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Concentrations of *Escherichia coli* in Streams in the Ohio River Watershed in Indiana, May–August 2000

By Cheryl A. Silcox, Bret A. Robinson, and Timothy C. Willoughby

Prepared in cooperation with the
Indiana Department of Environmental Management

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Conversion Factors, Abbreviations, and Definitions

Multiply	By	To obtain
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
pound per square inch (lb/in^2)	70.307	gram per square centimeter

Temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by use of the following equation:

$$°F = 1.8(°C) + 32$$

Abbreviated water-quality units used in this report: Chemical concentrations and water temperature are given in metric units. Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million. Concentrations of bacteria are given in colonies per 100 milliliters (col/100 mL).

Bacteria are microscopic unicellular organisms, typically spherical, rodlike, or spiral and threadlike in shape, often clumped into colonies.

***Escherichia coli* (*E. coli*)** bacteria are present in the intestine and feces of warm-blooded animals. *E. coli* are a member species of the fecal coliform group of indicator bacteria. Indicator bacteria for presumptive identification and enumeration are cultured on selective media after filtration of several different sample volumes onto gridded membrane filters. In the laboratory, they are defined as those bacteria that produce yellow or yellow-brown colonies that remain so when placed on a filter pad saturated with urea substrate broth for 15 minutes after resuscitation at 35.0 ± 0.5°C for 2 hours and primary culturing for 22 to 24 hours at 44.5 ± 0.2°C on mTEC medium. Concentrations of bacteria are given in colonies per 100 milliliters (col/100 mL).

Dissolved oxygen (DO) content of water in equilibrium with air is a function of atmospheric pressure, temperature, and dissolved-solids concentration of the water. The ability of water to retain oxygen decreases with increasing temperature or dissolved solids, with small temperature changes having the more significant offset. Photosynthesis and respiration may cause diurnal variations in dissolved-oxygen concentration in water from some streams.

Membrane filter (MF) is a thin microporous material of specific pore size used to filter bacteria, algae, and other very small particles from water.

Membrane-filter Thermotolerant *E. coli* (mTEC) is a bacteria medium designed to encourage the growth of certain indicator bacteria while restricting the growth of nontarget bacteria. Used for analysis of *Escherichia coli*, mTEC is a type of membrane-filter media.

Nephelometric turbidity unit (NTU) is the unit of measurement for reporting turbidity that is based on use of a standard suspension of Formazin. Turbidity measured in NTU uses nephelometric methods that depend on passing specific light of a specific wavelength through the sample.

Conversion Factors, Abbreviations, and Definitions—Continued

pH of water is the negative logarithm of the hydrogen-ion activity. Solutions with pH less than 7 are termed "acidic," and solutions with a pH of greater than 7 are termed "basic." Solutions with a pH of 7 are neutral. The presence and concentration of many dissolved chemical constituents found in water are, in part, influenced by the hydrogen-ion activity of water. Biological processes including growth, distribution of organisms, and toxicity of the water to organisms are also influenced, in part, by the hydrogen-ion activity of water.

River mile is the distance of a point on a river measured in miles from the river's mouth along the low-water channel.

Specific conductance of water is expressed in microsiemens per centimeter at 25 degrees Celsius (µS/cm). This unit is equivalent to micromhos per centimeter at 25 degrees Celsius (µmho/cm), formerly used by the U.S. Geological Survey.

Streamflow-gaging station is a site on a stream or canal where systematic observations of stage, discharge, or other hydrologic data are obtained. When used in connection with a discharge record, the term is applied only to those streamflow-gaging stations where a continuous record of discharge is computed.

Turbidity is a measurement of the collective optical properties of a water sample that cause light to be scattered and absorbed rather than transmitted in straight lines; the higher the intensity of scattered light, the higher the turbidity. Turbidity is expressed in nephelometric units (NTU) or Formazin turbidity units (FTU), depending on the method and equipment used.

Volumes of water-quality samples are given in liters (L) and milliliters (mL).

Concentrations of *Escherichia coli* in Streams in the Ohio River Watershed in Indiana, May–August 2000

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Abstract

Water samples collected from 40 stream sites in the Ohio River Watershed in Indiana from May through August 2000 were analyzed for concentrations of *Escherichia coli (E. coli)* bacteria. Each site was sampled five times in a 30-day period. Concentrations of *E. coli* in 72 of the 200 samples exceeded the State of Indiana single-sample standard of 235 colonies per 100 milliliters for waters used for recreation.

A five-sample geometric mean of concentrations was computed for each site. Concentrations in samples from 24 of the 40 sites exceeded the State of Indiana standard for a five-sample geometric mean of 125 colonies per 100 milliliters for waters used for recreation. Samples collected from 34 sites had *E. coli* concentrations that exceeded either or both the single-sample standard and the five-sample geometric mean standard.

Five of the 40 sampling sites were at or near U.S. Geological Survey streamflow-gaging stations. On the basis of records from these stations, 16 percent of the samples from these sites were collected at streamflows above the median daily mean discharge for each station.

E. coli concentrations and turbidity measurements collected during 2000 were analyzed in concert with *E. coli* concentration and turbidity data collected in 1999 at streams within the Kankakee and Lower Wabash River Watersheds in Indiana and in 1998 at streams within the Upper Wabash River Watershed in Indiana. These data were grouped together to investigate the relation between concentrations of bacteria and turbidity. The resulting analysis indicated a statistically significant correlation between concentrations of *E. coli* and turbidity.

Introduction

The presence of *E. coli* in water is direct evidence of the presence of fecal contamination from human or other warm-blooded animals and indicates the possible presence of pathogens (Myers and Sylvester, 1997; Francy and others, 2000). *E. coli* is one of the two preferred indicator bacteria used by the U.S. Environmental Protection Agency (USEPA) to determine the suitability of surface waters for recreational use. Contact with fecal-contaminated water puts swimmers at risk of contracting gastrointestinal illness, skin rashes, and ear and eye infections (Francy and others, 2000). The water-quality standards for *E. coli* in recreational waters in Indiana require the concentration of *E. coli* to be less than the single-sample standard of 235 colonies per 100 mL (milliliters) and less than the geometric mean of 125 colonies per 100 mL computed from five samples collected within a 30-day period (Oddi, 1995).

The Indiana Department of Environmental Management (IDEM) is responsible for monitoring watersheds in Indiana and reporting the quality of the State's waters to Congress. IDEM has published those data for the year 2000 through the State's Report to Congress on Water Quality, 305B

Report (Indiana Department of Environmental Management, 2000). As part of this statewide watershed-assessment program, IDEM entered into a cooperative agreement with the U.S. Geological Survey (USGS) to determine concentrations of *E. coli* at 40 stream sites in the Ohio River Watershed from May through August. Previous cooperative studies with IDEM determined *E. coli* concentrations at 46 sites in the Upper Wabash River Watershed in 1998 (Silcox and others, 2000) and at 58 sites in the Kankakee and Lower Wabash River Watersheds in 1999 (Silcox and others, 2001).

Purpose and Scope

This report documents the concentrations of *E. coli* measured in samples from selected streams in the Ohio River Watershed from May through August 2000. The report also describes the relation between concentrations of *E. coli* and streamflow at sites where streamflow records were available and examines the relation between concentrations of *E. coli* and turbidity. Quality-assurance data for the *E. coli* samples also are presented. Field measurements of water temperature, pH, dissolved oxygen, specific conductance, and turbidity collected at the same time as the samples collected for *E. coli* analysis also are presented in this report.

Description of the Study Area

Samples were collected in the Ohio River Watershed in Indiana (fig. 1). This watershed, which drains 4,224 mi^2 in Indiana (Fenelon, Bobay, and others, 1994, p. 177–181), includes all direct tributaries to the Ohio River except the Wabash River and Whitewater River Basins in Indiana. The study area extended from near Aurora, Indiana (Dearborn County), in the east to just west of Evansville, Indiana (Vanderburgh County). Major tributaries in the study area include Laughery Creek (Ripley, Ohio, and Dearborn Counties), Indian Creek[1] (Switzerland County), Fourteenmile Creek (Clark County), Indian Creek[1] (Floyd and Harrison Counties), Little Blue River (Crawford County), Blue River (Washington and Crawford Counties), Crooked Creek (Spencer County), Cypress Creek (Warrick County), and Pigeon Creek (Vanderburgh County).

The study area falls within seven physiographic units (Dearborn Upland, Muscatatuck Regional Slope, Scottsburg Lowland, Norman Upland, Mitchell Plain, Crawford Upland, and Wabash Lowland) of southern Indiana (Schneider, 1966). In general, when compared to the glacially derived topography of central and northern Indiana, the Ohio River Watershed can be described as a rugged area of relatively high topographic relief with physical characteristics controlled by the underlying bedrock.

Each physiographic unit within the Ohio River Watershed, however, has its own distinct physical characteristics distinguishing it from the other units. The Dearborn Upland, Norman Upland, and Crawford Upland physiographic units are underlain by relatively resistant rocks and show the greatest relief where bedrock has been dissected by streams. In places, the local relief in these three physiographic units is as much as 450 ft (Schneider, 1966). In comparison, the Muscatatuck Regional Slope, Scottsburg Lowland, and Wabash Lowland exhibit less overall topographic relief.

Study Methods

Selection of sampling sites, methods used to measure field parameters, and procedures used to collect the samples to meet a 6-hour sample-holding time limit are described in the following sections. Methods used to collect and process the water samples for analysis of *E. coli* and the equation used to calculate the geometric mean are discussed. Statistical methods used to evaluate the relation between concentrations of *E. coli* and turbidity also are described.

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[1]There are two streams in the Ohio River Watershed named Indian Creek. One is in Switzerland County and is just west of the town of Vevay. The other Indian Creek drains parts of Clark, Floyd, and Harrison Counties and is tributary to the Ohio River southwest of Corydon, Ind.

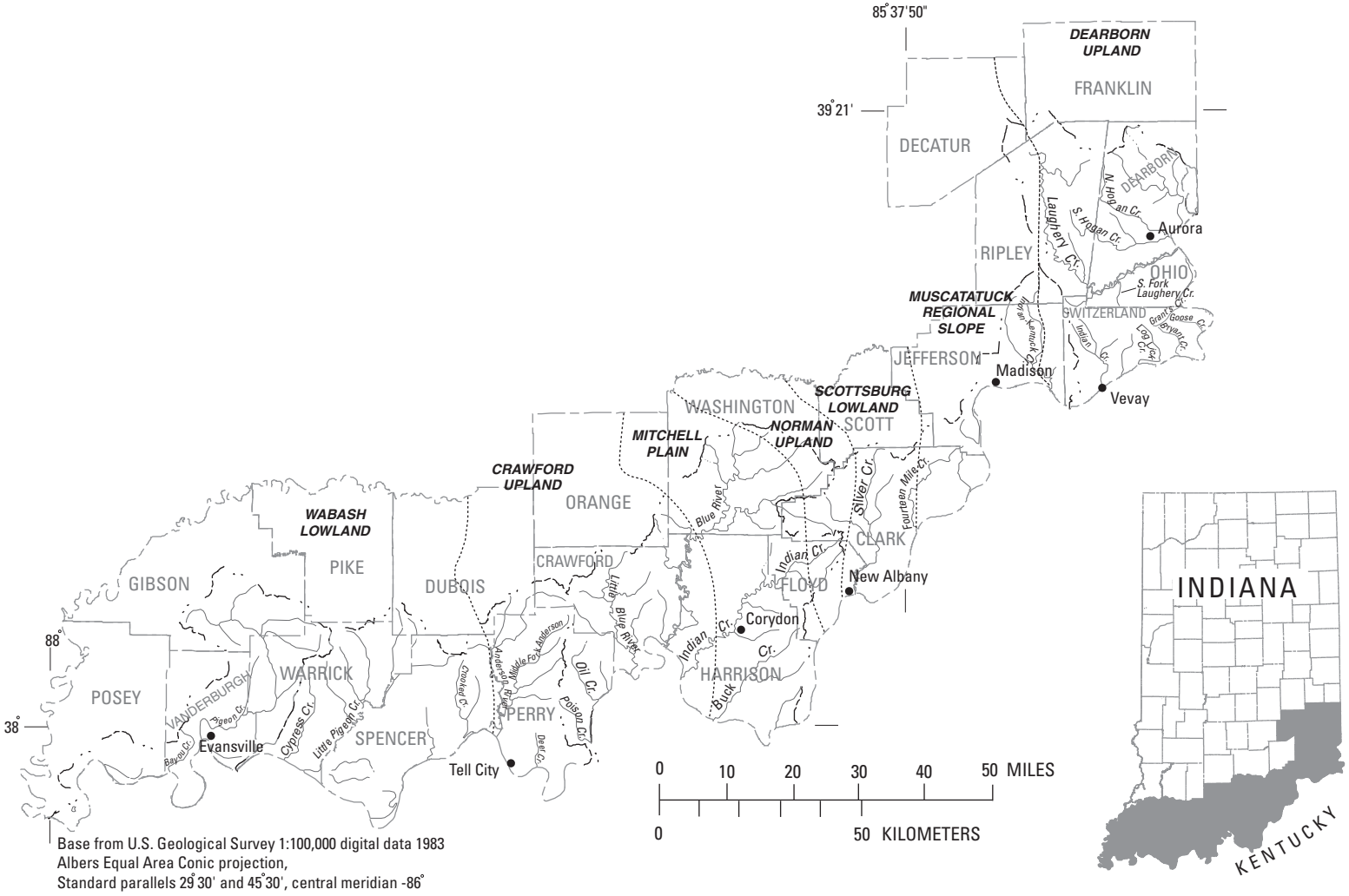


Figure 1. Location and principal streams of the Ohio River Watershed in Indiana.

Selection of Sampling Sites

Sampling sites initially were selected by IDEM personnel using responses from a 1987 poll of local health officials, conservation officers, and sheriff's departments regarding known areas of stream recreational uses. Additional sites then were added to improve spatial coverage or to locate sites at or near active USGS streamflow-gaging stations where streamflow data was readily available. Site locations were identified on topographic maps and field verified for safety and accessibility by USGS personnel prior to sample collection. Where sampling conditions were unsafe or where site characteristics interfered with the ability to collect a sample, the sampling site was relocated as close to the initial sampling site as possible. Changes to sampling-site locations were agreed upon by USGS and IDEM personnel.

The 40 selected sampling sites (fig. 2) were divided into two groups so that all sites could be sampled five times at equally spaced intervals within a 30-day period. Table 1 lists the Group 1 sites (sites 1 through 12) sampled during May and June 2000; table 2 lists the Group 2 sites (sites 13 through 40) sampled during July and August 2000.

Field Measurements

At each sampling site, a multi-parameter water-quality probe was used to make field measurements of water temperature, dissolved oxygen, pH, and specific conductance at several locations across the width of the stream. The probes used to measure dissolved oxygen, pH, and specific conductance were calibrated daily. If parameters measured in the field were not stable or if they displayed unreasonable values, the meters were recalibrated at the site and field parameters were remeasured.

Field determinations of turbidity were made by collecting samples of streamwater in polyethylene bottles and analyzing the samples with a portable turbidimeter. The measuring range of the turbidimeter was checked daily with reference standards. Water temperature, dissolved-oxygen concentration, pH, specific conductance, and turbidity were measured at the same locations in the stream where the samples were collected for analysis of *E. coli*.

Collection of Samples

Water samples were collected during Indiana's recreational season, defined as April through October. The samples were collected by two-person field crews to expedite the sampling process and to meet the mandated 6-hour sample-holding time limit prior to processing the samples.

Activities at the sampling sites included measuring and recording field parameters, measuring and recording water-surface-stage data, and collecting the water samples for analysis of *E. coli*. Water-surface stage was determined by using a measuring tape lowered to the surface of the stream from a reference mark on the bridge or documenting the stage levels of streams at sites where USGS streamflow-gaging stations were present or nearby. At the time of sampling, water-surface-stage elevation, water clarity, and weather conditions also were noted on the field forms.

Water samples for *E. coli* determinations were collected in 300 mL glass bottles with glass stoppers. Prior to use, the bottles were washed with detergent, rinsed three times with tap water and three times with deionized water, and then sterilized by autoclaving. To ensure optimum growth conditions for *E. coli*, two solutions were added to each sample bottle before the bottle was sterilized. To counter the effects of residual chlorine or other halogens used in water-disinfection processes, 0.3 mL of a 10-percent solution of sodium thiosulfate was added to the bottles. Residual chlorine and other halogen compounds act as bacterial-growth inhibitors; their effects need to be reduced so that *E. coli* can fully recover on the growth medium and produce accurate counts (Bordner and Winter, 1978; American Public Health Association and others, 1992).

In addition, 0.9 mL of a 15-percent solution of ethylenediaminetetraacetic acid (EDTA) was added to neutralize the effects of trace-element concentrations greater than 10 µg/L (micrograms per liter).

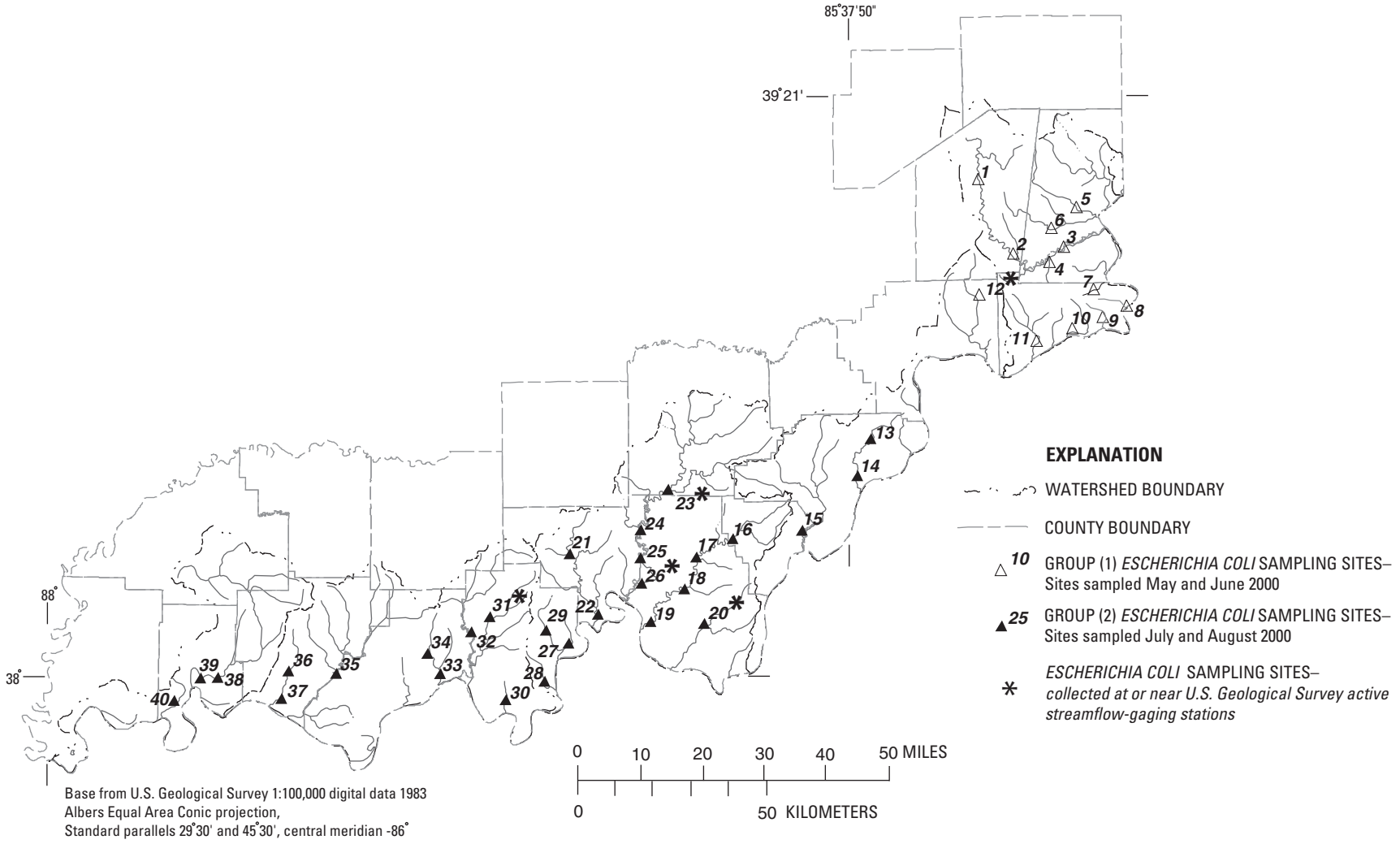


Figure 2. Location of sampling sites in the Ohio River Watershed in Indiana.

Table 1. Group 1 sites in the Ohio River Watershed in Indiana at which water samples were collected during May and June 2000 for analysis of *Escherichia coli*

[USGS, U.S. Geological Survey; SR, State Road; *, denotes active USGS streamflow-gaging station]

Site number	Site location	USGS site identification	Latitude and longitude	County
1	Laughery Creek at SR 350 near Osgood	390854085151301	39° 08′ 54″ 85° 15′ 13″	Ripley
2	Laughery Creek at SR 62 at Friendship	385821085091101	38° 58′ 21″ 85° 09′ 11″	Ripley
3	Laughery Creek at Cole Lane at Hartford	385941084572801	38° 59′ 41″ 84° 57′ 28″	Ohio
4	South Fork Laughery Creek at SR 262 at Milton	385812085003001	38° 58′ 12″ 85° 00′ 30″	Ohio
5	North Hogan Creek at North Hogan Road near Wilmington	390444084574601	39° 04′ 44″ 84° 57′ 46″	Dearborn
6	South Hogan Creek near Dillsboro	03276700	39° 01′ 47″ 85° 02′ 17″	Dearborn
7	Grant's Creek at Barkworks Road near Quercus Grove	385306084541201	38° 53′ 06″ 84° 54′ 12″	Switzerland
8	Goose Creek at SR 156 at Patriot	385042084490701	38° 50′ 42″ 84° 49′ 07″	Switzerland
9	Bryant Creek at Private Drive, 1 river mile upstream from SR 156	384835084520301	38° 48′ 35″ 84° 52′ 03″	Switzerland
10	Log Lick Creek at Bennett Road near Markland	384713084583101	38° 47′ 13″ 84° 58′ 31″	Switzerland
11	Indian Creek at SR 129 near Vevay	384443085054101	38° 44′ 43″ 85° 05′ 41″	Switzerland
12*	Indian-Kentuck Creek at SR 62 near Canaan	03291780	38° 52′ 41″ 85° 15′ 26″	Jefferson

EDTA, a chelating agent, binds particularly with copper and zinc, making the metals neutral so that they do not adversely affect bacterial growth (Britton and Greeson, 1989, p. 5–6; Bordner and Winter, 1978; American Public Health Association and others, 1992).

Samples were collected with a weighted hand-line sampler that was lowered beneath the surface of the water. Grab samples were collected by immersing the bottles by hand when the stream was not deep enough to use the hand-line sampler (Myers and Slyvester, 1997). At each site, the sample collected was a composite of water from one to four well-mixed areas of flow, depending on the width of the stream. The samples were kept on ice until processed. Duplicate samples were collected concurrently with the environmental samples at selected sites.

Processing of Samples

Processing equipment included a multi-port manifold filter stand, stainless-steel filter holders, vacuum pumps, and glass graduated cylinders. Equipment used to process the samples was washed with detergent prior to field work, rinsed three times with hot tap water and three times with de-ionized water, and then sterilized for a minimum of 15 minutes with an 8-watt ultraviolet (UV) lamp having a wavelength of 254 nanometers. Other processing equipment used but not washed or sterilized included vacuum pumps and sterile dis-

Table 2. Group 2 sites in the Ohio River Watershed in Indiana at which water samples were collected during July and August 2000 for analysis of *Escherichia coli*

[USGS, U.S. Geological Survey; SR, State Road; CR, County Road; US, U.S.Highway; W, N, and S, denote the geographic directions of West, North, and South; *, denotes active USGS streamflow-gaging station; ** , denotes site where streamflow data from nearby active USGS stream-flow-gaging station was applied]

Site number	Site location	USGS site identification	Latitude and longitude	County
13	Fourteenmile Creek at Zimmerman Road at New Market	383156085370001	38˚ 31´ 56˝ 85˚ 37´ 00˝	Clark
14	Fourteenmile Creek at SR 62 near Charlestown	03292400	38˚ 27´ 57˝ 85˚ 37´ 05˝	Clark
15	Silver Creek at Blackiston Mill Road near New Albany	0330000050	38˚ 20´ 03˝ 85˚ 47´ 41˝	Floyd
16	Indian Creek at Greenville Road near Georgetown	381903086000701	38˚ 19´ 03˝ 86˚ 00´ 07˝	Floyd
17	Indian Creek at SR 335 near Corydon	03302500	38˚ 16´ 35˝ 86˚ 06´ 35˝	Harrison
18	Indian Creek downstream from Little Indian Creek mouth at Corydon	381237086075801	38˚ 12´ 37˝ 86˚ 07´ 58˝	Harrison
19	Indian Creek at Lickford Bridge Road near Central	380733086145101	38˚ 07´ 33˝ 86˚ 14´ 51˝	Harrison
20*	Buck Creek at SR 337 near New Middletown	03302220	38˚ 07´ 13˝ 86˚ 05´ 17˝	Harrison
21	Little Blue River at SR 37 near Grantsburg	381709086290001	38˚ 17´ 09˝ 86˚ 29´ 00˝	Crawford
22	Little Blue River at CR 38 near Alton	380832086241001	38˚ 08´ 32˝ 86˚ 24´ 10˝	Crawford
23*	Blue River at US 150 at Fredericksburg	03302800	38˚ 26´ 02˝ 86˚ 11´ 30˝	Washington
24	Blue River at Main Street at Milltown	382026086162501	38˚ 20´ 26˝ 86˚ 16´ 25˝	Crawford
25	Blue River at Rothrock Mill near Moberly	381628086163101	38˚ 16´ 28˝ 86˚ 16´ 31˝	Crawford
26**	Blue River at SR 462 near White Cloud	381349086151301	38˚ 13´ 49˝ 86˚ 15´ 13˝	Crawford
27	Little Oil Creek at SR 66 near Dexter	380435086291701	38˚ 04´ 35˝ 86˚ 29´ 17˝	Perry
28	Poison Creek at CR 104 near Gerald	375903086334301	37˚ 59´ 03˝ 86˚ 33´ 43˝	Perry
29	Oil Creek at CR 34 near Mt. Pleasant	380629086332301	38˚ 06´ 29˝ 86˚ 33´ 23˝	Perry
30	Deer Creek at Trolly Road near Dodd	375716086393001	37˚ 57´ 16˝ 86˚ 39´ 30˝	Perry
31*	Middle Fork Anderson River at SR 145 at Bristow	03303300	38˚ 08´ 20˝ 86˚ 43´ 16˝	Perry
32	Anderson River at CR 1300N near Huffman	380432086464201	38˚ 04´ 32˝ 86˚ 46´ 42˝	Spencer
33	Crooked Creek at SR 70 at Maxville	380005086511701	38˚ 00´ 05˝ 86˚ 51´ 17˝	Spencer
34	Crooked Creek at SR 245 at Lamar	380317086541801	38˚ 03´ 17˝ 86˚ 54´ 18˝	Spencer
35*	Little Pigeon Creek at SR 161 near Midway	03304055	38˚ 00´ 23˝ 87˚ 10´ 31˝	Spencer
36	Cypress Creek at CR 300W–Eskew Road near Boonville	380143087180801	38˚ 01´ 43˝ 87˚ 18´ 08˝	Warrick
37	Cypress Creek at CR 550S–Sharon Road at Dayville	375720087195000	37˚ 57´ 15˝ 87˚ 19´ 51˝	Warrick
38	Pigeon Creek at Oak Hill Road at Evansville	375946087313001	37˚ 59´ 46˝ 87˚ 31´ 30˝	Vanderburgh
39	Pigeon Creek at First Avenue at Evansville	375944087342901	37˚ 59´ 44˝ 87˚ 34´ 29˝	Vanderburgh
40	Bayou Creek at Burdette Park near Evansville	375640087382101	37˚ 56´ 40˝ 87˚ 38´ 21˝	Vanderburgh

posable pipets. After the samples were processed, aluminum-block incubators were used to provide optimum conditions for bacterial growth.

Fresh membrane-filter Thermotolerant *E. coli* (mTEC) agar was prepared by personnel at the USGS Ohio District Microbiology Laboratory. The fresh mTEC agar was heated and poured into petri dishes in the USGS Indiana District laboratory for use in the field. Refrigeration units were used to keep the mTEC agar chilled before use. The 2-week holding time for mTEC agar, once it was prepared, was monitored in the laboratory and field. Urea/phenol red reagent was prepared as needed in the USGS Indiana District laboratory and was used to confirm the presence of *E. coli* colonies.

The samples collected for analysis of *E. coli* were processed either in mobile laboratories set up in hotel rooms near collection sites or in the USGS Indiana District laboratory. Surfaces on which the samples were processed were cleaned with isopropyl alcohol before the first sample was processed, between samples, and after the last sample was processed each day. Analysts washed their hands with bactericidal soap before processing the first sample, between samples, and after processing the last sample.

Five to eight different sample volumes, including one to three different dilutions, were filtered for each site because the concentration of *E. coli* was unknown. A range of small to large sample volumes and dilutions were used for processing. This was done to provide at least one sample volume capable of producing one or more filter plates with sufficient colony growth to achieve the ideal *E. coli* colony count of 20 to 80 colonies per filter plate (Myers and Sylvester, 1997). Stream conditions at the time of each sampling and previous colony counts for each site obtained after the first week of sampling guided the analysts in determining the sample quantities to process that would help them obtain one or more filter plates in an ideal range. Sample dilutions were made by adding 11 mL of sample water to 99 mL of sterile dilution water for a 1:10 ratio and 1 mL of sample water to another 99 mL of sterile dilution water for a 1:100 ratio.

Samples were shaken vigorously before each sample dilution volume was withdrawn to ensure uniform distribution of the bacteria throughout the sample. Sterile, disposable 1-mL and 10-mL glass pipets were used to measure and deliver concentrated sample volumes to dilution bottles and to measure and deliver dilution volumes to the interior of the funnel filter assembly. For sample dilution volumes less than 10 mL, about 20 mL of sterile saline buffer solution was poured into the funnel before pipetting the sample dilution to evenly distribute the bacteria on the filter. A sterile graduated cylinder was used to transfer sample dilution volumes greater than 10 mL. A three-port manifold with funnels or a single-use stainless-steel filter system was used to support a 0.45-µm (micrometer) filter designed to facilitate colony capture, incubation, and quantification. The water was pulled through the filter either by a vacuum pump set not to exceed 5 lb/in^2 or by a hand vacuum assembly to prevent damage to bacteria (Myers and Sylvester, 1997, p. 10).

After filtering each of the sample dilution volumes, 20 to 30 mL of sterile saline buffer solution were used to flush the sides of the funnel to ensure that any bacteria present on the funnel walls were rinsed onto the filter. The graduated cylinders used to measure and deliver sample dilution volumes to the funnel also were rinsed with sterile saline buffer solution, and the rinsate was processed through the filter.

Petri dishes containing the mTec agar used to encourage growth of *E. coli* colonies on the prepared filters were labeled prior to processing the sample. Undiluted environmental samples and sample dilutions were filtered from smallest to largest. The filters then were placed in petri dishes with the mTec agar and placed inverted in a pre-heated incubator set at 35.0°C for 1.75 to 2 hours, removed, and then placed in a preheated incubator set at 44.5°C for 22 to 24 hours. After the second incubation period was completed, the filter was transferred to a filter pad saturated with urea/phenol red reagent. After 15 to 20 minutes at room temperature, the yellow to yellow-brown *E. coli* colonies were counted under a microscope with magnification ranging from 7X to 10X. If the filter plate had

a colony count in the ideal range, verification of the count was made either by the second crew member or by rotating the filter 90 degrees and recounting the colonies.

Concentrations of *E. coli* were calculated according to the methods described by Myers and Sylvester (1997, p. 31–33-FIB) and recorded on the field sheet. If more than one dilution produced an ideal colony count, the concentration of *E. coli* was computed as the sum of the colony counts for each sample volume multiplied by 100 and divided by the sum of the sample volumes. For example, if 24 colonies were counted for a sample volume of 3 mL and 60 colonies were counted for a sample volume of 10 mL, the concentration of *E. coli* is calculated as follows:

$$\text{Col/100 mL} = (24 + 60) \times 100/(3 + 10) = 646, \quad (1)$$

where:

Col/100 mL = colonies per 100 milliliters,

24 + 60 are the colony counts on two different filter plates, and

3 + 10 are the sample volumes filtered for each plate.

For this example, the result would be reported as 650 colonies per 100 mL; whole numbers are reported to two significant figures.

The same calculation was used if *E. coli* colonies were present but none of the dilutions had concentrations of *E. coli* within the ideal colony count. All the dilutions having observable colonies present were used in the calculation, and the result was reported as an estimate based on a non-ideal colony count (denoted with a "K" preceding the number). Concentrations of *E. coli* were reported in whole numbers for results of less than 10, and results greater than or equal to 10 were reported to two significant figures (Myers and Sylvester, 1997, p. 30-FIB). Colony counts were recorded on field sheets labeled for each site. After counting, petri dishes were filled with chlorine bleach, placed in sealed plastic bags, and discarded.

Geometric Mean

The five single-sample calculations for each site, based on either ideal or estimated (K) non-ideal colony counts (whichever occurred), were used to determine the five-sample geometric mean. The five-sample geometric mean was calculated, using equation 2.

$$GM = \sqrt[5]{S_1 \cdot S_2 \cdot S_3 \cdot S_4 \cdot S_5}, \quad (2)$$

where:

GM is the geometric mean, and

S_i is the concentration of *E. coli* measured in each of the five samples.

Statistical Analysis

A Kendall's Tau test (Helsel and Hirsch, 1992, p. 212) for significant correlation was used to determine if there was a statistically significant correlation between the concentration of *E. coli* and turbidity. For this report, a 5-percent level of significance (α=0.05) was identified as the criterion for the statistical correlation. The p-value is derived from the data and measures the believability of the null hypothesis that states no correlation exists between concentrations of *E. coli* and turbidity. The smaller the p-value, the more likely there is a correlation between concentrations of *E. coli* and turbidity and the stronger the evidence for rejection of the null hypothesis.

A Wilcoxon signed-rank test (Helsel and Hirsch, 1992, p. 142) was used to determine if there were statistically significant differences between the environmental samples and the concurrent duplicates. The Wilcoxon signed-rank test measured whether one group of data tends to produce larger observations than the second group and made no assumptions regarding how the data are distributed (Helsel and Hirsch, 1992, p. 118). For this report, a 5-percent level of significance (α=0.05) was selected for the Wilcoxon signed-rank test. The p-values also are presented for the Wilcoxon signed-rank test. The smaller the p-value, the more likely there is a difference between the environmental samples and the concurrent duplicates.

Quality-Assurance Procedures

Quality-assurance procedures were followed for collection and processing of the samples. These procedures include frequent checking and calibration of equipment as well as collection of additional samples for quality control. Analysis of the quality-control samples provides quantitative information not only about the potential for bias from contamination during collection and processing but also about the variability of sampling.

The pH buffers and specific-conductance solutions used to calibrate the multi-parameter probe were quality assured by the USGS Quality of Water Services Unit (QWSU). Fresh *E. coli* substrate media kits were quality assured by the USGS Ohio District Microbiology Laboratory. Membrane filters, sterile saline buffer solution, premeasured sterile dilution water, petri dishes, and petri dishes with pads also were quality assured by the QWSU. The incubators were checked weekly with an American Society for Testing and Materials (ASTM) certified thermometer to assure that temperature ranges shown on the internal thermometer in the incubator were accurate to ±0.5°C. The incubators were inspected daily to assure they were operating properly.

Quality-control samples consisted of 199 filter blanks, 54 process blanks, 15 field blanks, and 21 duplicate samples. Filter blanks were processed before every set of samples to determine if the equipment used to process the samples was clean and the saline buffer solution used to rinse sample-processing equipment was not contaminated. While passing the saline buffer solution through the filter, every attempt was made to have the saline buffer solution come in contact with every surface that the environmental sample might touch.

Process blanks consisted of 100 mL of saline buffer solution filtered after an environmental sample through the same equipment used to process environmental samples, ensuring the equipment rinses following the filtering of each environmental sample were adequate. Process blanks were filtered for one sample daily.

Field blanks consisted of 250 mL of sterile saline buffer solution that was poured into a sample-collection bottle before personnel left for the first sampling site for the day. The field blanks were kept chilled and remained with the samples collected at all sites for that day. The field blanks were processed by passing 100 mL of the blank solution through the filter. Duplicate samples were collected concurrently with the environmental samples, processed in the same manner as the environmental samples, and used to evaluate the natural variability in the samples.

Concentrations of *Escherichia coli*

The Indiana Environmental Rules establish the bacteriological quality standard for waters for recreational uses (Oddi, 1995, 327 IAC 2-1-6 [d]). These rules are used to evaluate waters for full-body-contact recreational uses, to establish wastewater-treatment requirements, and to establish effluent limits during the recreational season. The standard states:

> *E. coli* bacteria, using membrane filter (MF) count, shall not exceed one hundred twenty-five (125) per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty-five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period.

Concentrations of *E. coli* at all 40 sites, listed in table 3 at the back of this report, ranged from 3 to 24,000 colonies per 100 mL (fig. 3), with concentrations in 72 of the 200 samples processed exceeding the single-sample standard in samples from 33 sites. The five-sample geometric mean of concentrations of *E. coli* for all sites ranged from 11 to 1,500 colonies per 100 mL (fig. 4). The concentrations of *E. coli* in samples from 24 sites exceeded the five-sample geometric mean standard. Concentrations of *E. coli* at 34 of the 40 sites sampled exceeded either the single-sample or the five-sample geometric mean standard(s) or both. Concentrations of *E. coli* at 6 of the 40 sites sampled did not exceed the single-sample or the five-sample geometric mean.

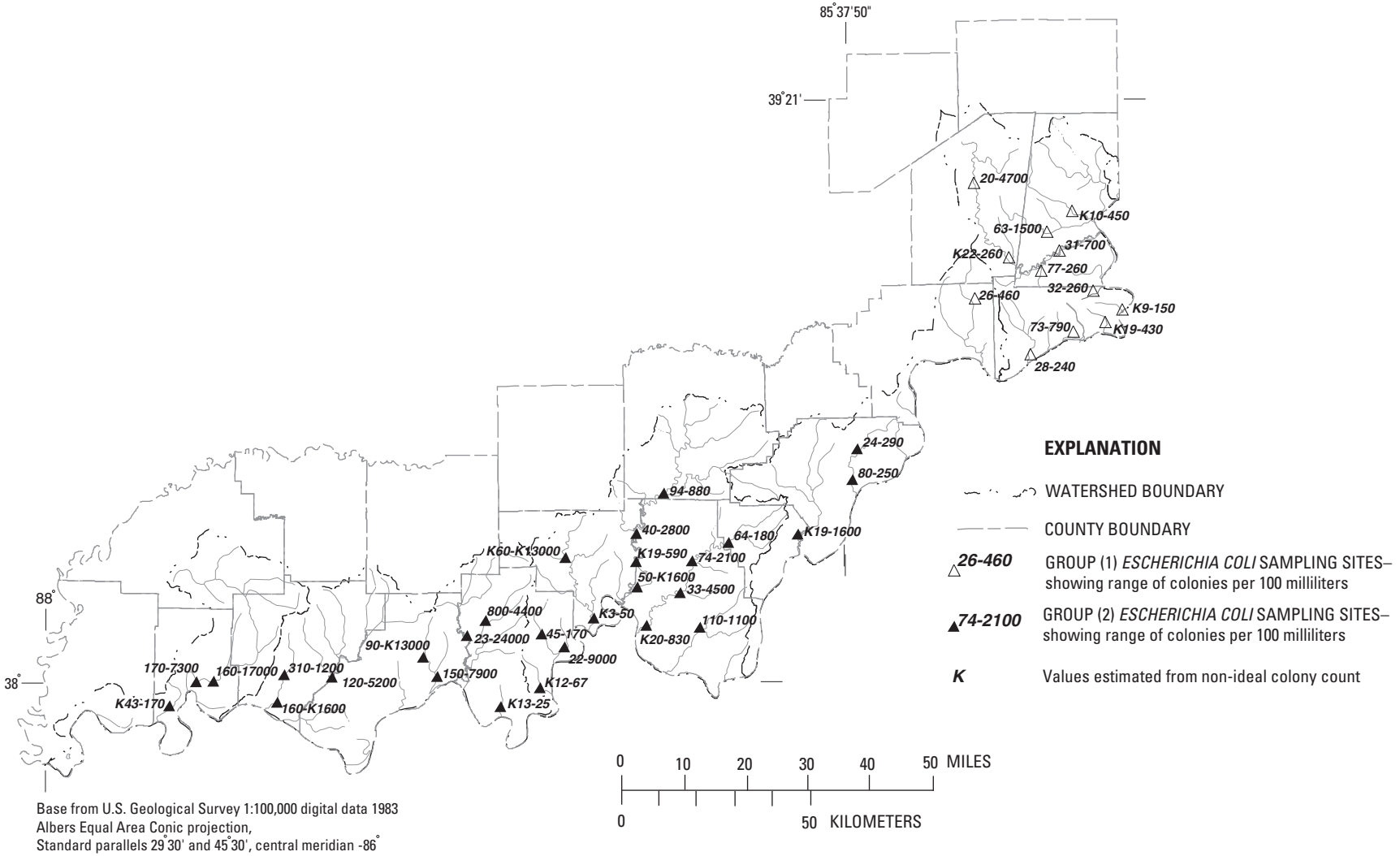


Figure 3. Ranges in concentrations of *Escherichia coli* for sampling sites in the Ohio River Watershed in Indiana, May–August 2000.

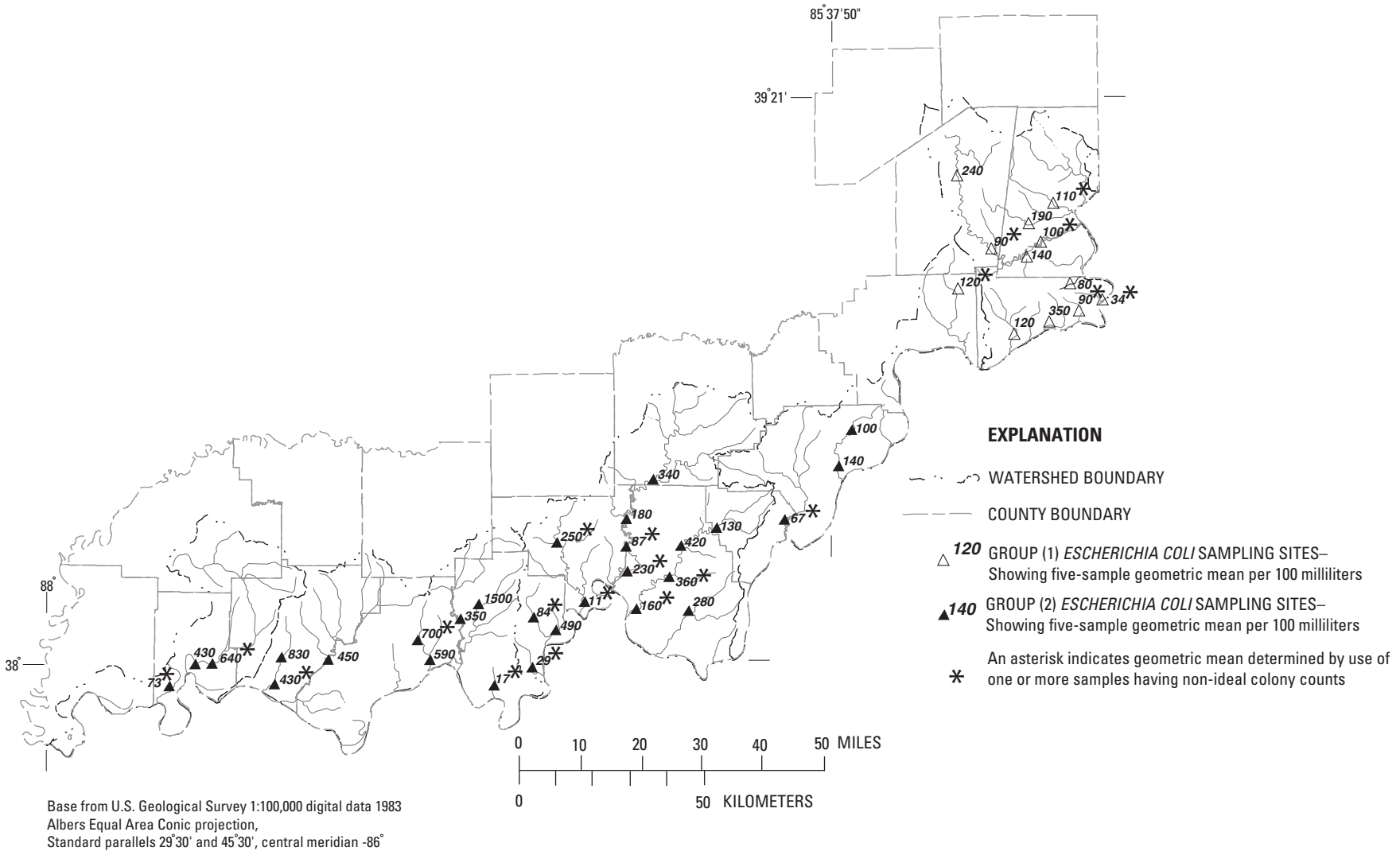


Figure 4. Five-sample geometric mean *Escherichia coli* concentration determined for sampling sites in the Ohio River Watershed in Indiana, May–August 2000.

Concentrations of *E. coli* were examined relative to their location at sampling sites along several stream reaches in the Ohio River Watershed in Indiana (figs. 5 and 6). Stream reaches sampled in May and June (Group 1 sites, fig. 5) were Laughery and South Fork Laughery, North Hogan and South Hogan, Grant's, Goose, Bryant, Log Lick, Indian (Switzerland County), and Indian-Kentuck Creeks. Concentrations of *E. coli* exceeded the single-sample standard for 16 of 60 samples from Group 1.

At Laughery and South Laughery Creek (sites 1–4) and North and South Hogan Creek (sites 5 and 6), concentrations of *E. coli* exceeded the single-sample standard for 9 of the 30 samples collected. Concentrations of *E. coli* ranged from K10 to 4,700 colonies per 100 mL. The five-sample geometric means ranged from 90 to 240 colonies per 100 mL.

Concentrations of *E. coli* in Group 1 sites (7–12) exceeded the single-sample standard for seven of 30 samples collected at six sites. Concentrations of *E. coli* ranged from K9 to 790 colonies per 100 mL. The five-sample geometric means ranged from 34 to 350 colonies per 100 mL.

Stream reaches for Group 2 sites (fig. 6) sampled in July and August were Fourteenmile, Silver, Indian, and Buck Creeks; Little Blue and Blue Rivers; Little Oil, Poison, and Deer Creeks; Middle Fork Anderson and Anderson Rivers; and Crooked, Little Pigeon, Cypress, and Bayou Creeks. Concentrations of *E. coli* in 56 of 140 samples exceeded the single-sample standard. Concentrations of *E. coli* exceeded the standard for the five-sample geometric mean at 20 of the 28 sites.

Concentrations of *E. coli* exceeded the single-sample standard in 3 of 15 samples from two sites on Fourteenmile Creek (sites 13 and 14) and one site on Silver Creek (site 15). Concentrations of *E. coli* ranged from K19 to 1,600 colonies per 100 mL. The five-sample geometric means ranged from 67 to 140 colonies per 100 mL.

Concentrations of *E. coli* exceeded the single-sample standard for 13 of 25 samples at three of four sites on Indian Creek (sites 16–19) and one site on Buck Creek (site 20). Concentrations ranged from K20 to 2,100 colonies per 100 mL. The five-sample geometric mean standard was exceeded at the five sites, with concentrations varying from 130 to 420 colonies per 100 mL.

Concentrations of *E. coli* exceeded the single-sample standard in 8 of 30 samples from two sites on the Little Blue River (sites 21 and 22) and four sites on the Blue River (sites 23–26). Concentrations of *E. coli* ranged from 3 to 13,000 colonies per 100 mL. The five-sample geometric mean ranged from 11 colonies to 340 colonies per 100 mL and was exceeded at four of the six sites.

Concentrations of *E. coli* exceeded the single-sample standard in three of five samples from one site on Little Oil Creek (site 27). Concentrations ranged from 22 to 9,000 colonies per 100 mL. The five-sample geometric mean was exceeded at this site, having a concentration of *E. coli* of 490 colonies per 100 mL.

None of the 15 samples from sites on Poison, Oil, and Deer Creeks (sites 2–30) exceeded the single-sample or the five-sample geometric mean standards. Concentrations ranged from K12 to 170 colonies per 100 mL. Concentrations for the five-sample geometric means ranged from 17 to 84 colonies per 100 mL.

All five samples from the Middle Fork Anderson River (site 31) exceeded the single-sample and the geometric mean standards; whereas, two of five samples from the Anderson River (site 32) exceeded the single-sample standard, and the five-sample geometric mean was exceeded also. Single-sample concentrations of *E. coli* ranged from 23 to 24,000 colonies per 100 mL, with the five-sample geometric means being 1,500 colonies per 100 mL (site 31) and 350 colonies per 100 mL (site 32).

Twenty-two of 35 samples from two sites each on Crooked, Cypress, and Pigeon Creeks (sites 33 and 34, 36 and 37, and 38 and 39) and one site on Little Pigeon Creek (site 35) exceeded the single-sample standard for concentrations of *E. coli*. Concentrations of *E. coli* ranged from 90 to 17,000 colonies per 100 mL. The five-sample geometric means was exceeded at all sites, with concentrations of *E. coli* varying from 430 to 830 colonies per 100 mL.

Twenty-two of 35 samples from two sites each on Crooked, Cypress, and Pigeon Creeks (sites 33 and 34, 36 and 37, and 38 and 39) and one site on

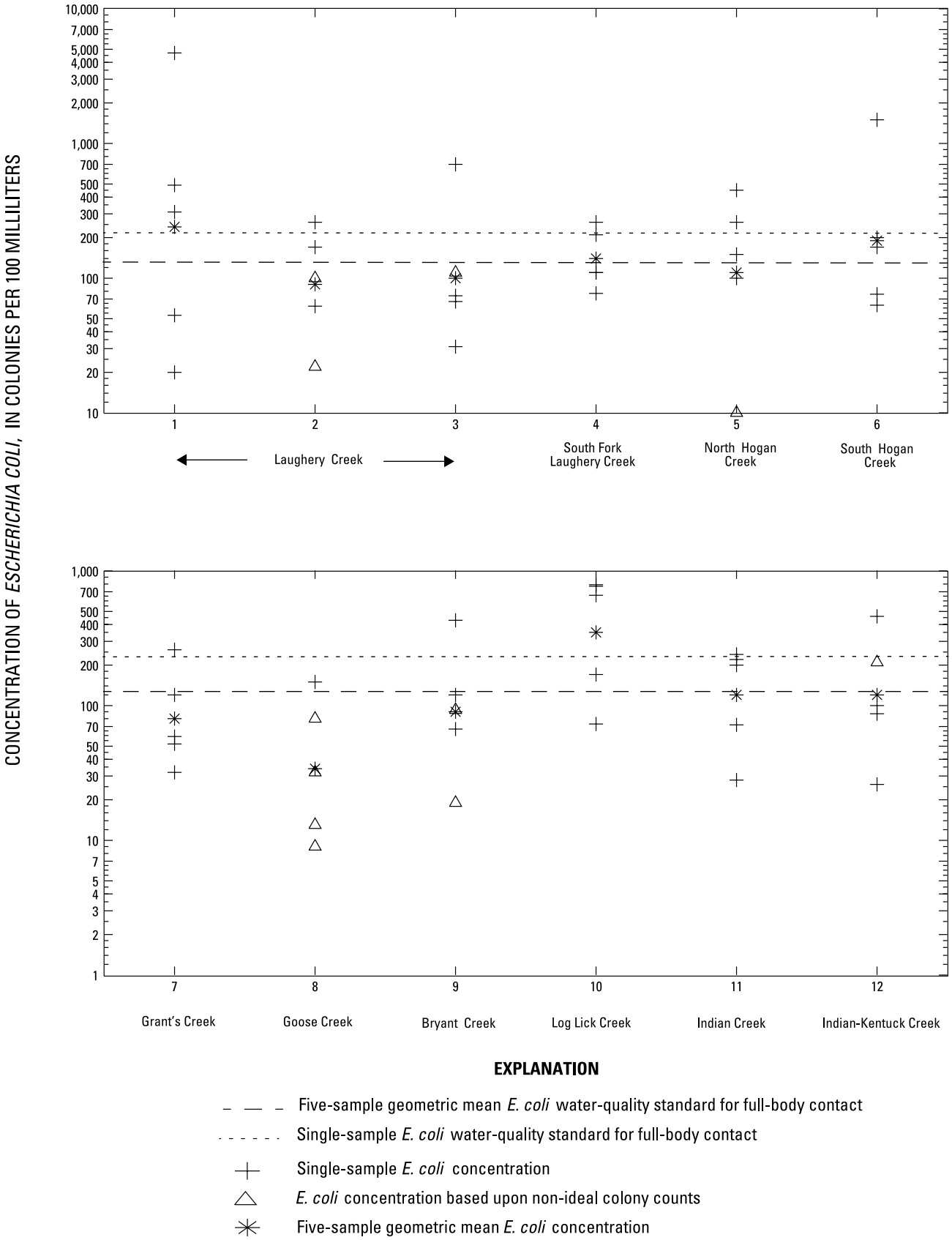


Figure 5. Concentrations of *Escherichia coli* (*E. coli*) and five-sample geometric means for selected sites in the Ohio River Watershed in Indiana, May–June 2000.

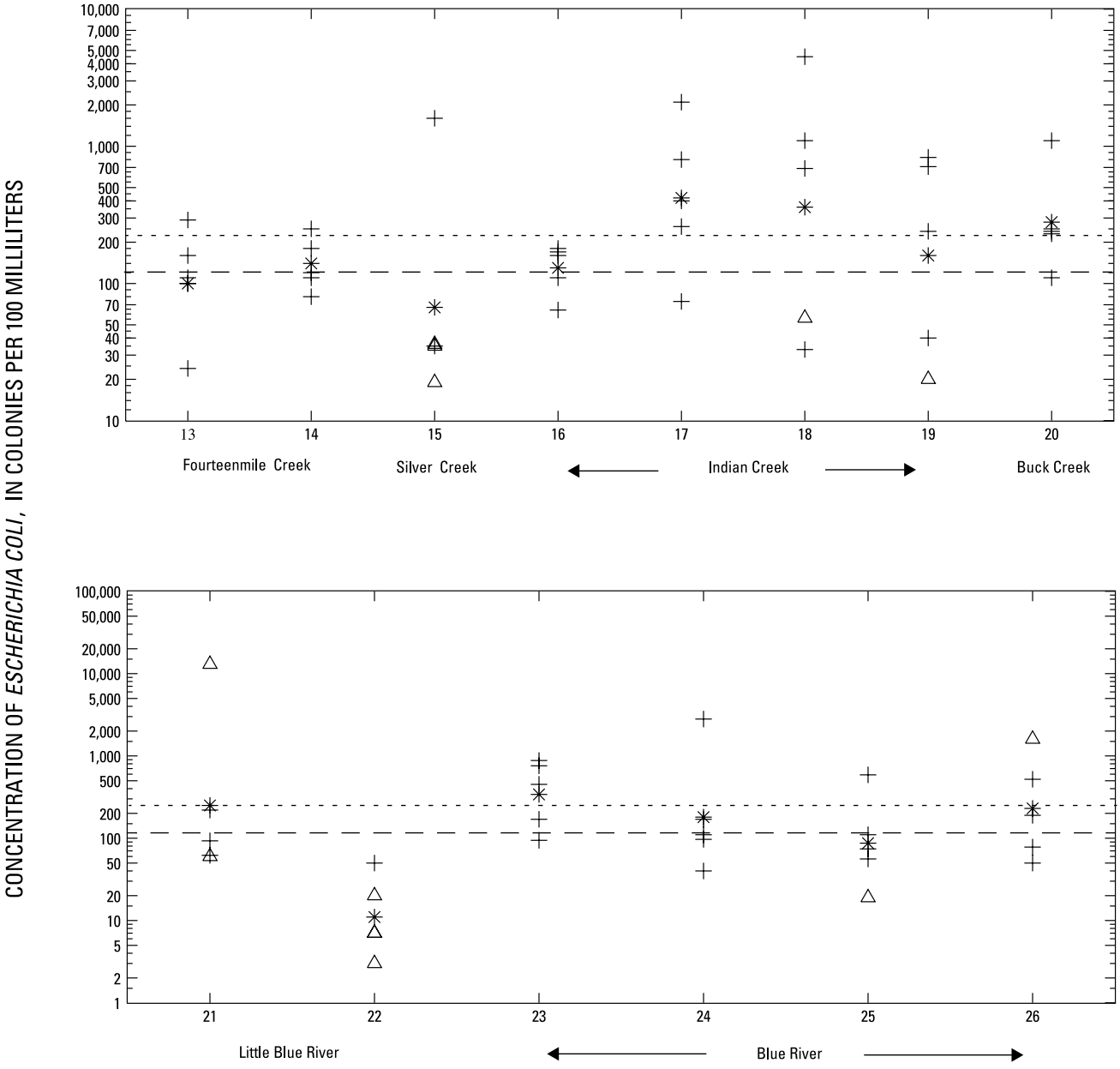
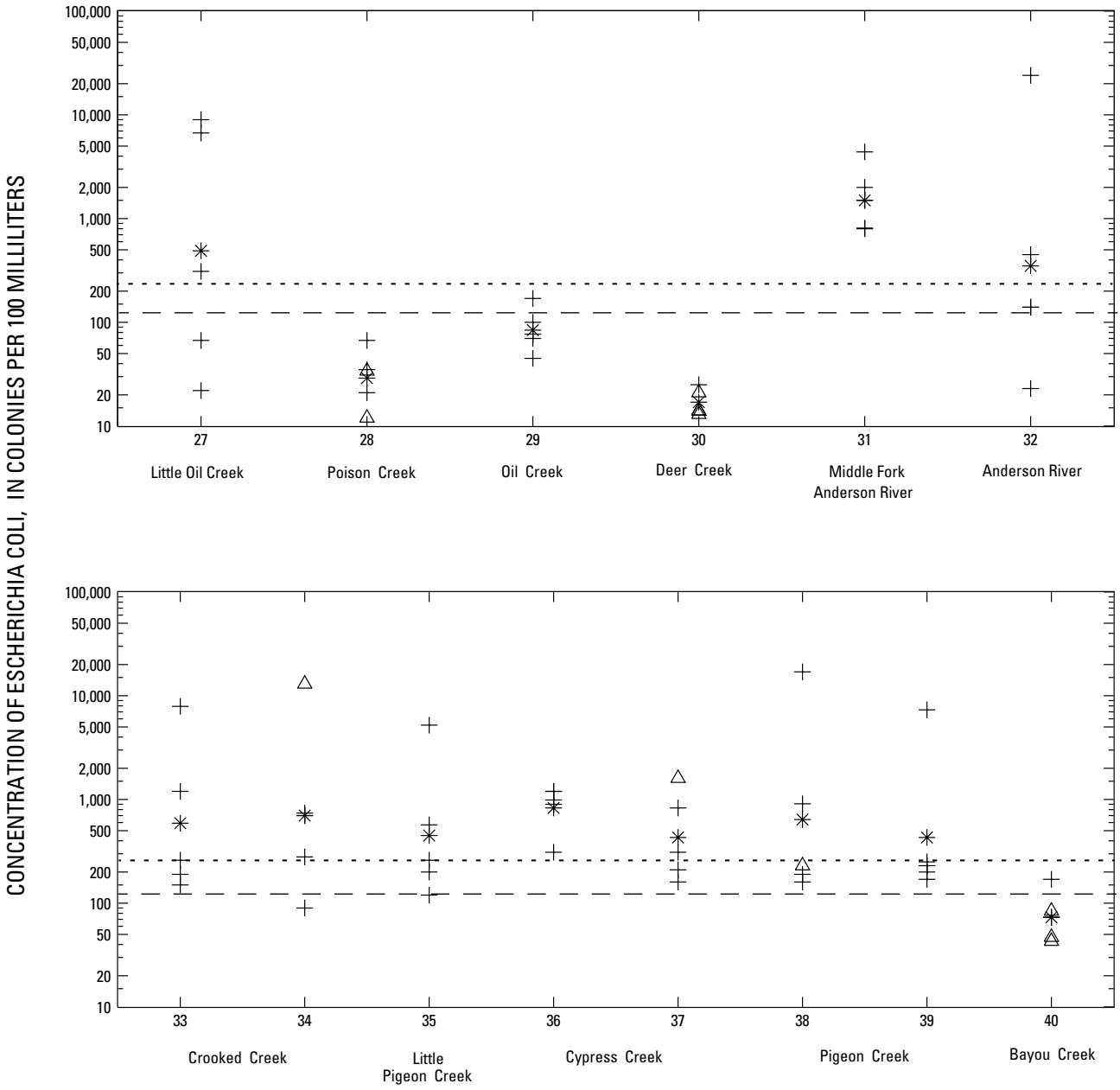


Figure 6. Concentrations of *Escherichia coli* (*E. coli*) and five-sample geometric means for selected sites in the Ohio River Watershed in Indiana, July–August 2000.



EXPLANATION

- Five-sample geometric mean *E. coli* water-quality standard for full-body contact
- Single-sample *E. coli* water-quality standard for full-body contact
- Single-sample *E. coli* concentration
- *E. coli* concentration based upon non-ideal colony counts
- Five-sample geometric mean *E. coli* concentration

Figure 6. Concentrations of *Escherichia coli* (*E. coli*) and five-sample geometric means for selected sites in the Ohio River Watershed in Indiana, July–August 2000—Continued.

Little Pigeon Creek (site 35) exceeded the single-sample standard for concentrations of *E. coli*. Concentrations of *E. coli* ranged from 90 to 17,000 colonies per 100 mL. The five-sample geometric means was exceeded at all sites, with concentrations of *E. coli* varying from 430 to 830 colonies per 100 mL.

None of the five samples from one site (40) on Bayou Creek exceeded the single-sample standard or the five-sample geometric mean. Concentrations of *E. coli* ranged from K43 to 170 colonies per 100 mL. The five-sample geometric mean was 73 colonies per 100 mL.

Relation between Concentrations of *Escherichia coli* and Streamflow

The relation between concentrations of *E. coli* and stream discharge was examined for five sites at or near active USGS streamflow-gaging stations in the Ohio River Watershed in Indiana (fig.7). Stream discharge at the time of sample collection was obtained from the active streamflow-gaging stations (noted by asterisk symbols in tables 1 and 2; listed in table 3 at the back of this report) and compared to the median daily mean discharge for the period of record at each station. For this comparison, the median daily mean discharge is the value for which 50 percent of the days are greater than this discharge and 50 percent of the days are less than this discharge for the long-term period of record ending with the 2000 water year.

Streamflow conditions varied during the 5-week sample-collection periods, May–June and July–August (fig. 7). Climatic data for southern Indiana indicated that precipitation amounts were below normal at the beginning of water year 2000 (Stewart and others, 2001). Near the end of the water year (June–September) when samples were collected for this study, precipitation was above average. On the basis of stream discharge from the five streamflow-gaging stations, 16 percent of the samples collected at these sites were collected at discharges above the median daily mean discharge (Stewart and others, 2001).

Only one of the Group 1 sites, Indian-Kentuck Creek near Canaan (fig. 7, site 12), was at or near a streamflow-gaging station; 40 percent of the samples at that site were collected at discharges above the long-term median daily mean discharge. Four of the Group 2 sites (fig. 7, sites 20, 23, 26, and 31) were at or near streamflow-gaging stations; 10 percent of the samples at those sites were collected at discharges above the long-term median daily mean discharge. Inspection of figure 7 indicates a general trend of increased concentration with increased discharge (although concentrations of *E. coli* can exceed the single-sample standard during low stream discharge and do not always exceed the standard at discharges greater than the median daily mean).

Relation between Concentrations of *Escherichia coli* and Turbidity

To determine if there was a relation between concentrations of *E. coli* and turbidity, data for samples collected in 1998 (Silcox and others, 2000), 1999 (Silcox and others, 2001), and 2000 were combined. Turbidity is a measure of the collective optical properties of a water sample that cause light to be scattered and absorbed rather than transmitted in straight lines (Wilde and Gibs, 1998). The primary contributors to turbidity include clay, silt, fine organic and inorganic matter, plankton, and microscopic organisms (American Public Health Association and others, 1992). Turbidity values measured in 1998 generally were greater than those measured during the studies in 1999 and 2000, due in part to higher streamflow discharges and runoff at the sites sampled in 1998. In 1998, 62 percent of the samples were collected at discharges above the long-term median daily mean discharge, compared to 18 percent in 1999 and 16 percent in 2000.

Turbidity data are plotted with concentrations of *E. coli* on figure 8 for data collected in 1998, 1999, and 2000, and for 1998 through 2000. Concentrations of *E. coli* exceeded the single-sample standard in 145 of 230 samples (15 percent) collected in 1998; in 1999, 126 of 289 samples (44 percent) exceeded the standard; and in 2000, 72

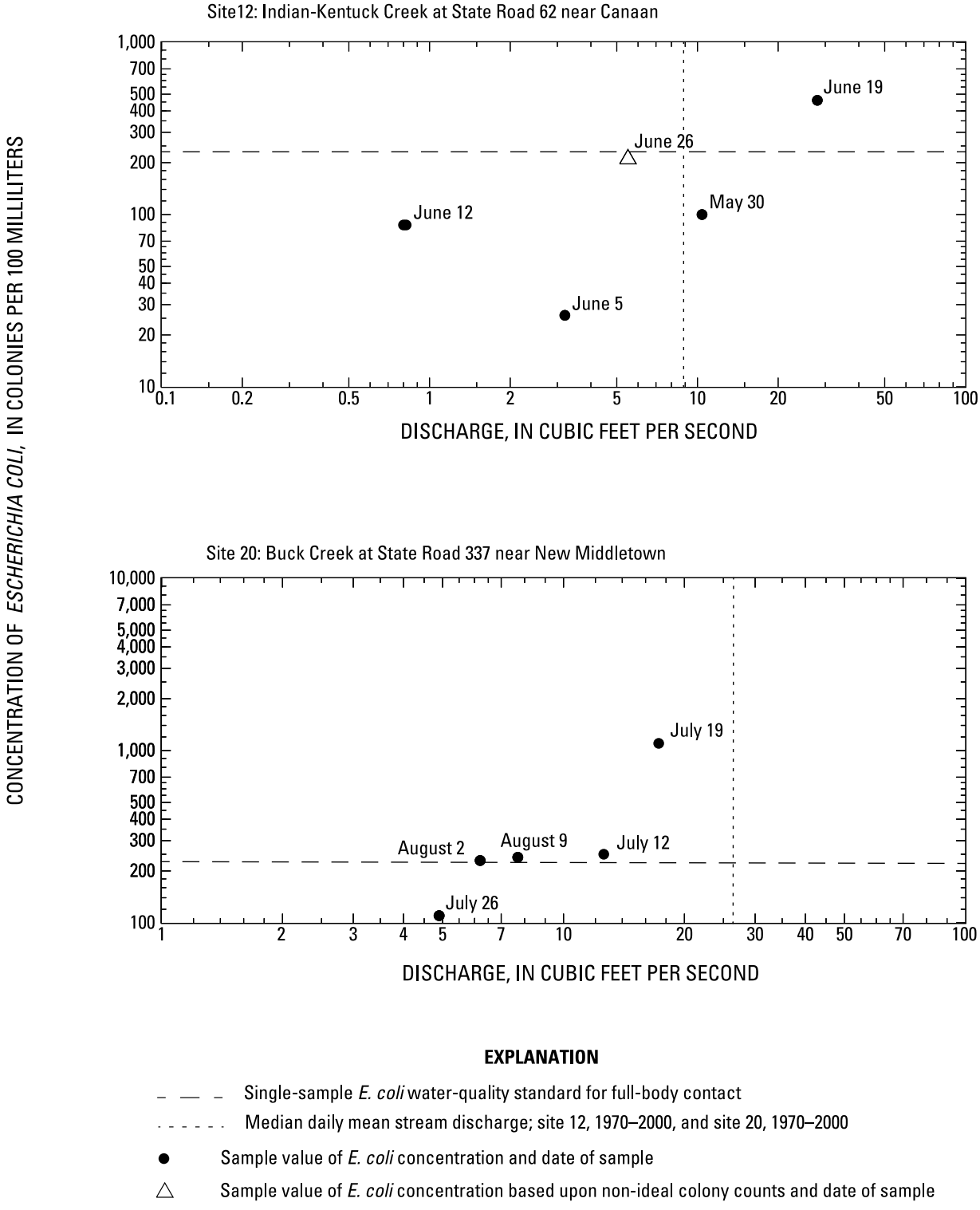


Figure 7. Stream discharge and concentrations of *Escherichia coli* for selected sites in the Ohio River Watershed in Indiana, May–August 2000.

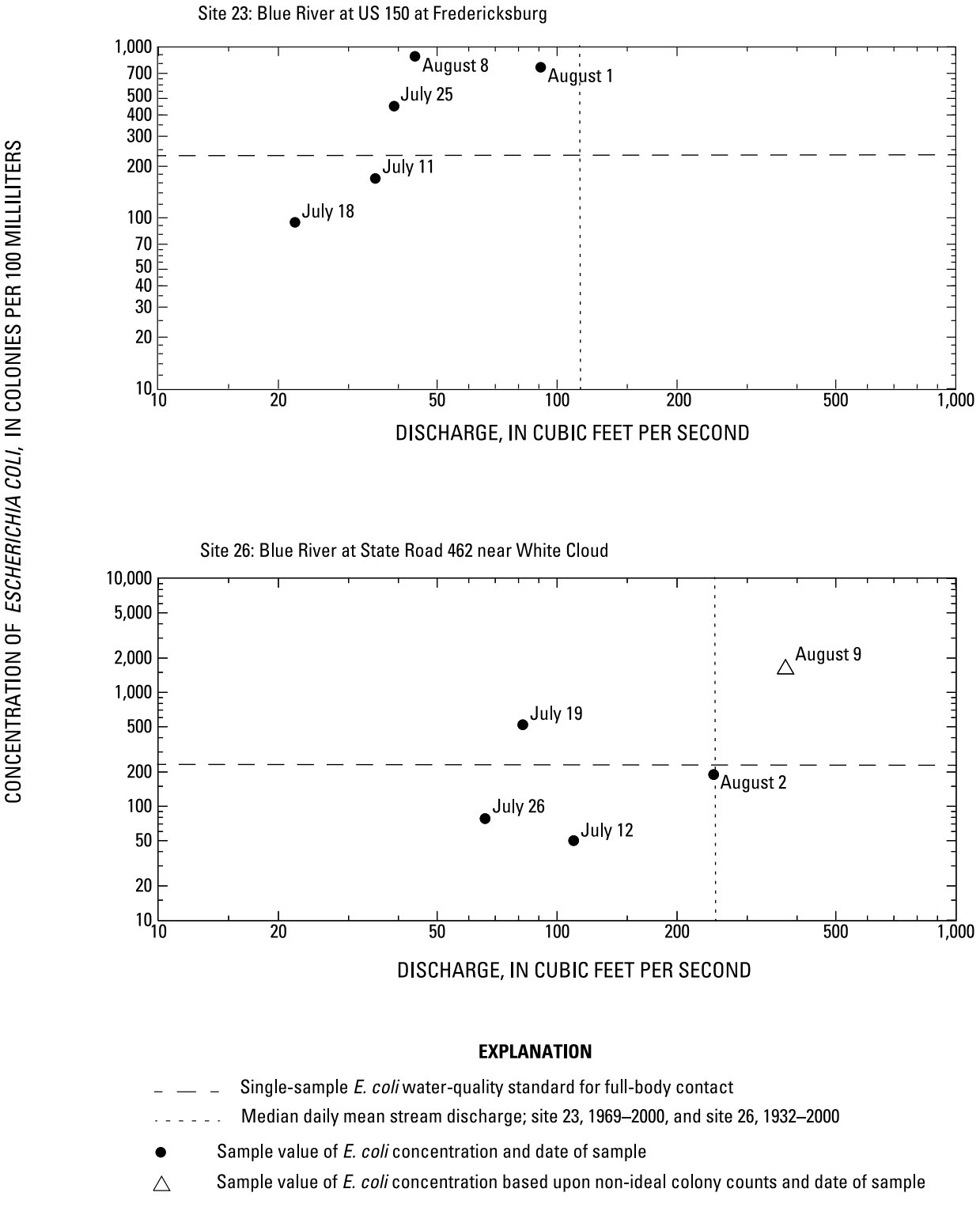


Figure 7. Stream discharge and concentrations of *Escherichia coli* for selected sites in the Ohio River Watershed in Indiana, May–August 2000—Continued.

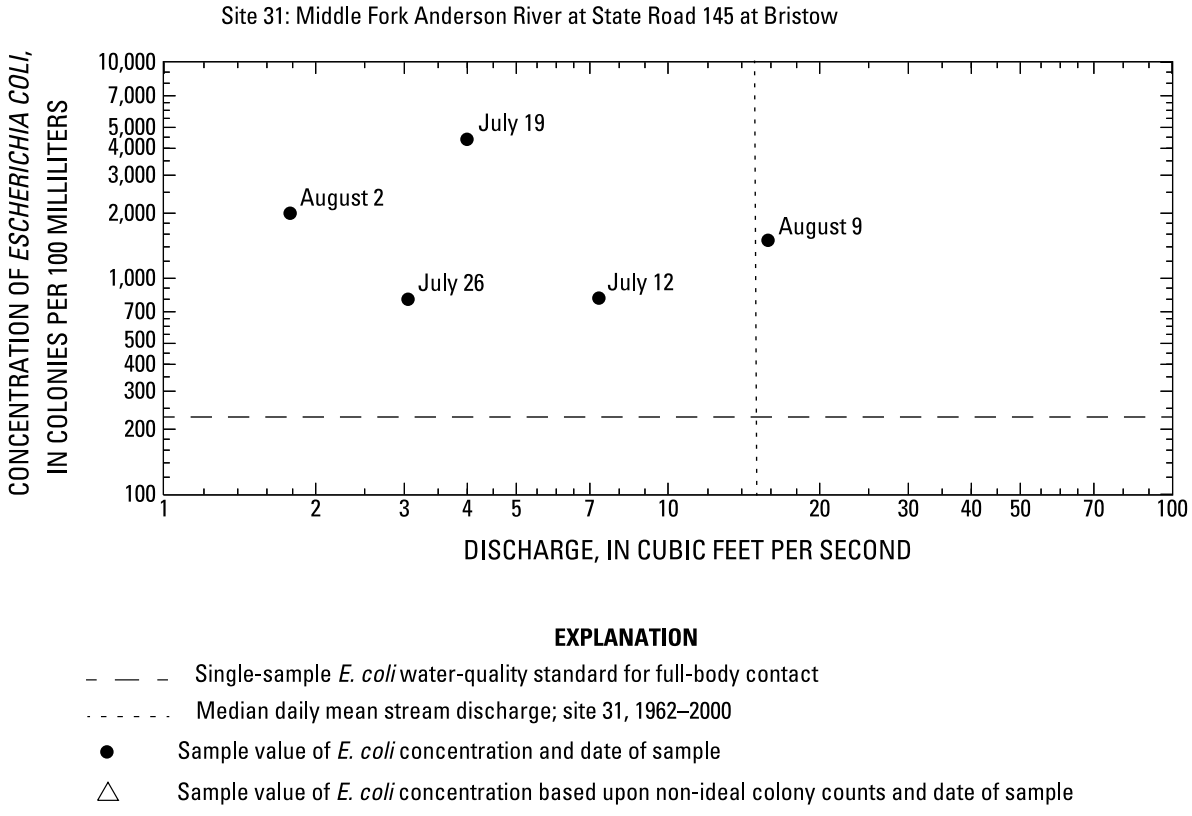


Figure 7. Stream discharge and concentrations of *Escherichia coli* for selected sites in the Ohio River Watershed in Indiana, May–August 2000—Continued.

of 200 samples (36 percent) exceeded the standard. Concentrations of *E. coli* exceeded the single-sample standard in 48 percent of the samples for the 3-year period. Statistically significant correlations were determined for data collected in 1998 ($p<0.001$), in 2000 ($p<0.001$), and for the combined 3-year data set ($p=0.001$). There was not a statistically significant correlation between concentrations of *E. coli* and turbidity in 1999.

A locally weighted scatterplot smoothing technique (LOWESS) was used to generate the lines in each scatterplot on figure 8. The LOWESS method was selected to depict the relation between turbidity and *E. coli* because it can accommodate outlying data (Helsel and Hirsch, 1992, p. 48). For data collected in 1998 and 1999, if the turbidity was greater than 83 nephelometric turbidity units (NTU), concentrations of *E. coli* in the sample always exceeded the single-sample standard. This was true for data collected in 2000, except for two samples from Pigeon Creek (sites 38 and 39, listed in table 3 at the back of this report) where the single-sample standard was not exceeded even though the measured turbidity was greater than 83 NTU.

The analysis indicates a general relation between concentrations of *E. coli* and turbidity, whereby increased turbidity indicates increased concentrations of *E. coli*. The value of turbidity above which all samples exceed a standard is variable and may be influenced by environmental factors in each watershed. Turbidity and *E. coli* data were collected with the same procedures for each of the 3 years, even though the data are from watersheds with different land uses and runoff rates

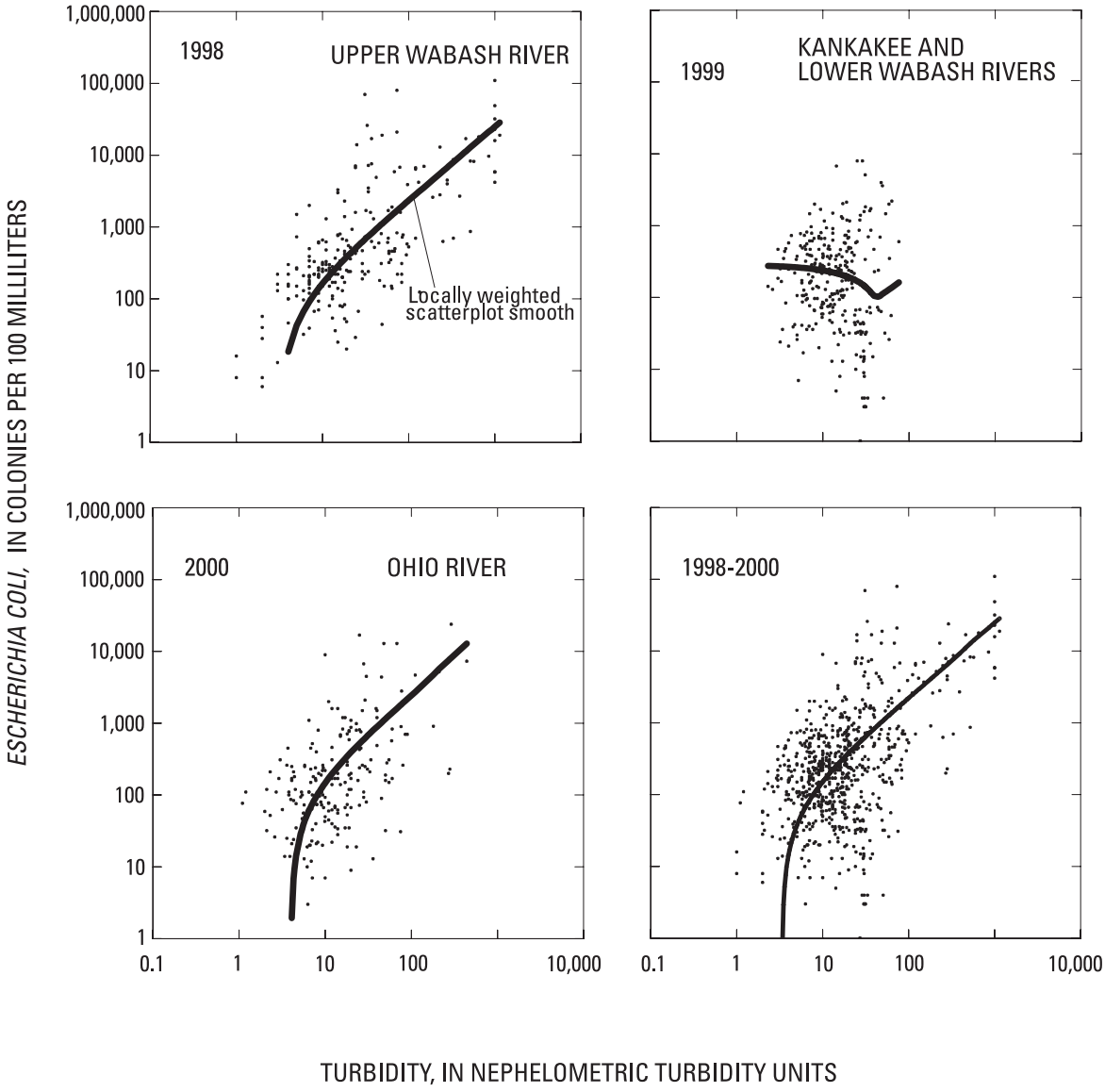


Figure 8. Turbidity and concentrations of *Escherichia coli* measured in samples collected at sites in the Upper and Lower Wabash, Kankakee, and Ohio River Watersheds in Indiana, June–September 1998 and 1999 and May–August 2000.

and the watersheds were sampled during various hydrologic conditions. In addition, if the measured turbidity was less than 83 NTU, concentrations of *E. coli* were not always below the single-sample standard, indicating that factors other than turbidity (such as soil type, land use, and the rate and duration of runoff) were affecting concentrations of *E. coli.*

Quality-Assurance Results

Quality-control samples consisted of 199 filter blanks, 54 process blanks, 15 field blanks, and 21 duplicate samples. Results of the quality-assurance and *E. coli* determinations are presented in table 4 at the back of this report. Blanks and duplicate samples are discussed separately.

Filter Blanks

Filter blanks were processed for 199 of the 200 samples collected (table 4). An oversight by the analyst resulted in a filter blank not being processed for the sample collected at site 1 on June 26. Concentrations of *E. coli* in the filter blanks ranged from 0 to 12 colonies per 100 mL. Only three of the 199 filter blanks exhibited observable *E. coli* growth—filter blanks processed for site 3 on June 27, site 10 on June 28, and site 31 on July 26. The presence of colonies on the filter blanks indicates a procedural error or that the glassware, the filtration equipment, and/or the saline buffer solution used for these three samples was contaminated. The filter blank associated with the sample from site 3 had a concentration of 12 colonies per 100 mL of *E. coli,* which was approximately 11 percent of the concentration in the environmental sample. Therefore, the result reported for the environmental sample was noted as being inconclusive. Filter blanks for samples from sites 10 and 31 contained concentrations of *E. coli* that were less than one-half percent of the environmental samples, indicating results for these samples probably are reliable.

Process Blanks

Nineteen of the 54 process blanks contained observable *E. coli* colonies. The maximum concentration of *E. coli* measured in the process blanks was 12 colonies per 100 mL; the presence of colonies indicates that the glassware or the filter-holding assembly used to process the sample was not rinsed completely or that the analyst made a procedural error. The process blank associated with the sample collected from site 1 on June 8 contained a concentration of *E. coli* that was 18.9 percent of the concentration in the environmental sample; concentrations of *E. coli* in the remaining process blanks were 2.5 percent or less of the concentration measured in the environmental sample. If the concentration of *E. coli* in the process blank is subtracted from the concentration in the environmental sample, in no cases would the result affect the comparison of the environmental sample with the water-quality standards.

Field Blanks

Fifteen field blanks were filtered during the study on randomly selected days determined by the analysts. Of the 15 field blanks, no *E. coli* colonies were present—indicating that there was no contamination resulting from transporting the samples and that there was adequate sterilization of the sample-collection bottles.

Duplicate Samples

Results of 21 concurrent duplicate samples collected from 20 sites were used to evaluate the natural variability in concentrations of *E. coli* for samples collected at the same time at a site. The natural log-percent difference between the two samples is shown in figure 9. The median difference between the environmental and duplicate samples was five colonies per 100 mL. The median natural log-percent difference between the environmental samples and the duplicate samples was 7 percent. A Wilcoxon signed-rank test (Helsel and Hirsch, 1992, p. 142) indicated no statistically significant differences between the environmental samples and

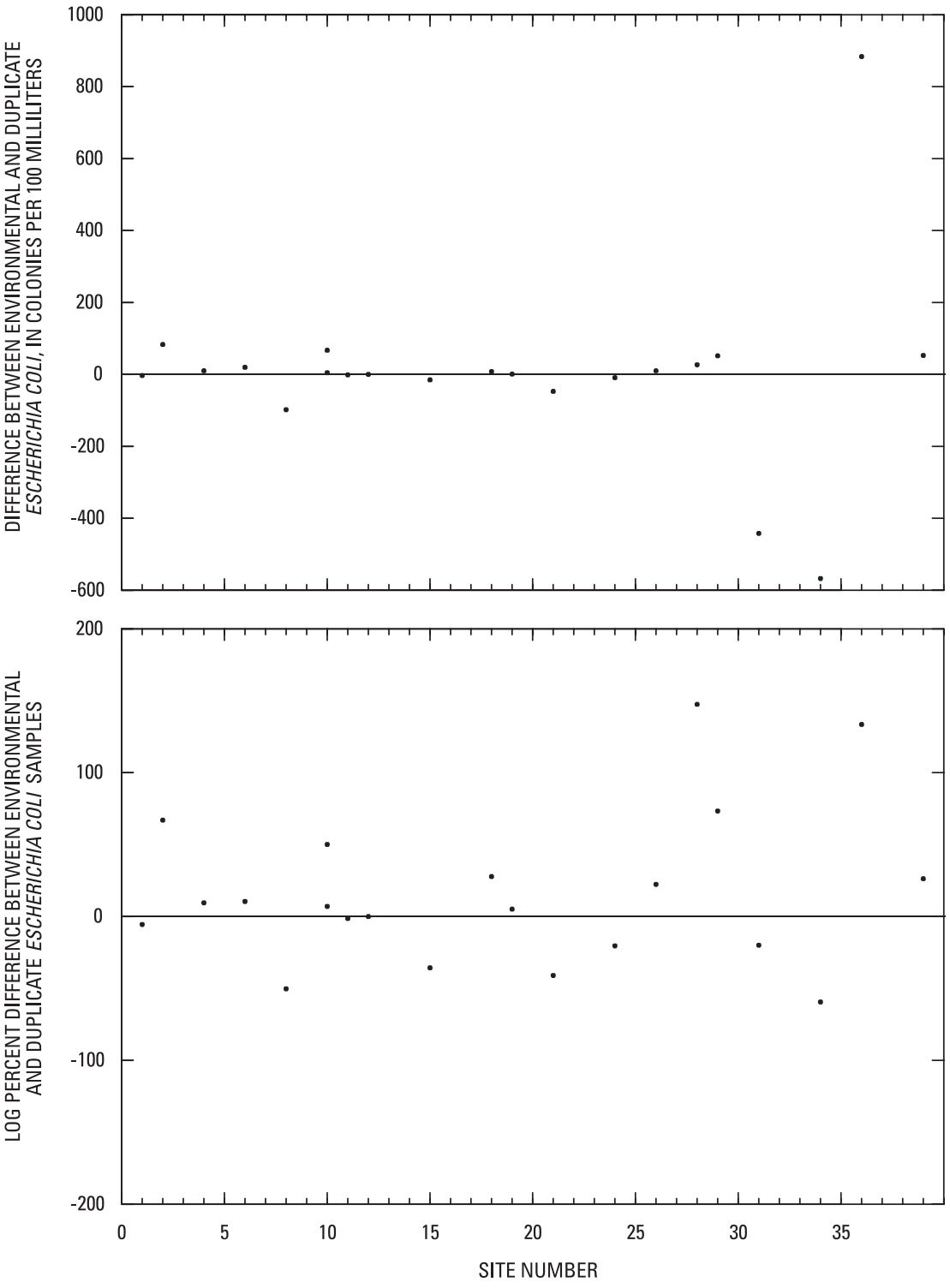


Figure 9. Difference between concentrations of *Escherichia coli* in environmental and duplicate samples and their natural log-percent differences. Samples were collected in the Ohio River Watershed in Indiana, May–August 2000.

the concurrent duplicate samples at the 5-percent significance level. The significance level obtained by the data, or the p-value, was 0.481.

Summary

Water samples collected from 40 stream sites in the Ohio River Watershed in Indiana, May–August 2000, were analyzed for concentrations of *E. coli*. Five samples were collected at 12 sites during May and June and at 28 other sites during July and August. A five-sample geometric mean was computed for each site. The five-sample geometric mean concentrations for all sites ranged from 11 to 1,500 colonies per 100 mL, and concentrations at 24 sites exceeded the five-sample geometric mean standard of 125 colonies per 100 mL. Of the 200 individual samples processed, 72 exceeded the single-sample standard of 235 colonies per 100 mL. Single-sample concentrations of *E. coli* ranged from K3 to 24,000 colonies per 100 mL during the study. The single-sample standard and/or the five-sample geometric mean standard for concentrations of *E. coli* in recreational waters were exceeded at 34 of the 40 sites.

Five of the 40 sites were at or near USGS streamflow-gaging stations. On the basis of records from these stations, 16 percent of the samples collected at these five sites were collected at streamflows above the median daily mean discharge. Results indicate a general trend of increased concentration with increased discharge, although concentrations of *E. coli* can exceed the single-sample standard during low stream discharge and do not always exceed the standard at discharges greater than the median daily mean.

E. coli concentration data and turbidity measurements collected in 1998 at streams within the Upper Wabash River Watershed and in 2000 at streams within the Ohio River Watershed showed a statistically significant correlation. The correlation was not as strong for the 1999 data collected in streams within the Kankakee and Lower Wabash River Watersheds but, overall, the combined data set for the 3 years was statistically significant. The concentration of *E. coli* always exceeded the single-sample standard when the turbidity exceeded 83 NTU for the studies in 1998 and 1999 and the majority of sample concentrations for the study in 2000. There were two occurrences in 2000 when the measured turbidity was greater than 83 NTU, but the single-sample standard for concentrations of *E. coli* was not exceeded. In contrast, when the measured turbidity was less than 83 NTU, concentrations of *E. coli* were not always below the single-sample standard.

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Supplemental Data

(Tables 3 and 4)

Table 3. Water-quality data for selected sites in the Ohio River Watershed in Indiana, May–August 2000

[--, no data; >, K, non-ideal colony count; date is month-day-year, time is in military notation]

Site number	Date	Time	Gage height[1] (feet)	Discharge at time of sample collection (cubic feet per second)	Water temperature (degrees Celsius)	pH (Standard units)	Dissolved oxygen (milligrams per liter)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	Turbidity (Nephelometric turbidity units)	*Escherichia coli* (colonies per 100 milliliters)
1	05-30-00	1230	70.50	--	18.0	7.6	8.1	375	40	490
1	06-08-00	1150	69.74	--	20.0	8.1	10.0	448	18	53
1	06-12-00	1126	69.64	--	25.0	8.2	12.5	449	9.3	20
1	06-19-00	1120	70.96	--	19.5	7.4	6.9	309	111	4,700
1	06-26-00	1045	70.00	--	24.5	7.9	7.4	438	34	310
	Five-sample geometric mean									**240**
2	05-31-00	1125	81.50	--	21.0	7.9	9.0	299	60	170
2	06-06-00	1530	81.00	--	23.0	9.0	15.1	294	14	62
2	06-13-00	1138	80.70	--	26.5	8.2	8.0	339	12	K22
2	06-20-00	1240	81.74	--	22.0	7.8	8.0	309	80	260
2	06-27-00	1141	81.05	--	24.5	8.2	8.8	338	18	K100
	Five-sample geometric mean									**90**
3	05-31-00	1000	67.10	--	21.0	7.7	7.5	301	75	31
3	06-06-00	1430	65.50	--	22.5	8.4	12.1	388	18	74
3	06-13-00	0955	65.84	--	25.5	7.5	7.9	359	17	67
3	06-20-00	1055	66.40	--	21.5	7.7	7.0	331	85	700
3	06-27-00	0947	65.95	--	26.0	8.1	9.3	398	28	K110
	Five-sample geometric mean									**100**
4	05-31-00	1035	68.10	--	20.5	8.3	11.6	458	2.7	110
4	06-06-00	1340	67.80	--	20.0	8.1	11.4	479	1.1	77
4	06-13-00	1028	67.69	--	24.0	8.0	8.1	343	1.2	110
4	06-20-00	1145	68.38	--	21.5	8.1	9.1	423	5.8	260
4	06-27-00	1015	68.00	--	23.0	8.0	8.2	460	2.3	210
	Five-sample geometric mean									**140**

Table 3. Water-quality data for selected sites in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Gage height[1] (feet)	Discharge at time of sample collection (cubic feet per second)	Water temperature (degrees Celsius)	pH (Standard units)	Dissolved oxygen (milligrams per liter)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	Turbidity (Nephelometric turbidity units)	*Escherichia coli* (colonies per 100 milliliters)
5	05-30-00	1335	79.50	--	18.5	8.1	10.6	440	6.8	150
5	06-05-00	1455	79.20	--	21.5	8.0	7.3	457	5.4	100
5	06-12-00	1223	79.06	--	26.5	7.9	7.2	484	6.2	K10
5	06-19-00	1225	79.51	--	20.0	8.0	8.5	356	26	450
5	06-26-00	1140	79.10	--	25.5	8.0	6.7	411	18	260
	Five-sample geometric mean									**110**
6	05-30-00	1430	77.40	--	20.0	8.5	11.1	394	8.4	200
6	06-05-00	1545	77.05	--	22.5	8.4	9.9	407	3.2	63
6	06-12-00	1357	76.76	--	24.5	8.4	10.5	421	2.9	170
6	06-19-00	1405	74.70	--	22.0	8.2	9.0	354	40	1,500
6	06-26-00	1225	76.45	--	25.5	8.5	12.1	434	4.6	76
	Five-sample geometric mean									**190**
7	05-31-00	0900	77.70	--	19.0	7.9	8.6	492	2.0	59
7	06-06-00	1110	77.53	--	20.0	7.8	7.5	487	2.1	32
7	06-13-00	0841	77.57	--	24.0	7.4	3.4	532	2.3	52
7	06-20-00	0940	77.75	--	19.5	8.1	8.9	464	3.6	260
7	06-27-00	0847	77.74	--	23.5	7.9	7.5	491	2.1	120
	Five-sample geometric mean									**80**
8	06-01-00	0840	78.80	--	24.0	8.0	7.7	385	30	K80
8	06-07-00	1040	78.28	--	22.5	8.1	7.9	379	36	K13
8	06-14-00	0847	78.69	--	27.5	8.3	9.0	384	20	K9
8	06-21-00	0915	78.93	--	24.5	7.6	5.8	313	55	150
8	06-28-00	0856	78.40	--	25.5	7.7	5.2	339	50	K32
	Five-sample geometric mean									**34**

Table 3. Water-quality data for selected sites in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Gage height[1] (feet)	Discharge at time of sample collection (cubic feet per second)	Water temperature (degrees Celsius)	pH (Standard units)	Dissolved oxygen (milligrams per liter)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	Turbidity (Nephelometric turbidity units)	*Escherichia coli* (colonies per 100 milliliters)
9	06-01-00	0950	86.20	--	22.0	7.8	6.3	447	20	67
9	06-07-00	1115	85.94	--	20.0	7.6	5.0	446	23	K19
9	06-14-00	0925	86.36	--	26.0	7.6	3.4	448	19	120
9	06-21-00	1105	86.37	--	21.5	7.8	6.8	434	25	430
9	06-28-00	0930	86.10	--	23.0	7.6	4.0	458	28	K93
	Five-sample geometric mean									**90**
10	06-01-00	1020	87.90	--	20.5	7.7	6.6	520	19	790
10	06-07-00	1230	87.80	--	17.5	6.7	7.6	548	14	170
10	06-14-00	0952	87.73	--	22.5	7.7	4.7	584	5.7	73
10	06-21-00	1135	88.10	--	22.0	7.7	6.9	481	19	770
10	06-28-00	1020	87.95	--	21.0	7.7	6.8	504	15	660
	Five-sample geometric mean									**350**
11	06-01-00	1105	58.50	--	20.5	7.7	6.3	398	25	240
11	06-07-00	1445	50.86	--	20.5	7.6	6.7	484	14	28
11	06-14-00	1030	51.10	--	24.5	7.6	4.9	514	10	220
11	06-21-00	1310	56.79	--	22.5	7.8	7.4	417	14	200
11	06-28-00	1105	50.60	--	22.0	7.6	6.4	444	25	72
	Five-sample geometric mean									**120**
12	05-30-00	1535	2.96	10.4	22.0	8.4	11.3	398	7.1	100
12	06-05-00	1656	2.73	3.2	22.5	8.2	10.3	408	2.6	26
12	06-12-00	1510	2.52	.8	28.0	7.8	9.1	453	4.0	87
12	06-19-00	1515	3.29	28	22.5	8.1	8.9	436	12	460
12	06-26-00	1400	2.79	5.5	25.5	8.2	12.4	452	4.3	K210
	Five-sample geometric mean									**120**

Table 3. Water-quality data for selected sites in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Gage height[1] (feet)	Discharge at time of sample collection (cubic feet per second)	Water temperature (degrees Celsius)	pH (Standard units)	Dissolved oxygen (milligrams per liter)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	Turbidity (Nephelometric turbidity units)	*Escherichia coli* (colonies per 100 milliliters)
13	07-10-00	1100	71.78	--	27.0	8.3	12.1	401	4.3	24
13	07-17-00	1205	71.87	--	28.0	8.3	12.2	377	4.1	160
13	07-24-00	1145	71.87	--	24.5	8.3	11.1	374	6.5	110
13	07-31-00	1153	71.99	--	23.5	7.7	7.2	241	18	290
13	08-07-00	1230	71.83	--	26.0	8.4	11.8	342	3.8	100
	Five-sample geometric mean									**100**
14	07-10-00	1135	59.09	--	26.0	7.8	7.4	397	4.4	180
14	07-17-00	1255	59.04	--	26.5	7.9	7.6	383	3.8	110
14	07-24-00	1220	59.16	--	24.5	7.8	7.5	303	4.5	120
14	07-31-00	1130	59.44	--	24.0	7.9	7.7	266	8.9	80
14	08-07-00	1300	59.06	--	25.5	7.7	6.9	306	4.1	250
	Five-sample geometric mean									**140**
15	07-10-00	1340	71.43	--	26.5	8.2	9.3	617	17	35
15	07-17-00	1355	71.10	--	27.5	7.9	7.3	528	12	1,600
15	07-24-00	1255	70.65	--	25.5	7.9	8.0	752	19	K35
15	07-31-00	1300	70.72	--	26.0	7.9	7.5	900	18	K19
15	08-07-00	1330	71.49	--	26.5	8.0	8.0	753	13	K36
	Five-sample geometric mean									**67**
16	07-10-00	1430	75.18	--	26.0	7.6	8.9	332	6.5	110
16	07-17-00	1450	74.42	--	24.5	7.6	7.5	337	7.0	64
16	07-24-00	1345	74.84	--	22.5	7.6	8.0	357	7.7	170
16	07-31-00	1345	74.93	--	24.0	7.6	7.0	334	7.8	160
16	08-07-00	1405	74.82	--	25.0	7.3	6.5	344	7.3	180
	Five-sample geometric mean									**130**

Table 3. Water-quality data for selected sites in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Gage height[1] (feet)	Discharge at time of sample collection (cubic feet per second)	Water temperature (degrees Celsius)	pH (Standard units)	Dissolved oxygen (milligrams per liter)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	Turbidity (Nephelometric turbidity units)	*Escherichia coli* (colonies per 100 milliliters)
17	07-10-00	1535	71.95	--	24.5	7.9	8.4	393	7.9	400
17	07-17-00	1535	71.75	--	23.0	7.7	8.2	400	8.0	74
17	07-24-00	1420	71.56	--	22.0	7.7	8.9	401	9.4	260
17	07-31-00	1415	71.82	--	21.0	7.4	6.2	421	29	2,100
17	08-07-00	1450	71.65	--	24.5	7.6	6.1	371	8.3	800
	Five-sample geometric mean									**420**
18	07-12-00	1405	91.52	--	28.0	8.1	8.5	417	5.6	K56
18	07-19-00	1225	92.58	--	24.5	7.9	7.6	508	30	4,500
18	07-26-00	1215	92.32	--	29.5	8.2	11.2	576	7.1	33
18	08-02-00	1110	92.72	--	27.0	8.2	9.7	399	15	690
18	08-09-00	1130	93.48	--	24.5	7.8	9.2	395	20	1,100
	Five-sample geometric mean									**360**
19	07-12-00	1035	71.60	--	26.0	7.8	7.8	406	9.5	240
19	07-19-00	1025	70.43	--	25.0	7.4	4.0	421	18	710
19	07-26-00	1010	69.68	--	22.5	7.4	4.0	447	12	40
19	08-02-00	0935	70.93	--	23.5	7.4	2.5	433	6.6	K20
19	08-09-00	1005	72.82	--	24.5	7.4	3.1	405	16	830
	Five-sample geometric mean									**160**
20	07-12-00	1300	1.69	13.3	25.0	8.0	8.6	377	5.8	250
20	07-19-00	1135	1.84	18.1	23.5	7.8	7.1	351	6.5	1,100
20	07-26-00	1100	1.73	4.9	21.5	7.8	7.8	354	5.3	110
20	08-02-00	1025	1.83	6.2	23.0	7.9	6.9	378	6.8	230
20	08-09-00	1055	1.85	7.7	24.0	7.8	8.1	357	7.7	240
	Five-sample geometric mean									**280**

Table 3. Water-quality data for selected sites in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Gage height[1] (feet)	Discharge at time of sample collection (cubic feet per second)	Water temperature (degrees Celsius)	pH (Standard units)	Dissolved oxygen (milligrams per liter)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	Turbidity (Nephelometric turbidity units)	*Escherichia coli* (colonies per 100 milliliters)
21	07-11-00	1030	65.90	--	26.0	7.5	5.2	556	9.3	220
21	07-18-00	1130	65.76	--	25.0	7.4	5.3	664	12	62
21	07-26-00	1030	66.05	--	21.5	7.4	5.5	841	11	K60
21	08-01-00	1000	66.10	--	22.5	7.4	5.3	567	48	K13,000
21	08-08-00	1010	66.03	--	24.5	7.4	4.9	823	10	93
	Five-sample geometric mean									**250**
22	07-11-00	0920	67.00	--	28.0	8.0	8.9	299	6.3	K3
22	07-18-00	1035	67.30	--	27.0	7.6	6.4	336	10	50
22	07-25-00	0930	66.95	--	24.5	7.3	4.1	340	10	K7
22	08-01-00	0910	67.20	--	24.5	7.3	2.8	323	7.1	K7
22	08-08-00	0925	67.65	--	26.5	7.7	7.0	332	6.7	K20
	Five-sample geometric mean									**11**
23	07-11-00	1440	2.29	35	24.5	7.9	8.6	409	11	170
23	07-18-00	1430	2.11	22	24.5	8.0	9.6	440	5.2	94
23	07-25-00	1325	2.33	39	21.0	8.0	9.7	447	6.8	450
23	08-01-00	1305	2.77	91	22.5	7.9	7.5	405	26	760
23	08-08-00	1320	2.38	44	22.5	7.8	7.4	431	20	880
	Five-sample geometric mean									**340**
24	07-11-00	1130	79.08	--	25.0	7.9	8.0	418	9.1	110
24	07-18-00	1220	79.00	--	23.5	7.9	7.1	434	7.8	40
24	07-25-00	1125	79.03	--	21.5	7.9	7.9	404	12	170
24	08-01-00	1050	79.42	--	20.0	7.5	6.8	361	77	2,800
24	08-08-00	1110	79.02	--	24.0	7.8	6.5	410	8.6	97
	Five-sample geometric mean									**180**

Table 3. Water-quality data for selected sites in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Gage height[1] (feet)	Discharge at time of sample collection (cubic feet per second)	Water temperature (degrees Celsius)	pH (Standard units)	Dissolved oxygen (milligrams per liter)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	Turbidity (Nephelometric turbidity units)	*Escherichia coli* (colonies per 100 milliliters)
25	07-11-00	1240	70.97	--	26.0	8.2	9.9	400	8	74
25	07-18-00	1330	70.99	--	27.0	8.3	10.3	401	6.2	K19
25	07-25-00	1210	71.11	--	23.0	8.1	9.4	321	14	56
25	08-01-00	1155	71.94	--	24.0	8.1	8.3	422	19	590
25	08-08-00	1210	71.06	--	24.5	8.0	7.8	407	9	110
	Five-sample geometric mean									**87**
26	07-12-00	0900	66.72	110	24.0	7.7	6.7	434	6.2	50
26	07-19-00	0930	66.58	82	23.5	7.8	6.8	450	7.1	520
26	07-26-00	0850	66.50	66	21.5	7.7	7.0	386	11	78
26	08-02-00	0845	67.31	247	23.0	7.8	7.2	454	9.0	190
26	08-09-00	0915	67.65	374	21.5	7.5	7.8	488	14	K1,600
	Five-sample geometric mean									**230**
27	07-10-00	1250	67.92	--	24.5	7.1	2.7	281	12	310
27	07-17-00	1242	67.70	--	24.5	7.2	2.1	320	8.2	22
27	07-24-00	1532	68.01	--	22.5	7.3	2.2	307	10	9,000
27	07-31-00	1405	67.56	--	23.0	7.2	2.5	279	28	6,700
27	08-07-00	1330	68.19	--	25.0	7.2	3.4	260	13	67
	Five-sample geometric mean									**490**
28	07-10-00	1343	78.20	--	23.0	7.1	.7	301	4.6	35
28	07-17-00	1355	77.90	--	22.5	7.2	3.2	333	7.9	21
28	07-24-00	1615	78.28	--	21.0	7.2	.9	315	6.9	K12
28	07-31-00	1450	77.71	--	22.5	7.2	2.6	306	14	K34
28	08-07-00	1420	78.34	--	23.5	7.1	2.3	277	9.6	67
	Five-sample geometric mean									**29**

Table 3. Water-quality data for selected sites in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Gage height[1] (feet)	Discharge at time of sample collection (cubic feet per second)	Water temperature (degrees Celsius)	pH (Standard units)	Dissolved oxygen (milligrams per liter)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	Turbidity (Nephelometric turbidity units)	*Escherichia coli* (colonies per 100 milliliters)
29	07-10-00	1210	71.90	--	25.0	7.5	7.1	305	11	77
29	07-17-00	1205	71.80	--	25.5	7.7	7.3	335	11	45
29	07-24-00	1412	71.83	--	21.5	7.5	5.2	326	13	170
29	07-31-00	1250	71.95	--	22.5	7.3	4.5	321	13	70
29	08-07-00	1230	71.85	--	25.0	7.4	5.1	289	9.4	100
	Five-sample geometric mean									**84**
30	07-10-00	1440	85.72	--	24.0	7.0	1.7	244	3.6	25
30	07-17-00	1506	85.43	--	24.0	7.1	2.7	266	3.9	K14
30	07-24-00	1701	85.88	--	22.0	7.1	2.0	260	3.4	K14
30	07-31-00	1540	85.62	--	23.0	7.1	2.5	258	4.1	K21
30	08-07-00	1520	85.77	--	24.0	7.1	2.0	242	5.7	K13
	Five-sample geometric mean									**17**
31	07-12-00	1147	6.72	5.9	26.0	7.0	3.3	186	25	810
31	07-19-00	1055	6.59	3.1	25.0	7.0	3.7	165	45	4,400
31	07-26-00	1202	6.52	2.3	22.0	7.0	4.7	158	23	800
31	08-02-00	1250	6.44	1.2	25.0	6.9	2.5	216	11	2,000
31	08-09-00	1210	7.04	16	25.0	7.0	5.9	149	27	1,500
	Five-sample geometric mean									**1,500**
32	07-12-00	1105	72.74	--	25.0	7.0	2.3	292	12	140
32	07-19-00	1005	72.57	--	23.5	7.1	2.2	297	3.7	450
32	07-26-00	1120	72.53	--	20.5	7.1	1.9	318	7.0	23
32	08-02-00	1155	72.82	--	23.0	7.1	4.0	264	15	140
32	08-09-00	1125	75.85	--	23.0	6.7	4.5	131	290	24,000
	Five-sample geometric mean									**350**

Table 3. Water-quality data for selected sites in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Gage height[1] (feet)	Discharge at time of sample collection (cubic feet per second)	Water temperature (degrees Celsius)	pH (Standard units)	Dissolved oxygen (milligrams per liter)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	Turbidity (Nephelometric turbidity units)	*Escherichia coli* (colonies per 100 milliliters)
33	07-12-00	1009	67.05	--	25.5	7.3	3.9	457	18	260
33	07-19-00	0930	67.00	--	24.5	7.3	3.0	458	40	1,200
33	07-26-00	1030	67.03	--	22.5	7.4	4.9	445	17	150
33	08-02-00	1055	67.10	--	23.5	7.3	4.0	632	19	190
33	08-09-00	1045	67.99	--	24.0	7.0	3.6	277	270	7,900
	Five-sample geometric mean									**590**
34	07-12-00	0925	79.40	--	26.0	7.0	1.3	462	52	280
34	07-19-00	0900	79.55	--	25.0	7.2	2.9	549	90	700
34	07-26-00	0950	79.33	--	21.5	7.2	2.3	736	45	90
34	08-02-00	0950	79.30	--	24.5	7.6	8.8	513	33	740
34	08-09-00	1010	79.95	--	24.0	6.9	2.8	357	68	K13,000
	Five-sample geometric mean									**700**
35	07-12-00	0835	71.97	--	26.0	7.5	4.3	1,800	20	200
35	07-19-00	0815	71.90	--	25.5	7.6	4.7	2,000	27	260
35	07-26-00	0855	71.70	--	22.0	7.6	5.6	2,000	20	120
35	08-02-00	0905	76.41	--	23.0	6.8	4.2	391	59	570
35	08-09-00	0910	78.14	--	23.5	6.8	5.4	302	210	5,200
	Five-sample geometric mean									**450**
36	07-11-00	1243	83.71	--	26.5	8.3	12.0	1,700	16	1,200
36	07-18-00	1230	83.75	--	29.5	8.1	9.8	1,900	17	1,200
36	07-25-00	1458	83.73	--	29.5	8.7	--	1,900	3	310
36	08-01-00	1530	83.84	--	28.0	7.5	7.8	1,600	23	990
36	08-08-00	1325	84.24	--	25.0	7.4	6.5	1,400	76	900
	Five-sample geometric mean									**830**

Table 3. Water-quality data for selected sites in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Gage height[1] (feet)	Discharge at time of sample collection (cubic feet per second)	Water temperature (degrees Celsius)	pH (Standard units)	Dissolved oxygen (milligrams per liter)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	Turbidity (Nephelometric turbidity units)	*Escherichia coli* (colonies per 100 milliliters)
37	07-11-00	1205	75.37	--	27.5	8.0	6.5	1,800	60	830
37	07-18-00	1105	75.27	--	27.5	8.1	8.5	1,900	33	210
37	07-25-00	1425	75.14	--	27.0	8.3	13.0	2,000	24	160
37	08-01-00	1450	76.53	--	26.5	7.7	7.7	1,300	55	310
37	08-08-00	1300	75.90	--	25.0	7.6	6.5	1,400	39	K1,600
	Five-sample geometric mean									**430**
38	07-11-00	1107	64.92	--	26.5	7.5	2.6	1,300	25	17,000
38	07-18-00	1030	64.68	--	26.0	7.6	3.3	1,500	50	160
38	07-25-00	1228	64.80	--	23.0	7.7	4.3	1,900	50	190
38	08-01-00	1250	68.83	--	23.0	7.4	5.1	880	180	910
38	08-08-00	1045	71.32	--	23.5	6.9	3.8	212	280	K230
	Five-sample geometric mean									**640**
39	07-11-00	1025	55.57	--	26.0	7.6	4.2	1,100	29	250
39	07-18-00	0950	56.43	--	25.5	7.6	4.3	1,300	20	170
39	07-25-00	1141	55.25	--	22.5	7.6	5.8	1,700	31	230
39	08-01-00	1135	56.54	--	22.5	7.4	5.4	846	270	200
39	08-08-00	1030	61.15	--	23.5	6.9	4.1	186	440	7,300
	Five-sample geometric mean									**430**
40	07-11-00	0942	96.57	--	28.0	7.0	.4	412	4.3	K84
40	07-18-00	0900	96.58	--	26.0	7.0	.6	463	4.1	170
40	07-25-00	1010	96.61	--	23.0	7.2	1.2	489	5.4	K47
40	08-01-00	0950	96.73	--	24.5	7.1	1.9	479	9.9	K43
40	08-08-00	0940	96.80	--	26.5	7.0	1.7	449	9.1	73
	Five-sample geometric mean									**73**

[1]Gage height number is either from a gage recorder or computed by subtracting the tape down value measured from a fixed point on a bridge from an arbitrary datum value of 100.

Table 4. Quality-assurance data associated with *Escherichia coli* samples collected in the Ohio River Watershed in Indiana, May–August 2000

[K, non-ideal colony count; --, no data]

Site number	Date	Time	Environmental sample (colonies per 100 milliliters)	Filter blank	Process blank	Field blank	Concurrent duplicate *Escherichia coli* (colonies per 100 milliliters)	Natural log-percent difference
1	05-30-00	1230	490	0	--	--	--	--
1	06-08-00	1150	53	0	10	--	56	-6
1	06-12-00	1126	20	0	--	--	--	--
1	06-19-00	1120	4,700	0	--	--	--	--
1	06-26-00	1045	310	--	--	--	--	--
2	05-31-00	1125	170	0	0	--	87	67
2	06-06-00	1530	62	0	0	0	--	--
2	06-13-00	1138	K22	0	--	--	--	--
2	06-20-00	1240	260	0	0	--	--	--
2	06-27-00	1141	K100	0	--	--	--	--
3	05-31-00	1000	31	0	--	--	--	--
3	06-06-00	1430	74	0	--	--	--	--
3	06-13-00	0955	67	0	--	--	--	--
3	06-20-00	1055	700	0	--	--	--	--
3	06-27-00	0947	K110	12	--	--	--	--
4	05-31-00	1035	110	0	--	--	--	--
4	06-06-00	1340	77	0	--	--	--	--
4	06-13-00	1028	110	0	0	--	100	10
4	06-20-00	1145	260	0	--	--	--	--
4	06-27-00	1015	210	0	1	--	--	--
5	05-30-00	1335	150	0	--	--	--	--
5	06-05-00	1455	100	0	--	--	--	--
5	06-12-00	1223	K10	0	--	--	--	--
5	06-19-00	1225	450	0	--	--	--	--
5	06-26-00	1140	260	0	--	--	--	--

Table 4. Quality-assurance data associated with *Escherichia coli* samples collected in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Environmental sample (colonies per 100 milliliters)	Filter blank	Process blank	Field blank	Concurrent duplicate *Escherichia coli* (colonies per 100 milliliters)	Natural log-percent difference
6	05-30-00	1430	200	0	--	--	180	11
6	06-05-00	1545	63	0	--	--	--	--
6	06-12-00	1357	170	0	--	--	--	--
6	06-19-00	1405	1,500	0	--	--	--	--
6	06-26-00	1225	76	0	--	--	--	--
7	05-31-00	0900	59	0	--	--	--	--
7	06-06-00	1110	32	0	--	--	--	--
7	06-13-00	0841	52	0	--	--	--	--
7	06-20-00	0940	260	0	--	0	--	--
7	06-27-00	0847	120	0	--	--	--	--
8	06-01-00	0840	K80	0	--	0	--	--
8	06-07-00	1040	K13	0	--	--	--	--
8	06-14-00	0847	K9	0	--	--	--	--
8	06-21-00	0915	150	0	--	--	248	-50
8	06-28-00	0856	K32	0	--	--	--	--
9	06-01-00	0950	67	0	--	--	--	--
9	06-07-00	1115	K19	0	--	--	--	--
9	06-14-00	0925	120	0	0	--	--	--
9	06-21-00	1105	430	0	--	--	--	--
9	06-28-00	0930	K93	0	--	--	--	--
10	06-01-00	1020	790	0	0	--	--	--
10	06-07-00	1230	170	0	0	--	103	50
10	06-14-00	0952	73	0	--	--	68	7
10	06-21-00	1135	770	0	0	--	--	--
10	06-28-00	1020	660	3	--	--	--	--

Table 4. Quality-assurance data associated with *Escherichia coli* samples collected in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Environmental sample (colonies per 100 milliliters)	Filter blank	Process blank	Field blank	Concurrent duplicate *Escherichia coli* (colonies per 100 milliliters)	Natural log-percent difference
11	06-01-00	1105	240	0	--	--	--	--
11	06-07-00	1445	28	0	--	--	--	--
11	06-14-00	1030	220	0	--	--	--	--
11	06-21-00	1310	200	0	--	--	--	--
11	06-28-00	1105	72	0	--	--	K73	-1
12	05-30-00	1535	100	0	0	--	--	--
12	06-05-00	1656	26	0	--	--	--	--
12	06-12-00	1510	87	0	0	0	--	--
12	06-19-00	1515	460	0	0	--	460	0
12	06-26-00	1400	K210	0	0	0	--	--
13	07-10-00	1100	24	0	--	--	--	--
13	07-17-00	1205	160	0	0	0	--	--
13	07-24-00	1145	110	0	--	0	--	--
13	07-31-00	1153	290	0	--	0	--	--
13	08-07-00	1230	100	0	--	0	--	--
14	07-10-00	1135	180	0	--	--	--	--
14	07-17-00	1255	110	0	0	--	--	--
14	07-24-00	1220	120	0	--	--	--	--
14	07-31-00	1130	80	0	--	--	--	--
14	08-07-00	1300	250	0	--	--	--	--
15	07-10-00	1340	35	0	--	--	K50	-36
15	07-17-00	1355	1,600	0	3	--	--	--
15	07-24-00	1255	K35	0	--	--	--	--
15	07-31-00	1300	K19	0	--	--	--	--
15	08-07-00	1330	K36	0	--	--	--	--

Table 4. Quality-assurance data associated with *Escherichia coli* samples collected in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Environmental sample (colonies per 100 milliliters)	Filter blank	Process blank	Field blank	Concurrent duplicate *Escherichia coli* (colonies per 100 milliliters)	Natural log-percent difference
16	07-10-00	1430	110	0	--	--	--	--
16	07-17-00	1450	64	0	1	--	--	--
16	07-24-00	1345	170	0	--	--	--	--
16	07-31-00	1345	160	0	1	--	--	--
16	08-07-00	1405	180	0	--	--	--	--
17	07-10-00	1535	400	0	0	--	--	--
17	07-17-00	1535	74	0	1	--	--	--
17	07-24-00	1420	260	0	1	--	--	--
17	07-31-00	1415	2,100	0	5	--	--	--
17	08-07-00	1450	800	0	1	--	--	--
18	07-12-00	1405	K56	0	--	--	--	--
18	07-19-00	1225	4,500	0	1	--	--	--
18	07-26-00	1215	33	0	--	--	K25	28
18	08-02-00	1110	690	0	0	--	--	--
18	08-09-00	1130	1,100	0	12	--	--	--
19	07-12-00	1035	240	0	--	--	--	--
19	07-19-00	1025	710	0	--	--	--	--
19	07-26-00	1010	40	0	--	--	--	--
19	08-02-00	0935	K20	0	--	--	K19	5
19	08-09-00	1005	830	0	--	--	--	--
20	07-12-00	1300	250	0	0	0	--	--
20	07-19-00	1135	1,100	0	--	--	--	--
20	07-26-00	1100	110	0	--	--	--	--
20	08-02-00	1025	230	0	--	--	--	--
20	08-09-00	1055	240	0	--	--	--	--

Table 4. Quality-assurance data associated with *Escherichia coli* samples collected in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Environmental sample (colonies per 100 milliliters)	Filter blank	Process blank	Field blank	Concurrent duplicate *Escherichia coli* (colonies per 100 milliliters)	Natural log-percent difference
21	07-11-00	1030	220	0	--	--	--	--
21	07-18-00	1130	62	0	0	--	--	--
21	07-26-00	1030	K60	0	--	--	--	--
21	08-01-00	1000	K13,000	0	--	--	--	--
21	08-08-00	1010	93	0	--	--	K140	-41
22	07-11-00	0920	K3	0	--	--	--	--
22	07-18-00	1035	50	0	0	--	--	--
22	07-25-00	0930	K7	0	--	--	--	--
22	08-01-00	0910	K7	0	--	--	--	--
22	08-08-00	0925	K20	0	--	--	--	--
23	07-11-00	1440	170	0	0	--	--	--
23	07-18-00	1430	94	0	0	--	--	--
23	07-25-00	1325	450	0	1	--	--	--
23	08-01-00	1305	760	0	1	--	--	--
23	08-08-00	1320	880	0	1	--	--	--
24	07-11-00	1130	110	0	--	--	--	--
24	07-18-00	1220	40	0	1	--	49	-20
24	07-25-00	1125	170	0	--	--	--	--
24	08-01-00	1050	2,800	0	--	--	--	--
24	08-08-00	1110	97	0	--	--	--	--
25	07-11-00	1240	74	0	--	--	--	--
25	07-18-00	1330	K19	0	0	--	--	--
25	07-25-00	1210	56	0	--	--	--	--
25	08-01-00	1155	590	0	--	--	--	--
25	08-08-00	1210	110	0	--	--	--	--

Table 4. Quality-assurance data associated with *Escherichia coli* samples collected in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Environmental sample (colonies per 100 milliliters)	Filter blank	Process blank	Field blank	Concurrent duplicate *Escherichia coli* (colonies per 100 milliliters)	Natural log-percent difference
26	07-12-00	0900	50	0	--	--	40	22
26	07-19-00	0930	520	0	--	--	--	--
26	07-26-00	0850	78	0	--	--	--	--
26	08-02-00	0845	190	0	--	--	--	--
26	08-09-00	0915	K1,600	0	--	--	--	--
27	07-10-00	1250	310	0	--	--	--	--
27	07-17-00	1242	22	0	0	0	--	--
27	07-24-00	1532	9,000	0	--	0	--	--
27	07-31-00	1405	6,700	0	--	0	--	--
27	08-07-00	1330	67	0	--	--	--	--
28	07-10-00	1343	35	0	0	--	K8	148
28	07-17-00	1355	21	0	--	--	--	--
28	07-24-00	1615	K12	0	0	--	--	--
28	07-31-00	1450	K34	0	0	--	--	--
28	08-07-00	1420	67	0	--	--	--	--
29	07-10-00	1210	77	0	--	--	--	--
29	07-17-00	1205	45	0	--	--	--	--
29	07-24-00	1412	170	0	0	--	--	--
29	07-31-00	1250	70	0	--	--	--	--
29	08-07-00	1230	100	0	--	--	48	73
30	07-10-00	1440	25	0	--	--	--	--
30	07-17-00	1506	K14	0	--	--	--	--
30	07-24-00	1701	K14	0	--	--	--	--
30	07-31-00	1540	K21	0	--	--	--	--
30	08-07-00	1520	K13	0	--	0	--	--

Table 4. Quality-assurance data associated with *Escherichia coli* samples collected in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Environmental sample (colonies per 100 milliliters)	Filter blank	Process blank	Field blank	Concurrent duplicate *Escherichia coli* (colonies per 100 milliliters)	Natural log-percent difference
31	07-12-00	1147	810	0	--	--	--	--
31	07-19-00	1055	4,400	0	--	--	--	--
31	07-26-00	1202	800	1	1	--	--	--
31	08-02-00	1250	2,000	0	0	--	2,442	-20
31	08-09-00	1210	1,500	0	1	--	--	--
32	07-12-00	1105	140	0	--	--	--	--
32	07-19-00	1005	450	0	0	--	--	--
32	07-26-00	1120	23	0	--	--	--	--
32	08-02-00	1155	140	0	--	--	--	--
32	08-09-00	1125	24,000	0	--	--	--	--
33	07-12-00	1009	260	0	0	--	--	--
33	07-19-00	0930	1,200	0	--	--	--	--
33	07-26-00	1030	150	0	0	--	--	--
33	08-02-00	1055	190	0	--	--	--	--
33	08-09-00	1045	7,900	0	--	--	--	--
34	07-12-00	0925	280	0	--	0	--	--
34	07-19-00	0900	700	0	--	--	1,267	-59
34	07-26-00	0950	90	0	--	--	--	--
34	08-02-00	0950	740	0	--	--	--	--
34	08-09-00	1010	K13,000	0	--	--	--	--
35	07-12-00	0835	200	0	--	--	--	--
35	07-19-00	0815	260	0	--	--	--	--
35	07-26-00	0855	120	0	--	--	--	--
35	08-02-00	0905	570	0	--	--	--	--
35	08-09-00	0910	5,200	0	--	--	--	--

Table 4. Quality-assurance data associated with *Escherichia coli* samples collected in the Ohio River Watershed in Indiana, May–August 2000—Continued

Site number	Date	Time	Environmental sample (colonies per 100 milliliters)	Filter blank	Process blank	Field blank	Concurrent duplicate *Escherichia coli* (colonies per 100 milliliters)	Natural log-percent difference
36	07-11-00	1243	1,200	0	0	--	316	133
36	07-18-00	1230	1,200	0	--	--	--	--
36	07-25-00	1458	310	0	0	--	--	--
36	08-01-00	1530	990	0	0	--	--	--
36	08-08-00	1325	900	0	5	--	--	--
37	07-11-00	1205	830	0	--	--	--	--
37	07-18-00	1105	210	0	--	--	--	--
37	07-25-00	1425	160	0	2	--	--	--
37	08-01-00	1450	310	0	--	--	--	--
37	08-08-00	1300	K1,600	0	--	--	--	--
38	07-11-00	1107	17,000	0	--	--	--	--
38	07-18-00	1030	160	0	--	--	--	--
38	07-25-00	1228	190	0	--	--	--	--
38	08-01-00	1250	910	0	--	--	--	--
38	08-08-00	1045	K230	0	--	--	--	--
39	07-11-00	1025	250	0	--	--	--	--
39	07-18-00	0950	170	0	--	--	--	--
39	07-25-00	1141	230	0	--	--	177	26
39	08-01-00	1135	200	0	--	--	--	--
39	08-08-00	1030	7,300	0	--	--	--	--
40	07-11-00	0942	K84	0	--	--	--	--
40	07-18-00	0900	170	0	0	--	--	--
40	07-25-00	1010	K47	0	--	--	--	--
40	08-01-00	0950	K43	0	--	--	--	--
40	08-08-00	0940	73	0	--	--	--	--