2006.

[UTHG, unfiltered total mercury; FTHG, filtered total mercury; UMHG, unfiltered methylmercury; R, field-duplicate sample]

Monitoring station number	Sample type	Analysis	Sample date (month/day/year)	Percent recovery[1]	Relative percent difference[2]
1	Spike	UTHG	08/23/2004	101	
12	Spike	UTHG	08/25/2004	100	
13	Spike	UTHG	09/09/2004	91	
25	Spike	UTHG	10/07/2004	100	
25	Spike	UTHG	10/07/2004	93	
6	Spike	UTHG	10/13/2004	102	
12	Spike	UTHG	10/15/2004	99	
13	Spike	UTHG	10/18/2004	97	
22	Spike	UTHG	10/20/2004	99	
17	Spike	UTHG	10/25/2004	101	
12	Spike	UTHG	02/24/2005	104	
5	Spike	UTHG	02/28/2005	101	
5R	Spike	UTHG	02/28/2005	99	
14	Spike	UTHG	03/02/2005	103	
20	Spike	UTHG	03/08/2005	104	
23	Spike	UTHG	03/10/2005	111	
23	Duplicate	UTHG	03/10/2005	112	9.0
24	Spike	UTHG	03/10/2005	102	
4	Spike	UTHG	03/17/2005	95	
25R	Spike	UTHG	06/08/2005	91	
8	Spike	UTHG	06/27/2005	95	

Monitoring station number	Sample type	Analysis	Sample date (month/day/year)	Percent recovery[1]	Relative percent difference[2]
13	Spike	UTHG	09/09/2005	96	
15	Spike	UTHG	11/30/2005	101	
23	Spike	UTHG	12/08/2005	103	
9	Spike	UTHG	03/08/2006	103	
9R	Spike	UTHG	03/08/2006	98	
1	Spike	UTHG	03/10/2006	96	
22	Spike	UTHG	03/15/2006	96	
23	Spike	UTHG	03/16/2006	98	
15	Spike	UTHG	05/10/2006	98	
13	Spike	UTHG	05/11/2006	97	
3	Spike	UTHG	05/25/2006	96	
6	Spike	UMHG	08/31/2004	82	
6	Duplicate	UMHG	08/31/2004	97	16.8
3	Spike	UMHG	10/19/2004	96	
20	Spike	UMHG	10/26/2004	114	
3	Duplicate	UMHG	10/19/2004	103	7.0
20	Duplicate	UMHG	10/26/2004	110	3.6
21R	Spike	UMHG	10/27/2004	112	
21R	Duplicate	UMHG	10/27/2004	95	16.4

Appendix 4. Matrix-spike and spike-duplicate sample quality-control data from mercury monitoring in Indiana streams, August 2004–September 2006.—Continued

[UTHG, unfiltered total mercury; FTHG, filtered total mercury; UMHG, unfiltered methylmercury; R, field-duplicate sample]

Monitoring station number	Sample type	Analysis	Sample date (month/day/year)	Percent recovery[1]	Relative percent difference[2]
11	Spike	UTHG	06/29/2005	82	
11	Duplicate	UTHG	06/29/2005	97	6.8
12	Spike	UTHG	06/29/2005	91	
17	Spike	UTHG	08/29/2005	81	
17	Duplicate	UTHG	08/29/2005	103	23.3
5	Spike	UTHG	09/06/2005	100	
25	Spike	UTHG	09/07/2005	100	
3	Spike	FTHG	05/25/2006	104	
17	Spike	FTHG	05/22/2006	103	
11	Spike	FTHG	05/12/2006	106	
12	Spike	FTHG	05/11/2006	106	
25	Spike	FTHG	05/09/2006	102	
23	Spike	FTHG	03/16/2006	97	
18R	Spike	FTHG	03/13/2006	100	
8	Spike	FTHG	03/10/2006	92	
7	Spike	FTHG	03/08/2006	97	

Monitoring station number	Sample type	Analysis	Sample date (month/day/year)	Percent recovery[1]	Relative percent difference[2]
13	Spike	UMHG	06/10/2005	99	
19	Spike	UMHG	06/21/2005	97	
13	Duplicate	UMHG	06/10/2005	109	9.6
19	Duplicate	UMHG	06/21/2005	97	.0
10	Spike	UMHG	06/30/2005	110	
10	Duplicate	UMHG	06/30/2005	105	4.7
6	Spike	UMHG	08/31/2004	82	
6	Spike	FTHG	03/03/2006	102	
13	Spike	FTHG	12/01/2005	97	
13	duplicate	FTHG	12/01/2005	101	4.5
16	Spike	FTHG	11/29/2005	91	
10	Spike	FTHG	09/16/2005	96	
7	Spike	FTHG	09/14/2005	102	
13	Spike	FTHG	09/09/2005	88	
6	Spike	FTHG	09/02/2005	92	
23	Spike	FTHG	09/01/2005	98	

[1] Percent recovery was computed as the mercury concentration in the matrix-spike sample divided by the sum of the mercury concentration in the sample and the mercury concentration in the spike solution, expressed as a percentage.

[2] Relative percent difference is the nonnegative difference of the duplicate and environmental sample concentrations divided by the average of the concentrations, expressed as a percentage.

Appendix 5. Total mercury and methylmercury concentrations in water samples from monitoring in Indiana streams, August 2004–September 2006, and streamflow conditions at the time of sample collection.

[Locations of stations shown on figure 1; ng/L, nanograms per liter; <, less than; E, estimated; ND, not determined]

Monitoring station number	Station name	Sample date (month/day/year)	Unfiltered total mercury (ng/L)	Filtered total mercury[1] (ng/L)	Unfiltered methylmercury (ng/L)	Filtered methylmercury[1] (ng/L)	Streamflow hydrograph condition	Streamflow statistical category
1	Fall Creek near Fortville	08/23/2004	1.28	0.23	0.07	<0.04	Stable low	Medium.
		10/12/2004	.58	.44	<.04	<.04	Stable low	Low.
		02/22/2005	1.16	.35	<.04	<.04	Falling	High.
		06/27/2005	2.35	.43	.11	.06	Stable low	Medium.
		09/15/2005	.86	.59	.10	.05	Falling	Low.
		12/16/2005	.39	.22	.04	<.04	Rising	Medium.
		03/10/2006	21.2	4.17	.29	.05	Rising	Event.
		05/15/2006	6.00	2.11	.14	<.04	Falling	Event.
		09/05/2006	1.66	.26	.07	<.04	Stable low	Low.
2	Eel River near Logansport	08/30/2004	14.7	3.99	.27	.09	Falling	Event.
		10/19/2004	.79	.55	<.04	<.04	Stable normal	Medium.
		03/17/2005	.88	.49	.04	.04	Stable low	High.
		06/14/2005	2.21	.94	.25	.11	Rising	High.
		09/13/2005	.67	.33	.12	.06	Stable low	Low.
		12/13/2005	.28	.18	<.04	<.04	Stable low	Medium.
		03/07/2006	.74	.39	.04	<.04	Stable normal	Medium.
		05/17/2006	7.92	3.02	.17	.06	Falling	Event.
		09/07/2006	.94	.54	.06	.06	Stable low	Medium.
3	Tippecanoe River at Winamac	09/02/2004	3.81	1.35	.16	.08	Falling	Event.
		10/19/2004	.61	.34	<.04	<.04	Stable low	Medium.
		03/17/2005	1.21	.49	.06	<.04	Falling	High.
		06/14/2005	2.63	.42	.19	.05	Rising	Medium.
		09/13/2005	.83	.28	.05	<.04	Stable low	Low.
		12/13/2005	.66	.23	<.04	<.04	Stable low	Medium.
		03/07/2006	.59	.27	<.04	<.04	Stable normal	Medium.
		05/25/2006	3.66	.68	.13	.04	Falling	High.
		08/31/2006	7.42	1.23	.13	.04	Falling	High.

Appendix 5. Total mercury and methylmercury concentrations in water samples from monitoring in Indiana streams, August 2004–September 2006, and streamflow conditions at the time of sample collection.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; <, less than; E, estimated; ND, not determined]

Monitoring station number	Station name	Sample date (month/day/year)	Unfiltered total mercury (ng/L)	Filtered total mercury[1] (ng/L)	Unfiltered methylmercury (ng/L)	Filtered methylmercury[1] (ng/L)	Streamflow hydrograph condition	Streamflow statistical category
4	Wildcat Creek near Lafayette	08/30/2004	8.33	1.11	0.21	0.05	Rising	High.
		10/21/2004	1.55	1.02	.05	<.04	Stable normal	Medium.
		03/16/2005	.57	.44	<.04	<.04	Falling	Medium.
		06/13/2005	2.78	.90	.33	.13	Rising	Medium.
		09/12/2005	.68	.28	.10	.06	Stable low	Low.
		12/12/2005	.34	.26	<.04	<.04	Falling	Medium.
		03/06/2006	.66	.33	<.04	<.04	Stable normal	Medium.
		05/17/2006	7.35	1.04	.14	<.04	Falling	Event.
		09/07/2006	1.39	.48	.08	.04	Stable low	Medium.
5	Wabash River at U.S. Highway 40 at Terre Haute	09/10/2004	5.13	1.06	.19	.05	Stable normal	Medium.
		11/03/2004	11.6	.86	.26	.05	Rising	High.
		02/28/2005	4.52	1.86	.06	<.04	Falling	High.
		06/07/2005	2.38	.52	.42	.05	Rising	Medium.
		09/06/2005	2.54	.3	.11	.05	Rising	Low.
		11/28/2005	3.22	.78	.08	<.04	Falling	Medium.
		02/27/2006	4.32	1.24	.06	<.04	Falling	Medium.
		05/08/2006	4.99	.56	.12	<.04	Falling	High.
		08/21/2006	2.14	.37	.16	<.04	Falling	Low.
6	Mill Creek at tailwater pool near Manhattan	08/31/2004	1.36	.37	.32	.06	Stable low	Low.
		10/13/2004	1.17	.32	.12	<.04	Stable low	Medium.
		03/04/2005	3.26	2.45	<.04	<.04	Falling	Medium.
		06/06/2005	2.18	.96	.14	.06	Stable normal	Medium.
		09/02/2005	2.32E	2.17E	.57	.42	Stable high	High.
		12/02/2005	1.39	.74	<.04	<.04	Stable normal	High.
		03/03/2006	1.67	.9	<.04	<.04	Stable normal	Medium.
		05/08/2006	1.94	.94	.06	<.04	Stable normal	High.
		08/21/2006	1.56	.31	.23	.05	Stable low	Low.

Appendix 5. Total mercury and methylmercury concentrations in water samples from monitoring in Indiana streams, August 2004–September 2006, and streamflow conditions at the time of sample collection.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; <, less than; E, estimated; ND, not determined]

Monitoring station number	Station name	Sample date (month/day/year)	Unfiltered total mercury (ng/L)	Filtered total mercury[1] (ng/L)	Unfiltered methylmercury (ng/L)	Filtered methylmercury[1] (ng/L)	Streamflow hydrograph condition	Streamflow statistical category
7	White River near Centerton	08/24/2004	9.10	0.64	0.29	0.12	Stable low	Medium.
		10/14/2004	10.1	1.47	.24	.12	Stable low	Medium.
		02/23/2005	6.34	.92	.09	.08	Falling	High.
		06/28/2005	6.47	.8	.07	.07	Stable low	Medium.
		09/14/2005	5.66	.77	.25	.1	Stable low	Low.
		12/14/2005	3.29	.54	.08	<.04	Falling	Medium.
		03/08/2006	2.90	.85	.07	<.04	Rising	Medium.
		05/16/2006	17.8	1.53	.26	.04	Falling	Event.
		09/06/2006	5.56	.61	.12	.05	Falling	Low.
8	White River near Nora	08/23/2004	2.55	.44	.11	.07	Stable low	Medium.
		10/12/2004	1.36	.53	.07	.06	Stable low	Low.
		02/22/2005	2.64	.75	<.04	<.04	Falling	High.
		06/27/2005	2.54	.55	.12	.07	Stable low	Medium.
		09/15/2005	2.07	.49	.11	.06	Stable low	Medium.
		12/16/2005	.88	.06	.09	.06	Stable normal	Medium.
		03/10/2006	11.3	1.44	.09	<.04	Rising	High.
		05/15/2006	9.51	2.35	.26	.05	Falling	Event.
		09/05/2006	3.08	.41	.09	.07	Stable low	Low.
9	Sugar Creek at New Palestine	08/24/2004	.76	.31	<.04	<.04	Stable low	Low.
		10/14/2004	1.36	.99	.04	.04	Stable low	Low.
		02/23/2005	1.10	.40	<.04	<.04	Falling	High.
		06/28/2005	1.31	.58	.1	.06	Stable low	Medium.
		09/14/2005	.75	.41	.07	.06	Stable low	Low.
		12/14/2005	.43	.18	<.04	<.04	Stable low	Medium.
		03/08/2006	1.34	.57	<.04	<.04	Rising	Medium.
		05/16/2006	4.76	1.95	.12	.04	Falling	Event.
		09/06/2006	.70	.34	.05	<.04	Falling	Low.

Appendix 5. Total mercury and methylmercury concentrations in water samples from monitoring in Indiana streams, August 2004–September 2006, and streamflow conditions at the time of sample collection.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; <, less than; E, estimated; ND, not determined]

Monitoring station number	Station name	Sample date (month/day/year)	Unfiltered total mercury (ng/L)	Filtered total mercury[1] (ng/L)	Unfiltered methylmercury (ng/L)	Filtered methylmercury[1] (ng/L)	Streamflow hydrograph condition	Streamflow statistical category
10	East Fork Whitewater River at Brookville	09/03/2004	0.54	0.40	<0.04	<0.04	Stable low	Low.
		10/22/2004	1.02	.41	<.04	<.04	Stable low	High.
		02/25/2005	1.85	1.21	<.04	<.04	Stable normal	High.
		06/30/2005	.34	.23	<.04	<.04	Rising	High.
		09/16/2005	.32	.22	<.04	<.04	Stable low	Medium.
		12/19/2005	.24	.17	<.04	<.04	Stable normal	High.
		03/17/2006	1.21	.65	<.04	<.04	Rising	Event.
		05/18/2006	.64	.44	<.04	<.04	Falling	Event.
		09/08/2006	.26	.22	.04	<.04	Stable low	Medium.
11	Vernon Fork Muscatatuck River at Vernon	08/25/2004	2.80	1.11	.11	.07	Stable low	Medium.
		10/15/2004	1.08	.90	<.04	<.04	Stable low	High.
		02/24/2005	1.50	1.25	.08	.05	Falling	High.
		06/29/2005	2.32	1.21	.13	.09	Rising	Low.
		09/19/2005	4.50E	1.07E	.07	.07	Stable low	Low.
		12/15/2005	1.82	.92	.06	.06	Rising	Medium.
		03/09/2006	16.2	6.14	.19	.06	Rising	Event.
		05/12/2006	7.59	4.80	.20	.13	Falling	High.
		08/24/2006	1.34	.96	.08	.09	Stable low	Low.
12	White River at State Road 258 near Seymour	08/25/2004	1.23	.16	.12	.06	Stable normal	Low.
		10/15/2004	.96	.34	.05	<.04	Stable low	Low.
		02/24/2005	1.82	.52	.05	<.04	Falling	High.
		06/29/2005	1.67	.35	.12	.04	Falling	Medium.
		09/19/2005	3.67E	1.35E	.10	.04	Falling	Low.
		12/15/2005	.73	.23	.05	<.04	Rising	Medium.
		03/09/2006	20.1	4.45	.25	.06	Rising	High.
		05/11/2006	17.9	2.20	.44	.08	Rising	High.
		08/24/2006	1.36	.29	.06	<.04	Stable low	Medium.

Appendix 5. Total mercury and methylmercury concentrations in water samples from monitoring in Indiana streams, August 2004–September 2006, and streamflow conditions at the time of sample collection.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; <, less than; E, estimated; ND, not determined]

Monitoring station number	Station name	Sample date (month/day/year)	Unfiltered total mercury (ng/L)	Filtered total mercury[1] (ng/L)	Unfiltered methylmercury (ng/L)	Filtered methylmercury[1] (ng/L)	Streamflow hydrograph condition	Streamflow statistical category
13	Blue River at Fredericksburg	09/09/2004	1.74	0.89	0.09	0.09	Stable low	Medium.
		10/18/2004	2.96	1.90	.10	<.04	Stable low	Medium.
		03/03/2005	.83	.43	<.04	<.04	Falling	High.
		06/10/2005	1.85	.67	.20	.13	Stable low	Medium.
		09/09/2005	1.98	.64	.08	.05	Falling	Low.
		12/01/2005	2.61	1.62	.05	<.04	Falling	High.
		03/02/2006	.93	.48	<.04	<.04	Stable low	Medium.
		05/11/2006	2.42	.68	.13	.04	Rising	High.
		08/24/2006	2.03	.48	.08	<.04	Stable low	Medium.
14	Patoka River at Winslow	09/01/2004	3.97	1.22	.05	<.04	Stable low	Medium.
		10/28/2004	16.0	4.30	.06	.06	Falling	High.
		03/02/2005	2.63	.63	.08	<.04	Falling	High.
		06/09/2005	2.70	.30	.13	<.04	Stable low	Low.
		09/08/2005	2.79	.95	.07	.06	Stable low	Low.
		11/30/2005	10.3	4.40	.19	.06	Falling	High.
		03/01/2006	1.78	.52	.07	<.04	Falling	Medium.
		05/10/2006	8.74	.78	.32	.14	Falling	High.
		08/23/2006	4.60	1.10	.07	<.04	Falling	Medium.
15	White River at Petersburg	10/07/2004	4.05	.79	.40	.1	Stable low	Low.
		10/28/2004	12.0	2.58	.20	.07	Falling	Medium.
		03/02/2005	3.60	.80	.06	<.04	Falling	High.
		06/09/2005	6.15	1.48	.28	<.04	Falling	Medium.
		09/08/2005	7.02	.96	.20	.07	Falling	Medium.
		11/30/2005	5.63	.97	.09	<.04	Rising	Medium.
		03/01/2006	3.42	.46	.06	<.04	Falling	Medium.
		05/10/2006	6.41	.65	.17	<.04	Stable normal	High.
		08/23/2006	4.40	.61	.41	.05	Falling	Low.

Appendix 5. Total mercury and methylmercury concentrations in water samples from monitoring in Indiana streams, August 2004–September 2006, and streamflow conditions at the time of sample collection.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; <, less than; E, estimated; ND, not determined]

Monitoring station number	Station name	Sample date (month/day/year)	Unfiltered total mercury (ng/L)	Filtered total mercury[1] (ng/L)	Unfiltered methylmercury (ng/L)	Filtered methylmercury[1] (ng/L)	Streamflow hydrograph condition	Streamflow statistical category
16	Busseron Creek near Carlisle	08/31/2004	4.02	0.56	0.18	0.08	ND	ND.
		10/29/2004	3.81	1.73	.17	.13	ND	ND.
		03/01/2005	1.37	.35	.05	.05	ND	ND.
		06/08/2005	2.47	2.44	.12	.07	ND	ND.
		09/07/2005	3.42E	.10E	.12	<.04	ND	ND.
		11/29/2005	6.24	2.19	.12	.05	ND	ND.
		02/28/2006	1.38	.32	.08	<.04	ND	ND.
		05/09/2006	1.55	.49	.10	.05	ND	ND.
		08/22/2006	2.49	.42	.13	<.04	ND	ND.
17	Mississinewa River at County Road 275 East near Peoria	08/26/2004	2.38	.99	.16	<.04	Stable low	Medium.
		10/25/2004	2.31	.32	.05	<.04	Stable low	Medium.
		03/07/2005	1.74	1.01	.05	.04	Stable normal	High.
		06/20/2005	1.12	.68	.18	.1	Stable normal	Medium.
		08/29/2005	1.19	.38	.12	<.04	Stable low	Low.
		12/05/2005	3.25	2.16	.05	<.04	Stable normal	High.
		03/13/2006	3.39	1.76	.06	.05	Stable normal	High.
		05/22/2006	3.33	2.09	.06	<.04	Stable low	High.
		08/28/2006	1.38	.69	.09	<.04	Rising	Medium.
18	Wabash River at County Road 200 West near Huntington	08/26/2004	1.48	.40	.13	.05	Stable low	Medium.
		10/25/2004	1.24	.35	.08	<.04	Stable low	Medium.
		03/07/2005	7.66	3.62	.13	<.04	Rising	High.
		06/20/2005	2.59	1.68	.40	.17	Stable normal	Medium.
		08/29/2005	2.67	.46	.04	<.04	Stable low	Medium.
		12/05/2005	7.14	3.79	.05	<.04	Falling	Medium.
		03/13/2006	15.0	5.85	.14	.05	Stable high	Event.
		05/22/2006	4.37	2.46	.12	<.04	Stable normal	High.
		08/28/2006	2.10	.47	.05	<.04	Stable normal	Event.

Appendix 5. Total mercury and methylmercury concentrations in water samples from monitoring in Indiana streams, August 2004–September 2006, and streamflow conditions at the time of sample collection.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; <, less than; E, estimated; ND, not determined]

Monitoring station number	Station name	Sample date (month/day/year)	Unfiltered total mercury (ng/L)	Filtered total mercury[1] (ng/L)	Unfiltered methylmercury (ng/L)	Filtered methylmercury[1] (ng/L)	Streamflow hydrograph condition	Streamflow statistical category
19	Maumee River at New Haven	08/27/2004	8.39	0.50	0.22	0.05	Stable low	Medium.
		10/26/2004	4.72	.80	.19	.06	Stable low	Medium.
		03/08/2005	9.64	3.81	.07	.06	Stable normal	High.
		06/21/2005	3.45	.46	.24	.09	Stable low	Low.
		08/30/2005	9.28	.50	.43	.07	Stable low	Low.
		12/06/2005	7.85	5.14	.07	<.04	Falling	High.
		03/14/2006	26.9	5.97	.32	<.04	Rising	Event.
		05/23/2006	23.6	1.89	.23	.06	Rising	High.
		08/29/2006	12.5	1.00	.27	.05	Falling	High.
20	Fish Creek near Artic	09/07/2004	2.48	1.13	.16	.07	Stable low	Medium.
		10/26/2004	1.00	.62	.08	.07	Stable low	Medium.
		03/08/2005	4.05	2.09	.09	.05	Rising	Event.
		06/21/2005	1.46	.63	.15	.10	Stable low	Low.
		08/30/2005	.98	.43	.08	<.04	Stable low	Low.
		12/06/2005	.76	.51	.06	<.04	Stable normal	High.
		03/14/2006	8.66	4.79	.09	.06	Rising	Event.
		05/23/2006	2.20	.77	.18	.06	Falling	High.
		08/29/2006	8.62	2.29	.21	<.04	Peak	High.
21	St. Joseph River at Elkhart	09/07/2004	1.80	.74	.10	.10	Stable normal	Medium.
		10/27/2004	1.30	.36	<.04	<.04	Stable low	Medium.
		03/09/2005	1.74	.59	.08	.05	Stable high	Event.
		06/22/2005	1.77	.38	.08	.06	Stable normal	Medium.
		08/31/2005	.96	.30	.12	.12E	Stable low	Medium.
		12/07/2005	.39	.25	<.04	<.04	Stable low	Low.
		03/15/2006	9.05	2.28	.10	<.04	Falling	Event.
		05/24/2006	2.34	.62	.08	.04	Falling	High.
		08/30/2006	3.27	.48	.07	.06	Stable normal	Medium.

Appendix 5. Total mercury and methylmercury concentrations in water samples from monitoring in Indiana streams, August 2004–September 2006, and streamflow conditions at the time of sample collection.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; <, less than; E, estimated; ND, not determined]

Monitoring station number	Station name	Sample date (month/day/year)	Unfiltered total mercury (ng/L)	Filtered total mercury[1] (ng/L)	Unfiltered methylmercury (ng/L)	Filtered methylmercury[1] (ng/L)	Streamflow hydrograph condition	Streamflow statistical category
22	Trail Creek at Michigan City Harbor	09/08/2004	1.16	0.48	0.06	0.05	Stable normal	Medium.
		10/20/2004	.55	.17	<.04	<.04	Stable low	Medium.
		03/09/2005	1.42	.83	.09	.08	Stable normal	High.
		06/22/2005	1.43	.30	.08	.05	Stable normal	Medium.
		08/31/2005	.79	.25	<.04	<.04	Stable normal	Medium.
		12/07/2005	.82	.33	<.04	<.04	Stable low	Medium.
		03/15/2006	5.94	2.14	.08	.05	Stable normal	Event.
		05/24/2006	1.86	.40	.09	.04	Stable normal	Medium.
		08/30/2006	7.15	3.31	.39	.23	Rising	Event.
23	Deep River at Lake George outlet at Hobart	09/08/2004	2.16	.88	<.04	<.04	Stable normal	Medium.
		10/20/2004	1.85	.59	<.04	<.04	Stable normal	Medium.
		03/10/2005	1.37	.80	.08	<.04	Falling	High.
		06/23/2005	1.43	.62	.09	<.04	Stable low	Low.
		09/01/2005	1.43	.64	.05	<.04	Falling	Low.
		12/08/2005	1.88	.85	.05	<.04	Stable low	Medium.
		03/16/2006	6.89	3.17	.05	.08	Falling	Event.
		05/25/2006	1.38	.55	.05	<.04	Rising	High.
		08/31/2006	3.02	1.52	.15	.11	Falling	Event.
24	Kankakee River at Shelby	09/08/2004	7.33	1.05	.13	.06	Stable normal	High.
		10/21/2004	.80	.19	<.04	<.04	Stable normal	Medium.
		03/10/2005	2.40	.99	.10	.06	Falling	Event.
		06/23/2005	5.28	.31	.04	.04	Falling	Low.
		09/01/2005	1.82E	.16E	.05	.05E	Falling	Low.
		12/08/2005	.75	.35	<.04	<.04	Stable normal	Medium.
		03/16/2006	12.2	3.49	.11	.04	Rising	Event.
		05/25/2006	3.73	.46	.07	<.04	Falling	High.
		08/31/2006	3.23	.52	.07	<.04	Peak	High.

Appendix 5. Total mercury and methylmercury concentrations in water samples from monitoring in Indiana streams, August 2004–September 2006, and streamflow conditions at the time of sample collection.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; <, less than; E, estimated; ND, not determined]

Monitoring station number	Station name	Sample date (month/day/year)	Unfiltered total mercury (ng/L)	Filtered total mercury[1] (ng/L)	Unfiltered methylmercury (ng/L)	Filtered methylmercury[1] (ng/L)	Streamflow hydrograph condition	Streamflow statistical category
25	Wabash River at Vigo Street at Vincennes	10/07/2004	1.95	0.16	0.22	<0.04	Stable low	Low.
		11/04/2004	9.73	1.69	.16	.08	Falling	High
		03/01/2005	4.12	2.00	.09	<.04	Falling	Event.
		06/08/2005	2.54	.34	.42	.08	Stable low	Medium.
		09/07/2005	2.44	.29	.27	.07	Stable low	Low.
		11/29/2005	4.11	.92	.09	<.04	Stable normal	Medium.
		02/28/2006	5.64	1.24	.09	<.04	Falling	Medium.
		05/09/2006	6.45	.53	.15	<.04	Falling	High.
		08/22/2006	3.86	.38	.21	.04	Stable low	Low.

[1]Filtered concentration determined from water sample processed with 0.7 micrometer nominal pore-size quartz-fiber filter.

Appendix 6. Estimated particulate total mercury and particulate methylmercury concentrations and methylation efficiencies in water samples from monitoring in Indiana streams, August 2004–September 2006.

[Locations of stations shown on figure 1; ng/L, nanograms per liter; ND, not determined; <, less than]

Monitoring station number	Station name	Sample date (month/day/year)	Total mercury: Estimated particulate[1] (ng/L)	Total mercury: Percentage of unfiltered[2]	Methylmercury: Estimated particulate[1] (ng/L)	Methylmercury: Percentage of unfiltered[2]	Methylmercury: Methylation efficiency (percent)[3]
1	Fall Creek near Fortville	08/23/2004	1.05	82.0	0.07	100	5.5
		10/12/2004	.14	24.1	ND	ND	ND
		02/22/2005	.81	69.8	ND	ND	ND
		06/27/2005	1.92	81.7	.05	45	4.7
		09/15/2005	.27	31.4	.05	50	11.6
		12/16/2005	.17	43.6	.04	100	10.3
		03/10/2006	17.03	80.3	.24	83	1.4
		05/15/2006	3.89	64.8	.14	100	2.3
		09/05/2006	1.40	84.3	.07	100	4.2
2	Eel River near Logansport	08/30/2004	10.71	72.9	.18	67	1.8
		10/19/2004	.24	30.4	ND	ND	ND
		03/17/2005	.39	44.3	.00	0	4.5
		06/14/2005	1.27	57.5	.14	56	11.3
		09/13/2005	0.34	50.7	.06	50	17.9
		12/13/2005	.10	35.7	ND	ND	ND
		03/07/2006	.35	47.3	.04	100	5.4
		05/17/2006	4.90	61.9	.11	65	2.1
		09/07/2006	.40	42.6	.00	0	6.4
3	Tippecanoe River at Winamac	09/02/2004	2.46	64.6	.08	50	4.2
		10/19/2004	.27	44.3	ND	ND	ND
		03/17/2005	.72	59.5	.06	100	5.0
		06/14/2005	2.21	84.0	.14	74	7.2
		09/13/2005	.55	66.3	.05	100	6.0
		12/13/2005	.43	65.2	ND	ND	ND
		03/07/2006	.32	54.2	ND	ND	ND
		05/25/2006	2.98	81.4	.09	69	3.6
		08/31/2006	6.19	83.4	.09	69	1.8

Appendix 6. Estimated particulate total mercury and particulate methylmercury concentrations and methylation efficiencies in water samples from monitoring in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; ND, not determined; <, less than]

			Total mercury		Methylmercury		
Monitoring station number	Station name	Sample date (month/day/year)	Estimated particulate[1] (ng/L)	Percentage of unfiltered[2]	Estimated particulate[1] (ng/L)	Percentage of unfiltered[2]	Methylation efficiency (percent)[3]
4	Wildcat Creek near Lafayette	08/30/2004	7.22	86.7	0.16	76	2.5
		10/21/2004	.53	34.2	.05	100	3.2
		03/16/2005	.13	22.8	ND	ND	ND
		06/13/2005	1.88	67.6	.20	61	11.9
		09/12/2005	.40	58.8	.04	40	14.7
		12/12/2005	.08	23.5	ND	ND	ND
		03/06/2006	.33	50.0	ND	ND	ND
		05/17/2006	6.31	85.9	.14	100	1.9
		09/07/2006	.91	65.5	.04	50	5.8
5	Wabash River at U.S. Highway 40 at Terre Haute	09/10/2004	4.07	79.3	.14	74	3.7
		11/03/2004	10.74	92.6	.21	81	2.2
		02/28/2005	2.66	58.8	.06	100	1.3
		06/07/2005	1.86	78.2	.37	88	17.6
		09/06/2005	2.24	88.2	.06	55	4.3
		11/28/2005	2.44	75.8	.08	100	2.5
		02/27/2006	3.08	71.3	.06	100	1.4
		05/08/2006	4.43	88.8	.12	100	2.4
		08/21/2006	1.77	82.7	.16	100	7.5
6	Mill Creek at tailwater pool near Manhattan	08/31/2004	.99	72.8	.26	81	23.5
		10/13/2004	.85	72.6	.12	100	10.3
		03/04/2005	.81	24.8	ND	ND	ND
		06/06/2005	1.22	56.0	.08	57	6.4
		09/02/2005	.15	6.5	.15	26	24.6
		12/02/2005	.65	46.8	ND	ND	ND
		03/03/2006	.77	46.1	ND	ND	ND
		05/08/2006	1.00	51.5	.06	100	3.1
		08/21/2006	1.25	80.1	.18	78	14.7

Appendix 6. Estimated particulate total mercury and particulate methylmercury concentrations and methylation efficiencies in water samples from monitoring in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; ND, not determined; <, less than]

Monitoring station number	Station name	Sample date (month/day/year)	Total mercury: Estimated particulate[1] (ng/L)	Total mercury: Percentage of unfiltered[2]	Methylmercury: Estimated particulate[1] (ng/L)	Methylmercury: Percentage of unfiltered[2]	Methylmercury: Methylation efficiency (percent)[3]
7	White River near Centerton	08/24/2004	8.46	93.0	0.17	59	3.2
		10/14/2004	8.63	85.4	.12	50	2.4
		02/23/2005	5.42	85.5	.01	11	1.4
		06/28/2005	5.67	87.6	.00	0	1.1
		09/14/2005	4.89	86.4	.15	60	4.4
		12/14/2005	2.75	83.6	.08	100	2.4
		03/08/2006	2.05	70.7	.07	100	2.4
		05/16/2006	16.27	91.4	.22	85	1.5
		09/06/2006	4.95	89.0	.07	58	2.2
8	White River near Nora	08/23/2004	2.11	82.7	.04	36	4.3
		10/12/2004	.83	61.0	.01	14	5.1
		02/22/2005	1.89	71.6	ND	ND	ND
		06/27/2005	1.99	78.3	.05	42	4.7
		09/15/2005	1.58	76.3	.05	45	5.3
		12/16/2005	.82	93.2	.03	33	10.2
		03/10/2006	9.86	87.3	.09	100	.8
		05/15/2006	7.16	75.3	.21	81	2.7
		09/05/2006	2.67	86.7	.02	22	2.9
9	Sugar Creek at New Palestine	08/24/2004	.45	59.2	ND	ND	ND
		10/14/2004	.37	27.2	0.0	0	2.9
		02/23/2005	.70	63.6	ND	ND	ND
		06/28/2005	.73	55.7	.04	40	7.6
		09/14/2005	.34	45.3	.01	14	9.3
		12/14/2005	.25	58.1	ND	ND	ND
		03/08/2006	.77	57.5	ND	ND	ND
		05/16/2006	2.81	59.0	.08	67	2.5
		09/06/2006	.36	51.4	.05	100	7.1

Appendix 6. Estimated particulate total mercury and particulate methylmercury concentrations and methylation efficiencies in water samples from monitoring in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; ND, not determined; <, less than]

			Total mercury		Methylmercury		
Monitoring station number	Station name	Sample date (month/day/year)	Estimated particulate[1] (ng/L)	Percentage of unfiltered[2]	Estimated particulate[1] (ng/L)	Percentage of unfiltered[2]	Methylation efficiency (percent)[3]
10	East Fork Whitewater River at Brookville	09/03/2004	0.14	25.9	ND	ND	ND
		10/22/2004	.61	59.8	ND	ND	ND
		02/25/2005	.64	34.6	ND	ND	ND
		06/30/2005	.11	32.4	ND	ND	ND
		09/16/2005	.10	31.3	ND	ND	ND
		12/19/2005	.07	29.2	ND	ND	ND
		03/17/2006	.56	46.3	ND	ND	ND
		05/18/2006	.20	31.3	ND	ND	ND
		09/08/2006	.04	15.4	0.04	100	15.4
11	Vernon Fork Muscatatuck River at Vernon	08/25/2004	1.69	60.4	.04	36	3.9
		10/15/2004	.18	16.7	ND	ND	ND
		02/24/2005	.25	16.7	.03	38	5.3
		06/29/2005	1.11	47.8	.04	31	5.6
		09/19/2005	3.43	76.2	.00	0	1.6
		12/15/2005	.90	49.5	.00	0	3.3
		03/09/2006	10.06	62.1	.13	68	1.2
		05/12/2006	2.79	36.8	.07	35	2.6
		08/24/2006	.38	28.4	ND	ND	6.0
12	White River at State Road 258 near Seymour	08/25/2004	1.07	87.0	.06	50	9.8
		10/15/2004	.62	64.6	.05	100	5.2
		02/24/2005	1.30	71.4	.05	100	2.7
		06/29/2005	1.32	79.0	.08	67	7.2
		09/19/2005	2.32	63.2	.06	60	2.7
		12/15/2005	.50	68.5	.05	100	6.8
		03/09/2006	15.65	77.9	.19	76	1.2
		05/11/2006	15.70	87.7	.36	82	2.5
		08/24/2006	1.07	78.7	.06	100	4.4

Appendix 6. Estimated particulate total mercury and particulate methylmercury concentrations and methylation efficiencies in water samples from monitoring in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; ND, not determined; <, less than]

Monitoring station number	Station name	Sample date (month/day/year)	Total mercury: Estimated particulate[1] (ng/L)	Total mercury: Percentage of unfiltered[2]	Methylmercury: Estimated particulate[1] (ng/L)	Methylmercury: Percentage of unfiltered[2]	Methylmercury: Methylation efficiency (percent)[3]
13	Blue River at Fredericksburg	09/09/2004	0.85	48.9	0.00	0	5.2
		10/18/2004	1.06	35.8	.10	100	3.4
		03/03/2005	.40	48.2	ND	ND	ND
		06/10/2005	1.18	63.8	.07	35	10.8
		09/09/2005	1.34	67.7	.03	38	4.0
		12/01/2005	.99	37.9	.05	100	1.9
		03/02/2006	.45	48.4	ND	ND	ND
		05/11/2006	1.74	71.9	.09	69	5.4
		08/24/2006	1.55	76.4	.08	100	3.9
14	Patoka River at Winslow	09/01/2004	2.75	69.3	.05	100	1.3
		10/28/2004	11.70	73.1	.00	0	.4
		03/02/2005	2.00	76.0	.08	100	3.0
		06/09/2005	2.40	88.9	.13	100	4.8
		09/08/2005	1.84	65.9	.01	14	2.5
		11/30/2005	5.90	57.3	.13	68	1.8
		03/01/2006	1.26	70.8	.07	100	3.9
		05/10/2006	7.96	91.1	.18	56	3.7
		08/23/2006	3.50	76.1	.07	100	1.5
15	White River at Petersburg	10/07/2004	3.26	80.5	.30	75	9.9
		10/28/2004	9.42	78.5	.13	65	1.7
		03/02/2005	2.80	77.8	.06	100	1.7
		06/09/2005	4.67	75.9	.28	100	4.6
		09/08/2005	6.06	86.3	.13	65	2.8
		11/30/2005	4.66	82.8	.09	100	1.6
		03/01/2006	2.96	86.5	.06	100	1.8
		05/10/2006	5.76	89.9	.17	100	2.7
		08/23/2006	3.79	86.1	.36	88	9.3

Appendix 6. Estimated particulate total mercury and particulate methylmercury concentrations and methylation efficiencies in water samples from monitoring in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; ND, not determined; <, less than]

			Total mercury		Methylmercury		
Monitoring station number	Station name	Sample date (month/day/year)	Estimated particulate[1] (ng/L)	Percentage of unfiltered[2]	Estimated particulate[1] (ng/L)	Percentage of unfiltered[2]	Methylation efficiency (percent)[3]
16	Busseron Creek near Carlisle	08/31/2004	3.46	86.1	0.10	56	4.5
		10/29/2004	2.08	54.6	.04	24	4.5
		03/01/2005	1.02	74.5	.00	0	3.6
		06/08/2005	.03	1.2	.05	42	4.9
		09/07/2005	3.32	97.1	.12	100	3.5
		11/29/2005	4.05	64.9	.07	58	1.9
		02/28/2006	1.06	76.8	.08	100	5.8
		05/09/2006	1.06	68.4	.05	50	6.5
		08/22/2006	2.07	83.1	.13	100	5.2
17	Mississinewa River at County Road 275 East near Peoria	08/26/2004	1.39	58.4	.16	100	6.7
		10/25/2004	1.99	86.1	.05	100	2.2
		03/07/2005	.73	42.0	.01	20	2.9
		06/20/2005	.44	39.3	.08	44	16.1
		08/29/2005	.81	68.1	.12	100	10.1
		12/05/2005	1.09	33.5	.05	100	1.5
		03/13/2006	1.63	48.1	.01	17	1.8
		05/22/2006	1.24	37.2	.06	100	1.8
		08/28/2006	.69	50.0	.09	100	6.5
18	Wabash River at County Road 200 West near Huntington	08/26/2004	1.08	73.0	.08	62	8.8
		10/25/2004	.89	71.8	.08	100	6.5
		03/07/2005	4.04	52.7	.13	100	1.7
		06/20/2005	.91	35.1	.23	58	15.4
		08/29/2005	2.21	82.8	.04	100	1.5
		12/05/2005	3.35	46.9	.05	100	.7
		03/13/2006	9.15	61.0	.09	64	.9
		05/22/2006	1.91	43.7	.12	100	2.7
		08/28/2006	1.63	77.6	.05	100	2.4

Appendix 6. Estimated particulate total mercury and particulate methylmercury concentrations and methylation efficiencies in water samples from monitoring in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; ND, not determined; <, less than]

Monitoring station number	Station name	Sample date (month/day/year)	Total mercury: Estimated particulate[1] (ng/L)	Total mercury: Percentage of unfiltered[2]	Methylmercury: Estimated particulate[1] (ng/L)	Methylmercury: Percentage of unfiltered[2]	Methylmercury: Methylation efficiency (percent)[3]
19	Maumee River at New Haven	08/27/2004	7.89	94.0	0.17	77	2.6
		10/26/2004	3.92	83.1	.13	68	4.0
		03/08/2005	5.83	60.5	.01	14	.7
		06/21/2005	2.99	86.7	.15	63	7.0
		08/30/2005	8.78	94.6	.36	84	4.6
		12/06/2005	2.71	34.5	.07	100	.9
		03/14/2006	20.93	77.8	.32	100	1.2
		05/23/2006	21.69	92.0	.17	74	1.0
		08/29/2006	11.50	92.0	.22	81	2.2
20	Fish Creek near Artic	09/07/2004	1.35	54.4	.09	56	6.5
		10/26/2004	.38	38.0	.01	13	8.0
		03/08/2005	1.96	48.4	.04	44	2.2
		06/21/2005	.83	56.8	.05	33	10.3
		08/30/2005	.55	56.1	.08	100	8.2
		12/06/2005	.25	32.9	.06	100	7.9
		03/14/2006	3.87	44.7	.03	33	1.0
		05/23/2006	1.43	65.0	.12	67	8.2
		08/29/2006	6.33	73.4	.21	100	2.4
21	St. Joseph River at Elkhart	09/07/2004	1.06	58.9	.00	0	5.6
		10/27/2004	.94	72.3	ND	ND	ND
		03/09/2005	1.15	66.1	.03	38	4.6
		06/22/2005	1.39	78.5	.02	25	4.5
		08/31/2005	.66	68.8	.00	0	12.5
		12/07/2005	.14	35.9	ND	ND	ND
		03/15/2006	6.77	74.8	.10	100	1.1
		05/24/2006	1.72	73.5	.04	50	3.4
		08/30/2006	2.79	85.3	.01	14	2.1

Appendix 6. Estimated particulate total mercury and particulate methylmercury concentrations and methylation efficiencies in water samples from monitoring in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; ND, not determined; <, less than]

Monitoring station number	Station name	Sample date (month/day/year)	Total mercury: Estimated particulate[1] (ng/L)	Total mercury: Percentage of unfiltered[2]	Methylmercury: Estimated particulate[1] (ng/L)	Methylmercury: Percentage of unfiltered[2]	Methylmercury: Methylation efficiency (percent)[3]
22	Trail Creek at Michigan City Harbor	09/08/2004	0.68	58.6	0.01	17	5.2
		10/20/2004	.38	69.1	ND	ND	ND
		03/09/2005	.59	41.5	.01	11	6.3
		06/22/2005	1.13	79.0	.03	38	5.6
		08/31/2005	.54	68.4	ND	ND	ND
		12/07/2005	.49	59.8	ND	ND	ND
		03/15/2006	3.80	64.0	.03	38	1.3
		05/24/2006	1.46	78.5	.05	56	4.8
		08/30/2006	3.84	53.7	.16	41	5.5
23	Deep River at Lake George outlet at Hobart	09/08/2004	1.28	59.3	ND	ND	ND
		10/20/2004	1.26	68.1	ND	ND	ND
		03/10/2005	.57	41.6	.08	100	5.8
		06/23/2005	.81	56.6	.09	100	6.3
		09/01/2005	.79	55.2	.05	100	3.5
		12/08/2005	1.03	54.8	.05	100	2.7
		03/16/2006	3.72	54.0	.00	0	.7
		05/25/2006	.83	60.1	.05	100	3.6
		08/31/2006	1.50	49.7	.04	27	5.0
24	Kankakee River at Shelby	09/08/2004	6.28	85.7	.07	54	1.8
		10/21/2004	.61	76.3	ND	ND	ND
		03/10/2005	1.41	58.8	.04	40	4.2
		06/23/2005	4.97	94.1	.00	0	.8
		09/01/2005	1.66	91.2	.00	0	2.7
		12/08/2005	.40	53.3	ND	ND	ND
		03/16/2006	8.71	71.4	.07	64	.9
		05/25/2006	3.27	87.7	.07	100	1.9
		08/31/2006	2.71	83.9	.07	100	2.2

Appendix 6. Estimated particulate total mercury and particulate methylmercury concentrations and methylation efficiencies in water samples from monitoring in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ng/L, nanograms per liter; ND, not determined; <, less than]

			Total mercury		Methylmercury		
Monitoring station number	Station name	Sample date (month/day/year)	Estimated particulate[1] (ng/L)	Percentage of unfiltered[2]	Estimated particulate[1] (ng/L)	Percentage of unfiltered[2]	Methylation efficiency (percent)[3]
25	Wabash River at Vigo Street at Vincennes	10/07/2004	1.79	91.8	0.22	100	11.3
		11/04/2004	8.04	82.6	.08	50	1.6
		03/01/2005	2.12	51.5	.09	100	2.2
		06/08/2005	2.20	86.6	.34	81	16.5
		09/07/2005	2.15	88.1	.20	74	11.1
		11/29/2005	3.19	77.6	.09	100	2.2
		02/28/2006	4.40	78.0	.09	100	1.6
		05/09/2006	5.92	91.8	.15	100	2.3
		08/22/2006	3.48	90.2	.17	81	5.4

[1]Particulate mercury estimated by subtracting filtered concentration from unfiltered concentration.

[2]Percentage unfiltered computed as the estimated particulate concentration divided by the unfiltered concentration, expressed as a percentage.

[3]Methylation efficiency computed as unfiltered methylmercury concentration divided by unfiltered total mercury concentration, expressed as a percentage.

Appendix 7. Instantaneous streamflow and water-quality characteristics at monitoring stations for mercury in Indiana streams, August 2004–September 2006.

[Locations of stations shown on figure 1; ft^3/s, cubic foot per second; ºC, degree Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; ntru, nephelometric turbidity ratio units; ND, no data; E, streamflow estimated with stage data and historical rating]

Monitoring station number	Station name	Sample date (month/day/ year)	Instantaneous streamflow (ft^3/s)	Water temperature (ºC)	pH (standard units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Turbidity (ntru)
1	Fall Creek near Fortville	08/23/2004	65	19.3	7.8	726	7.0	8.5
		10/12/2004	28	11.9	8.0	810	8.4	2.3
		02/22/2005	360	5.8	7.8	653	11.2	8.2
		06/27/2005	78	23.3	7.8	746	6.4	18
		09/15/2005	36	21.0	7.8	775	6.4	13
		12/16/2005	95	1.4	7.8	832	13.0	3.2
		03/10/2006	1,660	8.3	7.4	368	9.8	280
		05/15/2006	687	11.7	7.8	518	9.5	42
		09/05/2006	49	17.5	8.1	829	8.1	13
2	Eel River near Logansport	08/30/2004	3,730	20.6	7.6	365	7.8	140
		10/19/2004	244	9.4	8.2	688	11.2	1.5
		03/17/2005	829	5.3	8.0	647	11.7	7.8
		06/14/2005	611	22.6	7.7	650	6.5	19
		09/13/2005	115	21.6	7.9	684	7.9	3.4
		12/13/2005	214	–.2	7.5	804	12.8	2.4
		03/07/2006	378	2.3	8.2	708	14.1	3.9
		05/17/2006	2,690	13.6	7.8	510	9.3	65
		09/07/2006	240	20.6	8.3	697	10.9	5.7
3	Tippecanoe River at Winamac	09/02/2004	2,430	20.0	7.5	511	8.3	11
		10/19/2004	360	8.8	8.1	643	10.1	2.5
		03/17/2005	1,440	5.2	7.8	577	12.0	5.7
		06/14/2005	508	23.8	8.0	604	7.5	16
		09/13/2005	172	22.6	8.0	657	7.9	5.6
		12/13/2005	515	ND	ND	ND	ND	5.0
		03/07/2006	597	3.8	8.2	637	14.1	4.5
		05/25/2006	1,460	17.3	8.0	608	9.3	13
		08/31/2006	1,240	19.8	7.7	518	6.9	36

Appendix 7. Instantaneous streamflow and water-quality characteristics at monitoring stations for mercury in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ft^3/s, cubic foot per second; ºC, degree Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; ntru, nephelometric turbidity ratio units; ND, no data; E, streamflow estimated with stage data and historical rating]

Monitoring station number	Station name	Sample date (month/day/ year)	Instantaneous streamflow (ft^3/s)	Water temperature (ºC)	pH (standard units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Turbidity (ntru)
4	Wildcat Creek near Lafayette	08/30/2004	798	20.5	8.0	607	8.3	74
		10/21/2004	409	12.1	8.3	640	11.2	8.1
		03/16/2005	467	3.9	7.9	681	13.1	3.9
		06/13/2005	446	22.8	7.9	679	7.8	18
		09/12/2005	67	22.6	7.9	762	8.2	5.5
		12/12/2005	251	–.3	7.6	866	12.8	2.5
		03/06/2006	365	3.6	8.3	730	13.3	3.0
		05/17/2006	2,470	12.8	8.1	608	9.6	51
		09/07/2006	224	18.7	8.2	695	8.0	11
5	Wabash River at U.S. Highway 40 at Terre Haute	09/10/2004	7,220	24.1	8.1	535	7.0	39
		11/03/2004	9,430	15.7	8.0	597	7.7	69
		02/28/2005	26,700	5.3	7.8	508	12.1	44
		06/07/2005	4,410	27.8	8.0	572	12.0	38
		09/06/2005	2,130	28.8	8.0	649	5.5	32
		11/28/2005	4,840	9.8	8.1	632	11.2	35
		02/27/2006	8,190	5.6	8.0	663	13.8	73
		05/08/2006	9,510	19.3	8.4	654	11.1	44
		08/21/2006	3,210	30.7	8.7	548	ND	33
6	Mill Creek at tailwater pool near Manhattan	08/31/2004	18 E	24.0	7.5	289	7.2	8.2
		10/13/2004	39 E	18.6	7.2	302	8.1	9.5
		03/04/2005	61 E	4.5	7.4	287	12.2	13
		06/06/2005	113 E	16.4	7.5	377	9.1	13
		09/02/2005	632 E	25.1	7.4	296	7.3	17
		12/02/2005	429 E	6.3	7.1	319	12.3	9.9
		03/03/2006	136 E	4.9	7.8	445	14.5	11
		05/08/2006	273 E	14.0	7.3	396	10.1	14
		08/21/2006	12 E	24.8	7.9	310	6.8	14

Appendix 7. Instantaneous streamflow and water-quality characteristics at monitoring stations for mercury in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ft^3/s, cubic foot per second; ºC, degree Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; ntru, nephelometric turbidity ratio units; ND, no data; E, streamflow estimated with stage data and historical rating]

Monitoring station number	Station name	Sample date (month/day/ year)	Instantaneous streamflow (ft^3/s)	Water temperature (ºC)	pH (standard units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Turbidity (ntru)
7	White River near Centerton	08/24/2004	975	23.6	7.6	998	7.2	15
		10/14/2004	900	17.9	7.7	1,280	7.6	20
		02/23/2005	3,940	5.7	7.7	731	11.5	19
		06/28/2005	821	26.4	8.2	1,070	10.2	15
		09/14/2005	570	24.2	7.9	1,160	8.7	15
		12/14/2005	1,390	4.1	7.4	1,000	11.7	9.6
		03/08/2006	1,560	8.4	7.8	962	11.3	6.9
		05/16/2006	7,480	13.2	7.8	561	9.7	60
		09/06/2006	703	20.3	7.8	999	7.5	10
8	White River near Nora	08/23/2004	516	23.1	7.7	878	7.3	10
		10/12/2004	227	14.8	8.2	969	9.4	6.0
		02/22/2005	2,360	4.6	8.0	577	11.9	14
		06/27/2005	386	26.9	7.8	865	6.6	10
		09/15/2005	300	23.4	7.7	905	6.7	12
		12/16/2005	662	1.3	7.8	857	13.8	4.3
		03/10/2006	3,760	7.8	8.0	652	10.7	77
		05/15/2006	5,010	12.0	7.8	472	9.2	59
		09/05/2006	325	20.4	8.1	865	7.6	14
9	Sugar Creek at New Palestine	08/24/2004	11	22.0	7.9	635	9.3	5.9
		10/14/2004	9	12.9	7.9	657	7.1	5.2
		02/23/2005	129	5.2	7.9	604	12.3	10
		06/28/2005	21	25.7	8.1	632	8.1	8.0
		09/14/2005	11	22.5	7.9	621	9.6	4.3
		12/14/2005	40	.6	7.7	728	14.0	6.0
		03/08/2006	46	5.4	8.2	631	13.5	8.9
		05/16/2006	346	12.5	7.8	508	9.6	33
		09/06/2006	11	18.3	8.2	668	8.8	5.0

Appendix 7. Instantaneous streamflow and water-quality characteristics at monitoring stations for mercury in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ft^3/s, cubic foot per second; ºC, degree Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; ntru, nephelometric turbidity ratio units; ND, no data; E, streamflow estimated with stage data and historical rating]

Monitoring station number	Station name	Sample date (month/day/ year)	Instantaneous streamflow (ft^3/s)	Water temperature (ºC)	pH (standard units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Turbidity (ntru)
10	East Fork Whitewater River at Brookville	09/03/2004	50 E	21.8	7.7	457	8.3	1.5
		10/22/2004	468 E	16.2	7.8	446	9.5	14
		02/25/2005	307 E	3.9	7.8	418	12.5	7.8
		06/30/2005	384 E	13.4	7.8	464	10.2	5.4
		09/16/2005	60 E	17.7	7.6	473	10.0	1.1
		12/19/2005	182 E	5.3	7.8	485	13.4	1.4
		03/17/2006	1,690 E	5.8	8.3	503	13.8	13
		05/18/2006	2,010 E	9.5	8.0	492	12.5	2.9
		09/08/2006	67 E	21.4	7.8	472	7.7	1.3
11	Vernon Fork Muscatatuck River at Vernon	08/25/2004	36	23.0	7.6	348	6.5	13
		10/15/2004	139	13.4	7.9	729	7.4	2.6
		02/24/2005	144	4.4	8.0	385	12.4	7.4
		06/29/2005	8	26.7	8.4	412	7.5	9.3
		09/19/2005	5	20.5	8.1	432	9.1	2.5
		12/15/2005	65	1.8	7.8	508	13.9	15
		03/09/2006	2,030	6.8	7.4	180	11.1	180
		05/12/2006	296	14.3	7.8	261	8.9	64
		08/24/2006	7	25.3	8.1	308	8.8	4.6
12	White River at State Road 258 near Seymour	08/25/2004	688	24.8	7.9	640	8.3	8.0
		10/15/2004	362	13.7	8.1	709	9.2	5.2
		02/24/2005	3,440	5.9	7.8	622	11.4	15
		06/29/2005	1,090	27.5	8.3	615	11.0	18
		09/19/2005	694	22.8	8.1	708	9.4	9.9
		12/15/2005	1,220	3.2	7.9	708	13.3	7.3
		03/09/2006	6,740	6.7	7.7	334	10.4	290
		05/11/2006	6,660	16.2	7.8	422	7.5	260
		08/24/2006	758	25.3	8.2	665	8.7	9.4

Appendix 7. Instantaneous streamflow and water-quality characteristics at monitoring stations for mercury in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ft^3/s, cubic foot per second; ºC, degree Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; ntru, nephelometric turbidity ratio units; ND, no data; E, streamflow estimated with stage data and historical rating]

Monitoring station number	Station name	Sample date (month/day/ year)	Instantaneous streamflow (ft^3/s)	Water temperature (ºC)	pH (standard units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Turbidity (ntru)
13	Blue River at Fredericksburg	09/09/2004	20	20.5	7.9	454	8.2	9.2
		10/18/2004	16	10.5	7.8	520	8.6	13
		03/03/2005	246	3.4	7.4	347	12.8	3.5
		06/10/2005	33	24.3	7.7	469	7.1	15
		09/09/2005	10	20.7	7.5	435	6.5	18
		12/01/2005	302	5.8	7.7	332	13.2	14
		03/02/2006	151	10.1	7.9	378	11.7	5.4
		05/11/2006	351	15.8	7.8	381	8.2	17
		08/24/2006	30	20.8	7.7	465	6.2	16
14	Patoka River at Winslow	09/01/2004	147	23.4	7.3	350	6.7	47
		10/28/2004	1,220	16.1	7.2	303	5.3	240
		03/02/2005	1,240	4.4	7.4	269	11.0	26
		06/09/2005	47	25.9	7.5	626	9.4	51
		09/08/2005	57	22.6	7.2	436	6.1	39
		11/30/2005	621	8.0	7.1	398	8.8	160
		03/01/2006	218	6.4	7.3	353	12.7	15
		05/10/2006	598	17.1	7.2	275	7.5	48
		08/23/2006	311	24.1	7.2	235	5.2	61
15	White River at Petersburg	10/07/2004	1,780	18.6	8.1	831	9.9	35
		10/28/2004	10,000	16.6	7.6	460	6.9	110
		03/02/2005	15,100	5.5	7.7	503	10.9	26
		06/09/2005	5,800	27.8	8.1	578	14.5	53
		09/08/2005	4,550	27.3	8.2	502	8.8	61
		11/30/2005	7,650	7.7	7.8	590	11.5	41
		03/01/2006	9,260	7.9	8.0	614	13.1	22
		05/10/2006	14,400	19.1	7.9	485	8.4	52
		08/23/2006	3,450	28.7	8.2	545	9.1	47

Appendix 7. Instantaneous streamflow and water-quality characteristics at monitoring stations for mercury in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ft^3/s, cubic foot per second; ºC, degree Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; ntru, nephelometric turbidity ratio units; ND, no data; E, streamflow estimated with stage data and historical rating]

Monitoring station number	Station name	Sample date (month/day/ year)	Instantaneous streamflow (ft^3/s)	Water temperature (ºC)	pH (standard units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Turbidity (ntru)
16	Busseron Creek near Carlisle	08/31/2004	102 E	23.0	7.5	863	7.3	33
		10/29/2004	244	16.3	7.2	603	7.2	24
		03/01/2005	135	3.2	7.7	857	12.0	22
		06/08/2005	26	24.1	7.6	1,280	5.4	27
		09/07/2005	15	21.6	7.5	1,210	6.4	44
		11/29/2005	182	8.8	7.4	720	9.3	57
		02/28/2006	84	4.7	8.0	852	12.2	16
		05/09/2006	79	17.0	7.7	945	7.4	14
		08/22/2006	14	23.4	7.8	1,270	5.7	31
17	Mississinewa River at County Road 275 East near Peoria	08/26/2004	192 E	22.5	7.6	532	7.5	20
		10/25/2004	194 E	12.8	7.7	575	9.7	41
		03/07/2005	574 E	4.2	8.0	562	12.8	21
		06/20/2005	248 E	20.2	7.8	478	9.0	5.2
		08/29/2005	89 E	24.5	7.9	469	5.7	8.1
		12/05/2005	570 E	3.4	7.4	545	13.2	37
		03/13/2006	2,020 E	6.5	8.0	511	12.6	29
		05/22/2006	673 E	14.0	7.9	458	10.4	22
		08/28/2006	141 E	22.8	7.5	481	4.5	9.4
18	Wabash River at County Road 200 West near Huntington	08/26/2004	92 E	23.8	7.7	599	7.9	36
		10/25/2004	133 E	13.1	8.2	708	11.4	26
		03/07/2005	1,730 E	6.0	7.8	539	12.4	150
		06/20/2005	104 E	25.8	8.1	600	8.7	47
		08/29/2005	25 E	28.1	8.0	591	9.4	46
		12/05/2005	273 E	.6	7.5	625	13.5	140
		03/13/2006	2,290 E	10.7	7.7	478	10.7	280
		05/22/2006	1,280 E	15.7	7.9	531	10.1	36
		08/28/2006	100 E	26.0	7.9	580	7.5	33

Appendix 7. Instantaneous streamflow and water-quality characteristics at monitoring stations for mercury in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ft^3/s, cubic foot per second; ºC, degree Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; ntru, nephelometric turbidity ratio units; ND, no data; E, streamflow estimated with stage data and historical rating]

Monitoring station number	Station name	Sample date (month/day/ year)	Instantaneous streamflow (ft^3/s)	Water temperature (ºC)	pH (standard units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Turbidity (ntru)
19	Maumee River at New Haven	08/27/2004	634	23.2	7.8	660	7.4	35
		10/26/2004	591	12.8	7.7	795	8.6	40
		03/08/2005	4,020	4.6	7.4	493	12.5	110
		06/21/2005	106	22.0	7.8	813	9.3	22
		08/30/2005	145	24.5	7.4	905	4.4	31
		12/06/2005	1,300	–.1	7.5	580	11.9	120
		03/14/2006	8,140	9.3	7.7	384	10.4	500
		05/23/2006	2,530	14.5	7.8	548	9.3	68
		08/29/2006	1,380	22.6	7.6	525	5.4	92
20	Fish Creek near Artic	09/07/2004	15	20.9	8.2	619	7.0	21
		10/26/2004	19	12.1	7.9	669	8.4	4.4
		03/08/2005	336	2.3	7.7	392	12.3	36
		06/21/2005	10	18.9	8.0	671	8.3	22
		08/30/2005	6	20.4	8.0	692	7.7	9.5
		12/06/2005	59	–.2	7.0	661	11.5	ND
		03/14/2006	592	6.7	7.8	373	10.2	98
		05/23/2006	71	14.0	8.0	533	8.8	15
		08/29/2006	157	19.0	7.6	391	6.6	86
21	St. Joseph River at Elkhart	09/07/2004	1,920	23.5	8.2	594	8.6	4.2
		10/27/2004	1,560	13.0	7.9	618	9.9	2.7
		03/09/2005	5,930	2.3	7.9	535	12.8	5.4
		06/22/2005	1,790	22.3	7.8	586	8.6	4.5
		08/31/2005	1,060	23.0	8.1	596	8.4	3.2
		12/07/2005	1,200	.0	7.4	668	13.3	2.0
		03/15/2006	6,030	6.9	8.1	496	11.4	59
		05/24/2006	4,140	16.1	8.1	584	9.7	6.5
		08/30/2006	2,100	20.6	7.9	565	7.1	5.9

Appendix 7. Instantaneous streamflow and water-quality characteristics at monitoring stations for mercury in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ft^3/s, cubic foot per second; ºC, degree Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; ntru, nephelometric turbidity ratio units; ND, no data; E, streamflow estimated with stage data and historical rating]

Monitoring station number	Station name	Sample date (month/day/ year)	Instantaneous streamflow (ft^3/s)	Water temperature (ºC)	pH (standard units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Turbidity (ntru)
22	Trail Creek at Michigan City Harbor[1]	09/08/2004	–234	18.0	7.8	756	8.0	4.9
		10/20/2004	583	12.3	7.8	757	11.4	4.1
		03/09/2005	236	4.4	7.6	756	12.9	9.9
		06/22/2005	179	21.0	7.9	772	9.3	10
		08/31/2005	–282	21.7	8.2	774	9.4	6.1
		12/07/2005	–30	2.1	7.5	854	13.7	4.3
		03/15/2006	49	7.6	7.9	702	11.2	45
		05/24/2006	–23	14.0	7.9	795	9.4	13
		08/30/2006	199	19.0	7.6	610	7.5	39
23	Deep River at Lake George outlet at Hobart	09/08/2004	36	22.7	7.9	666	8.1	16
		10/20/2004	26	9.9	8.0	662	9.9	18
		03/10/2005	91	4.0	7.9	939	12.2	15
		06/23/2005	15	24.0	8.3	713	9.4	19
		09/01/2005	16	24.0	8.1	644	6.0	16
		12/08/2005	29	1.5	7.3	882	11.7	19
		03/16/2006	417	6.9	7.7	640	10.0	91
		05/25/2006	65	18.4	8.5	817	11.3	12
		08/31/2006	412	20.8	7.5	520	6.5	23
24	Kankakee River at Shelby	09/08/2004	2,390	20.2	7.7	597	7.4	23
		10/21/2004	796	10.6	8.0	662	9.7	5.9
		03/10/2005	3,440	3.4	7.8	602	11.6	14
		06/23/2005	676	22.9	7.9	687	7.9	28
		09/01/2005	629	21.6	7.9	739	7.5	12
		12/08/2005	1,240	–.3	7.7	766	12.7	8.2
		03/16/2006	3,290	7.4	7.8	522	9.3	160
		05/25/2006	1,860	16.7	8.0	679	8.7	21
		08/31/2006	1,590	18.9	7.8	635	7.4	19

Appendix 7. Instantaneous streamflow and water-quality characteristics at monitoring stations for mercury in Indiana streams, August 2004–September 2006.—Continued

[Locations of stations shown on figure 1; ft^3/s, cubic foot per second; ºC, degree Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; ntru, nephelometric turbidity ratio units; ND, no data; E, streamflow estimated with stage data and historical rating]

Monitoring station number	Station name	Sample date (month/day/ year)	Instantaneous streamflow (ft^3/s)		Water temperature (ºC)	pH (standard units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Turbidity (ntru)
25	Wabash River at Vigo Street at Vincennes	10/07/2004	3,400	E	18.8	8.5	597	14.5	24
		11/04/2004	15,500		15.1	7.6	506	7.7	93
		03/01/2005	35,200		4.4	7.6	487	11.8	44
		06/08/2005	5,660		27.5	8.0	609	8.3	29
		09/07/2005	2,340		27.1	8.3	570	11.6	39
		11/29/2005	6,050		7.7	7.8	624	11.0	49
		02/28/2006	9,560	E	6.3	8.5	605	13.0	98
		05/09/2006	11,300	E	19.4	8.2	629	10.0	69
		08/22/2006	4,150	E	28.0	8.6	539	13.6	54

[1]Instantaneous streamflow from Trail Creek at Michigan City Harbor includes positive values indicating a flow direction downstream toward nearby Lake Michigan and negative values indicating a flow direction upstream from Lake Michigan that were influenced by water levels in Lake Michigan.

Ulberg and Risch—**Total Mercury and Methylmercury in Indiana Streams, August 2004–September 2006**—Scientific Investigations Report 2008–5176

ISBN 978-1-4113-2290-5

9 781411 322905

Printed on recycled paper