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Mercury in Precipitation in Indiana, January 2004–December 2005

Scientific Investigations Report 2008–5148

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

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By Martin R. Risch and Kathleen K. Fowler

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Conversion Factors and Vertical Datum

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
acre	4.047	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
square meter (m^2)	0.0002471	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
liter (L)	0.2642	gallon (gal)
milliliter (mL)	0.06102	cubic inch (in^3)
	Mass	
pound, avoirdupois (lb)	0.4536	kilogram (kg)
gram (g)	0.03527	ounce, avoirdupois (oz)

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

°F=(1.8×°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 North American Vertical Datum of 1988 (NAVD 88).

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

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

Concentrations of chemical constituents in water are given in nanogram per liter (ng/L).

Mercury deposition is given in microgram per square meter (µg/m^2) or nanogram per square meter (ng/m^2). One microgram per square meter is equivalent to 1,000 nanograms per square meter.

Abbreviations

IDEM	Indiana Department of Environmental Management	USGS	U.S. Geological Survey
MDN	Mercury Deposition Network	QA	Quality Assurance
NADP	National Atmospheric Deposition Program	QC	Quality Control
NTN	National Trends Network	NWS	National Weather Service
RAPIDS	Regional Air Pollutant Inventory Development System	GIS	Geographic Information System

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Abstract

Mercury in precipitation was monitored during 2004–2005 at five locations in Indiana as part of the National Atmospheric Deposition Program–Mercury Deposition Network (NADP–MDN). Monitoring stations were operated at Roush Lake near Huntington, Clifty Falls State Park near Madison, Fort Harrison State Park near Indianapolis, Monroe County Regional Airport near Bloomington, and Indiana Dunes National Lakeshore near Porter. At these monitoring stations, precipitation amounts were measured continuously and weekly samples were collected for analysis of mercury by methods achieving detection limits as low as 0.05 ng/L (nanograms per liter). Wet deposition was computed as the product of mercury concentration and precipitation. The data were analyzed for seasonal patterns, temporal trends, and geographic differences.

In the 2 years, 520 weekly samples were collected at the 5 monitoring stations and 448 of these samples had sufficient precipitation to compute mercury wet deposition. The 2-year mean mercury concentration at the five monitoring stations (normalized to the sample volume) was 10.6 ng/L. As a reference for comparison, the total mercury concentration in 41 percent of the samples analyzed was greater than the statewide Indiana water-quality standard for mercury (12 ng/L, protecting aquatic life) and 99 percent of the concentrations exceeded the most conservative Indiana water-quality criterion (1.3 ng/L, protecting wild mammals and birds). The normalized annual mercury concentration at Clifty Falls in 2004 was the fourth highest in the NADP–MDN in eastern North America that year. In 2005, the mercury concentrations at Clifty Falls and Indiana Dunes were the ninth highest in the NADP–MDN in eastern North America.

At the five monitoring stations during the study period, the mean weekly total mercury deposition was 0.208 $\mu g/m^2$ (micrograms per square meter) and mean annual total mercury deposition was 10.8 $\mu g/m^2$. The annual mercury deposition at Clifty Falls in 2004 and 2005 was in the top 25 percent of the NADP–MDN stations in eastern North America.

Mercury concentrations and deposition varied at the five monitoring stations during 2004–2005. Mercury concentrations in wet-deposition samples ranged from 1.2 to 116.6 ng/L and weekly mercury deposition ranged from 0.002 to 1.74 $\mu g/m^2$. Data from weekly samples exhibited seasonal patterns. During April through September, total mercury concentrations and deposition were higher than the median for all samples. Annual precipitation at four of the five monitoring stations was within 10 percent of normal both years, with the exception of Indiana Dunes, where precipitation was 23 percent below normal in 2005.

Episodes of high mercury deposition, which were the top 10 percent of weekly mercury deposition at the five monitoring stations, contributed 39 percent of all mercury deposition during 2004–2005. Mercury deposition more than 1.04 $\mu g/m^2$ (5 times the mean weekly deposition) was recorded for 12 samples. These episodes of highest mercury deposition were recorded at all five monitoring stations, but the most (7 of 12) were at Clifty Falls and contributed 34.4 percent of the total deposition at that station during 2004–2005. Weekly samples with high mercury deposition may help to explain the differences in annual mercury deposition among the five monitoring stations in Indiana.

A statistical evaluation of the monitoring data for 2001–2005 indicated several statistically significant temporal trends. A statewide (5-station) decrease ($p = 0.007$) in mercury deposition and a statewide decrease ($p = 0.059$) in mercury concentration were shown. Decreases in mercury deposition ($p = 0.061$ and $p = 0.083$) were observed at Roush Lake and Bloomington. A statistically significant trend was not observed for precipitation at the five monitoring stations during this 5-year period. A potential explanation for part of the statewide decrease in mercury concentration and mercury deposition was a 28 percent decrease in the total estimated annual mercury emissions in Indiana between 2002 and 2005.

Mercury deposition statistically was correlated most closely to precipitation in the 448 samples, 2004–2005, and this relation was demonstrated by statewide maps of annual precipitation and annual mercury deposition based on precipitation data from 127 National Weather Service Cooperative Observer Program stations. However, one area in southeastern Indiana in the vicinity of Clifty Falls exhibited high mercury deposition that might be related more to mercury concentration than to precipitation. This is because areas with the same range of precipitation as southeastern Indiana were mapped with less mercury deposition.

Other data demonstrate a geographic difference for mercury in precipitation in the vicinity of the Clifty Falls monitoring station. The weekly mercury concentrations at Clifty Falls were statistically higher than concentrations at

Roush Lake, Fort Harrison, and Bloomington. Clifty Falls data ranked highest among the five monitoring stations for mercury concentration and mercury deposition, 2004–2005, and in the previous 3 years. Episodes of high mercury deposition were recorded most often at Clifty Falls in 2004–2005 and in the previous 3 years. Statistical trends in mercury concentration or mercury deposition were not observed for the Clifty Falls data. A potential explanation for this geographic difference is that annual mercury emissions from sources in the vicinity of Clifty Falls were higher than those at the other stations. Other factors may help explain the differences in total mercury concentrations, such as the types of mercury emissions, mercury transport from stationary sources outside Indiana, and meteorological conditions. Additional data are needed to assign a localized or regional boundary to the area affected by high deposition of mercury near Clifty Falls.

Introduction

A monitoring program for mercury in precipitation was operated in Indiana by the U.S. Geological Survey (USGS) in cooperation with the Indiana Department of Environmental Management (IDEM). This monitoring program began in late 2000 and the data and findings from four monitoring stations, January 2001–December 2003, were reported by Risch (2007).

Purpose and Scope

This report presents and interprets mercury data from precipitation samples collected concurrently at five monitoring stations in Indiana, January 2004–December 2005. Data on mercury concentrations (mass per unit volume of precipitation) are included with the computed mercury wet deposition (mass per unit area per unit time). Quality assurance for mercury concentrations and precipitation measurement is described. Geographic variability and seasonal patterns in mercury concentrations and mercury wet deposition are examined for Indiana; Indiana results are compared to NADP–MDN results for the eastern U.S. Annual mercury wet deposition is compared with episodes of high mercury deposition and precipitation normals. Trends in precipitation, mercury concentrations, and mercury deposition in Indiana are examined for the period 2001–2005.

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 2003 was 6.2 million, 14th in the Nation; population density was 172.7 per mi^2. Children are one fourth of the total Indiana population[1] (Indiana Business Research Center, 2007). Indiana has 35,673 mi of rivers, 575 publicly owned lakes and reservoirs (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 patterns may 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 (Midwestern Regional Climate Center, 2007).

The statewide mean annual precipitation is 41.5 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, with the greatest amounts of snowfall in northern Indiana (Morlock and others, 2004; Midwestern Regional Climate Center, 2007). According to Clark (1980), of the mean annual precipitation in Indiana, approximately 68 percent 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 of the State with steep slopes and relatively impermeable soils, which are characteristic of much of the southern third of Indiana.

Mercury in the Environment

Mercury in aquatic ecosystems is a public-health concern and a threat to wildlife because it accumulates and magnifies to unsafe levels in aquatic food chains. Much of the mercury in aquatic ecosystems comes from atmospheric deposition, and mercury emissions to the atmosphere from human activity have been implicated.

Mercury in Fish and Risks to Humans and Wildlife

Mercury—especially in the organic form, methylmercury—can have adverse health effects in adults and children. An important route of exposure to methylmercury for some humans is eating fish caught in rivers and lakes. Infants and young children are predicted to have a high susceptibility

[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 (1.17 million) total 1.6 million of the 6.2 million total Indiana population (25.8 percent).

to the detrimental effects of methylmercury because their nervous systems are still in development (National Research Council, 2000). Adults can have increased risks of adverse neurological and cardiovascular effects from methylmercury exposure (Mergler and others, 2007). Wildlife, including fish, fish-eating mammals, and fish-eating birds, suffer from reproductive and developmental impairments and reduced immunity caused by methylmercury (Scheuhammer and others, 2007). Population-level impacts in terrestrial wildlife may be linked to mercury as well (Evers, 2005).

Methylmercury is produced from inorganic mercury by microbial processes controlled by physical and chemical conditions in aquatic ecosystems. Fish living in aquatic ecosystems with low concentrations of inorganic mercury are known to accumulate methylmercury in their tissue. Concentrations of methylmercury magnify up the food chain so that higher-level organisms tend to accumulate the highest levels of methylmercury (Munthe and others, 2007). Studies have shown a reasonable correlation between methylmercury in water and in fish that reflects changes at the base of the food chain, including a prediction that mercury emissions reduction will rapidly decrease methylmercury concentrations in fish (Harris and others, 2007).

Mercury has been detected in more than 90 percent of fish-tissue samples collected in Indiana 1983–2006, according to Stahl (1997) and the Indiana Assessment Information Management System data base (unpublished data, Indiana Department of Environmental Management, 2006). Concentrations of mercury in some tissue samples from fish caught in Indiana waters have prompted State health officials to issue advisories that warn against human consumption of these fish (Indiana State Department of Health, 2007). These advisories apply statewide to certain sizes and species of fish and include additional warnings for specific streams and lakes. As of 2006, mercury advisories affected 3,113 mi of streams, 40,628 acres of lakes, and all of the 59 mi of Great Lakes shoreline in Indiana (Indiana Department of Environmental Management, 2006). Each year, some 833,000 resident anglers 16 years and older spend 15.5 million days and $469 million for fishing as recreation. 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 affect approximately 1 of 6 Indiana residents.[2]

Mercury in the Atmosphere

The forms and behavior of atmospheric mercury are complex, as explained by Schroeder and Munthe (1998), Lin and Pehkonen (1999), and Cohen and others (2004). Atmospheric mercury occurs in three forms—elemental, oxidized, and particulate-bound. Elemental mercury is more than 90 percent of the total mercury in the atmosphere. It is volatile, minimally water soluble[3] and becomes globally distributed because it can remain in the atmosphere as long as 1 year. Oxidized mercury can have a reactive gaseous form, can be a compound such as mercuric chloride, or can be dissolved in water droplets. Oxidized mercury makes up a few percent of the total mercury in the atmosphere but constitutes most of the mercury in atmospheric deposition. It is the most water soluble[3] of the three forms and is more readily removed from the atmosphere than is elemental mercury. Oxidized mercury lasts 1 week or less in the atmosphere and generally is dispersed locally near its sources. Some atmospheric elemental mercury can become oxidized mercury and some oxidized mercury can become elemental mercury by reactions with other atmospheric chemicals and physical processes. Particulate-bound mercury is oxidized mercury, such as mercuric oxide, that is reversibly adsorbed to atmospheric particles (soot, dust, and ash.) Particulate-bound mercury constitutes a few percent of the total mercury in the atmosphere, where it is relatively short-lived (1 to 2 weeks) and generally is dispersed locally near its sources. Particulate-bound mercury can contribute to atmospheric deposition and can desorb from atmospheric particulates by chemical and physical processes.

Atmospheric mercury can be transported to aquatic or terrestrial ecosystems through wet deposition and dry deposition (fig. 1). Wet deposition of atmospheric mercury is the transfer of oxidized and particulate-bound mercury to the water and land in precipitation (rain, snow, sleet, hail, and fog). Atmospheric mercury is transported as rainout from clouds and washout from the air. Wet deposition in open areas occurs directly to land and water or in forests as throughfall below tree canopies. Mercury has been detected in precipitation throughout North America since monitoring began in 1996 (Sweet and Prestbo, 1999; National Atmospheric Deposition Program, 2005, 2006). Often, mercury concentrations in precipitation exceed the water-quality criterion for a continuous freshwater concentration, 12 ng/L (U.S. Environmental Protection Agency, 1999a). Mercury wet deposition is better documented and better understood than mercury dry deposition, primarily because methods for measurement of wet deposition were developed earlier than those for dry deposition.

Methylmercury in precipitation was measured as part of the monitoring program in Indiana, 2001–2003. Methylmercury wet deposition in Indiana averaged 0.7 percent of total mercury deposition, which was consistent with data from 14 other sites in the Great Lakes region during this same time period (Risch, 2007). On the basis of these data, most of the methylmercury in aquatic ecosystems in Indiana does not come from methylmercury wet deposition and is believed to originate as total mercury.

[2]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 6.2 million Indiana residents (Indiana Business Research Center, 2007).

[3]The water solubility of elemental mercury is 49.4×10^{-6} grams per liter; the water solubility of oxidized mercury (as mercuric chloride, $HgCl_2$) is 66 grams per liter (Schroeder and Munthe, 1998).

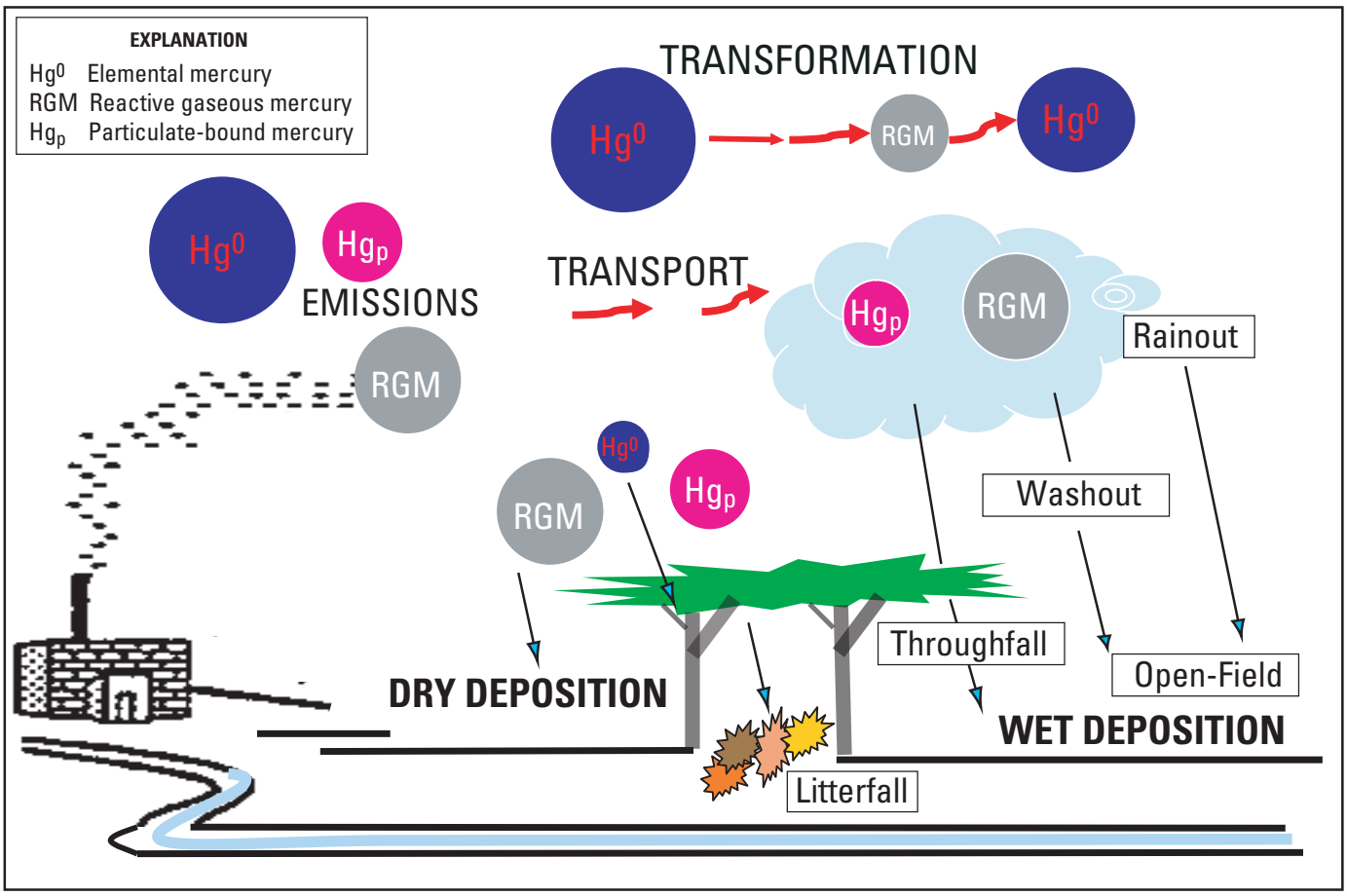


Figure 1. Schematic of atmospheric mercury and mercury wet and dry deposition.

As summarized by Grigal (2002), dry deposition of atmospheric mercury is a combination of oxidized mercury transfer onto and into vegetation, particulate-bound mercury transfer by gravity and air turbulence, and elemental mercury incorporation into foliage. Atmospheric deposition of mercury to forests is about four times that to water or open areas in the same geographic location, because additional mercury is retained in forests from throughfall, dry deposition to foliage, and accumulation in forest leaves and needles. Mercury dry deposition in open areas occurs directly to land and water and in forests is transferred to terrestrial and aquatic ecosystems by litterfall. Mercury dry deposition generally is not measured directly and a national monitoring program to estimate dry deposition was still in development in 2007 (National Atmospheric Deposition Program, 2007).

The Mercury Cycle

Atmospheric mercury can enter lakes and streams directly or in stormwater runoff. Once in surface water (fig. 2), inorganic mercury enters a complex cycle in which one form can be converted to another, as explained by Krabbenhoft and Rickert (1995). Inorganic mercury in the water can enter sediments by particle settling and later can be released into the water by diffusion or resuspension. Mercury in the water can be released back to the atmosphere by volatilization and later can redeposit to water. Typically, high acidity and high concentrations of dissolved organic carbon levels in the water enhance the mobility of mercury, thus making it more likely to enter the food chain. The way mercury enters the food chain is not fully understood and probably varies among ecosystems. It is known that bacteria that process sulfate in the environment take up inorganic mercury and metabolically convert it to methylmercury. The conversion of inorganic mercury to methylmercury is important because methylmercury is more toxic than inorganic mercury and organisms require a longer time to eliminate methylmercury. Methylmercury-containing bacteria may be consumed by the next higher level in the food chain or the bacteria may release the methylmercury to the water where it can adsorb quickly to plankton. Plankton then are consumed by the next level in the food chain. The concentration of methylmercury magnifies in organisms at higher levels in the food chain. Some methylmercury can convert back to inorganic mercury or enter sediments by particle settling. Details of the aquatic-mercury cycle are still areas of active research.

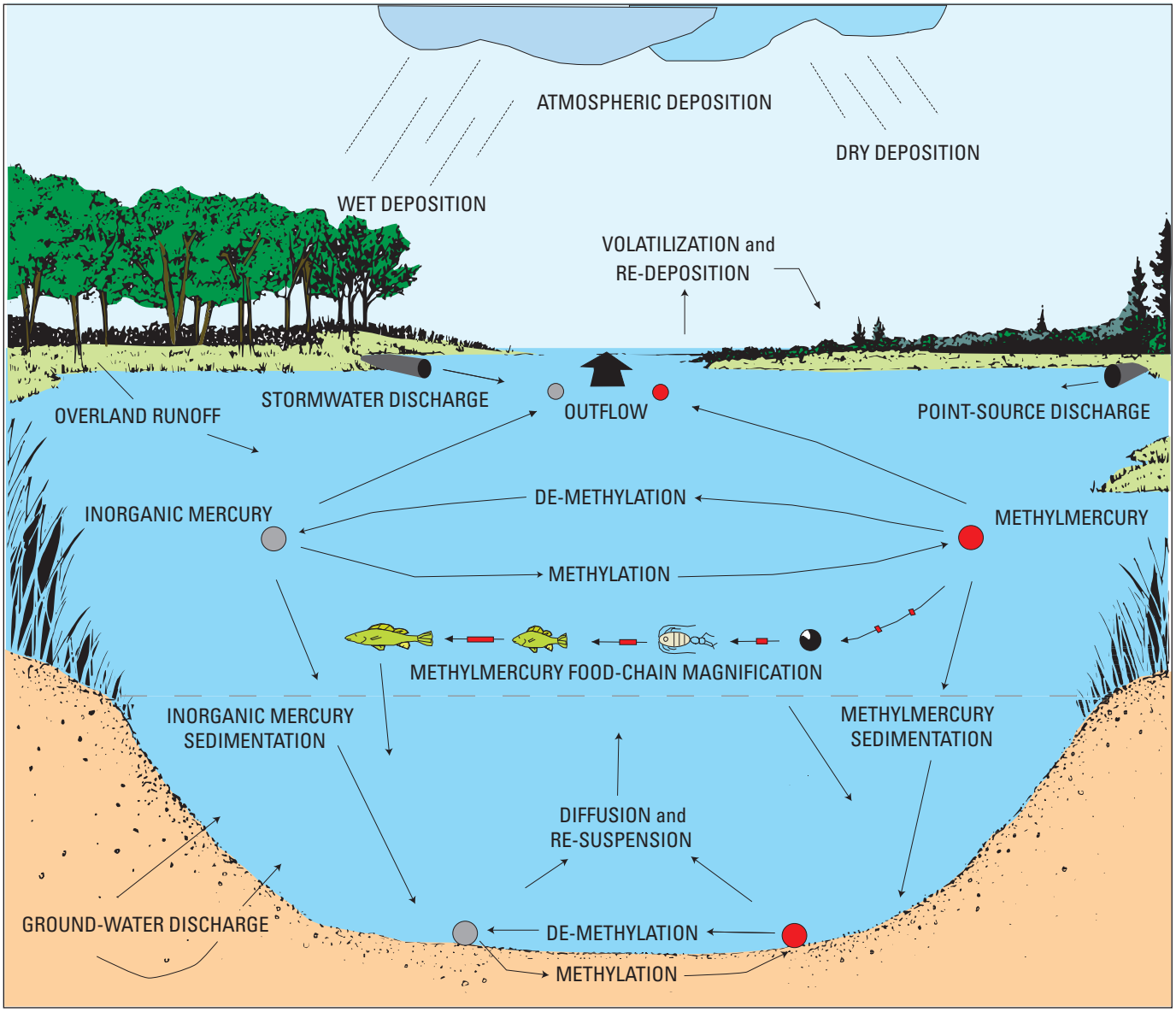


Figure 2. Mercury cycling in aquatic ecosystems.

Sources of Mercury

Sources of atmospheric mercury can be emissions from human activity or natural processes. Emissions from human activity come from stationary sources, such as coal combustion, waste incineration, steel mills, metal smelting, and refining, and from mobile sources (Seigneur and others, 2004; Schroeder and Munthe, 1998). Some mercury in aquatic ecosystems comes from point-source discharges of industrial and municipal wastewater and stormwater. Natural processes that cause mercury emissions are wildfires, volcanoes, and geothermal sources, plus re-emission or evasion from soil, vegetation, and water bodies (Schroeder and Munthe, 1998). Atmospheric deposition can contribute mercury directly to lakes and streams.

Information regarding stationary sources and estimated annual mercury emissions to the atmosphere was summarized from the 2002 Regional Air Pollutant Inventory Development System (RAPIDS) data for Indiana (Indiana Department of Environmental Management, Office of Air Quality, written commun., June 2005). The 2002 RAPIDS data include emissions reported by the owner or operator of the stationary source. Emissions from electric-power plants were calculated for RAPIDS with an emission factor (for the type of coal and type of electric-power plant) multiplied by the amount of coal used as fuel.

An estimated total of 10,390 lb of mercury was released to the atmosphere from 306 stationary sources in Indiana in 2002. This estimated total is for all types of stationary sources; however, they were mostly electric-power plants, foundries and steel mills, and cement and gypsum facilities (table 1).

Table 1. Stationary sources and estimated annual mercury emissions to the atmosphere in Indiana in 2002.

Category	Pounds of mercury emissions[1]	Number of emission sources[1]	Percentage of all mercury emissions from stationary sources in Indiana[1]	Range of annual emission rates per source (pounds)[1]
Electric-power plants	5,234	43	50.4	0.008 – 1,036
Foundries and steel mills (including coke ovens)	2,583	48	24.9	.070 – 659
Cement and gypsum production facilities	1,963	10	18.9	.134 – 1,261
Industries, manufacturing, and petroleum refineries	510	131	4.9	.002 – 143
Hospitals and medical-waste incinerators	25	23	.2	.003 – 10
Paving and asphalt plants	23	27	.2	.001 – 10
Natural gas pipeline operations	52	24	.5	.006 – 7

[1] Number of emission sources and annual mercury emissions from 2002 Regional Air Pollutant Inventory Development System for Indiana (Indiana Department of Environmental Management, Office of Air Quality, 2005, unpublished data), and includes only the sources that reported mercury emissions for the 2002 inventory.

The statewide distribution of these stationary sources and the annual mercury emissions per county was not uniform (fig. 3). Sources were more numerous in counties with large population centers. The highest annual emissions (more than 100 lb) were in 26 of the 92 counties, including 6 counties that had annual emissions of more than 500 lb. The 25 individual stationary sources with the highest annual mercury emissions for Indiana (more than 100 lb) included 14 electric-power plants, 5 steel mills, 1 foundry, 4 cement facilities, and 1 refinery.

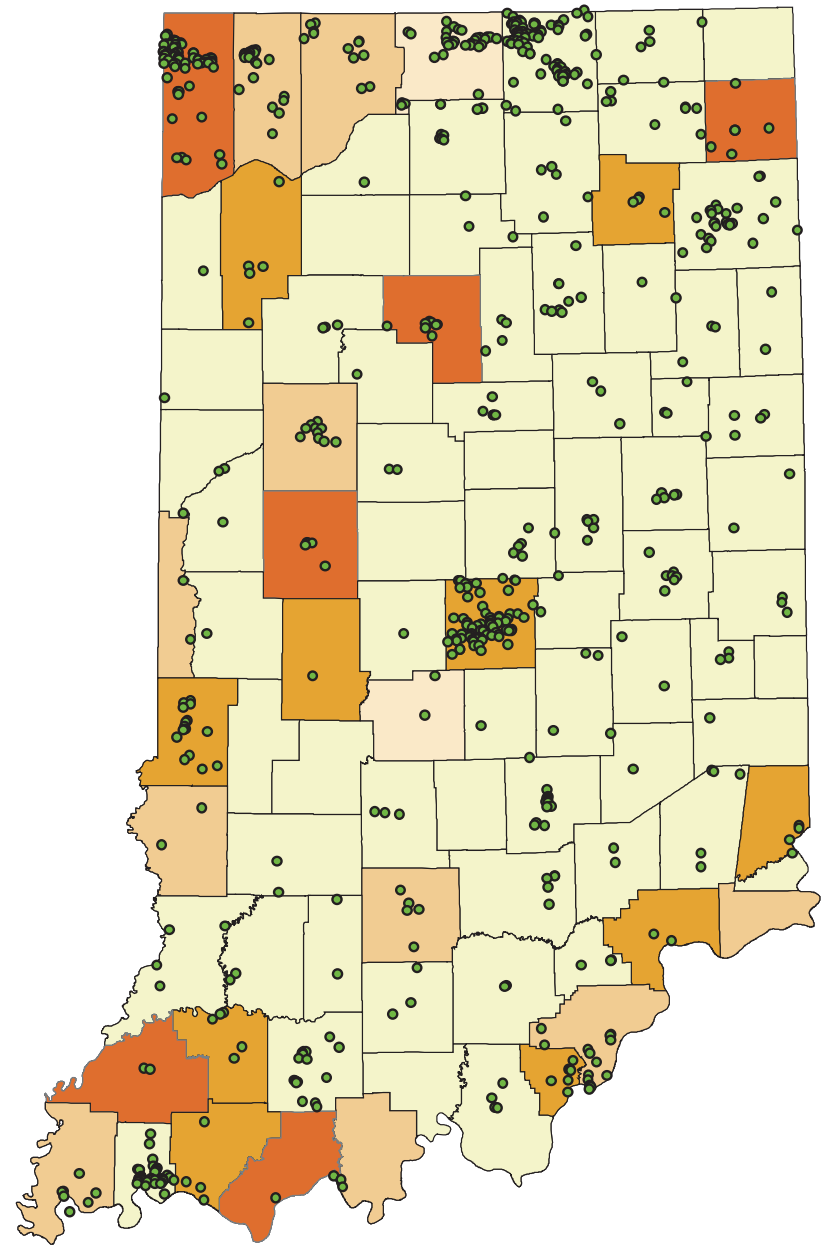
According to the Energy Information Administration (2007), Indiana ranked tenth in the Nation in 2005 for net electric power generation and sixth in the nation for power generation by electric utilities. The primary fuel source is coal, which accounted for 94 percent of Indiana's power generation. Indiana uses more than 63 million tons and ranks second in coal use (American Coal Foundation, 2007). Most of this coal was used by electric utilities in the State. In Indiana and the surrounding states of Ohio, Kentucky, Illinois, and Michigan, 115 coal-fueled electric-power plants emitted nearly 26,400 lb of mercury in 2000 (U.S. Environmental Protection Agency, 2007). Based on the 2002 inventory (table 1), the contribution from Indiana to this five-state total was 19.8 percent.

Mercury Monitoring in Indiana

Prior to 2001, few data were available that provided information about atmospheric deposition of mercury in Indiana, partly because the scientific methods to reliably measure mercury in precipitation were relatively new (U.S. Environmental Protection Agency, 1997) and partly because a national mercury-monitoring network was relatively new (Sweet and Prestbo, 1999). In addition, prior to 2001, most of the atmospheric deposition of mercury was believed to be from precipitation (U.S. Environmental Protection Agency, 1997) and accepted methods for monitoring dry deposition had not been developed.

The IDEM Mercury Work Group was organized in 1999 as a team of managers and technical personnel from IDEM's programs for planning and assessment, air quality, water quality, land quality, and pollution prevention. The IDEM Mercury Work Group, with scientists from the USGS, determined that the geographic distribution and trends in the atmospheric deposition of mercury could not be quantified in Indiana without a monitoring program. In 2000, mercury in precipitation (which causes mercury wet deposition) was selected for the initial study in Indiana because reliable methods for sampling and analysis were available through a national network. The USGS implemented the monitoring program for mercury in precipitation in Indiana (hereafter in this report, the "monitoring program"), starting in late 2000, in cooperation with the IDEM Office of Air Quality and Office of Water Quality.

The monitoring program is part of the Mercury Deposition Network (MDN) that was started in 1996 and coordinated through the National Atmospheric Deposition Program (NADP). The NADP is a consortium of federal agencies (including the USGS), state agencies, academic institutions, tribal governments, and private organizations in the United States and environmental agencies in Canada. For more than 25 years, NADP has provided consistent, accurate, quality-assured atmospheric-deposition data about acid rain to researchers, policy makers, and the general public (National Atmospheric Deposition Program, 2006).



Base from U.S. Geological Survey digital data 1:100,000 1983
Universal Transverse Mercator projection zone 16, NAD 1983

EXPLANATION

Annual mercury emissions per county in 2002, in pounds

- 0 - 50
- 50 - 100
- 100 - 250
- 250 - 500
- > 500

Stationary source of mercury emissions

Locations of stationary sources of mercury emissions and annual emissions in 2002 from Regional Air Pollutant Inventory Development System (Indiana Department of Environmental Management, Office of Air Quality, written commun., June 2005)

Figure 3. Locations of stationary sources of mercury emissions to the atmosphere in Indiana and annual mercury emissions per county in 2002.

Objectives of the monitoring program that were identified by the IDEM Mercury Work Group apply to mercury concentrations in precipitation and to mercury wet deposition.

- Obtain baseline information before and after implementation of regulatory controls on mercury emissions;
- Determine if the geographic distribution of mercury is uniform or if local emissions sources have an effect;
- Observe seasonal or annual trends in mercury; and
- Obtain mercury data that can be compared with that of other states.

The mercury-monitoring data for 2004 through 2005 in this report, when combined with similar data from Indiana for 2001 through 2003 (Risch, 2007), constitute a baseline of information for comparison with future data in Indiana and the NADP–MDN data from other states. Emissions controls for air pollutants such as nitrogen oxides, sulfur dioxides, ozone, fine particulates, and mercury are required at some mercury-emissions sources through implementation of Federal and State rules under authority of the Clean Air Act, particularly the Clean Air Interstate Rule (Code of Federal Regulations, 2005a) and the Clean Air Mercury Rule (Code of Federal Regulations, 2005b). A long-term, consistent monitoring program for mercury in precipitation in Indiana has the capability of detecting changes in mercury concentrations in precipitation and mercury wet deposition that may result from the emissions controls required by these rules.

Study Methods

The monitoring program in Indiana is part of a large-scale network in North America that has a uniformity in procedures and instrumentation that make the data inter-comparable. The monitoring locations in Indiana were selected by the IDEM Mercury Work Group and are described in this section. Precipitation at these locations was measured continuously and weekly samples were collected for analysis of mercury, using techniques explained in this section. The approaches for quality assurance, management, and reporting of data from the monitoring program are presented here as well.

Selection of Monitoring Locations

Five locations in Indiana were used by the USGS and IDEM for the monitoring program, 2004–2005, and are part of the NADP–MDN (fig. 4). As of early 2004, there were 80 NADP–MDN monitoring locations in North America; this number grew to 92 by the end of 2005 (National Atmospheric Deposition Program, 2005, 2006). Locations in the NADP–MDN are selected to be regionally representative and are not intended to evaluate the atmospheric mercury associated with a specific emissions source. The monitoring locations in Indiana met the NADP–MDN siting criteria, which include restrictions for minimum separation distances of 1,640 ft from combustion sources and highways and 328 ft from metal-working facilities, roads, waterways, runways, parking lots, maintenance yards, and fuel storage. The monitoring equipment at a location must be separated from nearby trees, buildings, towers, or structures by a distance greater than twice their height.

The mercury in precipitation monitoring program in Indiana consists of five monitoring stations (fig. 5). Four monitoring stations for mercury in precipitation in Indiana (hereafter in this report, “monitoring stations”) were established in late 2000–early 2001 at: Roush Lake in Huntington County, Clifty Falls in Jefferson County, Bloomington in Monroe County, and Indiana Dunes in Porter County. A fifth station was established in April 2003 at Fort Harrison in Marion County. The five locations are within five geographic regions and four major watersheds (table 2).

The following descriptions of monitoring stations use information about 2002 mercury emissions to generally compare and contrast the five monitoring stations, similar to the descriptions in Risch (2007). The Roush Lake monitoring station is collocated with a station of the NADP National Trends Network (NTN) for acid-rain monitoring. It is south of Huntington and at least 17 mi from any stationary sources of more than 0.1 lb/yr of mercury emissions to the atmosphere (fig. 6), although two sources with emissions less than 0.03 lb/yr are within 17 mi. The Roush Lake location was selected because of its rural setting and isolation from sources of high annual mercury emissions. The Clifty Falls monitoring station is near Madison, approximately 2 mi from a coal-fueled electric-power plant in Indiana and 12 and 19 mi from two coal-fueled electric-power plants in Kentucky (fig. 7). The Clifty Falls location was selected because of its high annual precipitation for Indiana and its position in the Ohio River watershed. The Fort Harrison monitoring station is within 31 mi of at least 93 stationary sources of mercury emissions to the atmosphere (fig. 8), including many of the categories in table 1. The Fort Harrison location was added to the NADP–MDN in Indiana because of its urban location in central Indiana. The Bloomington monitoring station is approximately 5 mi from a stationary source of 27 lb/yr of mercury emissions to the atmosphere (fig. 9), although two sources less than 0.01 lb/yr and one source less than 0.7 lb/yr are closer. The Bloomington location was selected because of its high annual precipitation for Indiana and its position in south central Indiana. The Indiana Dunes monitoring station is co-located with an NTN station of the NADP. It is near Porter, approximately 2 mi from a coal-fueled electric-power plant and within 31 mi of at least 93 stationary sources of mercury emissions to the atmosphere (fig. 10). The Indiana Dunes location was selected because of the proximity to Lake Michigan and its tributaries that have fish-consumption advisories for mercury.

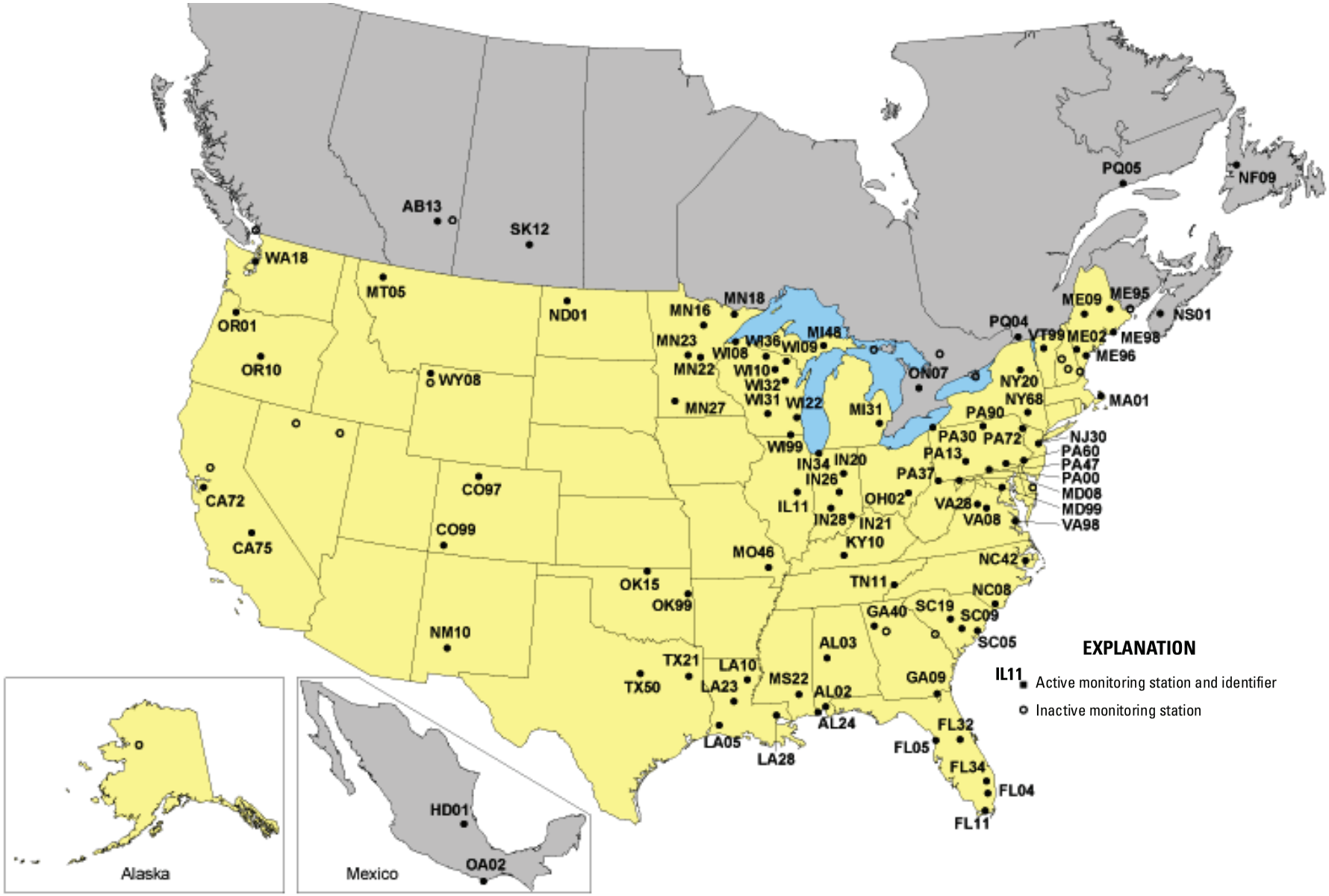


Figure 4. Locations of National Atmospheric Deposition Program Mercury Deposition Network monitoring stations in North America, late 2005.

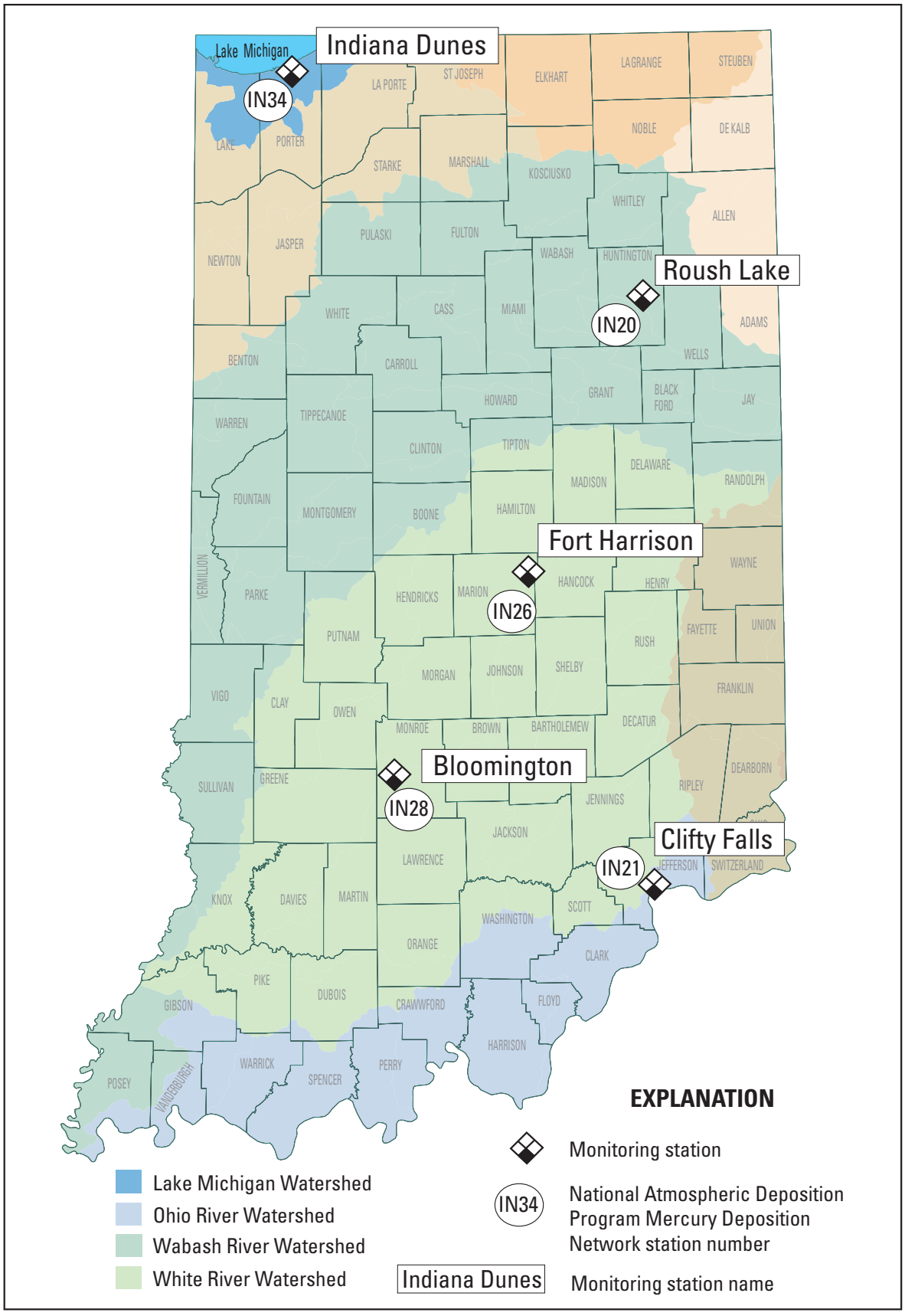


Figure 5. Monitoring locations for mercury in precipitation in Indiana, 2004–2005.

Table 2. Characteristics of monitoring stations for mercury in precipitation in Indiana.

[NADP, National Atmospheric Deposition Program]

Abbreviated station name	NADP station number	Latitude / longitude (degrees, minutes, seconds)	Geographic region	Major watershed[1]	Land-use setting	Normal annual precipitation[2] (inches)	2002 annual mercury emissions[3] (pounds)
Roush Lake[4]	IN20	40°50’24” 85°27’50”	Northeastern Indiana	Wabash River	Rural	37.21	522
Clifty Falls	IN21	38°45’42” 85°25’12”	Southeastern Indiana; Ohio River Valley	Ohio River	Suburban	44.97	1,789
Fort Harrison	IN26	39°51’30” 86°01’15”	Central Indiana	White River	Urban	41.04	350
Bloomington	IN28	39°08’46” 86°36’48”	South-Central Indiana	White River	Suburban	46.79	228
Indiana Dunes[4]	IN34	41°37’55” 87°05’16”	Northwestern Indiana; Lake Michigan shore	Lake Michigan	Suburban	38.56	1,132

[1] Watershed boundaries are shown in figure 5.

[2] Normal is for 1971 through 2000 (Midwestern Regional Climate Center, 2007).

[3] Annual mercury emissions from stationary sources within 31 miles of the monitoring station were based on the 2002 Regional Air Pollutant Inventory System for Indiana (Indiana Department of Environmental Management, written commun., 2005) and the 2000 Emissions and Generation Resource Integrated Database (U.S. Environmental Protection Agency, 2007) for sources on the Kentucky–Indiana border. The 31 mile distance is used in the USEPA Industrial Source Complex Model, a steady-state plume model that does not allow meteorology to vary within 31 miles (50 kilometers) of the emission source.

[4] National Atmospheric Deposition Program National Trends Network monitoring station is collocated.

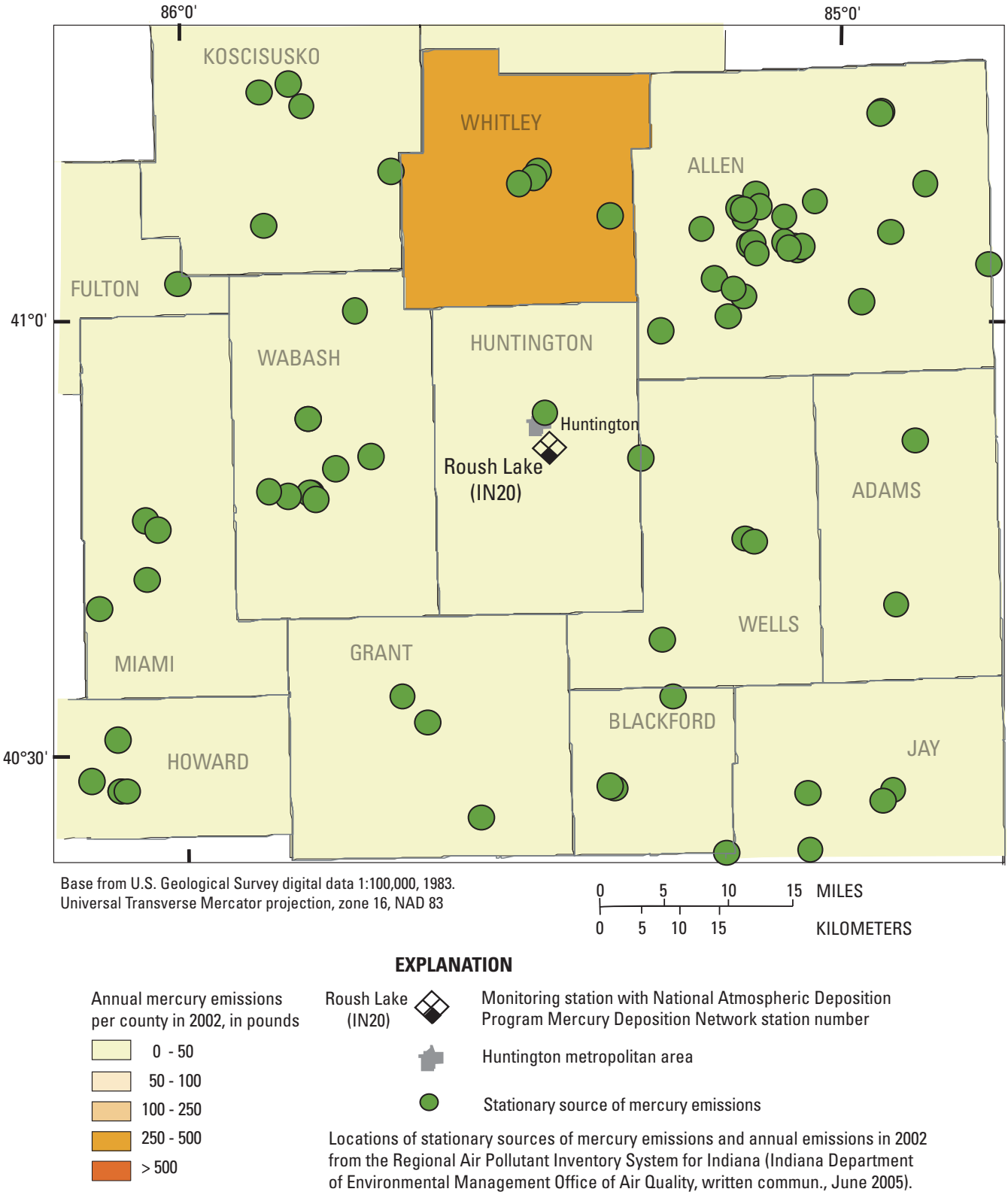


Figure 6. Roush Lake monitoring station for mercury in precipitation in Indiana, with nearby stationary sources of mercury emissions.

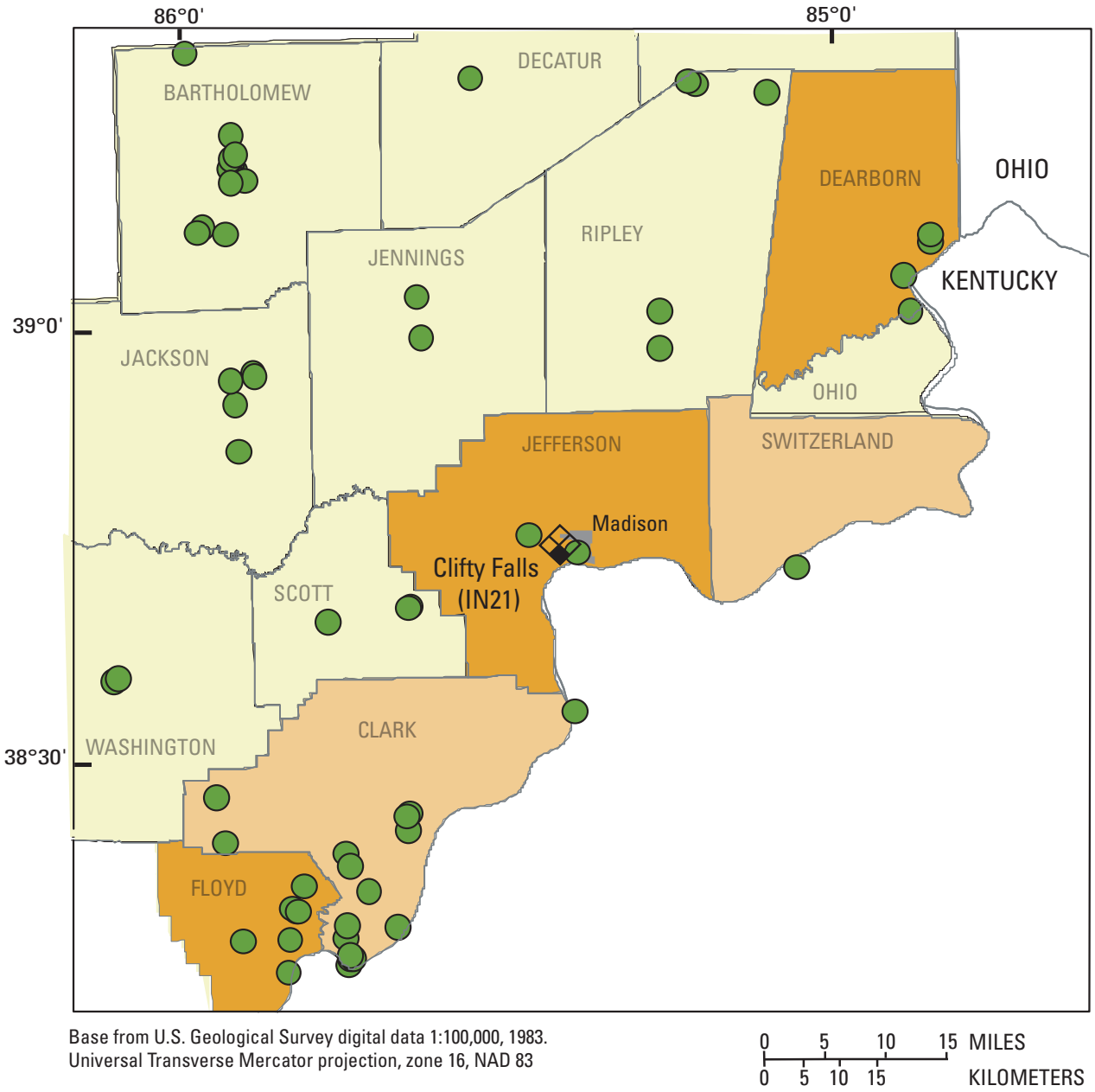


Figure 7. Clifty Falls monitoring station for mercury in precipitation in Indiana, with nearby stationary sources of mercury emissions.

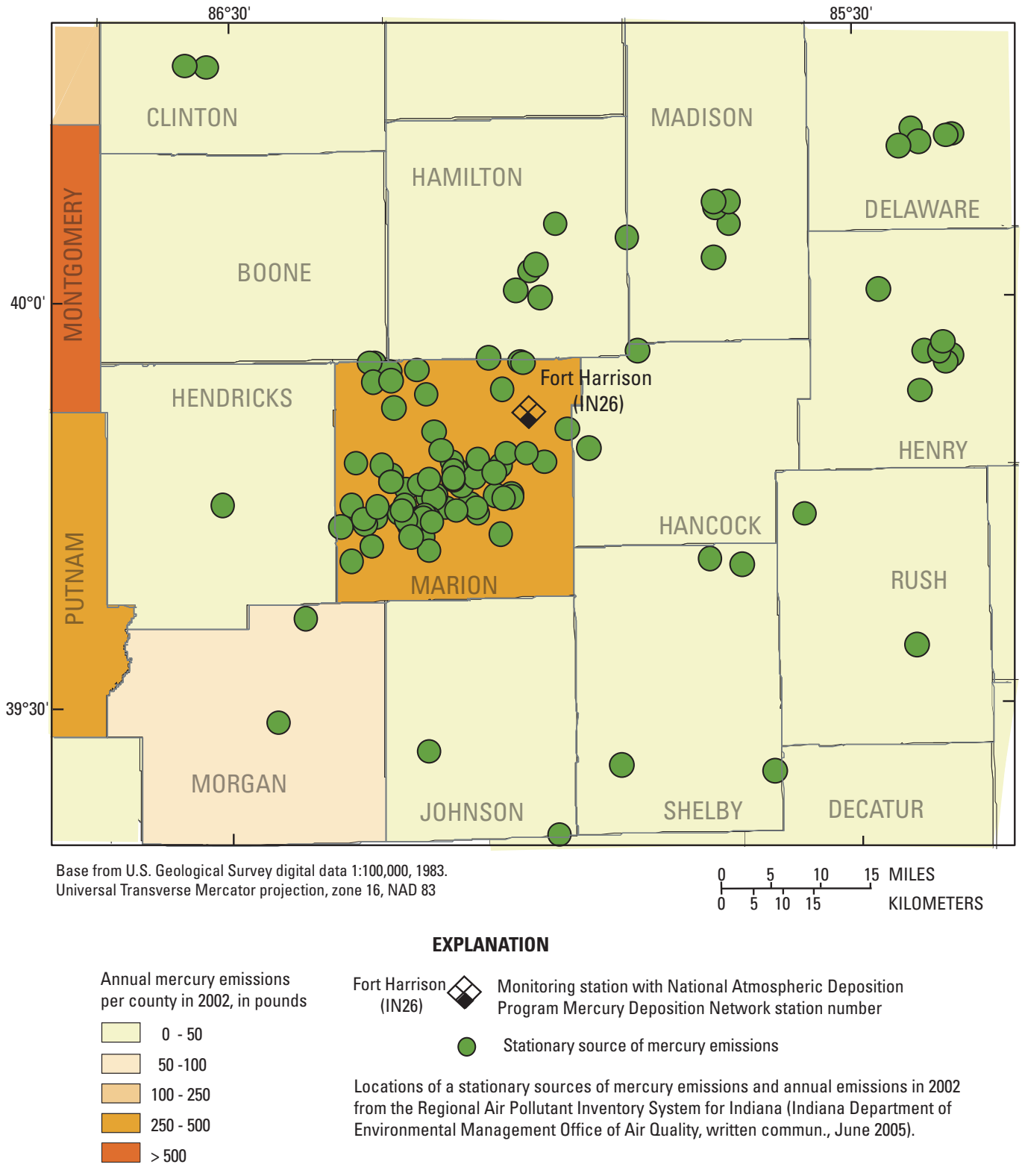


Figure 8. Fort Harrison monitoring station for mercury in precipitation in Indiana, with nearby stationary sources of mercury emissions.

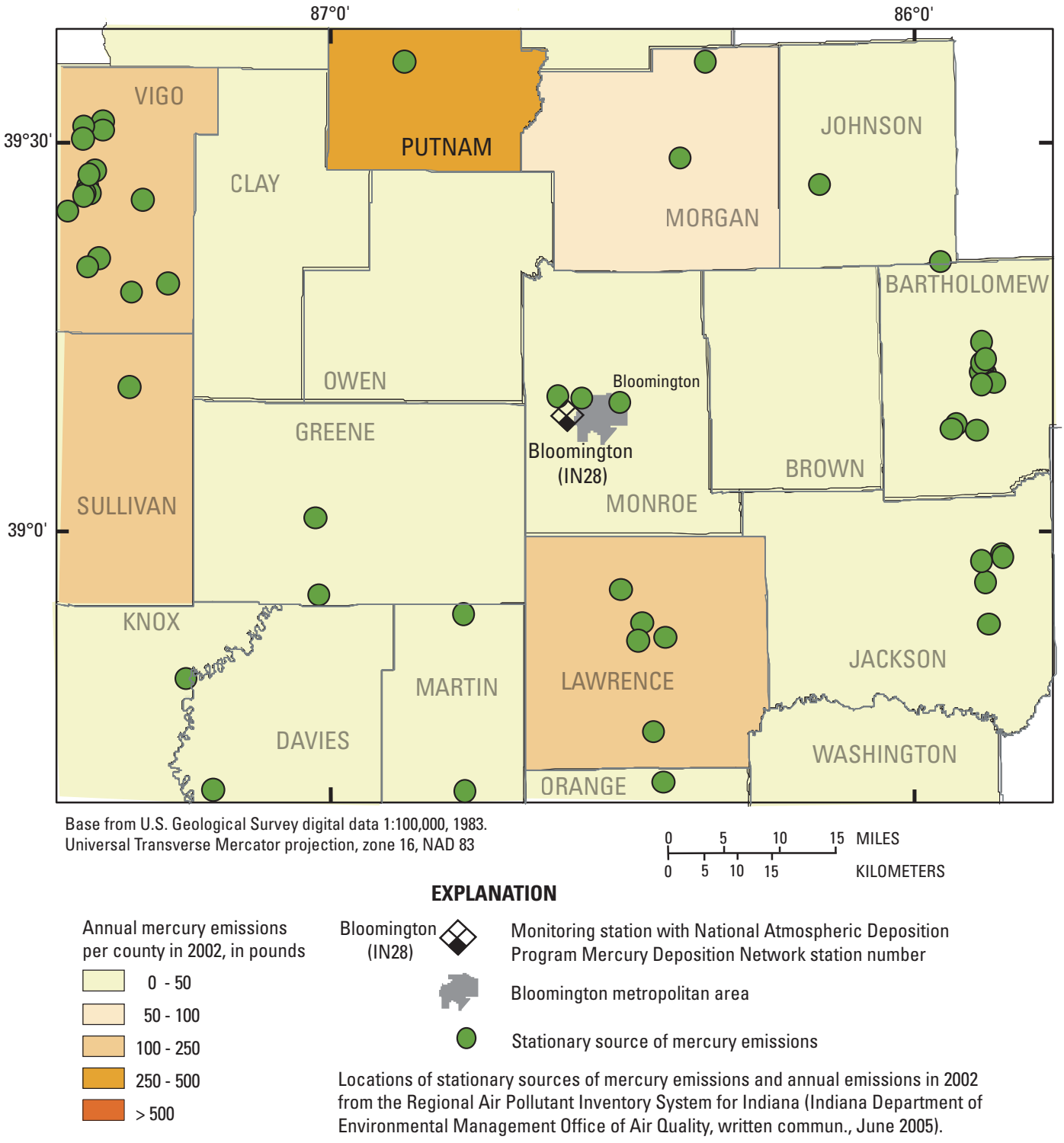


Figure 9. Bloomington monitoring station for mercury in precipitation in Indiana, with nearby stationary sources of mercury emissions.

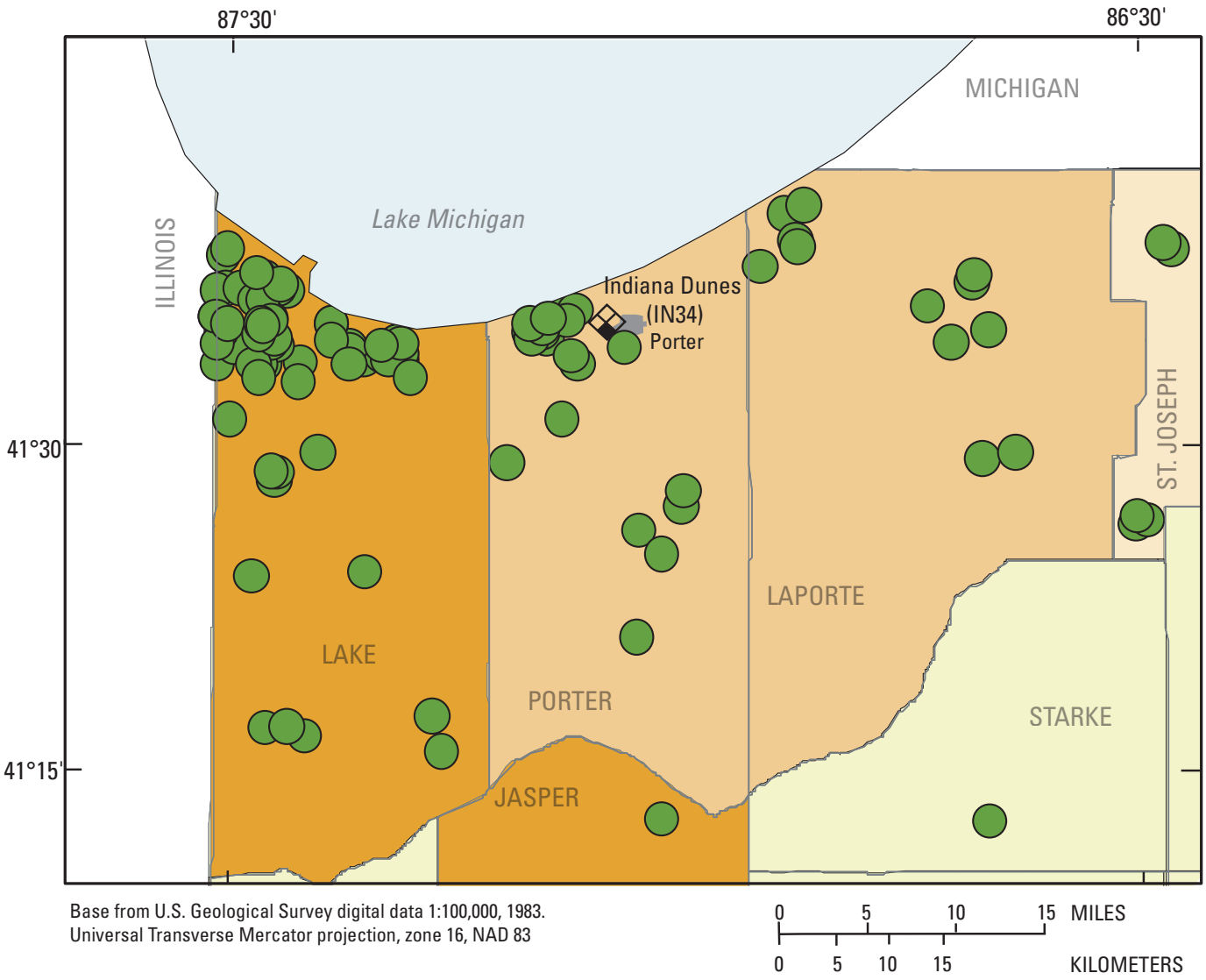


Figure 10. Indiana Dunes monitoring station for mercury in precipitation in Indiana, with nearby stationary sources of mercury emissions.

Instrumentation of Monitoring Stations

The five monitoring stations in Indiana were instrumented the same as other monitoring stations in the NADP–MDN—with an automated precipitation sampler and a recording rain gage. The automated precipitation sampler was an Aerochem Metrics Model 301, modified with an insulated sample-storage enclosure and internal heating and ventilation to operate year round (fig. 11). When precipitation was falling, a conductivity-grid sensor on the sampler activated a motor that opened a retractable lid over a chimney, which held a sampling train supported on an adjustable stand (fig. 12). The precleaned sampling train consisted of a glass funnel connected by a glass capillary tube to a preweighed 2,000-mL glass sample bottle. The sample bottle contained 20 mL of 1-percent high-purity hydrochloric acid as a preservative. The sampling train was prepared and quality assured at the NADP–MDN laboratory. In warm weather, when the sampler lid was open and the funnel of the sampling train was exposed, liquid precipitation falling into the funnel was collected in the bottle. In cold weather, a thermostat-controlled heater in the insulated enclosure caused heated air to rise around the glass funnel in the chimney to melt frozen precipitation in the funnel. A heated pad beneath the conductivity-grid sensor dried the grid when precipitation ceased, activating the motor to close the retractable lid and seal the chimney.

Precipitation was measured with a Belfort model 5-780 universal, weighing-bucket, recording rain gage (fig. 13). Cumulative precipitation was recorded as a continuous pen trace on a paper chart mounted on a revolving drum controlled by a mechanical clock. Openings and closings of the sampler were marked on the chart with an event-recorder pen activated by an electric pulse from the sampler. A funnel inside the rain-gage chimney served as a lid that minimized evaporation of precipitation in hot weather. In cold weather, the funnel was removed and antifreeze was added to the bucket to promote retention and melting of frozen precipitation.

The Belfort 5-780 rain gage was evaluated in a 26-week field study in 1999 at the USGS Hydrologic Instrumentation Facility in Bay St. Louis, Miss., (Gordon, 2003) during which precipitation greater than 0.01 in. occurred each week. Accuracy was measured by comparing the Belfort rain gage with a National Weather Service stick-type gage and there was no statistically significant difference. Precision was measured by comparing two Belfort rain gages and there was no statistically significant difference.

Figure 11. Automated precipitation sampler for mercury in precipitation at monitoring station IN20 at Roush Lake near Huntington, Indiana.

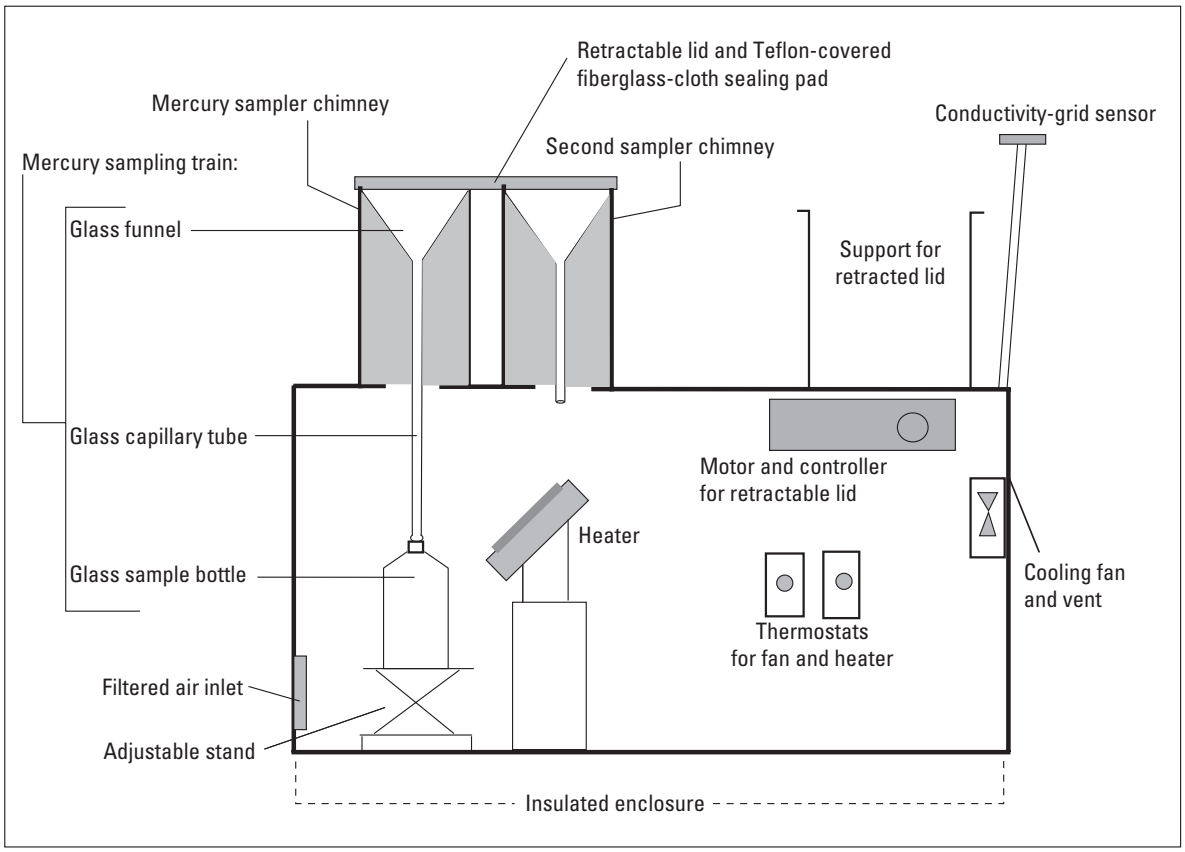


Figure 12. Diagram of automated precipitation sampler at monitoring station for mercury in precipitation in Indiana.

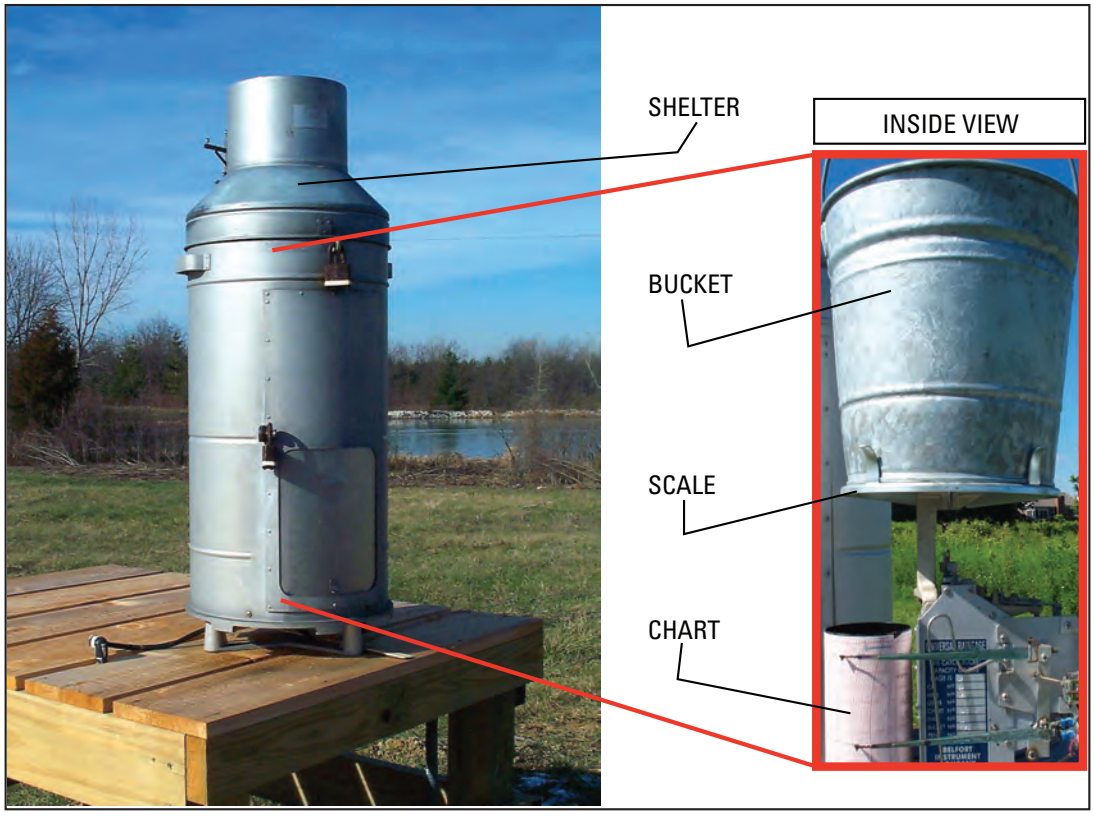


Figure 13. Recording rain gage at monitoring station for mercury in precipitation in Indiana.

Collection and Analysis of Precipitation Samples

The sampling train (funnel, bottle, and capillary tube) was exchanged every Tuesday, following the uniform procedure (Longley and Brunette, 2003) and schedule used at all NADP–MDN stations. Therefore, a weekly sample may have contained a single precipitation event[4] or it may have been a composite of two or more precipitation events. Weekly precipitation samples were analyzed by the NADP–MDN laboratory, Frontier Geosciences, Inc., in Seattle, Wash., to maintain consistency and comparability of results. Other descriptions of the sampling, analytical, and quality-assurance procedures are in Lindbergh and Vermette (1995), Vermette and others (1995), Sweet and Prestbo (1999), and Lehmann and Bowersox (2003).

The same field personnel serviced a monitoring station each week and used a kit of sampling supplies prepared by the NADP–MDN laboratory. Field personnel wore new, powder-free vinyl gloves when removing the exposed sampling train. The bottle was capped, inspected, bagged, and placed in a shipping container with the used funnel and capillary tube. New gloves were worn to assemble and install a new sampling train in the sampler. A new paper chart was installed on the rain gage and sample information was recorded on the paper field form. The sampling train, rain-gage chart, and field form were shipped to the NADP–MDN laboratory. The USGS retained copies of the charts and forms.

At the NADP–MDN laboratory, the sample bottle was weighed and the sample volume determined. An aliquot was obtained from the sample bottle for analysis of total mercury (called "mercury" hereafter in this report). Mercury was analyzed by Method 1631 (U.S. Environmental Protection Agency, 1999b), a method with a detection limit at the NADP–MDN laboratory of 0.05 ng/L. In this method, mercury was separated from the water by oxidation with bromium chloride and reduction with tin chloride, followed by thermal desorption and dual gold trap amalgamation. Mercury was quantified by cold vapor atomic fluorescence spectrometry.

Quality Assurance

Quality assurance (QA) was implemented through routine procedures, routine computations, calibration checks, field and laboratory quality-control data, and a data-review sequence. Programs and procedures for QA of network operations, laboratory services, and data management for the NADP–MDN are described in a comprehensive quality management plan (Lehmann and Bowersox, 2003). For the monitoring program in Indiana, QA was provided for the rain gage, precipitation sampler, field procedures, monitoring station, laboratory analysis, and monitoring data.

Rain gage QA included quarterly field calibration checks, monthly review of the computed capture efficiency for each sample, and routine maintenance procedures. Each quarter, a set of calibrated weights was used to check the accuracy of the rain gage at each station. Field personnel made a chart of the calibration check and submitted it to the laboratory. If the calibration check identified an inaccurate gage, field personnel recalibrated the gage. Capture efficiency was computed for each sample as the ratio of the precipitation amount in the sample bottle compared to the precipitation amount recorded by the rain gage. Capture efficiency was reported with the preliminary analytical data each month as a measure of whether a rain-gage malfunction was causing greater than 100-percent capture. If a rain gage malfunction had been indicated with the capture efficiency, then field personnel would inspect and correct the gage. The NADP–MDN laboratory provided seasonal reminders and instructions for summer and winter maintenance of the rain gage, along with instructions for periodic cleaning of the internal mechanism of the rain gage. The maintenance and cleaning of the rain gage helped assure accurate and consistent precipitation data.

Precipitation sampler QA included weekly inspection of the event recorder pen trace, the sampler sensor function, and the sampler lid drive, plus monthly review of the computed capture efficiency. The event-recorder pen trace on the rain-gage chart was inspected weekly to determine whether the precipitation sampler opened during precipitation only. If the precipitation sampler malfunctioned, based on the event recorder or on the weekly inspection of the sensor and lid drive, a troubleshooting procedure was used to correct and test the sampler before the following week's sample. Monthly review of the computed capture efficiency for each sample (the ratio of the precipitation amount in the sample bottle compared to precipitation amount recorded by the rain gage) was used to evaluate the function of the precipitation sampler. Repeated capture efficiency less than 75 percent would have indicated that the sampler needed to be inspected and a malfunction corrected.

External QA of field procedures and equipment was completed through a third-party audit of the five Indiana stations in 2003. Written reports of the audits were provided and discussed with USGS personnel and filed with the NADP–MDN Program Office. The audits gave satisfactory ratings of field procedures in Indiana. Personnel from the NADP Program Office inspected the location, configuration, and installation of the precipitation sampler and the rain gage at Fort Harrison in 2003 for compliance with the NADP–MDN siting criteria. Data from the inspections are available from an on-line archive (*http://nadp.sws.uiuc.edu/sites/sitemap.asp?net=mdn&state=in*).

External QA of the NADP–MDN was accomplished by the USGS in 2004 (Wetherbee and others, 2006a). Variability and bias of data attributed to field exposure, sample handling and shipping, and laboratory chemical analysis were estimated using system blanks and interlaboratory comparison. A system blank was mercury-free water poured through the mercury

[4]In this report, single precipitation events are defined as those separated by a break of 8 hours or more in precipitation accumulation.

sampling train at the conclusion of a dry sampling week; a system blank was attempted annually for each monitoring station. The 2004 system-blank data indicated that maximum contamination in 95 percent of NADP/MDN samples was less than the method reporting limit with 95-percent confidence. The median system blank concentration was 0.018 ng/L, nearly an order of magnitude less than the 0.15 ng/L NADP–MDN laboratory minimum reporting limit. In the interlaboratory comparison, precipitation and blank water solutions spiked with known amounts of mercury were submitted to the NADP–MDN laboratory. The median difference between the reported concentrations and the most-probable values was zero, indicating no bias was detected in the data. Wetherbee and others (2006b) also evaluated variability of measurements at two NADP–MDN stations in Illinois and Washington by use of collocated samplers, 1999–2004. They reported the overall measurement variability was sufficiently low so that all NADP–MDN measurements were ±2 ng/L for mercury concentration and ±2 $\mu g/m^2$ per year for mercury deposition.

Laboratory QA included field and laboratory quality-control (QC) data. Field QC data were obtained from 10 field bottle blanks from the Indiana stations in 2004–2005. The preservative was analyzed for mercury when the event recorder documented that the sampler did not open the entire week and there was no recorded precipitation. Mercury was not detected in these 10 samples, indicating that sample bottle preparation and sample handling did not introduce mercury contamination (appendixes 1–1 through 1–5).

The following laboratory QC data were used to assure laboratory analyses of mercury concentrations were within control limits: correlation coefficients of calibration standards, percent recoveries of standard reference materials, relative percent differences of duplicate samples, percent recoveries of matrix-spike samples, relative percent differences of matrix-spike duplicate samples, concentrations in reagent blanks, and concentrations in laboratory bottle blanks. Laboratory QC samples were analyzed at a rate of 4 for every 10 precipitation samples. If trace amounts of mercury were detected in laboratory bottle blank samples, the quarterly mean of the bottle blanks was subtracted as a blank correction in calculation of the sample concentration.

Monitoring data QA included a multi-step data-review sequence. The daily and weekly precipitation amounts were computed from the rain-gage chart by field personnel and recorded on the field-data form. At the NADP–MDN laboratory, the precipitation amounts were reviewed and entered into preliminary data. Each month, the laboratory sent the preliminary data to the USGS for verification of precipitation, mercury concentration, and mercury wet deposition values, along with information recorded on the field-data forms. After the preliminary data were revised and verified by the NADP–MDN laboratory, the data were sent to the NADP–MDN Program Office for review and verification before being finalized and posted in the NADP–MDN on-line archive *(http://nadp.sws.uiuc.edu/sites/sitemap.asp?net=mdn&state=in)*.

Data Management and Reporting

The following information was recorded on the field-data form for each weekly sample at a monitoring station:

- starting and ending dates and times of the sampling period (typically Tuesday through Tuesday);
- type of precipitation (rain, snow, or mixed rain and snow) each day;
- type of sample (wet, dry, trace, or quality control);
- amount of precipitation each day (in.), including zero or trace (<0.01 in.) amounts; and
- comments on equipment and field activities.

The following data were reported by the NADP–MDN laboratory for each weekly sample at a monitoring station:

- precipitation (mm and in.) in the rain gage;
- precipitation (mm and in.) in the sample bottle;
- sample volume (mL) in the sample bottle;
- mercury concentration (ng/L) in the sample—in this report “mercury concentration” means total recoverable mercury concentration in water;
- mercury wet deposition ($\mu g/m^2$), a computed value—in this report “mercury deposition” means wet deposition of total recoverable mercury;
- data-quality rating and associated qualifier codes; and
- comments from the NADP–MDN laboratory or monitoring station supervisor.

Four types of weekly samples were reported.

- Wet-deposition sample—more than 0.01 in. of precipitation was recorded by the rain gage or more than 10 mL of precipitation were collected in the sample bottle.
- Trace sample—1.5 to 10 mL of precipitation were collected in the sample bottle; a mercury concentration was not reported.
- Dry sample—less than 0.01 in. of precipitation was recorded by the rain gage or less than 1.5 mL of precipitation in the sample bottle; a mercury concentration was not reported.
- QC sample—the event recorder on the rain gage indicated the sampler did not open and less than 0.01 in. of precipitation was recorded by the rain gage; the preservative in the sample bottle was analyzed and a mercury concentration was reported for a field bottle blank.

Mercury wet deposition in this report and archived by the NADP–MDN was computed with the weekly sample concentration, weekly precipitation amount from the rain gage, and equation 1:

$$D = C * P \quad (1)$$

where

D = mercury deposition, in ng/m^2 (nanograms per square meter),
C = mercury concentration, in ng/L, and
P = precipitation amount from the rain gage, in mm.

Units of deposition in equation 1 were converted to µg/m^2 with equation 2:

$$\frac{ng}{L} * mm = \frac{ng}{L} * \frac{L}{1{,}000\ cm^3} * \frac{1{,}000{,}000\ cm^3}{m^3}$$
$$* mm * \frac{m}{1{,}000\ mm} = \frac{ng}{m^2} * \frac{\mu g}{1{,}000\ ng} = \frac{\mu g}{m^2} \quad (2)$$

In this report, weekly volume-weighted concentrations are used to compute a normalized concentration for a specific time period such as a quarter, a year, 2 years, or 5 years. The weekly volume-weighted concentration was computed with equation 3 and excludes samples missing a concentration.

$$VWC = C * \frac{S}{T} \quad (3)$$

where

VWC = weekly volume-weighted concentration, in ng/L,
C = weekly concentration, in ng/L,
S = weekly sample volume, in mL, and
T = sum of weekly sample volumes in samples with weekly concentrations, in mL.

Precipitation amount for the weekly sample in most cases was measured with the rain gage at the monitoring station. If the precipitation sampler had worked properly but the rain-gage data were missing or incomplete, deposition was computed with the precipitation amount in the sample bottle in place of the rain-gage data. An alternate rain-gage amount was used, if available, to determine if the amount in the sample bottle was representative of the sampling period.

Estimated deposition was computed if the sample concentration was missing and the rain gage measured the weekly precipitation. The sample concentration was missing if the precipitation sampler did not work properly (as indicated by the event recorder on the rain gage) or if there was a laboratory error. Estimated deposition was computed with equation 1 and the quarterly normalized concentration in place of the missing sample concentration. The quarterly normalized concentration is the sum of the weekly volume-weighted concentrations (equation 3) during the quarter. Quarters are 13 weeks, based on the reporting schedule of the NADP–MDN laboratory, grouped as January–February–March; April–May–June; July–August–September; and October–November–December.

Data-quality rating codes for each sample were assigned by the NADP–MDN laboratory:

- A—no field or laboratory problems, data quality acceptable for summary statistics;
- B—minor field or laboratory problems, data quality acceptable for summary statistics;
- C—field or laboratory problems, data quality suspect.

Samples with an A rating or B rating were included automatically among the data summarized in this report. Samples received a B rating if debris was visible in the sample, if the sample was low volume (1.5–10 mL), if the sample bottle had a small leak during transport, if the precipitation amount in the sample bottle rather than the rain gage was used to calculate deposition, or if sample information was missing or incomplete.

Samples received a C rating for precipitation-sampler or rain-gage malfunction, an error in sample handling, or a laboratory error. Samples with a C rating[5] were included among the data summarized in this report if one of the following conditions was documented for the sample.

- The sampler did not open during some or all precipitation events, the rain gage worked correctly, and mercury deposition was estimated.
- The sample concentration was not reported because of a laboratory error, the rain gage worked correctly, and mercury deposition was estimated.

For this report, the final weekly sample data for the five monitoring stations (appendixes 1–1 through 1–5) were obtained from the NADP–MDN on-line archive and from the weekly field forms. Summary values were computed with those weekly data for three time periods: the 2-year study period, 2004–2005, that is the focus of this report (called a 2-year value); the 5-year period, 2001–2005 (called a 5-year value), and a 1-year period (called an annual value). The summary values were computed for individual monitoring stations and all five monitoring stations and may include statistical descriptions of mean, median[6], minimum, or maximum.

In this report, the summary values are

- normalized mercury concentration, in units of ng/L—sum of weekly volume-weighted concentration values;
- cumulative mercury deposition, in units of µg/m^2—sum of weekly mercury deposition values, such as annual (cumulative) mercury deposition;

[5]Approximately 3 percent of the wet-deposition samples in this report have a C rating (appendixes 1–1 through 1–5), including 10 samples with no deposition and 7 samples with estimated deposition.

[6]Median is the value that separates the rank-ordered data into two parts (half of the concentrations are greater than the median and half of the concentrations are less than the median).

- cumulative precipitation[7], in units of inches—sum of weekly precipitation values, such as annual (cumulative) precipitation; and
- normalized mercury deposition, in units of μg/m²/in.—cumulative mercury deposition divided by cumulative precipitation.

Mercury in Precipitation in Indiana

Data for mercury in precipitation at four monitoring stations in Indiana (excluding Fort Harrison), January 2001–December 2003, were presented and described by Risch (2007). This section provides summary tables for the weekly samples, concentrations of mercury, and deposition of mercury for five monitoring stations, January 2004–December 2005. Weekly values are compared with box plots and annual values are presented in maps. The variability of mercury concentrations and deposition in Indiana is examined statistically and graphically.

Weekly Samples

Sampling trains were installed at the five monitoring stations each week in an attempt to collect weekly samples. Either wet-deposition samples were collected (rain, snow, or mixed rain and snow) or weekly samples without wet deposition were reported (trace, dry, or QC samples). During the 2-year period, 520 sampling trains were installed and 448 wet-deposition samples were collected (86 percent of total); 72 samples did not have wet deposition (table 3). The same number of weekly samples were attempted annually at each

[7]Inches are used for precipitation amounts in this report because inches are a common unit for precipitation amounts in weather reports.

Table 3. Number and types of weekly precipitation samples from mercury monitoring at five stations in Indiana, January 2004–December 2005.

[First five shaded rows contain totals for each station; last shaded row contains totals for all five stations]

Station name and Mercury Deposition Network identification number	Year	Number of weekly samples attempted	Number of mercury wet-deposition samples[1]	Number of dry samples[2]	Types of wet-deposition samples		
					Number of rain samples	Number of snow samples	Number of mixed samples[3]
Roush Lake (IN20)	2004	52	42	10	28	1	13
	2005	52	48	4	33	5	10
	2 years	104	90	14	61	6	23
Clifty Falls (IN21)	2004	52	43	9	36	1	6
	2005	52	49	3	38	2	9
	2 years	104	92	12	74	3	15
Fort Harrison (IN26)	2004	52	43	9	34	1	8
	2005	52	46	6	34	3	9
	2 years	104	89	15	68	4	17
Bloomington (IN28)	2004	52	41	11	33	1	7
	2005	52	45	7	33	3	9
	2 years	104	86	18	66	4	16
Indiana Dunes (IN34)	2004	52	47	5	35	4	8
	2005	52	44	8	31	6	7
	2 years	104	91	13	66	10	15
Five stations	2 years	520	448	72	335	27	86

[1]Number includes samples with estimated mercury deposition.

[2]Dry sample defined as less than 0.01 inch of precipitation and less than 1.5 mL sample volume. Dry sample count in this table includes trace samples (1.5–10 mL sample volume) and quality-control samples for less than 0.01 inch precipitation.

[3]Mixed wet-deposition sample type contains liquid and frozen precipitation.

station during the 2-year period (52), but the number with wet deposition ranged from 41 to 49 samples.

Overall, 75 percent of the wet-deposition samples were rain; the remainder were snow or mixed rain and snow. Monitoring stations in northern Indiana (Indiana Dunes and Roush Lake) had 30 percent frozen precipitation samples (snow plus mixed rain and snow) and the monitoring stations in central and southern Indiana (Clifty Falls, Fort Harrison, and Bloomington) had 22 percent. The number of precipitation events per sample was determined by visual inspection of the rain-gage charts for the wet-deposition samples. For purposes of this discussion, precipitation events are separated by a break of 8 hours or more in precipitation accumulation. For the 2-year period, the wet-deposition samples contained a median of two events. The greatest number of wet-deposition samples contained one event (176 samples), followed by two events (147 samples), three events (102 samples), and four to six events (23 samples).

The rain gages at the five monitoring stations operated reliably during the 2-year period. The precipitation amount for 438 of the 448 wet-deposition samples (98 percent) was determined with the rain-gage measurement. For the remaining samples, the precipitation amount was determined from the volume in the sample bottle. The precipitation samplers also operated reliably during the 2-year period; precipitation-sampler malfunction made estimated deposition necessary for 2 percent of wet-deposition samples.

Mercury Concentrations and Mercury Deposition

A mercury concentration was determined by laboratory analysis for 441 of the 448 wet-deposition samples from the five monitoring stations during the 2-year period. For 7 of the 448 wet-deposition samples, the seasonal volume-weighted concentration was computed in place of a missing concentration. The 2-year normalized mercury concentration for the 448 wet-deposition samples was 10.6 ng/L (table 4), which was less than 11.5 ng/L recorded for the previous 3-year period (Risch, 2007). Box plots of the distributions of mercury concentrations in weekly samples (fig. 14) can be used to compare the five monitoring stations. The median concentration at Clifty Falls (12.9 ng/L) was greater than the 2-year, 5-station median of 10.5 ng/L. All concentrations ranged from a minimum of 1.2 ng/L in a sample at Clifty Falls in February

Table 4. Mercury concentrations in wet-deposition samples at five monitoring stations in Indiana, January 2004–December 2005.

[ng/L, nanogram per liter; last shaded row contains median or normalized mercury concentrations or total number of samples for all five stations]

Station name and Mercury Deposition Network identification number	Year	Median mercury concentration[1] (ng/L)	Normalized mercury concentration[1] (ng/L)	Number of samples with mercury detected by laboratory	Number of samples with mercury deposition estimated	Number of mercury wet-deposition samples
Roush Lake (IN20)	2004	8.9	11.2	42	0	42
	2005	9.7	9.4	48	0	48
Clifty Falls (IN21)	2004	14.3	14.3	42	1	43
	2005	11.3	11.8	46	3	49
Fort Harrison (IN26)	2004	8.6	9.3	43	0	43
	2005	10.0	9.6	45	1	46
Bloomington (IN28)	2004	9.5	8.9	40	1	41
	2005	9.3	8.4	45	0	45
Indiana Dunes (IN34)	2004	10.1	10.8	47	0	47
	2005	11.2	12.5	43	1	44
Five stations	2 years	10.5	10.6	441	7	448

[1] Median and normalized mercury concentrations computed for samples with mercury detected by laboratory.

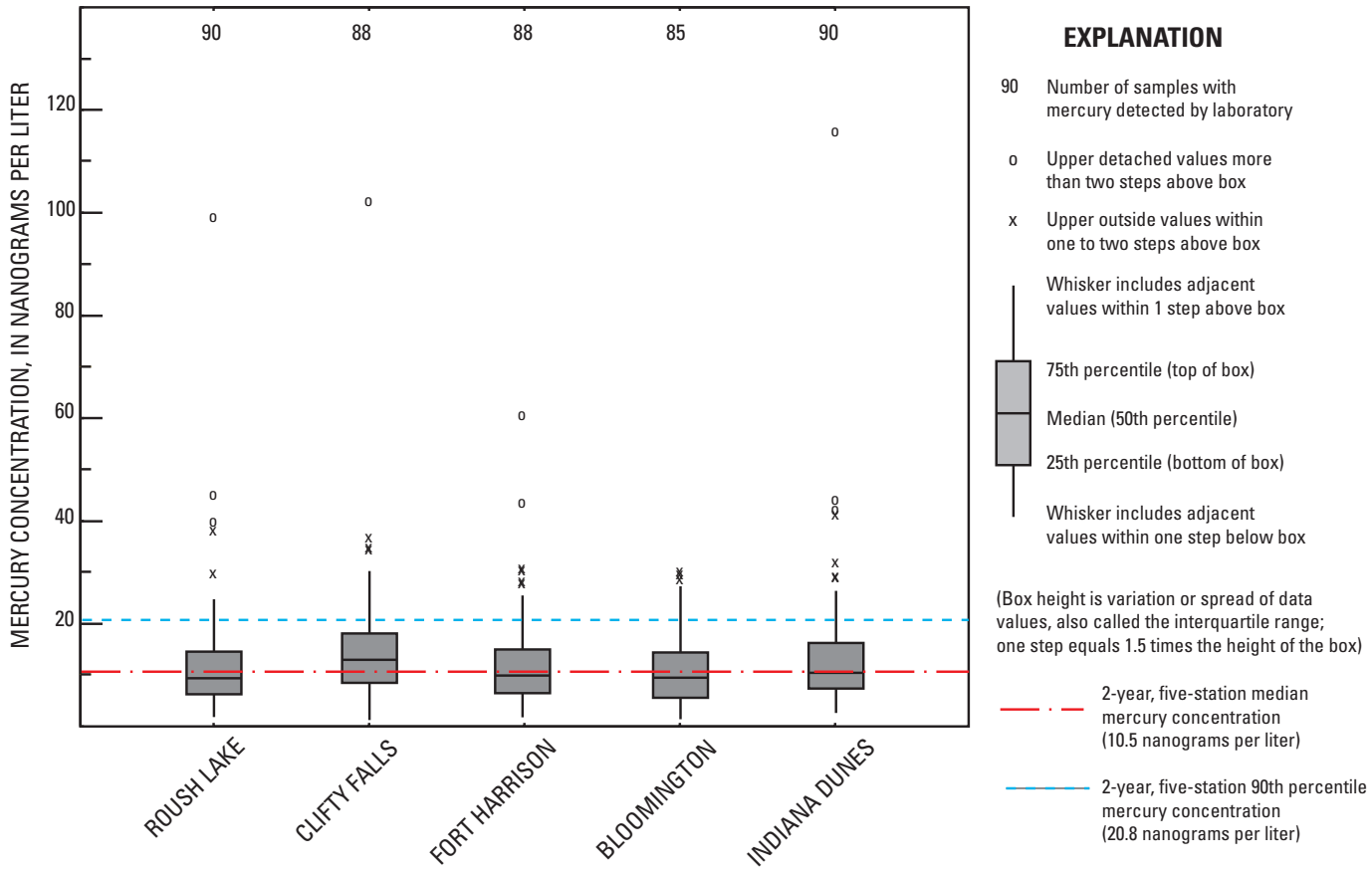


Figure 14. Distribution of mercury concentrations in weekly samples at five monitoring stations for mercury in precipitation in Indiana, January 2004–December 2005.

2005 (appendix 1–2) to a maximum of 116.6 ng/L in a sample at Indiana Dunes in June 2005 (appendix 1–5).

The highest mercury concentrations were in 52 samples with greater than 20.8 ng/L (the 2-year,5-station 90th percentile). Clifty Falls had 15 concentrations in the 90th percentile; Indiana Dunes and Fort Harrison each had 10. Most of the highest concentrations were associated with precipitation less than 0.70 in. and deposition less than 0.530 µg/m^2. Mercury concentrations in the 448 wet-deposition samples generally were higher in samples with small precipitation amounts than in samples with large precipitation amounts. Wet-deposition samples with less than 0.10 in. precipitation (the 10th percentile) had a mean concentration of 25.0 ng/L and samples with more than 2.2 in. precipitation (the 90th percentile) had a mean concentration of 9.93 ng/L.

Samples with precipitation as rain had a mean concentration of 14.5 ng/L, which was higher than the mean concentration in snow (6.0 ng/L) or mixed rain and snow (8.3 ng/L). In addition, mean mercury deposition from rain (0.287 µg/m^2) was approximately 7.5 times that for snow (0.038 µg/m^2) and approximately 2.2 times that for mixed rain and snow (0.127 µg/m^2). The mean precipitation amount for rain samples was 1.0 in., compared with 0.32 in. for snow, which explains the higher mercury deposition from rain.

As a reference, 41 percent of the mercury concentrations determined by the laboratory (181 of 441) were greater than the 12 ng/L Indiana statewide water-quality standard[8]; 47 percent of the concentrations in 2001–2003 were greater than this standard (Risch, 2007). The highest number of samples with mercury concentrations greater than 12 ng/L was recorded at Clifty Falls (46 of 181; 25 percent). Nearly all of the mercury concentrations (435 of 441) were greater than the most conservative Indiana water-quality criterion of 1.3 ng/L[9].

The mean weekly mercury deposition at the five monitoring stations during the 2-year period, including weeks with no precipitation, was 0.208 µg/m^2 (table 5). In comparison, the mean weekly deposition for 2001–2003 was higher, 0.243 µg/m^2 (Risch, 2007). Among the 448 wet-deposition samples, weekly mercury deposition ranged from a minimum of 0.002 µg/m^2 at Bloomington in November 2004

[8]For water in Indiana statewide, the chronic aquatic criterion for mercury is 12 ng/L to protect aquatic life from chronic toxic effects (Indiana Administrative Code, 2007a).

[9]The most conservative water-quality criterion for mercury (including methylmercury) is 1.3 ng/L to protect avian and mammalian wildlife populations from adverse effects that may result from consumption of aquatic organisms (Indiana Administrative Code, 2007b).

Table 5. Mercury deposition at five monitoring stations in Indiana, January 2004–December 2005.

[µg/m², microgram per square meter; µg/m²/in., microgram per square meter per inch]

Station name and Mercury Deposition Network identification number	Year	Cumulative precipitation (inch)	Cumulative mercury deposition[1] (µg/m²)	Normalized mercury deposition[2] (µg/m²/in.)	Weekly mercury deposition[3] (µg/m²)
Roush Lake (IN20)	2004	42.9	12.0	0.280	0.231
	2005	33.4	7.86	.236	.151
Clifty Falls (IN21)	2004	47.8	15.9	.333	.306
	2005	41.2	12.4	.301	.239
Fort Harrison (IN26)	2004	41.3	9.87	.239	.190
	2005	45.4	11.2	.247	.216
Bloomington (IN28)	2004	44.5	10.5	.235	.201
	2005	48.1	10.3	.213	.197
Indiana Dunes (IN34)	2004	38.0	10.3	.271	.198
	2005	24.7	7.70	.311	.148
Mean for 5 stations	2 years	40.7	10.8	.267	.208

[1] Includes samples with estimated mercury wet deposition.

[2] Computed as mercury deposition divided by precipitation.

[3] Computed as mercury deposition divided by number of samples attempted (table 1).

(appendix 1–4) to a maximum of 1.74 µg/m² at Clifty Falls in April 2004 (appendix 1–2).

Box plots of the distributions of the weekly deposition, 2004–2005 (fig. 15), can be used to compare the five monitoring stations. The median weekly mercury deposition at Clifty Falls (0.144 µg/m²) and Bloomington (0.111 µg/m²) were more than the 0.106 µg/m² median for all five stations. A further discussion of the variability of weekly mercury deposition is in the Episodes of High Mercury Deposition section of this report.

The mean annual mercury deposition for the five monitoring stations was 10.8 µg/m² in 2004–2005 and 12.6 µg/m² in 2001–2003 (Risch, 2007). The highest annual mercury deposition was at Clifty Falls in 2004–2005 (table 5) and 2001–2003 (Risch, 2007), although the highest annual precipitation did not occur at Clifty Falls each year (table 5).

Mercury deposition at all five monitoring stations varied during the 2-year period and related most to precipitation, considering that deposition is the product of concentration and precipitation. When estimated deposition and dry samples are excluded and data for all five monitoring stations, 2004–2005, are combined, the following statistical measures show the dominant influence of precipitation on mercury deposition. The Spearman's Rho correlation coefficient for weekly mercury deposition and weekly precipitation is 0.839, a high and significant correlation ($p < 0.001$). In contrast, the Spearman's Rho correlation for weekly mercury deposition and weekly mercury concentration is 0.217, a smaller but significant correlation ($p < 0.001$). A linear regression of weekly mercury deposition as the response variable and weekly precipitation as the explanatory variable resulted in a model showing a significant linear relationship (shown in log-log scale graph in fig. 16)[10]. The coefficient of determination (r^2) for the regression is 0.663, which means that 66 percent of the variance in mercury deposition is explained by the precipitation amount. Another discussion of the relation of precipitation to deposition is in the Precipitation Normals and Precipitation Distribution section of this report.

Geographic and Temporal Variability of Mercury in Precipitation

Geographic variability of mercury in precipitation was examined with statistical analysis of mercury concentrations and deposition at the five monitoring stations in Indiana and with detailed isopleth maps of deposition. Mercury concentrations and deposition in Indiana were compared with other stations in the NADP–MDN. Temporal variability of mercury concentrations and deposition was evaluated for seasonal

[10] The slope coefficient of the regression equation is significantly greater than zero, based on the t-test statistic ($p<0.001$). The residuals (departure) of the predicted values from the actual values are normally distributed.

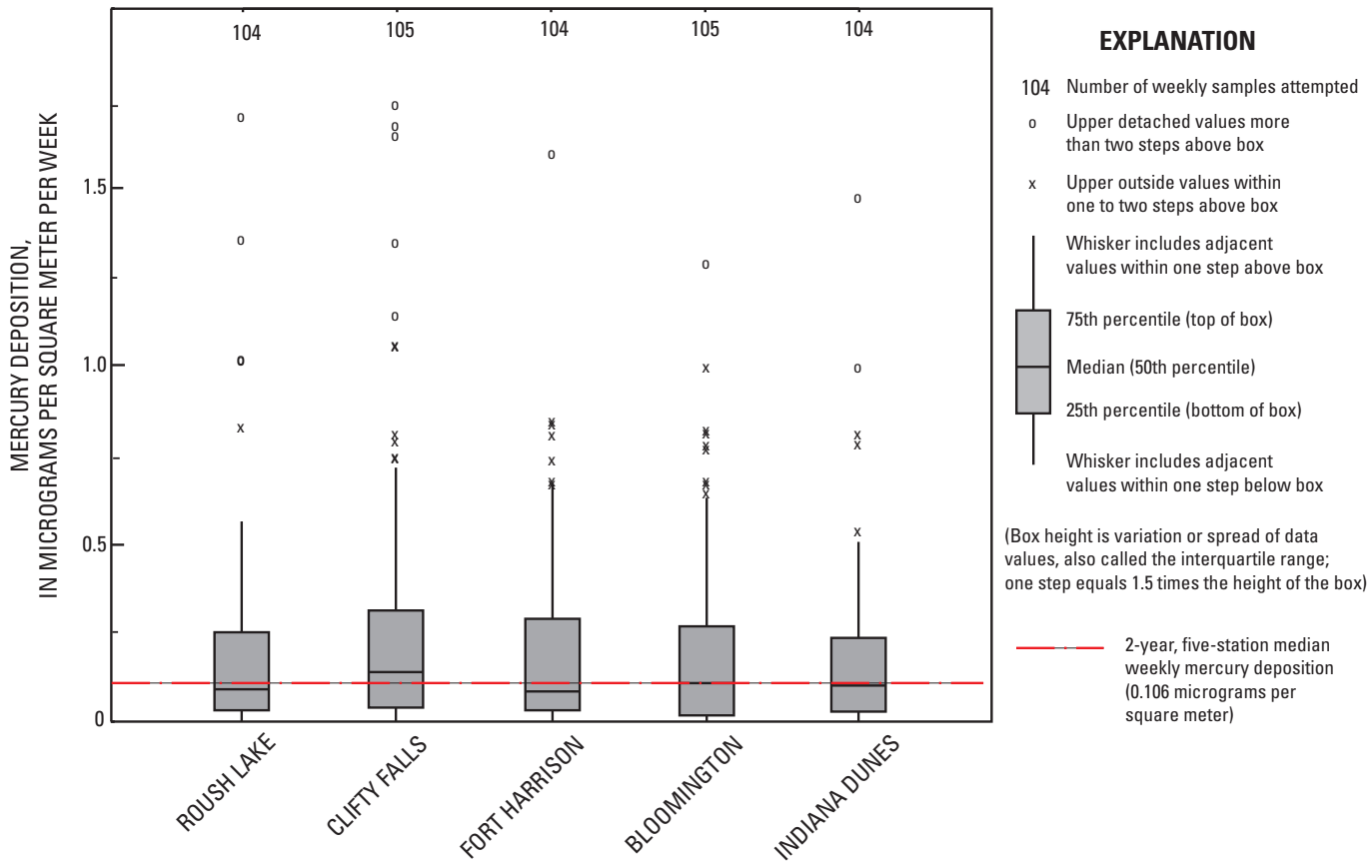


Figure 15. Distribution of mercury deposition in weekly samples at five monitoring stations for mercury in precipitation in Indiana, January 2004–December 2005.

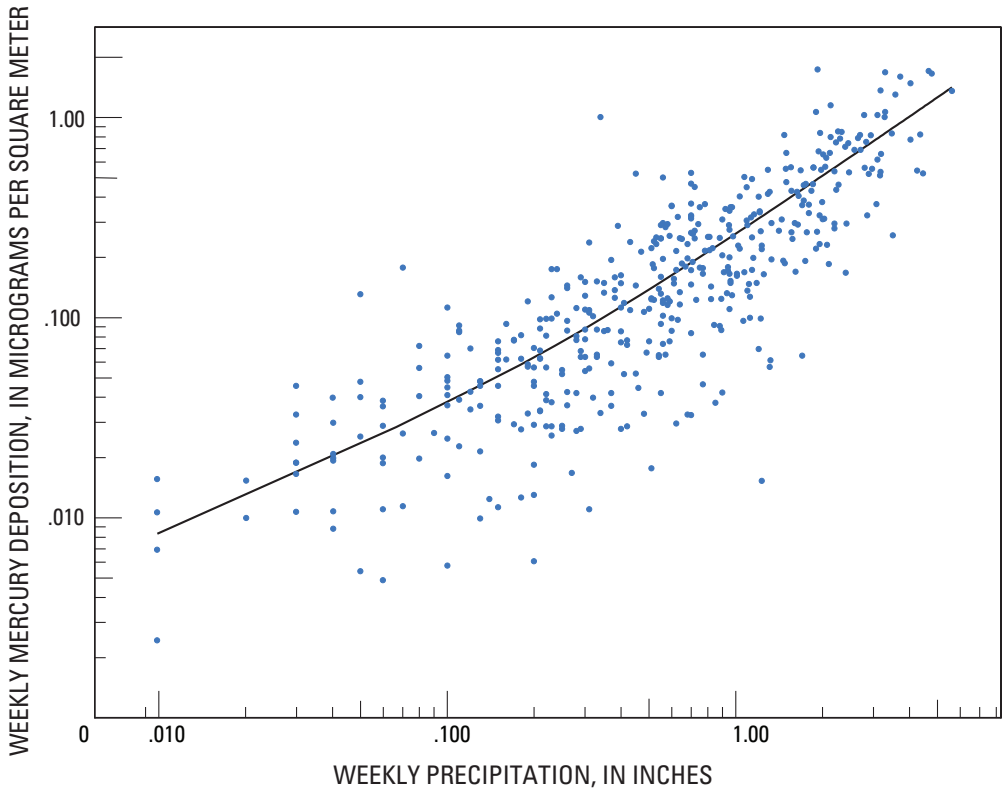


Figure 16. Weekly mercury deposition and weekly precipitation at five monitoring stations for mercury in precipitation in Indiana, 2004–2005.

patterns, episodes of high mercury deposition, trends during 2001–2005, and the relation to precipitation normals.

Geographic Variability

Weekly precipitation, mercury deposition, and mercury concentrations in weekly samples, 2004–2005, were examined statistically to determine whether there was a significant difference ($\alpha = 0.05$)[11] among the five monitoring stations. Weekly precipitation was not different (Kruskal-Wallis rank-sum test, p = 0. 798)[12]. Weekly mercury deposition was not different (Kruskal-Wallis rank-sum test), whether estimated deposition values were included (p= 0.466) or excluded (p = 0.631). Mercury concentrations were different (Kruskal-Wallis rank-sum test, p= 0.022). Concentrations at Clifty Falls (median 12.9 ng/L) were higher than those at Fort Harrison (median 9.8 ng/L), Bloomington (median 9.4 ng/L), and Roush Lake (median 9.3 ng/L), based on a multiple-stage test with the Kruskal-Wallis statistic[13]. Concentrations at Clifty Falls and Indiana Dunes were not significantly different, although concentrations at Indiana Dunes (median 10.4 ng/L) were significantly higher than those at Bloomington.

The annual mercury emissions in the vicinity of Clifty Falls (1,789 lb) were more than seven times the annual mercury emissions in the vicinity of Bloomington, more than five times the annual mercury emissions in the vicinity of Fort Harrison, and more than three times the annual mercury emissions in the vicinity of Roush Lake (table 2). Other factors such as the types of mercury emissions, long-range mercury transport from sources outside Indiana, and meteorological conditions also may help explain the differences in the mercury concentrations.

The five monitoring stations can be ranked by the 2-year and 5-year normalized mercury deposition and the 2-year and 5-year normalized mercury concentration (table 6). Use of normalized deposition and concentrations tends to remove differences caused by variability in precipitation amounts and sample volumes collected at each station. The rankings on this basis are similar to the statistical differences in concentration in weekly samples, with Clifty Falls the highest and similar to

[11] A significance level (α) of 0.05 or less was used to accept a statistically significant difference. The p-value is the significance attained by the data—the smaller the p-value, the lower the probability of incorrectly rejecting the hypothesis of no significant difference and the lower the probability that a significant difference arose by chance. The smaller the p-value, the more believable the statistical difference.

[12] The Kruskal-Wallis rank-sum test (Helsel and Hirsch, 1995) is a nonparametric procedure used to evaluate if the distributions of the data from more than two stations or years were different.

[13] The multiple-stage test with Kruskal-Wallis statistic (Helsel and Hirsch, 1995) is a nonparametric procedure used to evaluate in succession each of the two possible comparisons between the four monitoring stations.

Table 6. Five monitoring stations for mercury in precipitation in Indiana ranked by normalized mercury deposition and normalized mercury concentration, 2004–2005 and 2001–2005.

[µg/m²/in., microgram per square meter per inch of precipitation; ng/L, nanogram per liter]

Statewide rank	Station name	2004–2005		2001–2005	
		Normalized mercury deposition[1] (µg/m²/in.)	Normalized mercury concentration[2] (ng/L)	Normalized mercury deposition[1] (µg/m²/in.)	Normalized mercury concentration[2] (ng/L)
1	Clifty Falls	0.318	13.2	0.316	12.7
2	Indiana Dunes	.291	11.4	.314	12.2
3	Roush Lake	.261	10.4	.279	11.1
4	Fort Harrison	.243	9.47	.260	10.2
5	Bloomington	.224	9.03	.245	9.36

[1] Normalized mercury deposition computed as the 2-year or 5-year sum of annual deposition divided by the 2-year or 5-year sum of annual precipitation.

[2] Normalized mercury concentration computed as the 2-year or 5-year sum of weekly volume-weighted concentrations computed with equation 3.

Indiana Dunes and with Bloomington the lowest. Rankings are the same for 2004–2005 and 2001–2005.

Each year since 2001, the NADP used data from approximately 60 MDN stations that had a record more than 75 percent complete to create color isopleth maps of annual precipitation-weighted mercury concentrations and annual total mercury wet deposition. The NADP prepared the isopleth maps using geographic information system (GIS) software that applied an inverse-distance-weighted interpolation algorithm to estimate mercury concentrations or deposition for each cell in a map grid of North America. Isopleth bands were generated by the GIS software for selected ranges of the estimated mercury concentrations or deposition. These maps illustrate an interpretation of the spatial distribution of mercury concentrations in precipitation and mercury wet deposition.

The normalized annual mercury concentrations[14] and annual mercury deposition in 2004 and 2005 were summarized for the NADP–MDN in eastern North America (National Atmospheric Deposition Program, 2005, 2006) and compared with the 2004 and 2005 data from Indiana. The highest ranges of normalized annual mercury concentrations in 2004 and 2005 were 12.0–13.9 ng/L and 14.0–15.9 ng/L. In 2004, the highest concentrations were near stations in Florida, Minnesota, and Wisconsin (fig. 17) and the 13.0 ng/L concentration at Clifty Falls was the fourth highest. In 2005, the highest concentrations were near stations in Florida, Minnesota, and Wisconsin, plus Missouri, Oklahoma, and Louisiana (fig. 17) and the 12.1 ng/L concentrations at Clifty Falls and Indiana Dunes were the ninth highest. Normalized annual concentrations at Clifty Falls and Indiana Dunes also were among the highest in the NADP–MDN in eastern North America in 2003 (Risch, 2007).

The highest ranges of annual mercury deposition in 2004 and 2005 were 16.0–17.9 and more than 18 µg/m^2. The highest deposition was in Louisiana, Mississippi, Alabama, Florida, and Georgia (fig. 18) and mercury deposition at Clifty Falls was in the top 25 percent of stations in eastern North America both years. Annual mercury deposition at Clifty Falls was among the highest in the NADP–MDN in eastern North America in 2003 (Risch, 2007).

Isopleth maps of mercury wet deposition for an individual state derived from the NADP North America maps may lack the desired level of detail for interpretations at a state level because the spatial distribution of monitoring sites is limited and because the isopleth ranges are broad. In this report, an alternate method for preparing a statewide map of total mercury wet deposition was utilized for Indiana. Because mercury wet deposition is computed as the product of mercury concentration and precipitation, a more detailed wet deposition isopleth map can be made by using precipitation data from stations in addition to the five NADP–MDN stations in Indiana. Annual precipitation, 2004–2005, was obtained from 127 National Weather Service (NWS) Cooperative Observer Program stations in Indiana with a record that was more than 75 percent complete (Midwestern Regional Climate Center, 2007).

The alternate method for creating isopleth maps of mercury wet deposition for Indiana required four steps. First, concentration isopleth maps of annual precipitation-weighted average total mercury concentrations in Indiana, 2004 and 2005, were prepared with data from eight or nine NADP–MDN stations (five in Indiana and three or four from surrounding states, fig. 17). These isopleth maps were prepared with GIS software using an inverse-distance-weighted interpolation algorithm. (It was assumed that precipitation in Indiana was not affected significantly by altitude, unlike mountainous states. The altitude in Indiana ranges from 320 to 1,257 ft and the mean is 700 ft.)

Next, a map of the 127 NWS stations and concentration isopleths was overlain with a statewide grid of 2 km-square cells. In each cell with a NWS station, a mercury concentration value, determined from the isopleth map, was multiplied by the precipitation for the NWS station to obtain a mercury wet deposition value for that cell. Then, the GIS-software interpolation algorithm was applied to fill mercury wet-deposition values in the rest of the statewide grid. Last, the GIS software was used to create a color-coded isopleth map for 2004 (fig. 19) and for 2005 (fig. 20).

The isopleth maps prepared with the alternate method are more detailed in that they display eight to nine ranges of mercury deposition in Indiana, compared with three to four ranges in Indiana for the NADP North America maps (fig. 18). The isopleth maps prepared with the alternate method present different regional patterns of mercury deposition in Indiana than the NADP North America maps. For example, in 2004, the eastern third of Indiana in the NADP North America map (fig. 18) has a zone of 12–13.9 µg/m^2 mercury deposition, which is smaller in area and only in the southeast in the map made with the alternate method (fig. 19). In the 2004 deposition map made with the alternate method, areas in the middle of Indiana have mercury deposition of 9–10 µg/m^2 bordered by 10–11 µg/m2, which is unlike the pattern in the North America map. The maps prepared with the alternate method also present more detailed local patterns of mercury deposition that are influenced by local differences in precipitation that are not shown in the North America maps. However, both types of maps show a zone in southeastern Indiana that includes the Clifty Falls monitoring station, where the highest mercury deposition was mapped for 2004–2005. This zone is consistent with the statistically higher weekly mercury concentrations at the Clifty Falls station that were explained earlier and with the highest 2-year normalized deposition in Indiana at Clifty Falls (table 6).

[14]The NADP normalized annual concentration is the sum of weekly precipitation-weighted concentrations. It is computed in a way similar to the normalized concentration defined in the Data Management and Reporting section of this report, which is based on the sum of weekly volume-weighted concentrations.

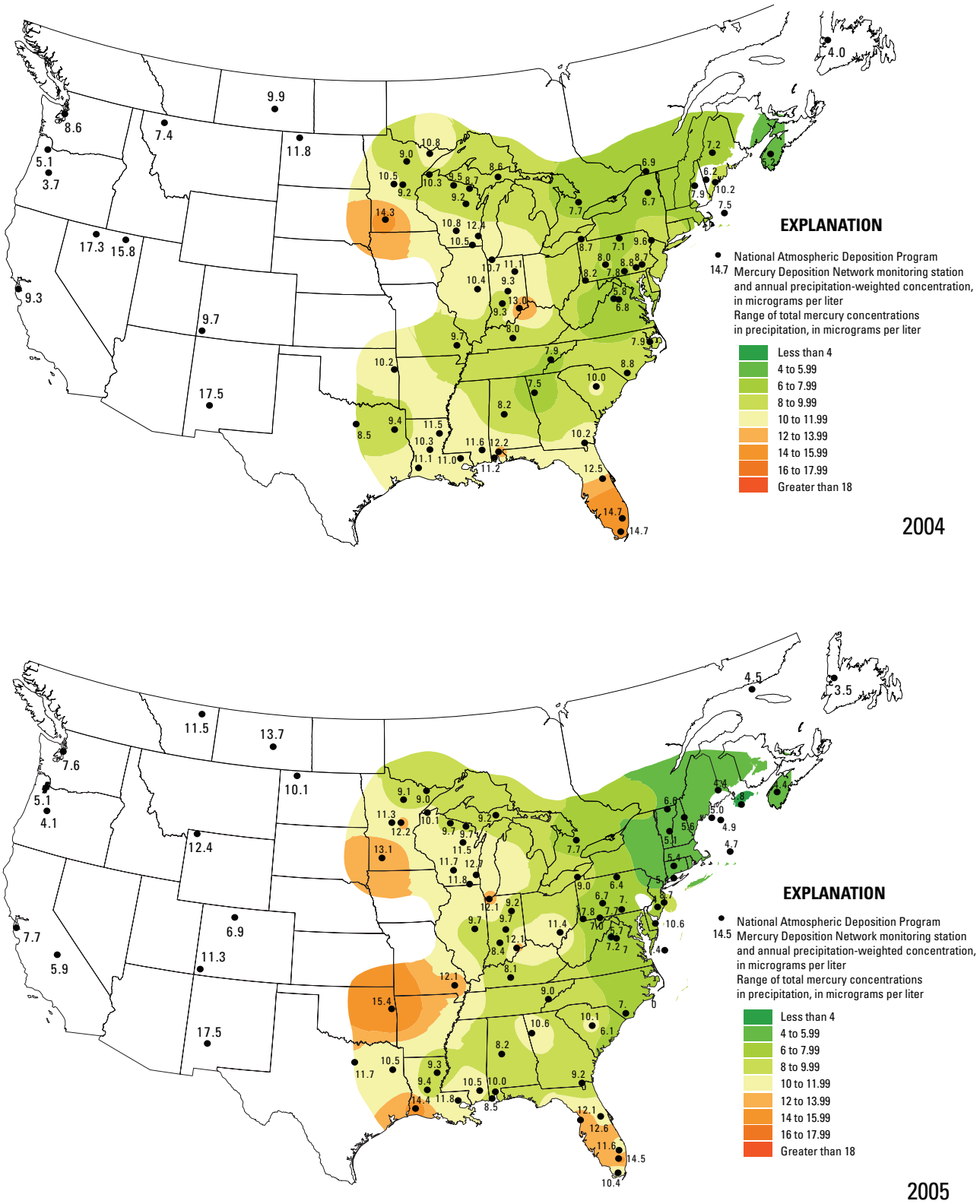


Figure 17. National Atmospheric Deposition Program Mercury Deposition Network monitoring stations with normalized annual mercury concentrations in 2004–2005 and ranges of mercury concentrations for eastern North America.

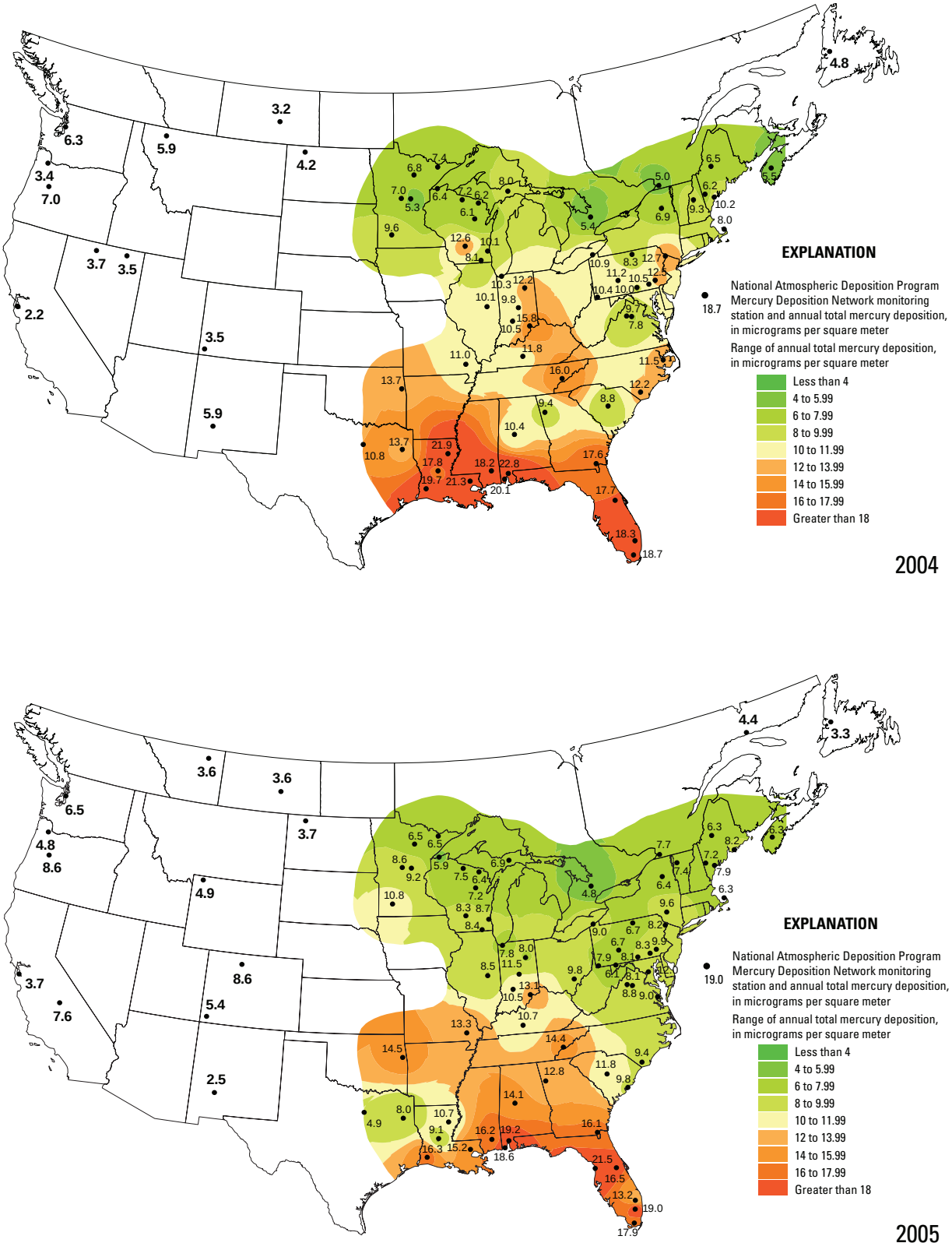


Figure 18. National Atmospheric Deposition Program Mercury Deposition Network monitoring stations with annual mercury deposition in 2004–2005 and ranges of mercury deposition for eastern North America.

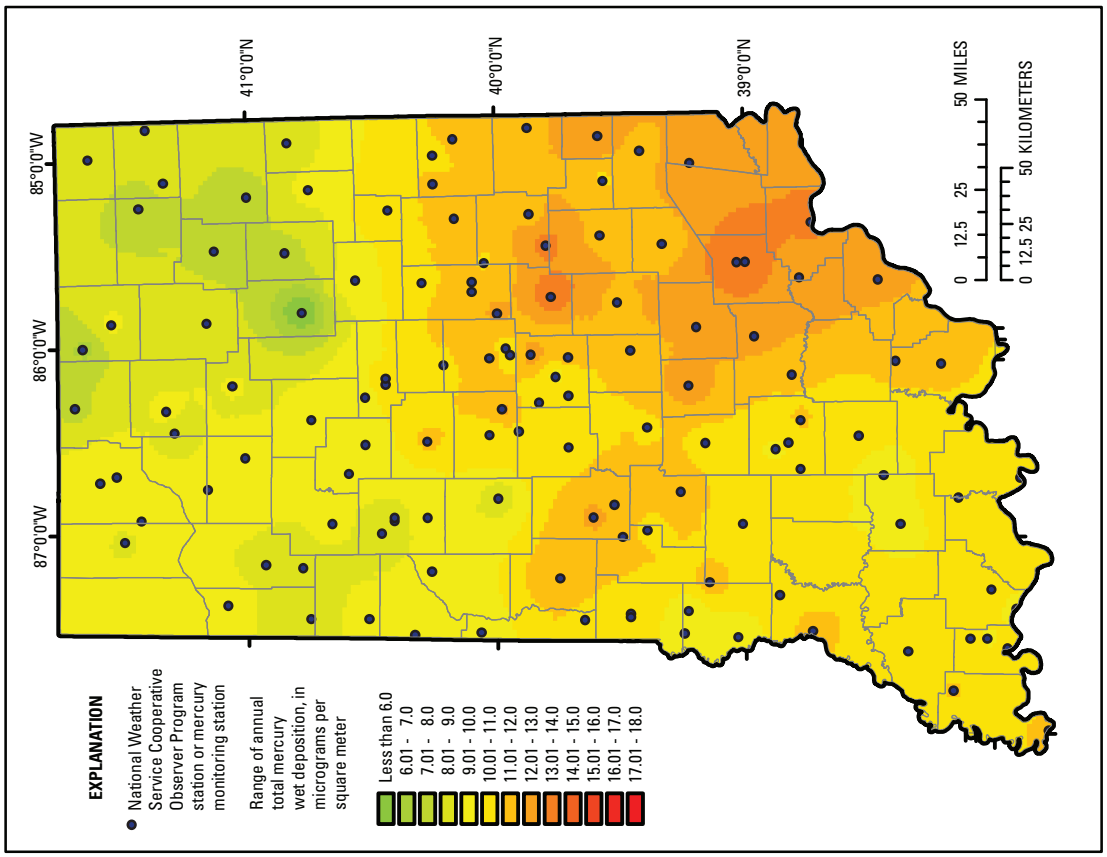


Figure 20. Isopleth map of annual wet deposition of mercury in Indiana in 2005.

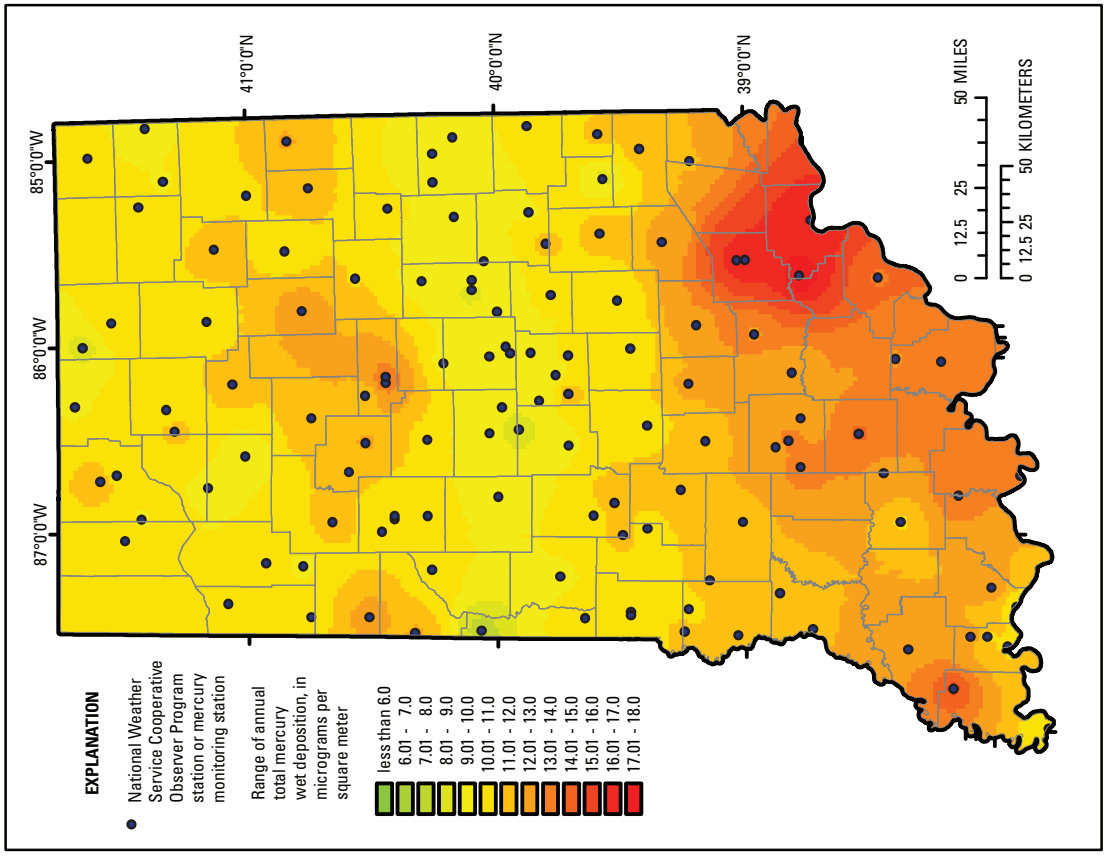


Figure 19. Isopleth map of annual wet deposition of mercury in Indiana in 2004.

Seasonal Patterns

Precipitation, mercury concentration, and mercury deposition in weekly samples were examined for seasonal patterns by use of graphical and statistical methods. Graphically, seasonal patterns were apparent for mercury concentration and mercury deposition plotted by month and these patterns were confirmed statistically.

Boxplots were made to examine the distributions of precipitation, mercury concentration, and mercury deposition, during the 12 months of the year. These boxplots combined weekly data from the five monitoring stations for 5 years (fig. 21). As indicated by these boxplots, mercury concentration and mercury deposition had a seasonal pattern where the median of weekly values grouped by month exceeded the 5-year statewide median during April through September. Precipitation did not exhibit a seasonal pattern, unlike mercury concentration and mercury deposition, although a statistical difference was shown, as explained below.

Precipitation, mercury concentration, and mercury deposition in weekly samples for the 2 years (2004–2005) and the 5 years (2001–2005) were examined statistically for significant differences ($\alpha = 0.05$)[11] when grouped according to the seasonal patterns indicated by the boxplots—April through September and October through March. For 2004–2005, mercury concentrations in April through September (median 13.4 ng/L) were statistically higher (Wilcoxon rank-sum test, $p < 0.001$)[15] than October through March (median 7.40 ng/L) and mercury deposition in April through September (median 0.151 µg/m^2) was statistically higher (Wilcoxon rank-sum test, $p < 0.001$)[15] than October through March (median 0.076 µg/m^2). For 2004–2005, precipitation in April through September (median 0.52 in.) was not statistically higher (Wilcoxon rank-sum test, $p = 0.317$) than October through March (median 0.42 in.). For 2001–2005, mercury concentrations, mercury deposition, and precipitation were statistically higher in April through September than October through March (Wilcoxon rank-sum test, $p < 0.001$, $p < 0.001$, and $p = 0.002$)[15].

Seasonal patterns of mercury concentrations and mercury deposition similar to those in Indiana have been reported for other states and regions of eastern North America, including Lynch and others (2005) for Pennsylvania, Mason and others (2000) for Maryland, Dvonch and others (2005) for Florida, and Vanarsdale and others (2005) and Miller and others (2005) for northeastern North America.

[15] The Wilcoxon rank-sum test is a nonparametric procedure used to evaluate if the distribution of the data from one of the two groups was statistically higher than the other group.

Trends in Mercury Concentrations and Mercury Deposition

The Seasonal Kendall test for trend (Hirsch and others, 1982) was developed by the USGS to analyze trends in water quality and has become the most used test for trend in the environmental sciences (Helsel and others, 2005). The Seasonal Kendall test is a generalization of the Mann–Kendal test (Mann, 1945; Kendall, 1975) and reduces the effect that seasonal variations may have on trend detection by making comparisons of data from similar seasons (Schertz, and others, 1991). The Seasonal Kendall test counts the number of increases and decreases in a parameter during a period of record, conducts the test within each season, and then combines the results from each season into an overall test for trend (Frans and Helsel, 2005). The direction of the trend is indicated by the Kendall's tau correlation coefficient. A negative tau indicates a decrease and a positive tau indicates an increase. The use of nonparametric procedures adjusted for serial correlation optimizes the sensitivity of the test for correctly detecting a significant trend.

Because seasonal patterns in the 2001–2005 monthly mercury concentration and mercury deposition data were demonstrated with box plots (fig. 21), these same 12 monthly seasonal periods were used for the Seasonal Kendall test of trends in the Indiana weekly monitoring data for the 5-year period. Each monthly seasonal period had as many as 25 weekly values for a test of trends at a single station or as many as 125 weekly values for a test of trends at all 5 stations. The seasonal medians were used in the test of trends. In this analysis, statistical significance is based on an adjusted p-value that corrects for the serial correlation from the seasonality of the data. A statistically significant trend is indicated by a p-value less than 0.10. (The p-value is the probability of incorrectly detecting a trend. In this report, the trends reported have less than a 10 percent chance of being incorrect.) The test was made for data from each of the monitoring stations and "statewide" (combining 5 years of weekly data from all five stations). For the statistically significant trends, the annual change is reported as the slope in the equation of the estimated trend and as a percent of the 5-year mean.

The Seasonal Kendall test did not show a statistically significant trend in precipitation at any of the monitoring stations or statewide. A statistically significant trend in mercury concentration was not shown for any of the monitoring stations. A statistically significant trend was shown for a statewide decrease in mercury concentration (table 7). In addition, a statistically significant trend was shown for a statewide decrease in mercury deposition and for decreases in mercury deposition at two of the five monitoring stations, Roush Lake and Bloomington (table 7). A statistically significant trend in mercury deposition was not shown at the other three monitoring stations. It is likely that the statewide decrease in mercury deposition is related to the statewide decrease in mercury concentration because a corresponding trend in statewide precipitation was not observed in 2001–2005.

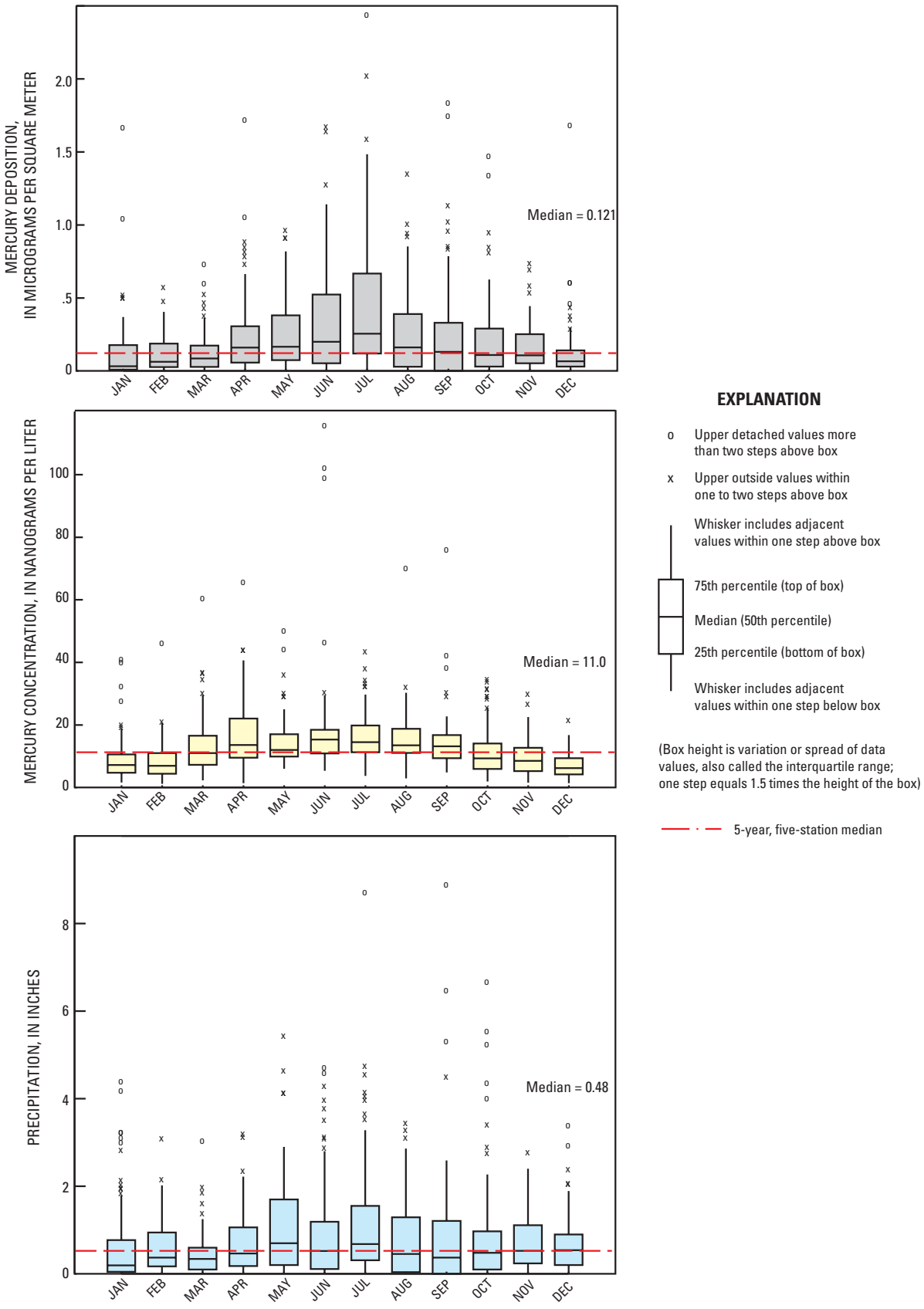


Figure 21. Monthly distributions of mercury deposition, mercury concentration, and precipitation at five monitoring stations for mercury in precipitation in Indiana, January 2004–December 2005.

Table 7. Seasonal Kendall test of statistically significant trends in weekly mercury deposition and mercury concentration at monitoring stations for mercury in precipitation in Indiana, 2001–2005.

[µg/m², microgram per square meter; ng/L, nanogram per liter]

Mercury data for Seasonal Kendall test	Adjusted p-value of test[1]	Kendall's tau[2]	Annual change[3]	5-year mean	Percent change[4]
Deposition, five stations, 5 years	0.007	-0.183	-0.018 µg/m²	0.228 µg/m²	-7.9
Deposition, Roush Lake, 5 years	.061	-.167	-.015 µg/m²	.218 µg/m²	-6.9
Deposition, Bloomington, 5 years	.083	-.167	-.005 µg/m²	.217 µg/m²	-2.3
Concentration, five stations, 5 years	.059	-.233	-.361 ng/L	13.07 ng/L	-2.7

[1] The p-value was adjusted for serial correlation of mercury data and time caused by seasonality. A statistically significant p-value is less than 0.10, meaning there is less than a 10 percent probability of incorrectly detecting a trend.

[2] The Kendall's tau correlation coefficient indicates the direction of change for the trend. A negative tau indicates a decrease.

[3] Annual change is the slope in the equation of the estimated trend.

[4] Percent change is computed as the annual change divided by the 5-year mean, expressed as a percentage.

Evidence for the statewide decrease in mercury deposition was examined graphically in time-series plots of weekly data using nonparametric locally-weighted scatterplot smoothing, called LOWESS (Helsel and Hirsch, 2002, 1995). Time-series plots of mercury concentration (fig. 22) and mercury deposition (fig. 23), 2001–2005, were made with LOWESS settings to produce a smooth curve that follows the shape and direction of the concentration and deposition data along the horizontal time-series axis and reflects the central tendency of the data.[16] In the plots for each monitoring station, the LOWESS line through the data points appears above and below the line for the statewide median value, 2001–2005. However, the LOWESS line begins to decline and extend below the median line in 2004–2005, indicating a decreasing trend in mercury concentration at all five stations and mercury deposition at four stations. This decline was not observed for mercury deposition at the Bloomington station, although mercury concentration did exhibit a decline according to the Seasonal Kendall test.

A potential explanation for some of the statewide decrease in mercury concentration (and the corresponding decrease in mercury deposition), 2001–2005, could be the difference in the amount and type of annual emissions of mercury from stationary sources in Indiana between 2002 and 2005. According to data from IDEM (Jon Bates, Office of Air Quality, written commun., December 2007), the statewide total estimated annual mercury emissions from stationary sources were 10,390 lb in 2002 and 7,483 lb in 2005, which is a 28 percent decrease from 2002. Much of the change in the annual mercury emissions between 2002 and 2005 was noted in three categories of sources. Estimated annual mercury emissions from coal-fired power plants were 5,234 lb in 2002 and 4,500 lb in 2005. Estimated annual mercury emissions from electric arc furnaces and foundries (excluding coke ovens) were 2,400 lb in 2002 and 1,550 lb in 2005. Estimated annual mercury emissions from cement and gypsum manufacturing were 1,963 lb in 2002 and 750 lb in 2005.

Wind direction data for 2004–2005 were available at or near the five monitoring stations. At Roush Lake, Clifty Falls, and Fort Harrison, the USGS maintained a sensor for wind direction. At Bloomington, approximately 1,200 ft southwest of the monitoring station, the National Weather Service and Federal Aviation Administration operated an Automated Surface Observing System that included wind direction. At Indiana Dunes, 1 mi north of the monitoring station, the IDEM Dune Acres ambient air-quality monitoring site recorded wind direction. The hourly wind direction data from these five locations were summarized in wind rose plots for 2004 and 2005 (appendix 2). The wind rose plot shows the percentages of time when the wind blew from each of 16 directions toward the monitoring station during each year (Lakes Environmental Software, 2006). The wind rose plots may indicate the predominant directions of origin for surface air moving toward each station, although air at higher altitudes is not included.

[16] These settings were the auto span, local-linear degree of fit, and symmetric options in the S-PLUS® statistical software (Insightful Corp., 2005). The span controls the smoothness of the curve. Decreasing the span makes the LOWESS line follow the individual data points more closely. Increasing the span makes a smoother LOWESS line. An auto span uses cross validation to optimize the smoothest line that follows the data points. The degree of fit option used was locally linear rather than locally quadratic. The symmetric option uses local fitting with a robustness feature that reduces distortion by outliers, whereas the Gaussian option only uses local-fitting.

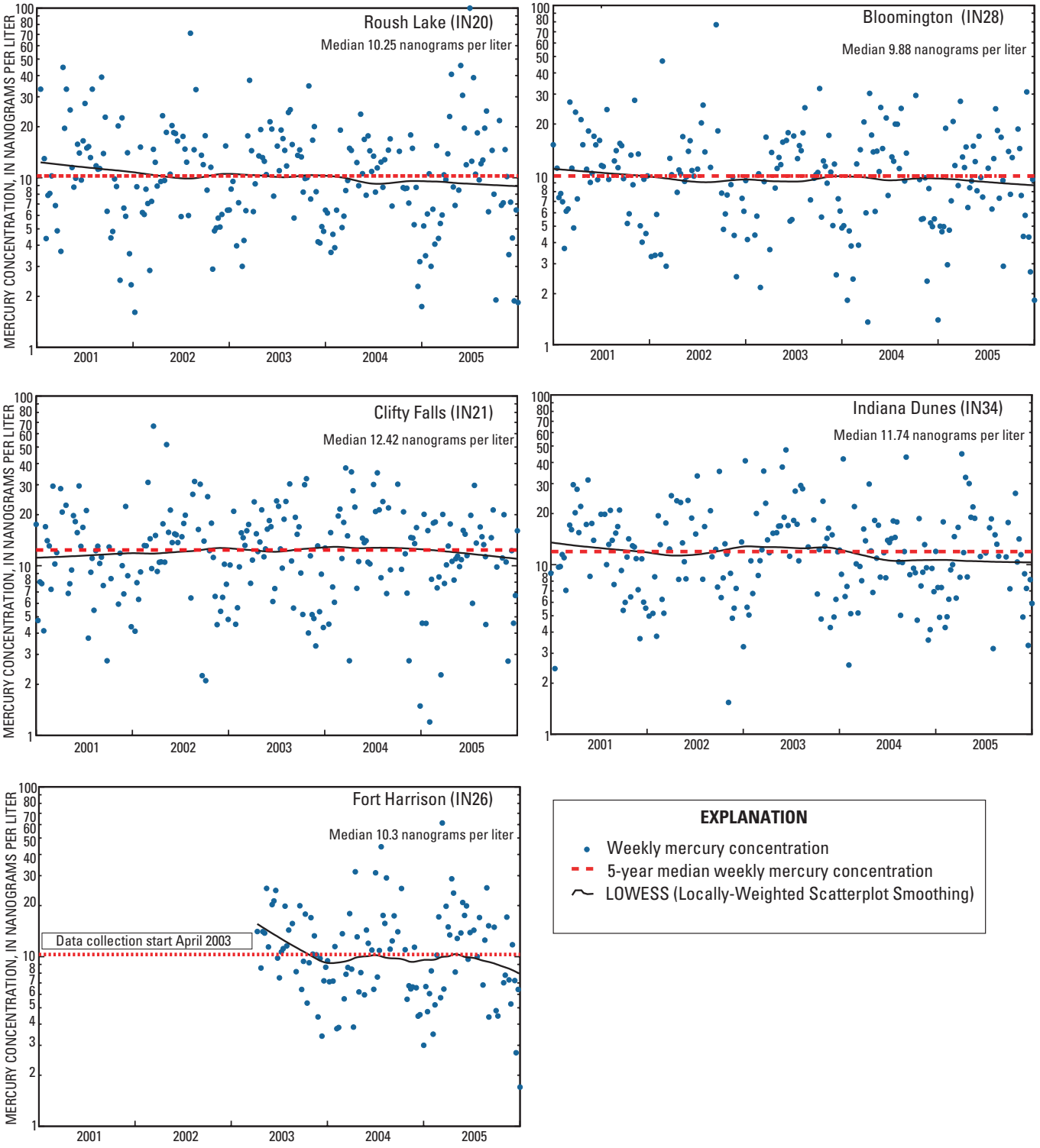


Figure 22. Weekly mercury concentrations at five monitoring stations for mercury in precipitation in Indiana, 2001–2005.

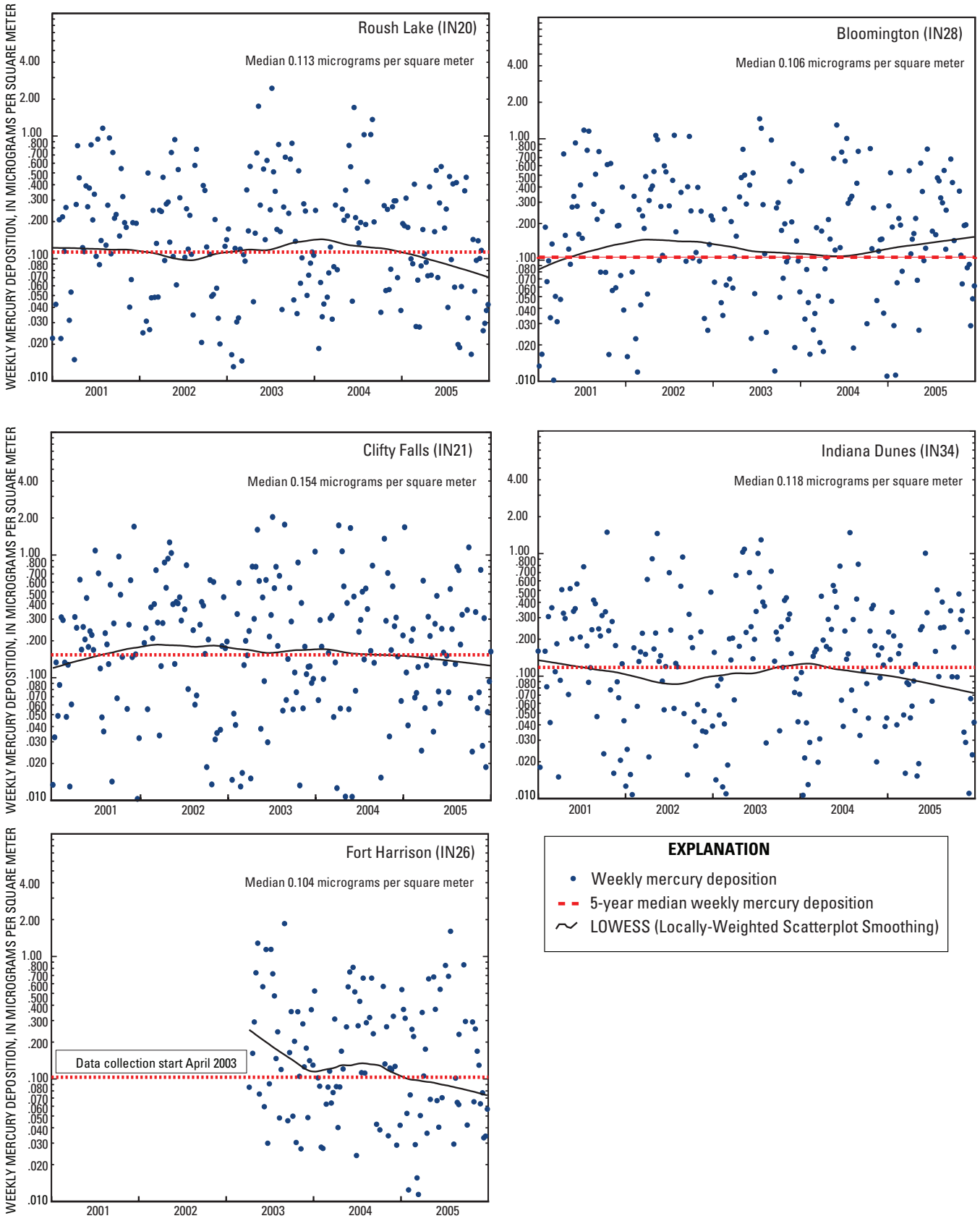


Figure 23. Weekly mercury deposition at five monitoring stations for mercury in precipitation in Indiana, 2001–2005.

At Roush Lake and Bloomington, winds came most often from the southwestern quadrant (appendix 2). Based on predominant wind directions, the statistically significant decreases in mercury deposition at Roush Lake and Bloomington may be related to decreases in the number of stationary mercury emissions sources and the amount of annual mercury emissions from stationary sources southwest of the monitoring stations. These stationary sources include those shown in figs. 6 and 9 and regional sources that are not shown.

The trends in statewide mercury concentration and statewide mercury deposition are similar to trends at NADP–MDN stations in the northern US and southern Canada, 1998–2005, reported by Butler and others (2007). They reported significant decreases in mercury concentrations at 14 of 14 stations and decreases in mercury deposition at 10 of 14 stations in the Midwest (Wisconsin, Minnesota, Pennsylvania, and Illinois), by use of linear regression ($p < 0.10$). In addition, Butler and others (2007) employed a random coefficient model analysis of 20 NADP–MDN stations in the northern US and southern Canada and detected a decrease in normalized mercury concentration that was 2.5 percent of the long-term (8-year) mean and a decrease in annual mercury deposition that was 2.1 percent of the long-term mean. Their values for percent change are in the range of those reported for Indiana, 2001–2005 (table 7).

The relation of a decrease in mercury emissions to a decrease in mercury concentrations and mercury deposition has been observed by other investigators. Butler and others (2007) hypothesized the decrease in mercury concentration and mercury deposition at 20 NADP–MDN stations in1998–2005 was affected by a decline in mercury emissions from the US and Canada during that time period. Lynch and others (2005) examined monitoring data from a NADP–MDN station in Pennsylvania from 1997–2004 and reported that a statistically-significant decrease in mercury concentration of 5.37 percent per year at PA90 was not related to precipitation. However, they reported a strong relation of decreasing mercury concentrations to decreasing sulfate concentrations at this station that appeared to be related to reductions in regional emissions.

Episodes of High Mercury Deposition

Episodes of high mercury deposition during 2004–2005 are identified in this report as samples with weekly mercury deposition that are in the top 10 percent, and out of that group, samples with the highest weekly mercury deposition had more than five times the 2-year statewide mean weekly deposition. For purposes of this discussion: an episode is one or more precipitation events collected in a weekly sample, and precipitation events are separated by a break of 8 hours or more in precipitation accumulation.

Statewide, episodes of high mercury deposition at the five monitoring stations, 2004–2005, were recorded for 45 of 448 wet-deposition samples for which deposition was at least 0.563 $\mu g/m^2$ (the 90th percentile). Mercury deposition for these samples ranged from 0.563 to 1.74 $\mu g/m^2$, which is approximately 2.7 to 8.4 times the mean weekly deposition for Indiana (0.208 $\mu g/m^2$). The mercury deposition in these top 45 samples represents 39 percent of the mercury deposition from all 448 wet-deposition samples, 2004–2005. Samples with high mercury deposition averaged 2.7 in. or more of rain from two to three precipitation events and mercury concentrations averaged 16.1 ng/L. More than 80 percent of the high mercury deposition samples were in the months April through September, consistent with a seasonal pattern described in the previous section (fig. 21).

Statewide, the episodes of highest mercury deposition were in 12 samples (table 8) with more than five times the 0.208 $\mu g/m^2$ 2-year mean weekly mercury deposition (more than 1.04 $\mu g/m^2$). These episodes of highest mercury deposition were recorded at all 5 monitoring stations, but the most (7 of 12) were at Clifty Falls. These seven samples at Clifty Falls contributed 34.4 percent of the total deposition at that station in 2004–2005. The weekly mercury deposition in three episodes of highest deposition (one each at Roush Lake, Fort Harrison, and Indiana Dunes) was more than 14 percent of the annual mercury deposition at each station that year. One episode, in the week ending June 1, 2004, was recorded at more than one monitoring station—at Clifty Falls and Bloomington.

Most of the episodes of highest mercury deposition were in samples with more than 3 in. of rain from two to three events. Mercury concentrations in the episodes of highest mercury deposition ranged from 9.52 to 35.7 ng/L, but were not the highest mercury concentrations recorded in Indiana, 2004–2005. The sample with the 35.7 ng/L mercury concentration also had the highest mercury deposition (Clifty Falls, week ending April 14, 2004). Other investigators have reported high mercury concentrations for high-intensity or short duration precipitation events (for example, Mason and others, 1997, Downs and others, 1998, Keeler and others, 2005, and Keeler and others, 2006).

The wind rose plots (appendix 2), described in the previous section, may indicate the predominant directions of origin for surface air moving toward each station, although air at higher altitudes is not included. At Clifty Falls, winds came most often from the southwestern quadrant in 2004 and the two southern quadrants in 2005. On the basis of predominant wind direction, many of the samples at Clifty Falls with mercury deposition in the top 10 percent for Indiana 2004–2005, including the episodes of highest mercury deposition, may be related to mercury emissions from stationary sources south of the monitoring station. These stationary sources include those in fig. 7 and regional sources that are not shown.

Episodes of high mercury deposition in 2004–2005 were similar to those reported in 2001–2003 in Indiana (Risch, 2007). For that 3-year period, episodes of high mercury deposition were 5 to 10 times the mean weekly deposition; most of the episodes were from more than 3 in. of rain in 2 or more events. Also, the most episodes of high mercury deposition were at Clifty Falls, which had the highest annual mercury deposition, 2001–2003.

Table 8. Episodes of highest mercury deposition in Indiana, January 2004–December 2005.

[µg/m², microgram per square meter; ng/L, nanogram per liter]

Station name	Date sample removed	Mercury deposition (µg/m²)	Percentage of annual mercury deposition[1]	Mercury concentration (ng/L)	Weekly precipitation (inches)	Type of precipitation	Number of precipitation events[2]
Clifty Falls	April 14, 2004	1.74	11.0	35.7	1.92	rain	2
Roush Lake	June 15, 2004	1.71	14.2	14.4	4.66	rain	3
Clifty Falls	January 11, 2005	1.69	13.6	20.1	3.30	rain	3
Clifty Falls	June 1, 2004	1.66	10.4	13.7	4.78	rain	2
Fort Harrison	July 26, 2005	1.61	14.5	17.0	3.72	rain	3
Indiana Dunes	July 27, 2004	1.48	14.4	14.5	4.03	rain	3
Roush Lake	August 31, 2004	1.37	11.4	17.0	3.17	rain	2
Clifty Falls	October 19, 2004	1.36	8.5	9.52	5.61	rain	2
Bloomington	June 1, 2004	1.30	12.4	14.3	3.57	rain	2
Clifty Falls	September 27, 2005	1.15	9.3	21.3	2.13	rain	2
Clifty Falls	April 27, 2004	1.07	6.7	22.2	1.90	rain	3
Clifty Falls	January 6, 2004	1.07	6.7	12.7	3.30	mixed	2

[1] Percentage of annual mercury deposition is for the station listed.

[2] For this report, precipitation events are defined as being separated by a break of at least 8 hours in precipitation accumulation.

The top 10 percent of weekly mercury deposition at each of the 5 monitoring stations consisted of 9 or 10 samples that contributed 35 to 42 percent of the total mercury deposition at the station, 2004–2005. Nearly all the top 10 percent of mercury deposition was associated with weeks that had more than 1 in. of rain. Most samples with more than 1 in. precipitation were associated with mercury deposition greater than median deposition for a station. As an example, for 28 of the 29 samples at Fort Harrison with more than 1 in. precipitation, mercury deposition was more than twice the median deposition.

Episodes of high mercury deposition were not unique to Indiana. In a study of patterns of mercury deposition at NADP–MDN stations in northeastern North America, 1996–2002, Vanarsdale and others (2005) reported episodes[17] of high mercury deposition occurred networkwide, with some stations recording more episodes than others. In that study, it was shown that the greater the number of episodes of high mercury deposition[18] at a station, the greater their contribution to annual deposition. In a study of mercury deposition at a site in eastern Ohio, 2003–2004, Keeler and others (2006) observed that the top five mercury deposition episodes[19] (0.77 to 1.69 µg/m²) had above average mercury concentrations and precipitation. In an 11-year study at a site in Vermont, 1993–2003, Keeler and others (2005) observed that high mercury deposition episodes[19] (more than 0.4 µg/m²) contributed 5 to 17 percent of annual deposition and 13 percent of the 11-year deposition.

For Indiana, the relation of the number of high mercury deposition episodes to annual mercury deposition may help to explain the numerical differences in annual mercury deposition among the stations, 2004–2005. Clifty Falls had the most episodes of highest mercury deposition, which, along with statistically higher mercury concentrations, likely contributed to that station having the highest statewide annual mercury deposition in 2004 and 2005.

Precipitation Normals and Precipitation Distribution

Monthly precipitation amounts measured at the five monitoring stations, January 2004–December 2005 (table 9), were compared with monthly precipitation normals, 1971–2000, for the five climate divisions in Indiana where the monitoring stations were located (Midwestern Regional Climate Center, 2007). Annual precipitation at the five monitoring stations was within approximately 10 percent of normal in 2004–2005, with the exception of Indiana Dunes in 2005, where precipitation was 23 percent below normal.

[17]Episodes were called "periods" by Vanarsdale and others (2005).

[18]High mercury deposition was called "enhanced mercury deposition" by Vanarsdale and others (2005).

[19] Episodes were called events by Keeler and others (2005) and Keeler and others (2006).

Table 9. Precipitation normals, 1971–2000, with annual precipitation and mercury deposition at five monitoring stations for mercury in precipitation in Indiana, January 2004–December 2005.

[NE, northeast; SE, southeast; CE, central; SC, south central; NW, northwest; in., inch; μg/m², microgram per square meter]

Precipitation and deposition information	Station name and Mercury Deposition Network identification number				
	Roush Lake (IN20)	Clifty Falls (IN21)	Fort Harrison (IN26)	Bloomington (IN28)	Indiana Dunes (IN34)
Climate division	NE	SE	CE	SC	NW
Precipitation normal, 1971–2000 (in.)[1]	37.2	45.0	41.0	46.8	38.6
Annual precipitation, 2004 (in.)	39.1	47.8	41.4	44.5	37.0
2004 precipitation as percent of normal	105.1	106.3	100.8	95.1	96.0
Relation of 2004 precipitation to precipitation normal	above	above	above	below	below
Annual precipitation in 2005 (in.)	33.4	41.2	45.4	48.1	25.9
2005 precipitation as percent of normal	89.8	91.6	110.6	102.8	67.2
Relation of 2005 precipitation to precipitation normal	below	below	above	above	below
2005 precipitation to 2004 precipitation (percentage)	85.4	86.2	109.7	108.1	70.0
Relation of 2005 precipitation to 2004 precipitation	lower	lower	higher	higher	lower
Annual mercury deposition, 2004 (μg/m²)	12.0	15.9	9.86	10.5	10.3
Annual mercury deposition, 2005 (μg/m²)	7.86	12.4	11.1	10.3	7.79
2005 deposition to 2004 deposition (percentage)	65.5	78.0	112.6	98.1	75.6
Relation of 2005 deposition to 2004 deposition	lower	lower	higher	lower	lower

[1] Midwestern Regional Climate Center, 2007.

Annual precipitation was higher in 2004 than 2005 at Roush Lake, Clifty Falls, and Indiana Dunes and the annual mercury deposition at these stations was higher in 2004 than 2005 (table 9). Precipitation was higher in 2005 than 2004 at Fort Harrison and Bloomington and annual mercury deposition was higher in 2005 than 2004 at Fort Harrison and similar for both years at Bloomington (table 9). These observations are consistent with the general relation of mercury deposition to precipitation (fig. 16).

Annual precipitation data, 2004–2005, from the 127 National Weather Service Cooperative Observer Program stations in Indiana with a record more than 75 percent complete, were made into color isopleth maps using GIS software with an inverse-distance weighting algorithm as described in the section Geographic Variability (fig. 24). Precipitation distribution in Indiana was not uniform statewide and differed noticeably between 2004 and 2005. In 2004, southern Indiana had the highest precipitation (more than 47.2 in.), while in 2005, central Indiana had the highest precipitation (more than 47.2 in.). In addition, a larger area of northern Indiana had the lowest precipitation (23.5 to 39.4 in.) in 2005, compared to 2004.

Factors Affecting Geographic and Temporal Variability of Mercury in Precipitation

Generally, geographic variability of mercury deposition in Indiana is most affected by precipitation amount, as shown earlier with correlation statistics and fig. 16 and the maps in figs. 19 and 20 compared with fig. 24. In contrast, temporal variability of mercury deposition is most affected by mercury concentration, as shown by the seasonal patterns in fig. 21 and the downward trends in statewide mercury deposition and mercury concentration, that are evident statistically and shown in figs. 22 and 23.

As discussed earlier, a potential explanation for some of the downward trends in mercury concentration and mercury deposition is a decrease in annual mercury emissions in Indiana. The following discussion examines information from this report about whether mercury concentrations and mercury deposition might be affected by changes in mercury emissions from nearby stationary sources.

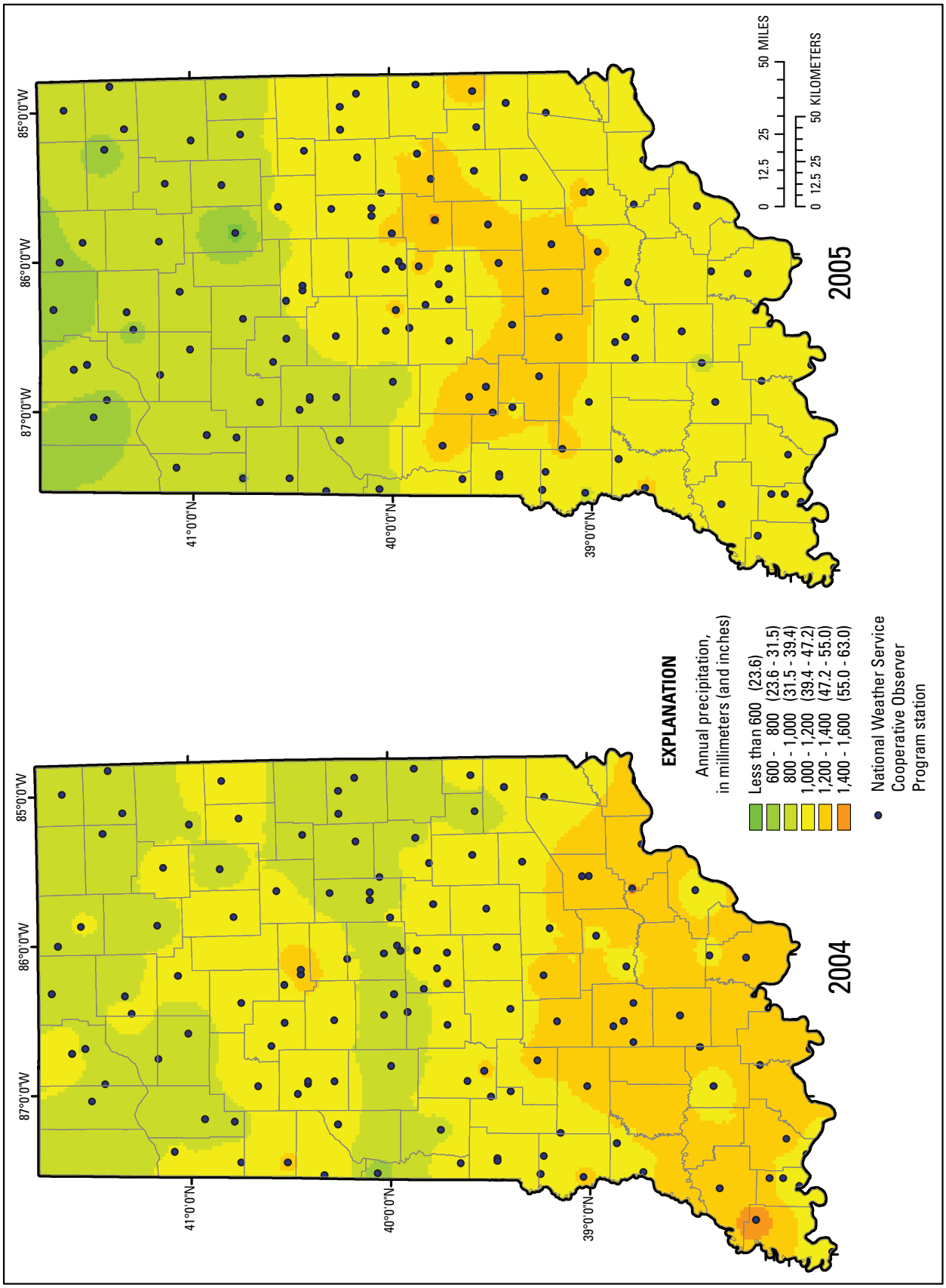


Figure 24. Isopleth maps of annual precipitation at 127 National Weather Service Cooperative Observer Program stations in Indiana, January 2004–December 2005.

The areas of the state that differed in the ranges of precipitation in 2004 and 2005 (fig. 24) had a corresponding difference in mercury deposition (figs. 19 and 20), with the exception of the area near Clifty Falls. As was discussed in the section Geographic Variability, weekly mercury concentrations at the Clifty Falls station were statistically higher than concentrations at the other stations. As was discussed in the section Episodes of High Mercury Deposition, the Clifty Falls station had more episodes of high mercury deposition than the other stations. As was discussed in the section Trends in Mercury Concentrations and Mercury Deposition, statistical trends in mercury concentration and mercury deposition were not observed for the Clifty Falls data. Therefore, the relation of mercury deposition to precipitation appears to be less dominant in the vicinity of the Clifty Falls station than the relation of mercury concentration to mercury deposition. The greater influence of mercury concentration on mercury deposition in the vicinity of Clifty Falls may be related to the estimated annual mercury emissions in Indiana and Kentucky within 31 mi of the monitoring station (1,789 lb, table 2) that are higher than those at the other four monitoring stations. Mercury concentrations at Clifty Falls also may be influenced by the estimated 804 lb annual mercury emissions from the other 32 stationary sources in the 7 adjacent counties along the Ohio River in southeastern Indiana (fig. 3) and mercury emissions in adjacent counties in Kentucky. When the statewide relation of mercury deposition, precipitation, and mercury emissions is examined in a map format (fig. 25), the influence of mercury emissions is demonstrated for the area near Clifty Falls monitoring station but not for the other four stations.

The absence of monitoring data for mercury concentrations in precipitation in other areas of Indiana that have substantial annual mercury emissions makes it difficult to assign a localized or a regional boundary to the area of high (greater than 14 µg/m2) mercury deposition near Clifty Falls. As an example of how monitoring data could help explain whether the high mercury deposition area near Clifty Falls is localized or part of a larger region of high mercury deposition in Indiana, data from southwest Indiana are considered. Southwest Indiana was in the same zone of similar annual precipitation as southeast Indiana in 2004 and 2005 (fig. 25). Estimated annual mercury emissions from stationary sources in southwest and southeast Indiana are similar. Based on the 2002 RAPIDS data for Indiana (explained in the section Sources of Mercury), 7 counties in southwest Indiana have 82 stationary sources of mercury emissions, including 10 electric power plants. Annual emissions in these seven counties total 2,334 lb and two of these counties had annual emissions of more than 500 lb. These mercury emissions in southwest Indiana, combined with mercury emissions from adjoining counties in Kentucky and Illinois, potentially could demonstrate a relation to mercury concentration (and mercury concentration to mercury deposition) that is similar to the one observed for Clifty Falls. Because there are no mercury monitoring data for southwest Indiana or nearby Kentucky or Illinois, maps that interpolate mercury deposition in southwest Indiana are based more on precipitation than on mercury concentration and do not show sizeable areas of high deposition. Therefore, the area of high deposition near Clifty Falls is mapped with a local boundary (fig. 25) because data are not available to extend a regional boundary into southwest Indiana.

The influence of local and regional sources on mercury in precipitation has been reported by other investigators in states not far from Indiana. Keeler and others (2006) applied two multivariate statistical models and meteorological analysis to monitoring data collected in 2003–2004 at a site in the Ohio River valley of eastern Ohio. They found the majority of the mercury wet deposition was contributed by coal combustion from local and regional sources. Lynch and others (2005) summarized data from eight NADP–MDN stations in Pennsylvania for 2003–2004 and observed a spatial correspondence of higher normalized annual mercury concentrations at stations in the western part of the state that had the most annual mercury emissions. They acknowledged that other factors, such as meteorological conditions or mercury sources outside the state, could have contributed to the high mercury concentrations in western Pennsylvania and that the high mercury concentrations could not be resolved without the use of source-receptor modeling. Cohen and others (2004) used a sophisticated source-receptor model and 1996 mercury emissions data to estimate mercury deposition to the Great Lakes. For Lake Michigan, as an example, they found that approximately half the deposition came from local sources within 100 km of the lake and that the largest contributor was coal combustion.

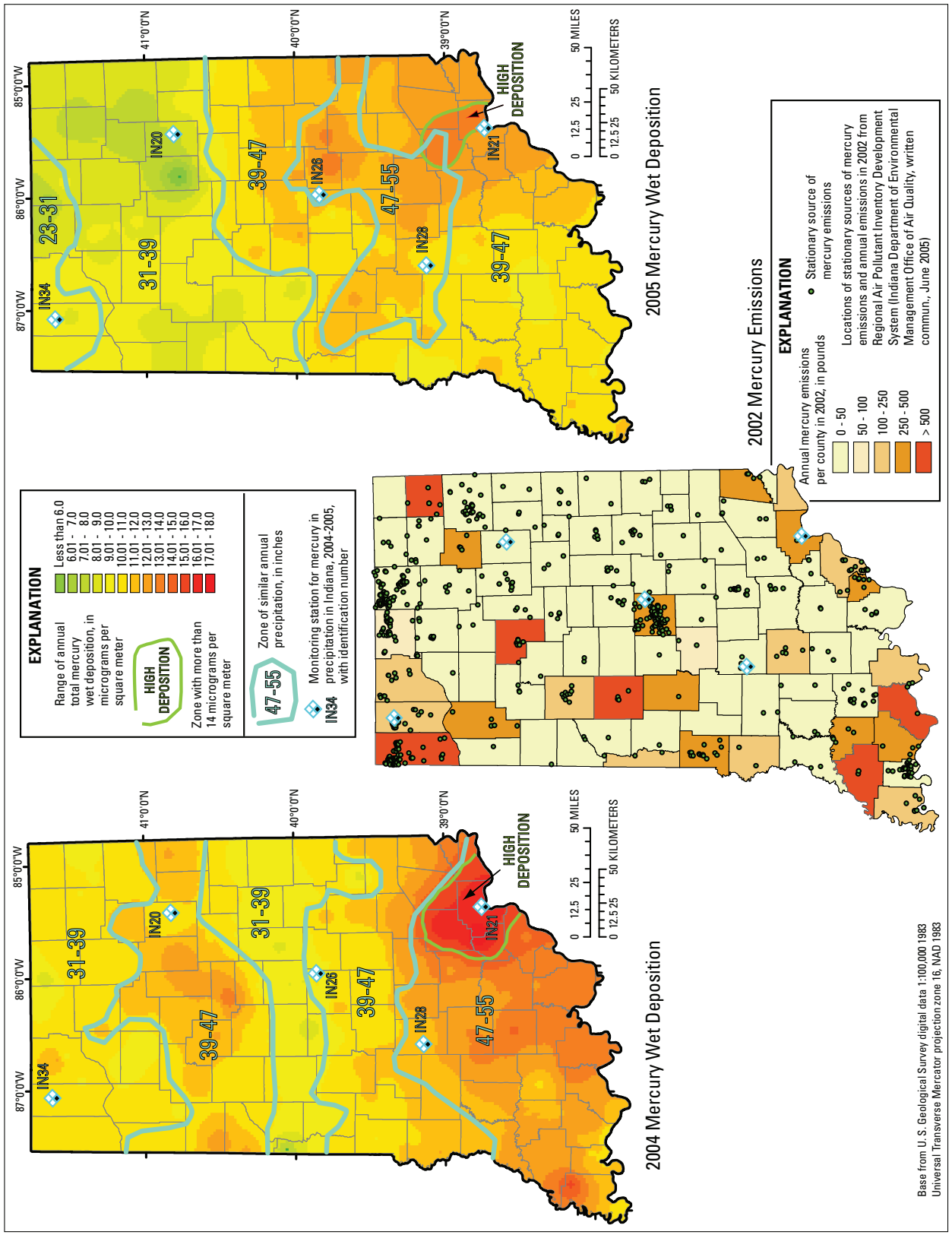


Figure 25. Isopleth maps of annual mercury deposition in Indiana, 2004 and 2005, showing annual precipitation and estimated annual mercury emissions per county.

Summary and Conclusions

Atmospheric mercury is transported to aquatic ecosystems by precipitation and dry deposition. Fish living in aquatic ecosystems with low concentrations of inorganic mercury can accumulate levels of methylmercury in their tissue that pose a health risk to humans and wildlife that eat these fish. Prior to 2001, few data were available that provided information about atmospheric deposition of mercury in Indiana. The U.S. Geological Survey, in cooperation with the Indiana Department of Environmental Management, operated a monitoring program for mercury in precipitation in Indiana during 2001–2005.

The monitoring program in Indiana was part of the National Atmospheric Deposition Program Mercury Deposition Network, which had 92 monitoring stations throughout North America by the end of 2005. The monitoring stations in Indiana were located at Roush Lake, Clifty Falls, Fort Harrison, Bloomington, and Indiana Dunes. Precipitation was measured and weekly samples were analyzed for total mercury by methods achieving detection limits as low as 0.05 ng/L (nanograms per liter). Mercury deposition was computed using the total mercury concentrations and the precipitation amounts.

During 2004–2005 in Indiana, 520 weekly samples were attempted and 448 weekly precipitation samples were collected for which mercury deposition was computed. The normalized mercury concentration in the weekly samples for the 2 years was 10.6 ng/L. As a reference, mercury concentrations exceeded the 12 ng/L Indiana statewide water-quality standard in 41 percent of the samples and exceeded the most conservative Indiana water-quality criterion of 1.3 ng/L in 99 percent of the samples. Weekly mercury concentrations at Clifty Falls were statistically higher than those at Roush Lake, Fort Harrison, and Bloomington. Among the NADP–MDN stations in eastern North America, the normalized annual mercury concentration at Clifty Falls was fourth highest in 2004 and ninth highest in 2005.

The 2-year mean weekly mercury deposition computed for 520 samples in Indiana, 2004–2005, including weeks with no precipitation, was 0.208 $\mu g/m^2$ (micrograms per square meter). Normalized deposition for Indiana in the 2 years was 0.267 $\mu g/m^2$ per inch of precipitation. Among the NADP–MDN stations in eastern North America, the annual mercury deposition at Clifty Falls and Indiana Dunes were in the top 25 percent in 2004 and 2005.

Twelve of the 448 weekly wet-deposition samples in Indiana recorded episodes of high mercury deposition that were at least 5 times the statewide mean annual mercury deposition. Each of these samples contributed at least 14 percent of the annual mercury deposition for a station. The top 10 percent of the weekly mercury deposition at the five monitoring stations contributed 39 percent of all mercury deposition measured at these stations, 2004–2005. Weekly samples with episodes of high mercury deposition are not unique to Indiana. Although weekly mercury deposition was not statistically different among the five monitoring stations, episodes of high mercury deposition may contribute to the differences in annual mercury deposition among the stations.

Mercury concentration and mercury deposition exhibited a seasonal pattern in which the median of weekly values grouped by month exceeded the 5-year statewide median during April through September. This seasonal pattern in mercury concentration and mercury deposition was shown to be statistically significant.

The Seasonal Kendall test was used to detect trends in precipitation, mercury concentration, and mercury deposition for the 5-year period, 2001–2005. The tests were made for data from each of the five monitoring stations and statewide, combining data from the five monitoring stations. A statistically significant trend was not shown for precipitation. Statistically significant trends were shown for a statewide decrease of 0.018 $\mu g/m^2$ per year in mercury deposition ($p = 0.007$) and a statewide decrease of 0.361 ng/L per year in mercury concentration ($p = 0.059$). Statistically significant trends were shown for a decrease in mercury deposition of 0.015 $\mu g/m^2$ per year at Roush Lake ($p = 0.061$) and 0.005 $\mu g/m^2$ per year at Bloomington ($p = 0.083$) and both potentially contributed to the statewide decrease. It is likely that the decrease in mercury deposition is related to the decrease in mercury concentration because a corresponding trend in precipitation was not observed. A potential explanation for some of the statewide decrease in mercury concentration (and the corresponding decrease in mercury deposition), 2001–2005, could be a 28 percent decrease in the annual emissions of mercury from stationary sources in Indiana between 2002 and 2005. Most of the change in the annual mercury emissions between 2002 and 2005 was noted in coal-fired power plants, electric arc furnaces and foundries, and cement and gypsum manufacturing.

Generally, geographic variability of mercury deposition in Indiana is affected mostly by precipitation amount. In contrast, temporal variability of mercury deposition is affected mostly by mercury concentration, evidenced by the corresponding seasonal patterns and 5-year trends.

Data for the Clifty Falls monitoring station might indicate that annual mercury emissions from stationary sources in the vicinity are affecting the geographic and temporal variability of mercury in precipitation in that part of Indiana. Weekly mercury concentrations at Clifty Falls were statistically higher than concentrations at three other Indiana stations. Clifty Falls had more episodes of highest mercury deposition than the other Indiana stations. Normalized annual mercury concentrations at Clifty Falls were among the top nine in the NADP–MDN in eastern North America in 2004–2005. Clifty Falls ranked highest in Indiana for normalized annual concentration and normalized annual deposition, 2001–2005. A statistically significant trend in mercury deposition was not shown for Clifty Falls, unlike two other Indiana stations. When the statewide relation of mercury deposition, precipitation, mercury concentration, and mercury emissions are examined in a map format, a potential influence of mercury concentra-

tion and mercury emissions is demonstrated for the area near Clifty Falls monitoring station but not for the other monitoring stations.

A factor that may explain these differences in mercury concentration and the resulting mercury deposition at Clifty Falls is that annual mercury emissions in the vicinity of Clifty Falls are higher than those for the other four Indiana stations. In addition, mercury from sources outside Indiana and meteorological conditions may help explain the high mercury deposition at Clifty Falls. The absence of monitoring data for mercury in precipitation in other areas of southern Indiana that have substantial annual mercury emissions makes it difficult to assign a localized or a regional boundary to the area of high mercury deposition near Clifty Falls.

The monitoring program for mercury in precipitation in Indiana, 2004–2005, provided data that, when combined with data from the previous 3 years, revealed a potential trend of decreasing statewide mercury deposition, along with an area of high mercury deposition that may be explained by mercury emissions in the vicinity. This report describes part of a continuous set of data that can be compared with future data from Indiana and with NADP–MDN data from other states. A long-term, consistent monitoring program for mercury in precipitation in Indiana has the capability of detecting further changes that may result from emission controls required by Federal and State rules after 2005.

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Appendixes 1–1 through 1–5

The data in appendixes 1-1 through 1-5 were downloaded from the National Atmospheric Deposition Program Mercury Deposition Network on-line archive on June 25, 2006, and the values are presented without adjustment to the same number of significant digits. The values listed in the appendixes were used for the interpretations and summaries in this report. Note that values for precipitation, concentration, and deposition were rounded to two decimals places before they were entered into the on-line archive. As stated in the Methods section, deposition is the product of precipitation and concentration. For some weekly data in these appendixes, the precipitation in millimeters multiplied by the concentration will not exactly equal the listed deposition. The reason for any discrepancy is that deposition values listed in the appendixes and the on-line archive were computed with values for precipitation and concentration that were precise to more than two decimal places and had not been rounded.

Mercury deposition in this report is given in microgram per square meter ($\mu g/m^2$), with the exception of the appendixes, where units are nanogram per square meter (ng/m^2), as in the on-line archive.

One microgram per square meter is equivalent to 1,000 nanograms per square meter.

One nanogram per square meter is equivalent to 0.001 microgram per square meter.

Nanogram per square meter in the appendixes can be converted to microgram per square meter by multiplying by 0.001.

Appendix 1-1. Weekly precipitation and total mercury at Roush Lake monitoring station near Huntington, Indiana, January 2004–December 2005.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
01/06/2004	39.88	1.57	481.2	W	mixed	1	A	6.20	247.56	No comment.
01/13/2004	0.00	0.00	0.0	D	dry	0	B	--	0.00	No comment.
01/20/2004	5.08	0.20	41.1	W	mixed	1	A	3.63	18.45	No comment.
01/27/2004	13.72	0.54	66.1	W	mixed	3	A	4.64	63.75	No comment.
02/03/2004	8.64	0.34	80.0	W	mixed	3	A	3.87	33.44	No comment.
02/10/2004	6.60	0.26	35.6	W	mixed	2	A	6.44	42.58	No comment.
02/17/2004	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	System blank.
02/24/2004	2.54	0.10	24.3	W	mixed	1	A	19.08	48.47	No comment.
03/02/2004	14.99	0.59	180.1	W	rain	2	A	5.09	76.30	No comment.
03/09/2004	20.83	0.82	255.7	W	mixed	3	A	5.94	123.88	No comment.
03/16/2004	3.81	0.15	25.0	W	mixed	1	A	8.40	32.02	No comment.
03/23/2004	8.89	0.35	78.0	W	mixed	4	A	9.64	85.74	No comment.
03/30/2004	18.29	0.72	250.1	W	rain	2	B	14.91	272.80	No comment.
04/06/2004	5.59	0.22	83.6	W	rain	1	A	14.50	81.07	No comment.
04/13/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
04/20/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
04/27/2004	20.57	0.81	277.1	W	rain	3	B	12.29	253.04	No comment.
05/04/2004	22.86	0.90	273.9	W	rain	1	B	8.97	205.21	No comment.
05/11/2004	15.24	0.60	181.2	W	rain	2	A	23.67	360.86	No comment.
05/18/2004	21.08	0.83	248.6	W	rain	2	A	10.57	222.90	No comment.
05/25/2004	49.78	1.96	594.3	W	rain	4	A	16.83	838.06	No comment.
06/01/2004	71.12	2.80	867.7	W	rain	1	B	7.89	561.20	No comment.
06/08/2004	2.54	0.10	33.2	W	rain	1	A	17.66	44.85	No comment.
06/15/2004	118.36	4.66	1,412.3	W	rain	3	B	14.43	1,708.82	No comment.
06/22/2004	19.81	0.78	217.9	W	rain	1	A	10.89	215.91	No comment.
06/29/2004	13.21	0.52	161.0	W	rain	2	A	13.40	177.01	No comment.
07/06/2004	16.26	0.64	189.2	W	rain	1	A	8.24	134.06	No comment.
07/13/2004	17.27	0.68	195.2	W	rain	2	A	11.42	197.26	No comment.

Appendix 1-1. Weekly precipitation and total mercury at Roush Lake monitoring station near Huntington, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
07/20/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
07/27/2004	78.5	3.09	994.2	W	rain	2	B	12.38	1,027.79	Bottle catch used for precipitation amount.
08/03/2004	18	0.71	258.4	W	rain	2	B	8.80	189.89	No comment.
08/10/2004	33.27	1.31	402.6	W	rain	1	A	12.77	425.14	No comment.
08/17/2004	0.25	0.01	(0.4)	D	dry	0	B	--	0.00	No comment.
08/24/2004	70.87	2.79	874.9	W	rain	3	B	14.53	1,029.68	No comment.
08/31/2004	80.52	3.17	979.1	W	rain	2	B	16.95	1,365.10	No comment.
09/07/2004	29.21	1.15	344.5	W	rain	2	B	6.81	199.00	No comment.
09/14/2004	0.00	0.00	0.0	D	dry	0	B	--	0.00	No comment.
09/21/2004	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	Field bottle blank.
09/28/2004	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	Field bottle blank.
10/05/2004	2.54	0.10	27.7	W	rain	2	A	14.31	36.37	No comment.
10/12/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
10/19/2004	30.99	1.22	380.3	W	rain	3	A	8.73	270.55	No comment.
10/26/2004	6.35	0.25	65.6	W	rain	1	A	8.63	54.81	No comment.
11/02/2004	28.96	1.14	354.4	W	rain	3	A	8.68	251.48	No comment.
11/09/2004	7.87	0.31	91.1	W	rain	1	A	7.09	55.82	No comment.
11/16/2004	4.57	0.18	53.5	W	mixed	1	B	17.89	81.82	No comment.
11/23/2004	17.78	0.70	201.9	W	rain	1	A	14.90	264.94	No comment.
11/30/2004	55.88	2.20	648.0	W	mixed	3	A	5.28	295.32	No comment.
12/07/2004	33.78	1.33	399.5	W	rain	2	B	8.77	296.36	No comment.
12/14/2004	30.48	1.20	332.2	W	mixed	3	B	2.29	69.86	No comment.
12/21/2004	1.52	0.06	3.8	W	mixed	2	B	3.20	4.88	No comment.
12/28/2004	21.59	0.85	104.6	W	snow	2	A	1.74	37.65	No comment.
01/04/2005	37.08	1.46	451.4	W	rain	2	A	5.20	192.80	No comment.
01/11/2005	53.34	2.10	561.9	W	mixed	3	A	3.47	185.30	No comment.
01/18/2005	50.80	2.00	662.2	W	mixed	3	A	6.12	310.95	No comment.
01/25/2005	17.02	0.67	118.9	W	snow	3	A	10.56	179.78	No comment.
02/01/2005	3.30	0.13	19.3	W	snow	1	A	3.00	9.92	No comment.

Appendix 1-1. Weekly precipitation and total mercury at Roush Lake monitoring station near Huntington, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
02/08/2005	15.24	0.60	165.5	W	rain	1	B	6.52	99.37	No comment.
02/15/2005	22.35	0.88	252.9	W	mixed	3	A	4.06	90.77	No comment.
02/22/2005	26.16	1.03	276.3	W	mixed	2	A	15.44	404.02	No comment.
03/01/2005	6.35	0.25	31.4	W	mixed	1	B	4.39	27.90	No comment.
03/08/2005	12.45	0.49	148.3	W	mixed	2	A	5.37	66.85	No comment.
03/15/2005	4.57	0.18	15.1	W	snow	1	A	6.04	27.62	No comment.
03/22/2005	8.38	0.33	96.2	W	rain	1	B	10.40	87.20	No comment.
03/29/2005	17.78	0.70	204.9	W	mixed	2	B	9.73	172.95	No comment.
04/05/2005	7.87	0.31	94.1	W	rain	2	B	13.84	109.04	No comment.
04/12/2005	4.06	0.16	47.7	W	rain	1	A	22.97	93.36	No comment.
04/19/2005	2.03	0.08	25.1	W	rain	1	A	40.66	72.30	No comment.
04/26/2005	43.69	1.72	523.7	W	rain	4	B	8.82	385.37	No comment.
05/03/2005	10.67	0.42	131.5	W	rain	6	B	6.86	73.25	No comment.
05/10/2005	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
05/17/2005	19.56	0.77	238.3	W	rain	3	B	8.46	165.57	No comment.
05/24/2005	11.43	0.45	147.4	W	rain	2	B	45.87	524.32	No comment.
05/31/2005	3.05	0.12	37.3	W	rain	2	A	30.61	93.30	No comment.
06/07/2005	14.48	0.57	171.5	W	rain	2	A	19.61	283.97	No comment.
06/14/2005	47.24	1.86	563.9	W	rain	2	B	11.91	563.00	No comment.
06/21/2005	0.00	0.00	0.0	D	QC	0	A	--	0.00	System blank.
06/28/2005	1.78	0.07	9.1	W	rain	1	B	99.90	177.62	No comment.
07/05/2005	20.32	0.80	257.1	W	rain	4	A	12.50	254.00	No comment.
07/12/2005	1.02	0.04	12.3	W	rain	2	A	38.90	39.87	Bottle catch used for precipitation amount.
07/19/2005	44.45	1.75	558.3	W	rain	4	B	10.50	466.72	No comment.
07/26/2005	5.33	0.21	65.0	W	rain	2	A	18.40	98.14	No comment.
08/02/2005	41.91	1.65	505.6	W	rain	1	A	9.70	406.52	No comment.
08/09/2005	4.83	0.19	53.6	W	rain	1	A	12.10	58.39	No comment.
08/16/2005	32.77	1.29	419.9	W	rain	3	B	12.70	416.12	No comment.
08/23/2005	1.02	0.04	11.5	W	rain	2	A	19.60	19.91	No comment.

Appendix 1-1. Weekly precipitation and total mercury at Roush Lake monitoring station near Huntington, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
08/30/2005	0.76	0.03	3.9	W	rain	2	B	24.70	18.82	No comment.
09/06/2005	9.40	0.37	102.9	W	rain	1	A	6.30	59.20	No comment.
09/13/2005	0.00	0.00	(1.2)	D	dry	0	B	--	0.00	No comment.
09/20/2005	24.64	0.97	296.2	W	rain	3	A	14.50	357.25	No comment.
09/27/2005	57.66	2.27	698.0	W	rain	4	B	8.00	461.26	No comment.
10/04/2005	17.27	0.68	210.0	W	rain	1	A	1.90	32.81	No comment.
10/11/2005	0.51	0.02	0.0	T	trace rain	0	C	--	0.00	No comment.
10/18/2005	0.76	0.03	7.9	W	rain	2	B	21.71	16.54	No comment.
10/25/2005	20.83	0.82	234.9	W	rain	3	A	6.87	143.13	No comment.
11/01/2005	7.62	0.30	91.1	W	rain	1	A	7.11	54.20	No comment.
11/08/2005	6.60	0.26	81.8	W	rain	2	A	14.64	96.70	No comment.
11/15/2005	13.72	0.54	160.5	W	rain	4	A	10.16	139.46	No comment.
11/22/2005	28.45	1.12	340.9	W	rain	1	A	3.52	100.16	No comment.
11/29/2005	16.26	0.64	158.7	W	mixed	3	A	7.17	116.60	No comment.
12/06/2005	5.84	0.23	44.6	W	mixed	2	A	4.41	25.79	No comment.
12/13/2005	15.75	0.62	118.0	W	snow	2	A	1.88	29.60	No comment.
12/20/2005	5.84	0.23	39.3	W	snow	3	A	6.45	37.69	No comment.
12/27/2005	22.86	0.90	249.5	W	mixed	1	A	1.84	42.15	No comment.

[1]Data-quality rating codes for each sample were assigned by the NADP-MDN laboratory:
A—no field or laboratory problems, data quality acceptable for summary statistics;
B—minor field or laboratory problems, data quality acceptable for summary statistics;
C—field or laboratory problems, data quality suspect.

Appendix 1-2. Weekly precipitation and total mercury, at Clifty Falls monitoring station near Madison, Indiana, January 2004–December 2005.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
01/06/2004	83.82	3.30	1,037.9	W	mixed	2	B	12.71	1,066.10	No comment.
01/13/2004	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	Field bottle blank.
01/20/2004	14.48	0.57	186.4	W	rain	1	B	4.52	65.52	No comment.
01/27/2004	18.80	0.74	165.1	W	mixed	2	B	15.66	294.49	No comment.
02/03/2004	23.88	0.94	275.3	W	mixed	2	A	7.49	178.83	No comment.
02/10/2004	16.00	0.63	184.2	W	mixed	1	A	6.09	97.46	No comment.
02/17/2004	0.00	0.00	0.0	D	QC	0	A	--	0.00	Field bottle blank.
02/24/2004	0.51	0.02	6.1	W	rain	1	B	19.65	9.98	No comment.
03/02/2004	7.37	0.29	101.4	W	rain	1	B	21.57	158.95	No comment.
03/09/2004	27.69	1.09	383.7	W	rain	2	B	11.03	305.37	No comment.
03/16/2004	17.78	0.70	213.0	W	mixed	1	A	18.01	320.28	No comment.
03/23/2004	1.27	0.05	20.4	W	rain	1	A	37.67	47.85	No comment.
03/30/2004	8.89	0.35	112.9	W	rain	2	A	15.00	133.36	No comment.
04/06/2004	4.57	0.18	62.8	W	rain	1	A	2.75	12.61	No comment.
04/14/2004	48.77	1.92	578.5	W	rain	2	B	35.72	1,742.04	No comment.
04/20/2004	2.03	0.08	27.7	W	rain	1	A	27.64	56.16	No comment.
04/27/2004	48.26	1.90	623.6	W	rain	3	B	22.16	1,069.68	No comment.
05/04/2004	75.44	2.97	907.5	W	rain	2	B	7.35	554.62	No comment.
05/11/2004	1.02	0.04	12.9	W	rain	1	A	10.58	10.75	No comment.
05/18/2004	25.40	1.00	0.0	W	rain	2	C	[16.0]	406.70	Estimated deposition with rain gage precipitation.
05/25/2004	3.81	0.15	45.4	W	rain	1	B	14.52	55.33	No comment.
06/01/2004	121.41	4.78	1,453.6	W	rain	2	B	13.65	1,657.88	No comment.
06/08/2004	0.76	0.03	15.7	W	rain	1	A	14.05	10.71	No comment.
06/15/2004	43.69	1.72	522.3	W	rain	3	B	10.49	458.63	No comment.
06/22/2004	7.62	0.30	97.0	W	rain	3	B	10.25	78.13	No comment.
06/29/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
07/06/2004	7.87	0.31	923.4	W	rain	1	A	30.11	237.10	No comment.
07/13/2004	14.22	0.56	180.2	W	rain	2	B	20.85	296.58	No comment.
07/20/2004	14.22	0.56	179.4	W	rain	2	B	35.24	501.31	No comment.

Appendix 1-2. Weekly precipitation and total mercury, at Clifty Falls monitoring station near Madison, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
07/27/2004	6.60	0.26	89.3	W	rain	1	A	21.34	140.96	No comment.
08/03/2004	62.74	2.47	811.1	W	rain	1	A	8.50	533.52	No comment.
08/10/2004	15.24	0.60	181.5	W	rain	1	A	23.83	363.20	No comment.
08/17/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
08/24/2004	24.13	0.95	288.4	W	rain	1	A	6.85	165.29	No comment.
08/31/2004	37.34	1.47	464.3	W	rain	3	B	21.94	819.34	No comment.
09/07/2004	13.97	0.55	167.4	W	rain	1	A	9.45	132.04	No comment.
09/14/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
09/21/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
09/28/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
10/05/2004	0.51	0.02	13.7	W	rain	1	A	30.19	15.34	No comment.
10/12/2004	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	System blank.
10/19/2004	142.49	5.61	1,725.4	W	rain	2	A	9.52	1,357.82	No comment.
10/26/2004	13.97	0.55	174.6	W	rain	2	B	20.78	290.40	No comment.
11/02/2004	60.71	2.39	765.0	W	rain	3	A	11.75	713.66	No comment.
11/09/2004	4.83	0.19	44.2	W	rain	1	B	6.88	33.23	No comment.
11/16/2004	60.96	2.40	721.8	W	rain	1	A	2.75	167.82	No comment.
11/23/2004	37.85	1.49	466.4	W	rain	2	A	14.64	554.06	No comment.
11/30/2004	18.03	0.71	228.9	W	rain	2	B	14.56	262.70	No comment.
12/07/2004	22.86	0.90	254.2	W	rain	3	A	13.51	308.88	No comment.
12/14/2004	8.89	0.35	120.6	W	mixed	2	B	16.78	149.17	No comment.
12/21/2004	0.00	0.00	(1.9)	T	trace snow	0	B	--	0.00	No comment.
12/28/2004	43.18	1.70	166.9	W	snow	2	B	1.49	64.55	No comment.
01/04/2005	48.26	1.90	574.9	W	rain	1	A	4.58	221.03	No comment.
01/11/2005	83.82	3.30	1,037.5	W	rain	3	B	20.11	1,685.20	No comment.
01/18/2005	24.13	0.95	320.2	W	rain	3	A	4.57	110.37	No comment.
01/25/2005	2.54	0.10	28.3	W	mixed	2	A	16.09	40.88	No comment.
02/01/2005	5.08	0.20	63.7	W	snow	1	A	1.20	6.07	No comment.
02/08/2005	24.13	0.95	300.2	W	mixed	2	B	8.31	200.42	No comment.

Appendix 1-2. Weekly precipitation and total mercury, at Clifty Falls monitoring station near Madison, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
02/15/2005	13.97	0.55	166.3	W	mixed	2	A	17.83	249.11	No comment.
02/22/2005	3.81	0.15	44.2	W	rain	1	A	18.08	68.89	No comment.
03/01/2005	10.16	0.40	135.3	W	mixed	2	B	7.40	75.19	No comment.
03/08/2005	14.22	0.56	191.7	W	rain	1	B	8.58	121.97	No comment.
03/15/2005	2.54	0.10	27.0	W	snow	1	A	2.27	5.77	No comment.
03/22/2005	1.27	0.05	19.9	W	rain	1	A	20.05	25.47	No comment.
03/29/2005	78.74	3.10	936.1	W	rain	3	B	7.85	617.79	No comment.
04/05/2005	5.59	0.22	64.8	W	rain	2	A	10.11	56.54	No comment.
04/12/2005	9.65	0.38	118.3	W	rain	3	A	13.05	126.03	No comment.
04/19/2005	17.78	0.70	217.0	W	rain	1	A	17.62	313.44	No comment.
04/26/2005	20.57	0.81	277.1	W	rain	3	B	10.60	218.14	No comment.
05/03/2005	17.78	0.70	224.1	W	rain	3	B	8.24	146.52	No comment.
05/10/2005	3.30	0.13	39.5	W	rain	1	A	10.99	36.28	No comment.
05/17/2005	24.13	0.95	302.0	W	rain	2	B	11.38	274.62	No comment.
05/24/2005	46.99	1.85	596.3	W	rain	2	B	9.88	464.30	No comment.
05/31/2005	7.11	0.28	82.0	W	rain	1	B	10.86	77.25	No comment.
06/07/2005	3.81	0.15	57.6	W	rain	1	B	16.15	61.55	No comment.
06/14/2005	16.26	0.64	196.6	W	rain	4	B	15.36	249.77	No comment.
06/21/2005	13.97	0.55	176.0	W	rain	1	B	11.45	160.05	No comment.
06/28/2005	1.27	0.05	5.3	W	rain	1	B	103.19	131.05	No comment.
07/05/2005	7.62	0.30	86.1	W	rain	2	B	19.80	150.87	No comment.
07/12/2005	12.70	0.50	143.4	W	rain	1	B	6.00	76.20	No comment.
07/19/2005	17.78	0.70	177.9	W	rain	2	B	29.70	528.06	No comment.
07/26/2005	18.29	0.72	213.2	W	rain	1	B	13.60	248.71	No comment.
08/02/2005	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
08/09/2005	7.62	0.30	92.4	W	rain	1	B	16.90	128.77	No comment.
08/16/2005	54.10	2.13	653.2	W	rain	4	B	14.80	800.71	No comment.
08/23/2005	56.39	2.22	716.3	W	rain	3	B	13.30	751.45	Bottle catch used for precipitation amount.
08/29/2005	16.51	0.65	195.6	W	rain	1	A	11.30	186.56	No comment.

Appendix 1-2. Weekly precipitation and total mercury, at Clifty Falls monitoring station near Madison, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
09/06/2005	72.39	2.85	872.4	W	rain	1	A	4.50	325.75	Hurricane Katrina sample, 08/29–08/31.
09/13/2005	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	System blank.
09/20/2005	24.38	0.96	311.1	W	rain	4	B	14.60	356.00	No comment.
09/27/2005	54.10	2.13	599.8	W	rain	2	B	21.30	1,152.37	No comment.
10/04/2005	7.11	0.28	0.0	W	rain	1	C	[9.63]	68.47	Estimated deposition with rain gage precipitation.
10/11/2005	2.54	0.10	27.8	W	rain	3	B	9.81	24.93	No comment.
10/18/2005	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
10/25/2005	35.56	1.40	(158.6)	W	rain	3	C	[9.63]	342.44	Estimated deposition with rain gage precipitation.
11/01/2005	5.08	0.20	58.0	W	rain	1	A	11.11	56.47	No comment.
11/07/2005	3.81	0.15	41.7	W	rain	1	A	19.96	76.06	No comment.
11/15/2005	71.88	2.83	882.9	W	rain	2	A	10.52	756.27	No comment.
11/22/2005	10.16	0.40	125.0	W	mixed	2	A	2.74	27.86	No comment.
11/29/2005	31.75	1.25	(19.7)	W	mixed	3	C	[9.63]	305.75	Estimated deposition with rain gage precipitation.
12/06/2005	1.52	0.06	26.6	W	mixed	1	A	12.27	18.70	No comment.
12/13/2005	11.43	0.45	137.8	W	mixed	2	A	4.58	52.42	No comment.
12/20/2005	13.97	0.55	182.2	W	mixed	1	A	6.67	93.22	No comment.
12/27/2005	10.16	0.40	110.9	W	rain	1	A	16.06	163.22	No comment.

[1]Data-quality rating codes for each sample were assigned by the NADP-MDN laboratory:
A—no field or laboratory problems, data quality acceptable for summary statistics;
B—minor field or laboratory problems, data quality acceptable for summary statistics;
C—field or laboratory problems, data quality suspect.

Appendix 1-3. Weekly precipitation and total mercury at Fort Harrison monitoring station near Indianapolis, Indiana, January 2004–December 2005.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
01/06/2004	73.41	2.89	924.5	W	rain	2	B	7.11	522.50	No comment.
01/13/2004	0.25	0.01	(2.3)	T	trace snow	0	B	--	0.00	No comment.
01/20/2004	14.22	0.56	167.2	W	rain	1	A	7.17	102.00	No comment.
01/27/2004	7.62	0.30	63.1	W	mixed	2	A	11.47	87.44	No comment.
02/03/2004	7.37	0.29	95.8	W	mixed	2	A	3.76	27.76	No comment.
02/10/2004	7.11	0.28	93.6	W	mixed	1	A	3.82	27.18	No comment.
02/17/2004	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	Field bottle blank.
02/24/2004	4.57	0.18	57.1	W	rain	1	A	13.64	62.39	No comment.
03/02/2004	15.24	0.60	188.9	W	rain	1	A	5.63	85.87	No comment.
03/09/2004	14.73	0.58	188.2	W	rain	1	A	7.87	116.04	No comment.
03/16/2004	7.37	0.29	84.2	W	mixed	2	A	8.64	63.68	No comment.
03/23/2004	4.32	0.17	57.9	W	mixed	2	A	17.94	77.48	No comment.
03/30/2004	36.58	1.44	451.1	W	rain	3	A	8.44	309.03	No comment.
04/06/2004	22.61	0.89	307.6	W	rain	1	A	3.84	86.85	No comment.
04/13/2004	1.27	0.05	10.3	W	rain	1	A	31.63	40.17	No comment.
04/20/2004	6.60	0.26	86.6	W	rain	1	B	13.06	86.28	No comment.
04/27/2004	27.18	1.07	344.8	W	rain	3	A	6.20	168.72	No comment.
05/04/2004	14.99	0.59	182.2	W	rain	2	A	8.06	120.80	No comment.
05/11/2004	0.76	0.03	(0.6)	T	trace rain	0	C	--	0.00	No comment.
05/18/2004	44.70	1.76	535.5	W	rain	2	A	5.96	266.57	No comment.
05/25/2004	39.37	1.55	515.8	W	rain	3	A	14.36	565.51	No comment.
06/01/2004	62.23	2.45	804.8	W	rain	3	A	11.98	745.51	No comment.
06/08/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
06/15/2004	74.68	2.94	925.3	W	rain	3	B	10.92	815.68	No comment.
06/22/2004	80.26	3.16	1,072.1	W	rain	2	A	6.41	514.49	No comment.
06/29/2004	0.76	0.03	7.4	W	rain	1	B	31.15	23.74	No comment.
07/06/2004	35.81	1.41	1,216.4	W	rain	1	A	7.58	271.79	No comment.
07/13/2004	39.62	1.56	462.7	W	rain	2	A	10.87	430.91	No comment.
07/20/2004	2.54	0.10	32.5	W	rain	1	A	44.34	112.62	No comment.

Appendix 1-3. Weekly precipitation and total mercury at Fort Harrison monitoring station near Indianapolis, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
07/27/2004	38.10	1.50	432.0	W	rain	2	B	17.51	667.39	No comment.
08/03/2004	7.11	0.28	79.3	W	rain	1	A	15.70	111.67	No comment.
08/09/2004	9.91	0.39	122.5	W	rain	1	A	29.07	288.02	No comment.
08/17/2004	0.25	0.01	0.0	T	trace rain	0	C	--	0.00	No comment.
08/23/2004	28.70	1.13	354.8	W	rain	1	A	11.07	317.78	No comment.
08/31/2004	53.85	2.12	639.2	W	rain	3	A	12.38	666.69	No comment.
09/07/2004	13.46	0.53	144.1	W	rain	2	B	17.38	234.05	No comment.
09/14/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
09/21/2004	3.05	0.12	67.0	W	rain	1	A	14.00	42.68	No comment.
09/28/2004	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	System blank.
10/05/2004	1.52	0.06	9.3	W	rain	1	B	25.21	38.42	No comment.
10/12/2004	0.51	0.02	0.0	T	trace rain	0	C	--	0.00	No comment.
10/19/2004	51.82	2.04	655.0	W	rain	2	B	10.97	568.73	No comment.
10/26/2004	23.62	0.93	293.4	W	rain	1	B	5.61	132.68	No comment.
11/02/2004	39.62	1.56	489.7	W	rain	3	A	6.74	267.26	No comment.
11/09/2004	5.33	0.21	64.5	W	rain	2	A	6.45	34.43	No comment.
11/16/2004	18.54	0.73	229.6	W	rain	2	A	6.63	122.98	No comment.
11/23/2004	10.41	0.41	127.8	W	rain	2	A	11.37	118.47	Rain gage calibration check performed.
11/30/2004	49.53	1.95	609.1	W	mixed	3	A	6.55	324.86	No comment.
12/07/2004	28.45	1.12	352.5	W	mixed	2	B	4.46	127.10	No comment.
12/14/2004	6.35	0.25	72.4	W	mixed	2	A	4.55	28.89	No comment.
12/21/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
12/28/2004	13.97	0.55	58.2	W	snow	2	A	3.00	41.93	No comment.
01/04/2005	80.52	3.17	1,045.1	W	rain	3	A	6.66	536.25	No comment.
01/11/2005	77.98	3.07	1,297.3	W	rain	3	A	4.74	369.77	No comment.
01/18/2005	51.56	2.03	640.9	W	mixed	3	A	6.06	312.62	No comment.
01/25/2005	6.35	0.25	41.8	W	snow	2	B	8.25	52.38	No comment.
02/01/2005	3.56	0.14	33.3	W	snow	1	B	3.49	12.43	No comment.
02/08/2005	14.22	0.56	167.8	W	rain	1	A	5.20	74.01	No comment.

Appendix 1-3. Weekly precipitation and total mercury at Fort Harrison monitoring station near Indianapolis, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
02/15/2005	24.89	0.98	287.0	W	mixed	2	B	10.22	254.40	No comment.
02/22/2005	12.95	0.51	164.4	W	mixed	2	A	17.16	222.25	No comment.
03/01/2005	5.08	0.20	58.9	W	mixed	2	A	5.73	29.11	No comment.
03/08/2005	0.25	0.01	2.0	W	rain	2	B	61.36	15.59	No comment.
03/14/2005	1.78	0.07	10.0	W	snow	1	B	6.43	11.43	No comment.
03/22/2005	2.54	0.10	36.9	W	rain	1	A	19.81	50.31	No comment.
03/30/2005	23.37	0.92	294.2	W	rain	4	A	14.94	349.05	No comment.
04/05/2005	7.87	0.31	95.1	W	rain	2	A	13.43	105.81	No comment.
04/12/2005	6.10	0.24	91.1	W	rain	3	B	28.76	175.35	No comment.
04/19/2005	1.52	0.06	21.8	W	rain	1	A	23.67	36.08	No comment.
04/26/2005	81.03	3.19	989.5	W	rain	3	B	8.11	657.36	No comment.
05/03/2005	5.33	0.21	51.3	W	rain	5	A	12.80	68.31	No comment.
05/10/2005	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	Field bottle blank.
05/17/2005	49.28	1.94	603.3	W	rain	2	B	13.79	679.71	No comment.
05/24/2005	17.78	0.70	222.3	W	rain	2	B	20.84	370.64	No comment.
05/31/2005	3.81	0.15	42.2	W	rain	3	A	17.49	66.65	No comment.
06/07/2005	2.03	0.08	19.5	W	rain	2	A	19.90	40.44	No comment.
06/13/2005	55.88	2.20	674.7	W	rain	3	A	9.65	539.35	No comment.
06/21/2005	5.08	0.20	60.5	W	rain	2	A	13.86	70.41	No comment.
06/28/2005	0.00	0.00	0.0	D	dry	0	B	--	0.00	No comment.
07/05/2005	59.18	2.33	723.1	W	rain	2	B	14.30	846.30	No comment.
07/11/2005	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
07/18/2005	68.83	2.71	851.7	W	rain	4	B	10.00	688.34	No comment.
07/26/2005	94.49	3.72	1141.1	W	rain	3	B	17.00	1,606.29	No comment.
08/02/2005	11.68	0.46	(168.8)	W	rain	1	C	[11.48]	134.09	Estimated deposition with rain gage precipitation.
08/09/2005	4.32	0.17	57.5	W	rain	1	A	6.80	29.36	No comment.
08/16/2005	8.13	0.32	85.9	W	rain	5	A	12.50	101.60	No comment.
08/23/2005	2.54	0.10	42.1	W	rain	1	A	25.40	64.51	No comment.
08/30/2005	4.06	0.16	61.8	W	rain	2	A	15.20	61.77	No comment.

Appendix 1-3. Weekly precipitation and total mercury at Fort Harrison monitoring station near Indianapolis, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
09/06/2005	52.58	2.07	662.2	W	rain	1	B	4.40	231.34	Hurricane Katrina sample, 08/30–08/31.
09/13/2005	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	System blank.
09/20/2005	57.40	2.26	695.1	W	rain	4	B	14.90	855.32	No comment.
09/27/2005	61.47	2.42	805.2	W	rain	2	B	4.80	295.04	No comment.
10/04/2005	9.40	0.37	97.4	W	rain	1	A	4.47	42.05	No comment.
10/11/2005	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
10/18/2005	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	Field bottle blank.
10/26/2005	41.66	1.64	523.5	W	rain	3	B	7.01	292.09	No comment.
11/01/2005	8.38	0.33	89.3	W	rain	2	B	7.78	65.25	No comment.
11/07/2005	14.99	0.59	172.5	W	rain	1	A	17.08	256.00	No comment.
11/15/2005	23.11	0.91	274.5	W	rain	3	A	7.29	168.70	No comment.
11/22/2005	24.64	0.97	295.2	W	rain	1	A	5.26	129.64	No comment.
11/28/2005	5.33	0.21	57.3	W	mixed	3	B	11.76	62.74	No comment.
12/07/2005	10.67	0.42	143.6	W	mixed	4	B	7.23	77.17	No comment.
12/12/2005	12.19	0.48	64.8	W	mixed	3	A	2.71	33.07	No comment.
12/20/2005	5.33	0.21	55.4	W	mixed	2	A	6.40	34.14	No comment.
12/27/2005	33.27	1.31	396.1	W	mixed	1	A	1.70	56.73	No comment.

[1]Data-quality rating codes for each sample were assigned by the NADP-MDN laboratory:
A—no field or laboratory problems, data quality acceptable for summary statistics;
B—minor field or laboratory problems, data quality acceptable for summary statistics;
C—field or laboratory problems, data quality suspect.

Appendix 1-4. Weekly precipitation and total mercury at Bloomington monitoring station near Bloomington, Indiana, January 2004–December 2005.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
01/06/2004	107.95	4.25	1,099.9	W	rain	3	A	5.03	543.42	No comment.
01/13/2004	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	Field bottle blank.
01/20/2004	17.78	0.70	181.6	W	rain	1	A	1.83	32.57	No comment.
01/27/2004	17.78	0.70	22.9	W	mixed	2	A	4.69	83.54	No comment.
02/03/2004	11.68	0.46	18.1	W	mixed	1	A	3.82	44.63	No comment.
02/10/2004	6.86	0.27	79.3	W	mixed	1	A	2.44	16.75	No comment.
02/17/2004	0.00	0.00	0.0	D	dry	0	B	--	0.00	No comment.
02/24/2004	2.29	0.09	18.0	W	rain	1	A	11.63	26.60	No comment.
03/02/2004	9.40	0.37	127.0	W	rain	1	B	3.86	36.31	No comment.
03/09/2004	13.08	0.51	92.8	W	rain	2	A	14.12	184.79	No comment.
03/16/2004	9.53	0.38	0.0	W	mixed	1	C	[5.33]	50.76	Estimated deposition with rain gage precipitation.
03/23/2004	1.02	0.04	15.3	W	mixed	1	A	20.55	20.88	No comment.
03/30/2004	28.96	1.14	386.1	W	rain	3	B	5.99	173.44	No comment.
04/06/2004	12.95	0.51	193.1	W	rain	1	A	1.36	17.65	No comment.
04/13/2004	2.79	0.11	38.2	W	rain	1	A	30.33	84.75	No comment.
04/20/2004	6.10	0.24	71.0	W	rain	1	A	17.21	104.93	No comment.
04/27/2004	15.75	0.62	193.6	W	rain	2	A	13.69	215.62	No comment.
05/04/2004	24.38	0.96	306.6	W	rain	1	A	6.11	149.05	No comment.
05/11/2004	3.30	0.13	46.0	W	rain	1	A	13.83	45.69	No comment.
05/19/2004	65.53	2.58	849.7	W	rain	4	A	10.50	688.15	No comment.
05/25/2004	4.83	0.19	58.1	W	rain	1	B	25.05	120.90	No comment.
06/01/2004	90.68	3.57	1,147.4	W	rain	2	B	14.32	1,298.69	No comment.
06/07/2004	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	Field bottle blank.
06/15/2004	5.84	0.23	89.2	W	rain	1	B	21.70	126.78	No comment.
06/22/2004	102.36	4.03	1,249.2	W	rain	3	A	7.58	776.62	No comment.
06/29/2004	0.25	0.01	0.0	T	trace rain	0	C	--	0.00	No event record.
07/06/2004	51.05	2.01	615.4	W	rain	1	A	12.79	653.28	No comment.
07/13/2004	83.31	3.28	1,799.4	W	rain	2	B	12.07	1,005.65	No comment.
07/19/2004	14.73	0.58	126.2	W	rain	1	A	19.95	293.91	No comment.

Appendix 1-4. Weekly precipitation and total mercury at Bloomington monitoring station near Bloomington, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
07/27/2004	16.00	0.63	212.9	W	rain	2	A	19.92	318.84	No comment.
08/03/2004	30.73	1.21	378.0	W	rain	1	A	10.93	336.10	No comment.
08/10/2004	0.76	0.03	12.3	W	rain	1	A	24.73	18.85	No comment.
08/17/2004	0.25	0.01	0.0	T	trace rain	0	C	--	0.00	No comment.
08/24/2004	46.48	1.83	1,359.8	W	rain	1	A	9.24	429.86	No comment.
08/30/2004	58.42	2.30	783.6	W	rain	2	A	13.48	788.02	No comment.
09/07/2004	0.76	0.03	0.0	T	trace rain	0	C	--	0.00	No comment.
09/14/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
09/21/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
09/28/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
10/05/2004	1.02	0.04	8.4	W	rain	1	B	29.45	29.92	No comment.
10/12/2004	0.00	0.00	(2.4)	T	trace rain	0	B	--	0.00	No comment.
10/19/2004	88.14	3.47	1,060.3	W	rain	3	A	9.42	830.96	No comment.
10/26/2004	22.61	0.89	290.4	W	rain	1	A	5.49	124.17	No comment.
11/02/2004	48.51	1.91	607.9	W	rain	3	B	5.54	268.86	No comment.
11/09/2004	0.25	0.01	7.3	W	rain	1	B	9.64	2.44	No comment.
11/16/2004	19.56	0.77	255.1	W	rain	2	A	2.37	46.39	No comment.
11/23/2004	14.22	0.56	178.4	W	rain	2	A	8.33	118.60	No comment.
11/30/2004	28.19	1.11	322.1	W	mixed	3	B	5.22	147.28	No comment.
12/07/2004	29.97	1.18	384.6	W	mixed	3	B	4.97	149.20	No comment.
12/14/2004	6.60	0.26	81.0	W	rain	2	A	5.52	36.47	No comment.
12/21/2004	0.00	0.00	0.0	D	dry	0	B	--	0.00	No comment.
12/28/2004	7.87	0.31	21.8	W	snow	1	A	1.40	11.03	No comment.
01/04/2005	55.88	2.20	653.0	W	rain	4	A	5.00	279.50	No comment.
01/11/2005	113.28	4.46	1,413.1	W	mixed	3	B	4.64	525.19	No comment.
01/18/2005	37.59	1.48	412.8	W	rain	2	A	4.97	186.91	No comment.
01/25/2005	1.52	0.06	6.9	W	snow	2	B	18.89	28.80	No comment.
02/01/2005	3.81	0.15	24.2	W	snow	1	A	2.96	11.27	No comment.
02/08/2005	13.72	0.54	163.5	W	mixed	3	A	4.74	65.06	No comment.

Appendix 1-4. Weekly precipitation and total mercury at Bloomington monitoring station near Bloomington, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
02/15/2005	31.24	1.23	358.6	W	mixed	2	B	7.05	220.35	No comment.
02/22/2005	9.40	0.37	102.7	W	rain	2	B	20.70	194.52	No comment.
03/01/2005	7.11	0.28	79.7	W	mixed	2	B	11.38	80.91	No comment.
03/08/2005	0.00	0.00	(2.9)	T	trace mixed	0	B	--	0.00	No comment.
03/14/2005	1.02	0.04	15.3	W	snow	3	B	8.68	8.81	No comment.
03/22/2005	0.25	0.01	6.1	W	rain	1	B	27.21	6.91	No comment.
03/30/2005	42.67	1.68	570.8	W	rain	3	B	12.77	544.79	No comment.
04/06/2005	10.16	0.40	138.6	W	rain	2	B	11.08	112.61	No comment.
04/12/2005	10.16	0.40	146.9	W	rain	2	A	14.65	148.92	No comment.
04/19/2005	25.65	1.01	343.5	W	rain	1	A	6.44	165.34	No comment.
04/26/2005	26.16	1.03	345.5	W	rain	3	B	8.43	220.59	No comment.
05/03/2005	7.37	0.29	108.2	W	rain	3	A	9.24	68.06	No comment.
05/10/2005	1.78	0.07	16.4	W	rain	1	A	14.83	26.38	No comment.
05/17/2005	52.32	2.06	660.9	W	rain	3	B	12.02	629.30	No comment.
05/24/2005	45.47	1.79	554.8	W	rain	1	B	8.08	367.36	No comment.
05/31/2005	5.84	0.23	65.3	W	rain	2	A	16.95	99.03	No comment.
06/07/2005	12.95	0.51	176.2	W	rain	2	A	9.67	125.31	No comment.
06/14/2005	110.74	4.36	1,323.8	W	rain	3	B	7.42	822.49	No comment.
06/21/2005	0.51	0.02	(1.1)	T	trace rain	0	C	--	0.00	Low capture efficiency.
06/28/2005	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
07/05/2005	15.75	0.62	189.9	W	rain	2	A	11.00	173.22	Used alternate rain gage data.
07/11/2005	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	System blank.
07/19/2005	25.65	1.01	404.7	W	rain	4	B	6.30	161.62	Used alternate rain gage data.
07/26/2005	38.10	1.50	449.6	W	rain	2	B	12.50	476.25	No comment.
08/02/2005	18.29	0.72	195.2	W	rain	1	B	24.60	449.88	Used alternate rain gage data.
08/09/2005	17.78	0.70	215.1	W	rain	2	B	18.30	325.37	No comment.
08/16/2005	40.64	1.60	506.2	W	rain	2	B	7.30	296.67	Used alternate rain gage data.
08/23/2005	32.77	1.29	403.1	W	rain	2	B	16.70	547.19	No comment.
08/30/2005	13.21	0.52	186.0	W	rain	3	A	9.30	122.83	No comment.

Appendix 1-4. Weekly precipitation and total mercury at Bloomington monitoring station near Bloomington, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
09/06/2005	88.90	3.50	973.5	W	rain	1	B	2.90	257.81	Hurricane Katrina sample, 08/30–08/31.
09/13/2005	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
09/20/2005	49.28	1.94	599.5	W	rain	3	B	13.80	680.00	No comment.
09/27/2005	56.64	2.23	676.2	W	rain	3	B	7.70	436.14	No comment.
10/04/2005	11.43	0.45	135.8	W	rain	2	A	12.68	144.95	No comment.
10/11/2005	0.25	0.01	0.0	T	trace rain	0	C	--	0.00	No comment
10/18/2005	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
10/26/2005	19.81	0.78	263.8	W	rain	3	B	18.65	369.61	Used alternate rain gage data.
11/01/2005	7.62	0.30	92.6	W	rain	2	B	14.36	109.48	No comment.
11/07/2005	8.38	0.33	88.0	W	rain	1	A	7.59	63.66	No comment.
11/15/2005	44.20	1.74	571.8	W	rain	2	A	4.35	192.42	No comment.
11/22/2005	33.78	1.33	439.0	W	rain	1	A	5.79	195.59	No comment.
11/28/2005	2.79	0.11	29.6	W	mixed	3	A	30.89	86.31	No comment.
12/06/2005	21.34	0.84	249.8	W	mixed	3	A	4.31	92.10	No comment.
12/12/2005	10.67	0.42	65.1	W	mixed	3	A	2.69	28.74	No comment.
12/20/2005	5.08	0.20	54.1	W	mixed	2	A	9.43	47.92	No comment.
12/27/2005	33.53	1.32	402.7	W	mixed	1	A	1.83	61.35	No comment.

[1]Data-quality rating codes for each sample were assigned by the NADP-MDN laboratory:
A—no field or laboratory problems, data quality acceptable for summary statistics;
B—minor field or laboratory problems, data quality acceptable for summary statistics;
C—field or laboratory problems, data quality suspect.

Appendix 1-5. Weekly precipitation and total mercury at Indiana Dunes monitoring station near Porter, Indiana, January 2004–December 2005.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
01/06/2004	12.19	0.48	67.8	W	mixed	3	A	8.77	106.93	No comment.
01/13/2004	0.25	0.01	2.2	W	rain	1	B	41.99	10.66	No comment.
01/20/2004	3.30	0.13	14.4	W	mixed	1	A	6.49	21.44	No comment.
01/27/2004	5.59	0.22	38.0	W	mixed	2	A	7.44	41.58	No comment.
02/03/2004	5.08	0.20	23.6	W	snow	2	B	2.56	13.01	No comment.
02/10/2004	5.59	0.22	34.5	W	snow	2	A	5.14	28.73	No comment.
02/17/2004	0.25	0.01	0.0	T	trace snow	0	C	--	0.00	No comment.
02/24/2004	6.60	0.26	61.3	W	mixed	1	B	21.98	145.16	No comment.
03/02/2004	15.49	0.61	221.5	W	rain	2	A	10.11	156.78	No comment.
03/09/2004	31.75	1.25	369.7	W	rain	1	A	5.19	164.91	No comment.
03/16/2004	2.03	0.08	35.1	W	mixed	1	B	9.76	19.84	No comment.
03/23/2004	3.81	0.15	39.0	W	mixed	2	A	8.05	30.69	No comment.
03/30/2004	27.69	1.09	350.4	W	rain	3	A	16.20	448.54	No comment.
04/06/2004	14.22	0.56	187.5	W	rain	1	A	13.82	196.63	No comment.
04/13/2004	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	Field bottle blank.
04/20/2004	5.84	0.23	73.8	W	rain	1	A	29.86	174.47	No comment.
04/27/2004	24.08	0.95	288.5	W	rain	2	B	12.06	290.46	Bottle catch.
05/04/2004	24.13	0.95	284.3	W	rain	1	B	6.85	165.43	Used alternate rain gage data.
05/11/2004	13.21	0.52	162.0	W	rain	3	A	18.22	240.68	No comment.
05/18/2004	50.29	1.98	581.2	W	rain	2	B	10.90	548.53	No comment.
05/25/2004	28.96	1.14	365.9	W	rain	4	A	17.04	493.43	No comment.
06/01/2004	43.18	1.70	560.5	W	rain	1	B	8.44	364.69	No comment.
06/08/2004	0.00	0.00	1.1	T	trace rain	0	A	--	0.00	No comment.
06/15/2004	67.31	2.65	812.3	W	rain	2	B	11.74	790.69	No comment.
06/22/2004	7.62	0.30	92.5	W	rain	1	A	8.35	63.66	No comment.
06/29/2004	2.79	0.11	34.6	W	rain	1	A	13.90	38.85	No comment.
07/06/2004	17.27	0.68	1,020.3	W	rain	1	A	13.51	233.43	No comment.
07/13/2004	9.65	0.38	111.1	W	rain	2	A	14.24	137.44	No comment.
07/20/2004	8.38	0.33	107.9	W	rain	1	A	18.08	151.62	No comment.

Appendix 1-5. Weekly precipitation and total mercury at Indiana Dunes monitoring station near Porter, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
07/27/2004	102.36	4.03	1,171.4	W	rain	3	A	14.47	1,481.79	No comment.
08/03/2004	4.32	0.17	57.6	W	rain	1	A	17.82	76.95	No comment.
08/10/2004	27.94	1.10	332.7	W	rain	1	A	10.38	290.01	No comment.
08/17/2004	10.41	0.41	145.5	W	rain	1	A	5.02	52.27	No comment.
08/24/2004	41.40	1.63	1,341.2	W	rain	2	B	10.29	426.06	No comment.
08/31/2004	68.58	2.70	882.8	W	rain	2	A	11.93	818.36	No comment.
09/07/2004	0.76	0.03	12.0	W	rain	1	A	43.03	32.79	Low volume sample.
09/14/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
09/21/2004	12.70	0.50	154.1	W	rain	1	A	8.72	110.82	No comment.
09/28/2004	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
10/05/2004	9.14	0.36	104.3	W	rain	1	B	9.51	86.95	No comment.
10/12/2004	5.08	0.20	63.1	W	rain	1	A	8.95	45.47	No comment.
10/19/2004	49.53	1.95	609.6	W	rain	2	A	4.70	233.03	No comment.
10/26/2004	19.05	0.75	241.0	W	rain	1	A	18.67	355.83	No comment.
11/02/2004	50.55	1.99	616.8	W	rain	2	A	7.48	378.43	No comment.
11/09/2004	19.56	0.77	257.3	W	rain	1	A	9.03	176.66	No comment.
11/16/2004	1.52	0.06	20.6	W	rain	1	A	13.10	19.96	No comment.
11/23/2004	15.49	0.61	185.7	W	rain	2	A	9.57	148.32	No comment.
11/30/2004	26.92	1.06	333.6	W	mixed	3	B	3.59	96.76	No comment.
12/07/2004	40.89	1.61	544.3	W	rain	3	A	4.14	169.62	No comment.
12/14/2004	12.95	0.51	150.0	W	mixed	3	A	9.50	123.15	No comment.
12/21/2004	5.59	0.22	39.0	W	snow	1	A	6.93	38.76	No comment.
12/28/2004	3.81	0.15	22.3	W	snow	2	A	11.95	45.56	No comment.
01/04/2005	31.24	1.23	394.2	W	rain	3	A	7.33	228.85	No comment.
01/11/2005	27.94	1.10	255.0	W	mixed	3	A	4.89	136.60	No comment.
01/18/2005	45.47	1.79	562.4	W	mixed	3	A	7.33	333.08	No comment.
01/25/2005	11.94	0.47	81.9	W	snow	2	A	17.84	212.91	No comment.
02/01/2005	1.27	0.05	9.4	W	snow	1	B	4.26	5.41	No comment.
02/08/2005	8.13	0.32	84.6	W	rain	1	A	4.92	39.97	No comment.

Appendix 1-5. Weekly precipitation and total mercury at Indiana Dunes monitoring station near Porter, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
02/15/2005	24.38	0.96	285.8	W	mixed	3	B	6.25	152.45	No comment.
02/22/2005	19.05	0.75	229.1	W	mixed	3	A	9.32	177.58	No comment.
03/01/2005	10.92	0.43	87.9	W	mixed	1	B	10.00	109.20	No comment.
03/08/2005	3.30	0.13	54.4	W	mixed	3	A	14.61	48.23	No comment.
03/15/2005	2.54	0.10	21.0	W	snow	1	A	6.35	16.13	No comment.
03/22/2005	5.33	0.21	70.6	W	rain	1	B	16.57	88.37	No comment.
03/22/2005	5.33	0.21	70.6	W	rain	1	B	16.57	88.37	No comment.
03/29/2005	10.16	0.40	100.3	W	mixed	2	A	8.41	85.42	No comment.
04/05/2005	0.76	0.03	15.5	W	rain	1	A	44.94	34.24	No comment.
04/12/2005	4.83	0.19	67.5	W	rain	1	A	11.79	56.89	No comment.
04/19/2005	2.79	0.11	35.2	W	rain	1	A	32.69	91.35	No comment.
04/26/2005	14.73	0.58	186.3	W	rain	2	B	8.47	124.83	No comment.
05/03/2005	31.24	1.23	9.5	W	rain	1	B	30.08	15.28	Low volume sample.
05/10/2005	1.02	0.04	16.0	W	rain	1	A	18.99	19.29	No comment.
05/17/2005	10.92	0.43	148.3	W	rain	3	B	21.86	238.75	No comment.
05/24/2005	13.46	0.53	175.6	W	rain	1	A	18.76	252.60	No comment.
05/31/2005	0.00	0.00	(1.3)	T	trace rain	0	A	--	0.00	No comment.
06/07/2005	8.64	0.34	104.3	W	rain	3	B	116.62	1,007.16	No comment.
06/14/2005	29.46	1.16	356.6	W	rain	3	B	11.16	328.96	No comment.
06/21/2005	0.00	0.00	(0.3)	T	trace rain	0	A	--	0.00	No comment.
06/28/2005	0.00	0.00	0.0	D	QC	0	A	<.05	0.00	System blank.
07/05/2005	5.33	0.21	65.7	W	rain	1	A	11.70	62.40	No comment.
07/12/2005	0.00	0.00	(0.6)	T	trace rain	0	A	--	0.00	No comment.
07/19/2005	9.65	0.38	128.0	W	rain	3	A	16.50	159.25	No comment.
07/26/2005	27.18	1.07	349.9	W	rain	3	B	18.60	505.51	No comment.
08/02/2005	30.99	1.22	346.8	W	rain	1	A	3.20	99.16	No comment.
08/09/2005	16.51	0.65	211.9	W	rain	1	B	15.00	247.65	No comment.
08/16/2005	30.48	1.20	383.9	W	rain	3	B	13.20	402.33	No comment.
08/23/2005	22.35	0.88	268.2	W	rain	2	B	11.20	250.34	No comment.

Appendix 1-5. Weekly precipitation and total mercury at Indiana Dunes monitoring station near Porter, Indiana, January 2004–December 2005–Continued.

[mm, millimeter; in., inch; mL, milliliter; ng/L, nanogram per liter; ng/m^2, nanogram per square meter; W, wet deposition; D, dry sample; T, trace sample; QC, quality-control sample; parentheses, sample volume not included in volume-weighted concentration; brackets, volume-weighted concentration for estimated deposition; --, no analysis; <, less than reporting limit; significant digits in this table are consistent with raw data from National Atmospheric Deposition Program Mercury Deposition Network on-line data archive]

Date sample removed	Precipitation (mm)	Precipitation (in.)	Sample volume (mL)	Sample type	Precipitation type	Wet deposition events	Data-quality rating[1]	Total mercury concentration (ng/L)	Total mercury deposition (ng/m^2)	Comments
08/30/2005	0.00	0.00	(0.1)	T	trace rain	0	B	--	0.00	No comment.
09/06/2005	0.00	0.00	(0.2)	T	trace rain	0	A	--	0.00	No comment.
09/13/2005	0.00	0.00	0.0	D	dry	0	B	--	0.00	No comment.
09/20/2005	30.73	1.21	377.6	W	rain	3	A	11.10	341.14	No comment.
09/27/2005	5.59	0.22	72.4	W	rain	3	B	17.70	98.90	No comment.
10/04/2005	23.88	0.94	294.8	W	rain	2	B	7.20	172.02	No comment.
10/11/2005	0.00	0.00	0.0	D	dry	0	A	--	0.00	No comment.
10/18/2005	1.02	0.04	(11.7)	W	rain	3	C	[9.67]	9.86	Estimated deposition with rain gage precipitation.
10/25/2005	17.78	0.70	214.6	W	rain	4	A	26.32	467.97	No comment.
11/01/2005	27.94	1.10	354.3	W	rain	2	B	10.37	289.79	No comment.
11/08/2005	24.13	0.95	300.5	W	rain	1	A	14.17	341.99	No comment.
11/15/2005	3.05	0.12	52.8	W	rain	2	A	11.44	34.88	No comment.
11/22/2005	5.84	0.23	70.8	W	rain	2	A	4.91	28.73	No comment.
11/29/2005	25.91	1.02	305.4	W	rain	3	B	8.84	229.10	No comment.
12/06/2005	1.52	0.06	41.7	W	snow	2	A	7.24	11.03	No comment.
12/13/2005	19.56	0.77	231.2	W	snow	4	B	3.34	65.48	No comment.
12/20/2005	2.79	0.11	13.1	W	snow	3	A	8.15	22.78	No comment.
12/27/2005	7.11	0.28	62.3	W	rain	1	A	5.90	42.01	No comment.

[1]Data-quality rating codes for each sample were assigned by the NADP-MDN laboratory:
A—no field or laboratory problems, data quality acceptable for summary statistics;
B—minor field or laboratory problems, data quality acceptable for summary statistics;
C—field or laboratory problems, data quality suspect.

Appendix 2. Wind Rose Plots

Percentages of time for 16 directions from which the wind blew toward 5 monitoring stations for mercury in precipitation in Indiana, 2004 and 2005, summarized using hourly data.

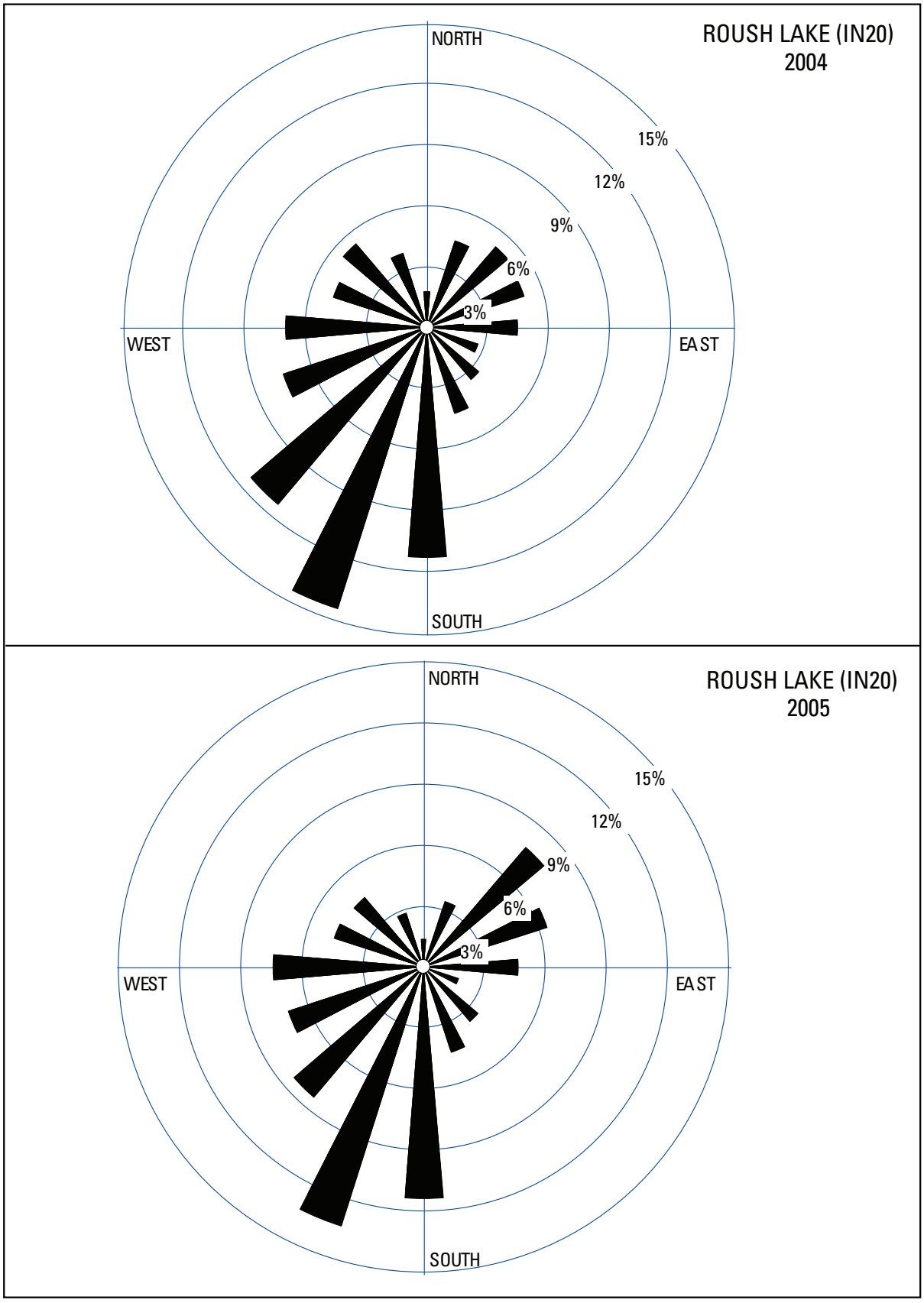

Figure 2–1. Roush Lake, Indiana, wind rose plots, 2004 and 2005.

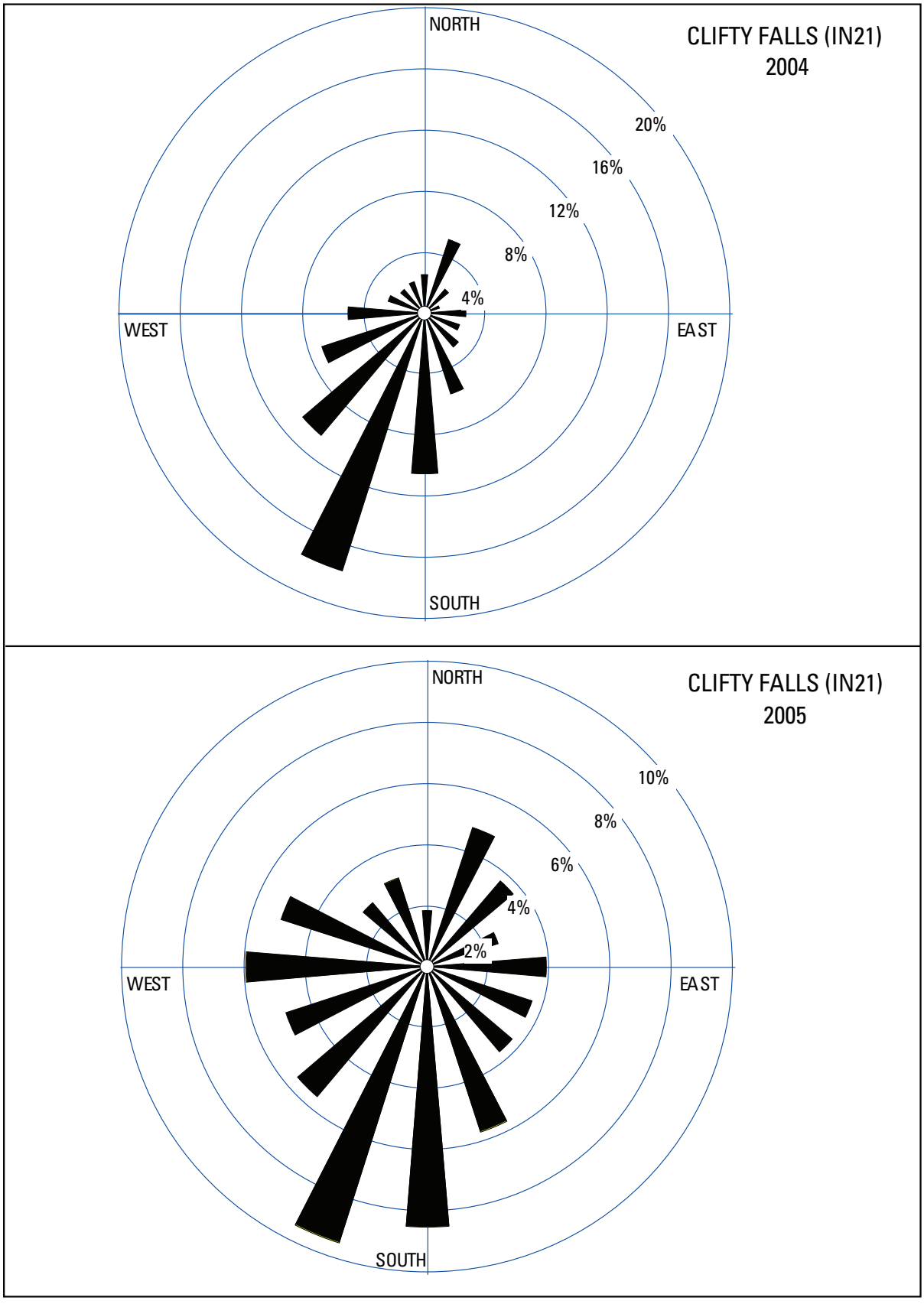

Figure 2–2. Clifty Falls, Indiana, wind rose plots, 2004 and 2005.

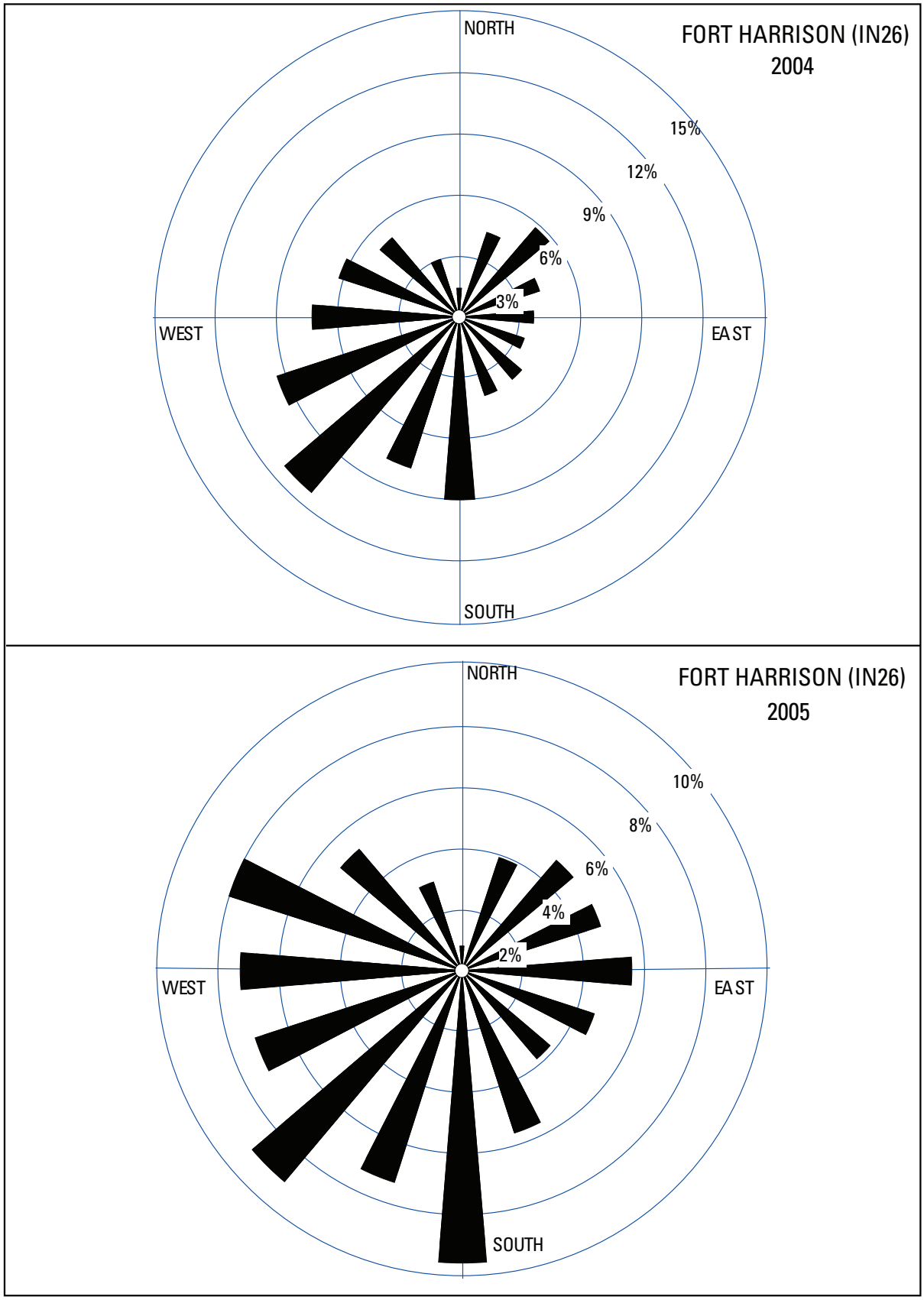

Figure 2–3. Fort Harrison, Indiana, wind rose plots, 2004 and 2005.

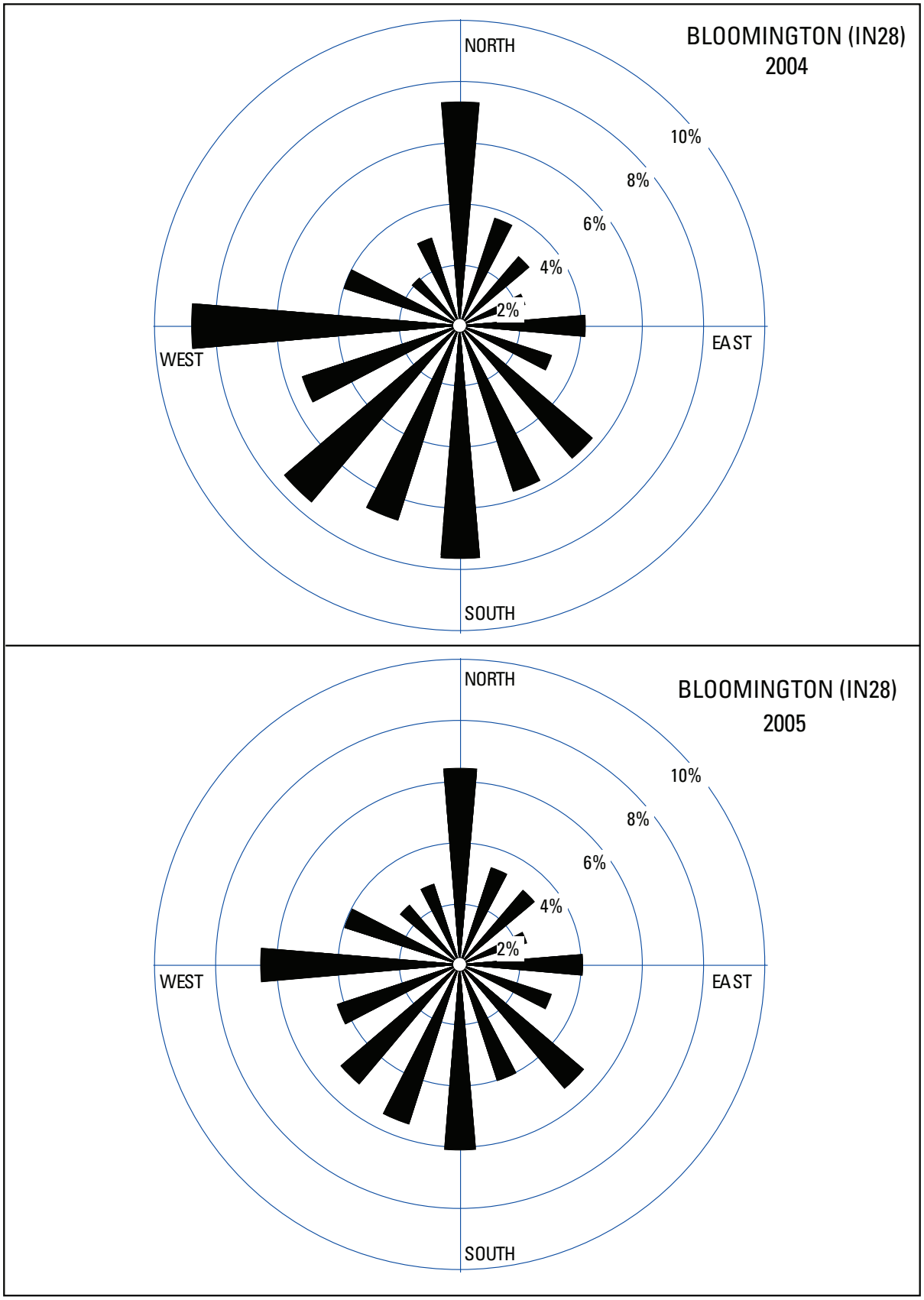

Figure 2–4. Bloomington, Indiana, wind rose plots, 2004 and 2005.

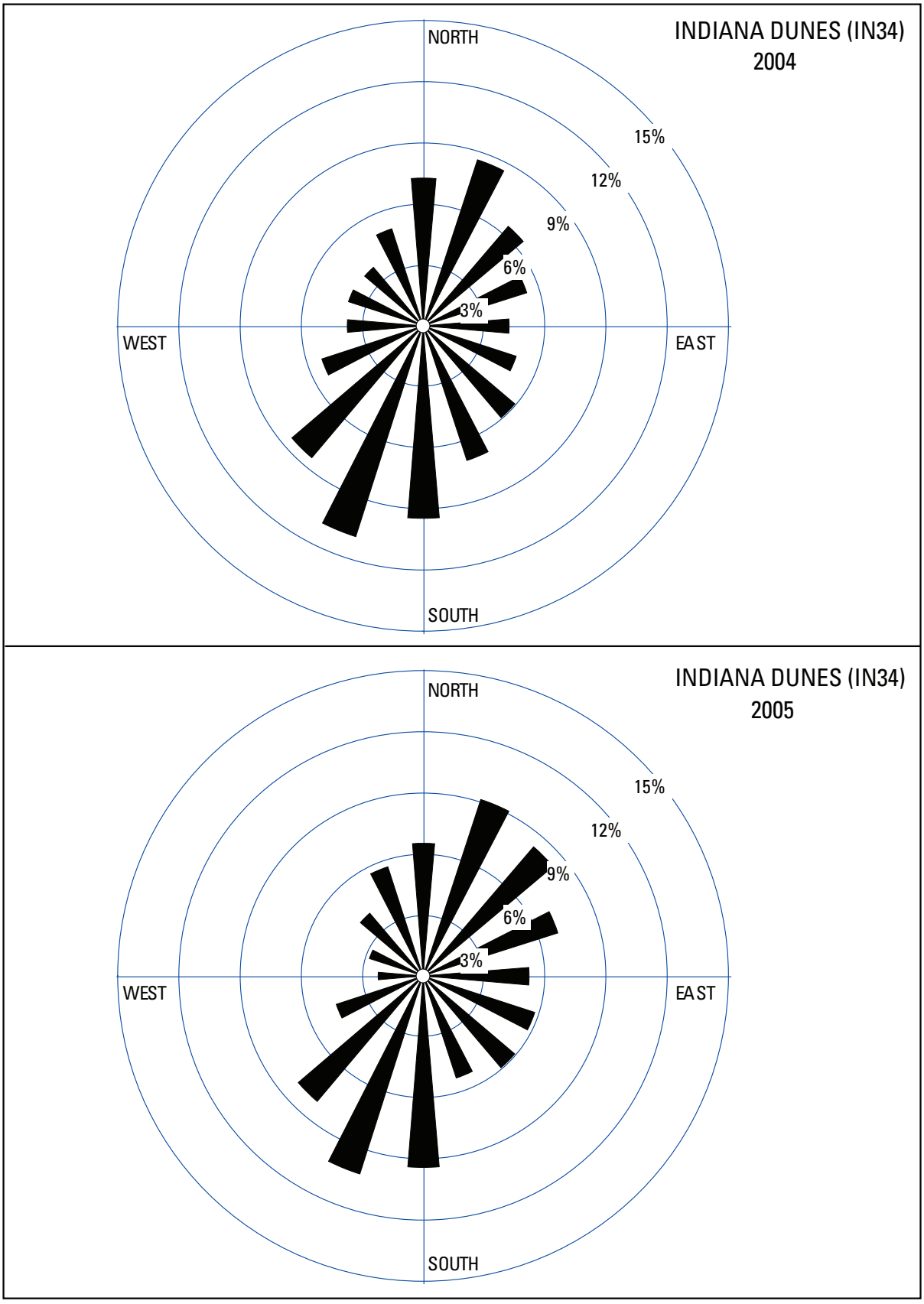

Figure 2–5. Indiana Dunes, Indiana, wind rose plots, 2004 and 2005.