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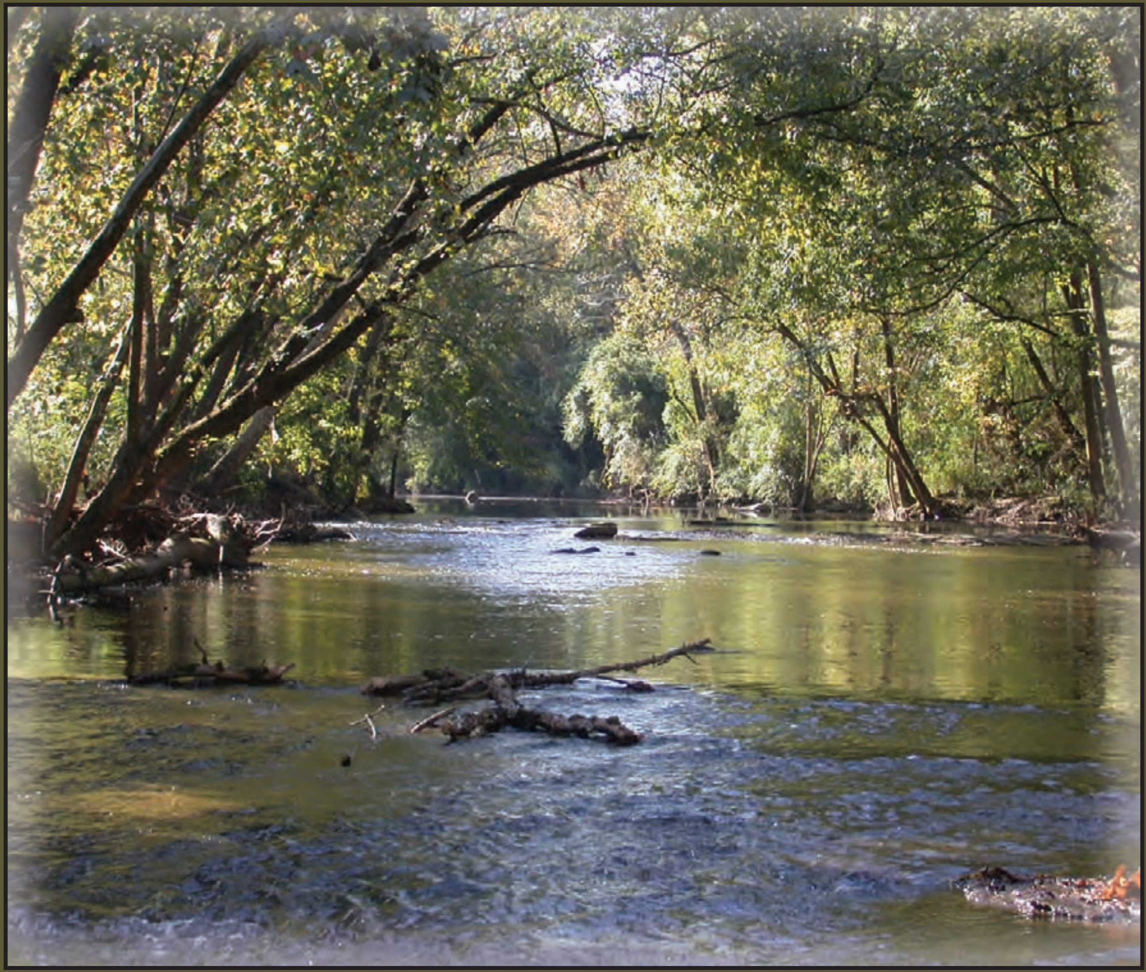
Assessment of Water-Quality Conditions in Fivemile Creek in the Vicinity of the Fivemile Creek Greenway, Jefferson County, Alabama, 2003–2005



Scientific Investigations Report 2007–5272

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

Cover photograph: A forested reach of Fivemile Creek, Alabama, courtesy of Hilary Aten, Cawaco Resource, Conservation and Development Council.

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Conversion Factors, Datums, and Acronyms

SI to Inch/Pound

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)
centimeter (cm)	0.3937	inch (in.)
kilometer (km)	0.6214	mile (mi)
	Area	
square meter (m^2)	1.196	square yard (yd^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
milliliter (mL)	0.3381	ounce, fluid (fl. oz)
liter (L)	33.81	ounce, fluid (fl. oz)
liter (L)	0.2642	gallon (gal)
	Flow rate	
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
millimeter per year (mm/yr)	0.03937	inch per year (in/yr)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.6093	kilometer (km)
	Area	
square mile (mi^2)	2.59	square kilometer (km^2)
	Flow rate	
inch per year (in/yr)	25.4	millimeter per year (mm/yr)

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

$$°F=(1.8\times°C)+32$$

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

$$°C=(°F-32)/1.8$$

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

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

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

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

Acronyms

ADEM	Alabama Department of Environmental Management
AHTN	6-Acetyl-1,1,2,4,4,7-hexamethyltetraline
Alkyl-PAH	Alkylated polycyclic aromatic hydrocarbon
BI	Biotic index
CIAT	2-Chloro-4-isopropylamino-6-amino-s-triazine
DCPA	Dacthal
DEET	*N*,*N*-diethyl-*m*-toluamide
e	Concentration is estimated
E. coli	*Escherichia coli*
EPT	Ephemeroptera, Plecoptera, Trichoptera
FCGP	Fivemile Creek Greenway Partnership
FMC	Fivemile Creek
FNU	Formazin nephelometric units
HAL	Health advisory level
HHCB	1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran
MCL	Maximum contaminant level
MRL	Minimum reporting level
NAWQA	National Water-Quality Assessment
NGVD 29	National Geodetic Vertical Datum of 1929
NLCD	National Land Cover Dataset
NTRU	Nephelometric turbidity ratio units
NWIS	National Water Information System
NWQL	National Water Quality Laboratory
OWC	Organic wastewater compounds
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyls
PEC	Probable-effect concentration
QMH	Qualitative multihabitat
RTH	Richest targeted habitat
SQG	Sediment-quality guideline
SVOC	Semivolatile organic compound
TEC	Threshold-effect concentration
TKN	Total Kjeldahl nitrogen
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WWTP	Wastewater-treatment plants
YSI	Yellow Springs Instrument

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By Amy C. Gill, John A. Robinson, Jymalyn E. Redmond, and Michael W. Bradley

Abstract

The watershed of Fivemile Creek (FMC), a tributary to the Locust Fork of the Black Warrior River, is located north of Birmingham, Alabama. Areas that have been previously coal-mined border the creek, and portions of the upper watershed have been and are currently (2007) being used for industrial and urban uses.

The U.S. Geological Survey (USGS), in cooperation with the City of Tarrant, the Freshwater Land Trust, and the Jefferson County Commission, conducted a water-quality assessment of 12 sites along FMC during 2003–2005. Water samples were analyzed for basic physical and chemical properties and concentrations of major ions, nutrients, fecal indicator bacteria, organic wastewater compounds, pesticides, trace elements, and semivolatile organic compounds. Streambed-sediment samples were analyzed for concentrations of trace elements and semivolatile organic compounds. Benthic invertebrate communities were evaluated for taxonomic composition and relation to water-quality conditions.

Nutrient concentrations in the FMC watershed reflect the influences of natural and anthropogenic sources. Concentrations of total nitrogen in all samples and total Kjeldahl nitrogen in at least one sample each collected from FMC at Hewitt Park, FMC below Springdale Road, FMC at Lewisburg, FMC near Republic, FMC at Brookside, and FMC at Linn Crossing exceeded U.S. Environmental Protection Agency (USEPA) ecoregion nutrient criteria. Total phosphorus concentrations in about 58 percent of all samples were above the ecoregion nutrient criteria. Concentrations of chlorophyll *a*, an indicator of algal biomass, in the FMC watershed were below the appropriate USEPA ecoregion criteria.

Fecal indicator bacteria concentrations occasionally exceeded criteria established by the Alabama Department of Environmental Management (ADEM) and the USEPA to protect human health and aquatic life. Median fecal-coliform concentrations equaled or exceeded USEPA criteria at four of the six sites with multiple samples. Maximum *Escherichia coli* (*E. coli*) concentrations usually occurred during high-flow conditions and exceeded the single-sample criterion for infrequently-used whole-body contact (576 colonies per 100 milliliters) at all but one site. Median *E. coli* concentrations for two of the seven sites with multiple samples exceeded USEPA criteria.

Twenty-nine samples were collected from sites along FMC and analyzed by the USGS National Water Quality Laboratory for the presence of 57 organic wastewater compounds. Forty-six of the 57 organic wastewater compounds, representing all 11 general-use categories, were detected in samples from FMC. All detections of organic wastewater compounds were estimated below laboratory reporting limits except for several detections of the herbicide bromacil.

Herbicides accounted for approximately 62 percent of the number of pesticide detections in the FMC study area. Two herbicides, atrazine and simazine, were detected most frequently, in 100 percent of the surface-water samples. Fipronil sulfide was the most commonly detected insecticide-derived compound, occurring in 52 percent of the surface-water samples. Concentrations of one insecticide, dieldrin, exceeded the USEPA's health advisory level for drinking water in one sample at FMC at Hewitt Park and in one sample at FMC below Springdale Road. Concentrations of carbaryl in two samples and malathion in one sample exceeded aquatic-life criteria.

Only a few trace element concentrations measured in FMC exceeded established standards or criteria. Some concentrations of aluminum and manganese were above secondary drinking-water standards. One cadmium concentration and three selenium concentrations measured at FMC at Lewisburg exceeded ADEM chronic aquatic-life criteria.

Streambed-sediment samples were collected at seven sites along FMC, and analyzed for selected semivolatile organic compounds and trace elements. Forty-nine of 98 semivolatile organic compounds were detected in streambed-sediment samples from one or more sites. Forty-five of 47 trace elements were detected at one or more sites. Concentrations of some semivolatile organic compounds exceeded consensus-based sediment-quality guidelines at three sites. Sediment-quality guidelines were exceeded for seven of the eight trace elements for which they are established, and streambed-sediment samples from most sites contained concentrations of multiple trace elements that exceeded sediment-quality guidelines.

Samples of the benthic invertebrate communities were collected from selected sites along FMC during July 2003 and November 2004. Invertebrates were identified to the lowest taxonomic level possible, and 137 taxa were identified among all of the FMC samples. Metrics of community health were

calculated from the taxonomic data. Some metrics of benthic invertebrate community health indicated that sites were in poor biotic condition, in terms of even distribution of abundance among taxa. In contrast, biotic index values and the number of intolerant taxa present in samples indicated that stream conditions at most sites were able to support species that are sensitive to organic enrichment.

Introduction

The Fivemile Creek (FMC) watershed is a 91-square-mile watershed located in northern Jefferson County north of the city of Birmingham, Alabama (fig. 1). The creek originates in an area near the city of Center Point and flows roughly westward through the communities of Tarrant, Fultondale, Coalburg, Republic, Birmingham, Brookside, and Graysville, until it joins the Locust Fork of the Black Warrior River below Linn Crossing. Within this report, the portion of the FMC watershed upstream from Boyles Gap is designated the upper watershed, and the watershed portion that is downstream from Boyles Gap is referred to as the lower watershed (fig. 1).

FMC has a history of water-quality problems and was once dubbed “creosote creek” by local residents because of the pungent odor of its water (Bouma, 2002). In recent years, reductions in industrial discharges to the creek have resulted in an upgrade of the use classification from an Agriculture and Industrial use designation to a Fish and Wildlife designation by the Alabama Department of Environmental Management (ADEM; 2004 and 2006a). The watershed has a broad range of land uses that include residential and commercial activities in the upper reaches of the creek near Center Point. As the creek flows westward, industrial land uses become more common. Numerous coal mines from the Warrior fields once dotted the landscape of the lower watershed near Coalburg, Brookside, and Lewisburg. Turn-of-the-century coke batteries near the major mines processed coal into coke. Coke, a condensed form of coal that is a nearly smoke-free fuel, is produced when coal is heated in an oxygen-free atmosphere and volatile compounds are removed. The coke was then used to fuel the iron and steel industry in Birmingham. The lower watershed, site of most of the historic coke batteries, is now (2006) mostly forested and rural with much less residential development than the upper watershed.

In 2002, Jefferson County and the communities along FMC formed the Fivemile Creek Greenway Partnership through a landmark memorandum of agreement signed by the cities of Tarrant, Fultondale, Brookside, Graysville, Center Point, and Birmingham; Jefferson County; the Freshwater Land Trust; Greater Birmingham Regional Planning Commission; and Cawaco Resource Conservation and Development Council. The Fivemile Creek Greenway Partnership (FCGP) and the Freshwater Land Trust are working to acquire land and establish a 27-mile greenway along the length of FMC. The greenway will be an area limited to recreational and educational uses, and is intended to improve water quality within the creek, mitigate future floods, establish protected habitat along the stream, and provide a recreation venue for the citizens of the watershed.

Planned construction of new highways has the potential to substantially change land uses and affect development in the entire watershed. Some of this anticipated development is already underway with the construction of several residential subdivisions with homes numbering in the hundreds per development (Daryl Aldrich, Building Inspector, City of Fultondale, oral commun., 2005).

Purpose and Scope

The U.S. Geological Survey (USGS) conducted a water-quality assessment of 12 sites along FMC during 2003–2005, in cooperation with the City of Tarrant, the Freshwater Land Trust, and the Jefferson County Commission. The data collected during this investigation will serve as a baseline for assessing water-quality changes brought about by implementation of the greenway and increased urbanization of the watershed.

The purpose of this report is to present sampling results from the 2003–2005 investigation of water-quality conditions in FMC. Data are summarized to allow for comparisons between sites and the identification of water-quality conditions warranting further investigation. In addition, where standards exist, data are used to evaluate the suitability of the creek for human body-contact recreation, such as wading, fishing, and canoeing, and as habitat for aquatic organisms.

This investigation supports three high-priority science issues identified by the USGS—the remediation of contaminated environments, suitability of aquatic habitat for biota, and effects of urbanization on water resources (U.S. Geological Survey, 1999). Multiple sites in the FMC watershed have been contaminated by historical industrial and mining practices, and many of these have been identified by the U.S. Environmental Protection Agency’s Brownfields Program as potential targets of remediation efforts (Cawaco Resource Conservation and Development Council, 2005). Data from this investigation can be used by local and Federal officials to prioritize the location and order of remediation efforts to maximize improvements in water quality and suitability of FMC for aquatic habitat. In addition, this study provides the scientific community with additional data on the effects of urbanization and suburbanization on streams.

Environmental Setting

Streamwater quality is strongly influenced by the environmental characteristics of the contributing watershed. Climate, geology, topography, ecology, land cover, and other physical factors contribute to the chemical makeup of streamwater. In addition, human uses of watersheds can change the types and rates of constituent loading to streams.

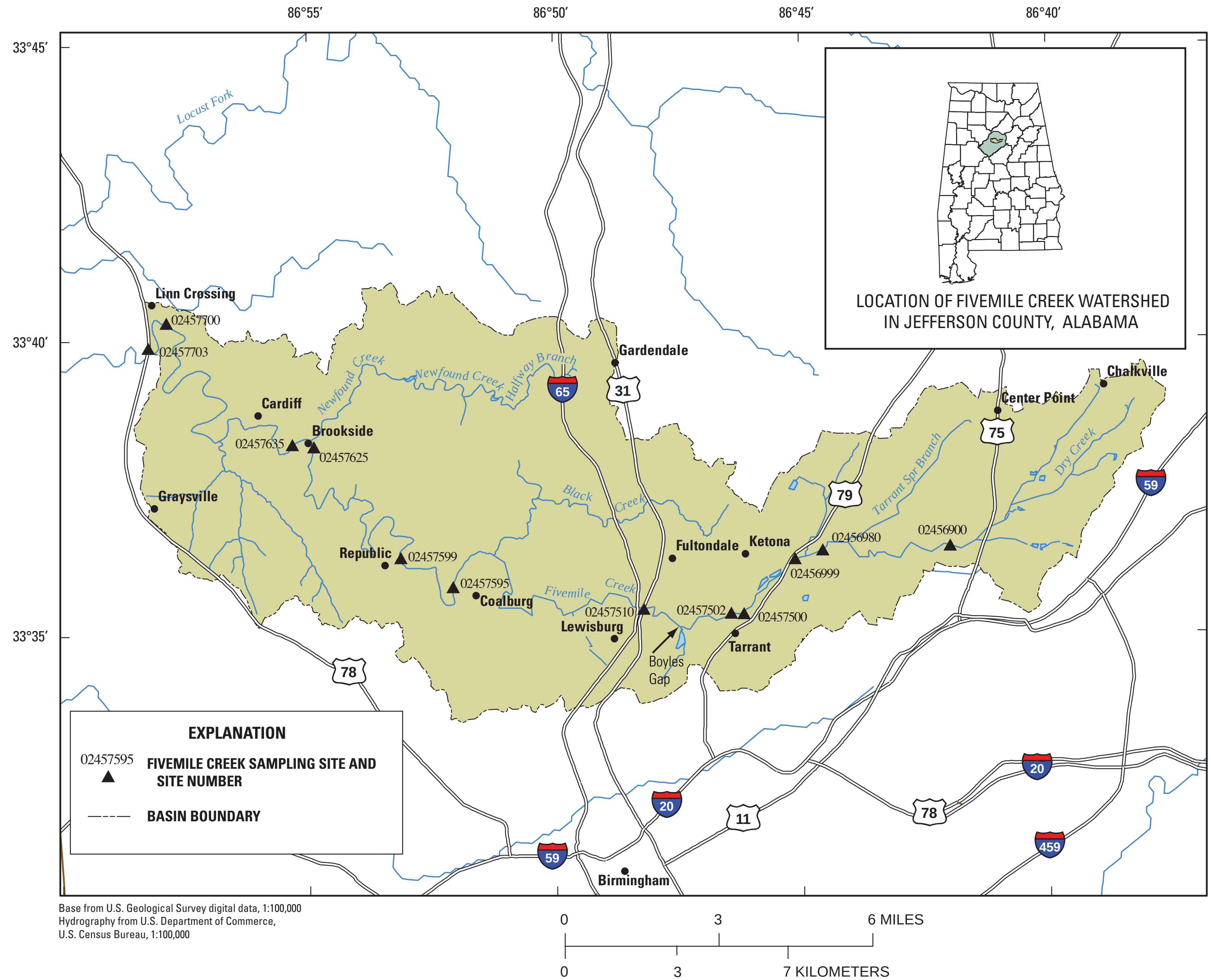

Figure 1. The Fivemile Creek watershed, Jefferson County, Alabama.

Climate

Birmingham has a temperate climate with a relatively high annual rainfall. The average annual rainfall from 1930 to 2005 was 54 inches per year (Southeast Regional Climate Center, 2006). Records compiled for the period of record (1930–2005) at the Birmingham airport indicate that rainfall in the area is relatively well distributed throughout the year with March having the highest average monthly rainfall and October having the lowest average monthly rainfall (Southeast Regional Climate Center, 2006). During the study period, 2003 and 2004 were wetter than average years (fig. 2) with 65.6 and 61.3 inches of rainfall, respectively.

During the last 10 years, each year has experienced periods of heavy rainfall. At least 1 month in which rainfall exceeded 8 inches occurred in every year except 1997. Average monthly rainfall is between 3 and 6 inches. Greater than normal amounts of rainfall can saturate soils and contribute to flooding when heavy rainfall occurs. These conditions occurred during the May 2003 flood; in May 2003, the monthly rainfall total was 17.2 inches (Southeast Regional Climate Center, 2006).

Ecoregions

FMC flows through two U.S. Environmental Protection Agency (USEPA) Level IV ecoregions, which represent broad differences in geology, topography, and ecology. The upstream reach of the creek, from the headwaters to Boyles Gap, is in the Southern Limestone/Dolomite Valleys and Low Rolling Hills Ecoregion (designated 67f) of the Ridge and Valley Level III Ecoregion (fig. 3). The Southern Limestone/Dolomite Valleys and Low Rolling Hills Ecoregion is characterized by limestone and cherty dolomite hills and valleys with multiple caves and springs. Forest cover is usually oak-hickory and oak-pine (U.S. Environmental Protection Agency, 2001a). From Boyles Gap downstream to the confluence with Locust Fork, FMC runs through the Shale Hills Ecoregion (designated 68f) of the Southwestern Appalachian Mountains Level III Ecoregion. The Shale Hills Ecoregion also is known as the Warrior Coal Field. The area is characterized by strongly sloping hills, relatively impermeable shale, siltstone, and sandstone, and consequently lower base flow in streams. Coal mining has altered the natural landscape and has greatly affected local streams (U.S. Environmental Protection Agency, 2001a).

Geology

The FMC watershed is located in two geologic provinces that nearly mirror the ecoregions. The upper part of the watershed is in the Valley and Ridge Province, and the middle and lower parts of the watershed are in the Appalachian Plateaus Province. The Valley and Ridge Province is characterized by its limestone and dolomite deposits, whereas the Appalachian Plateaus Province is rich in coal. The mineral deposits of these two provinces vary substantially, and these differences have an influence on water-quality characteristics in each province.

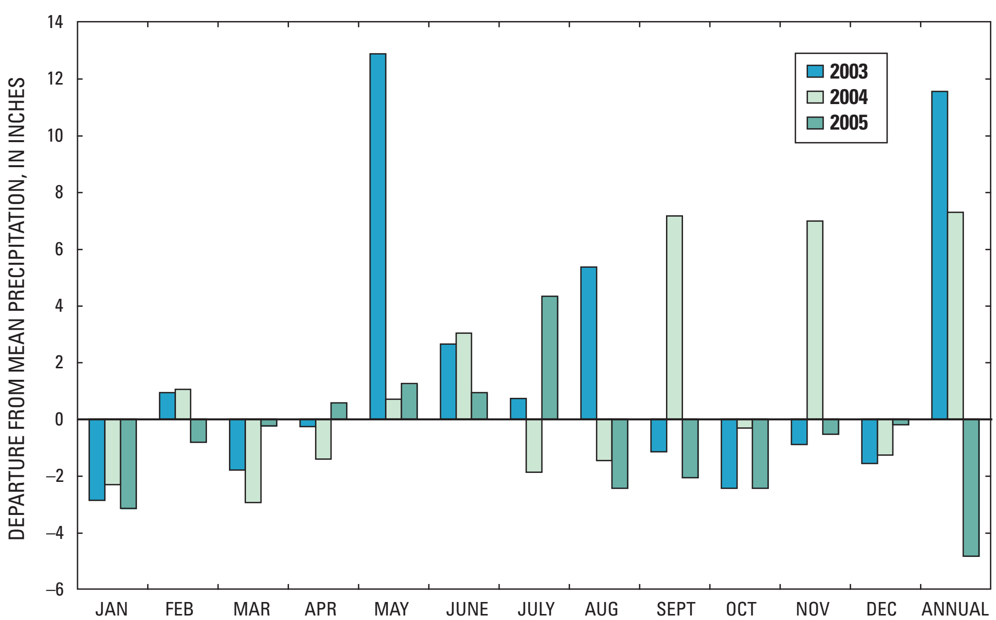

Figure 2. Monthly and annual departure from long-term (1930–2005) normal precipitation at the Birmingham Regional Airport during 2003–2005 (Southeast Regional Climate Center, 2006).

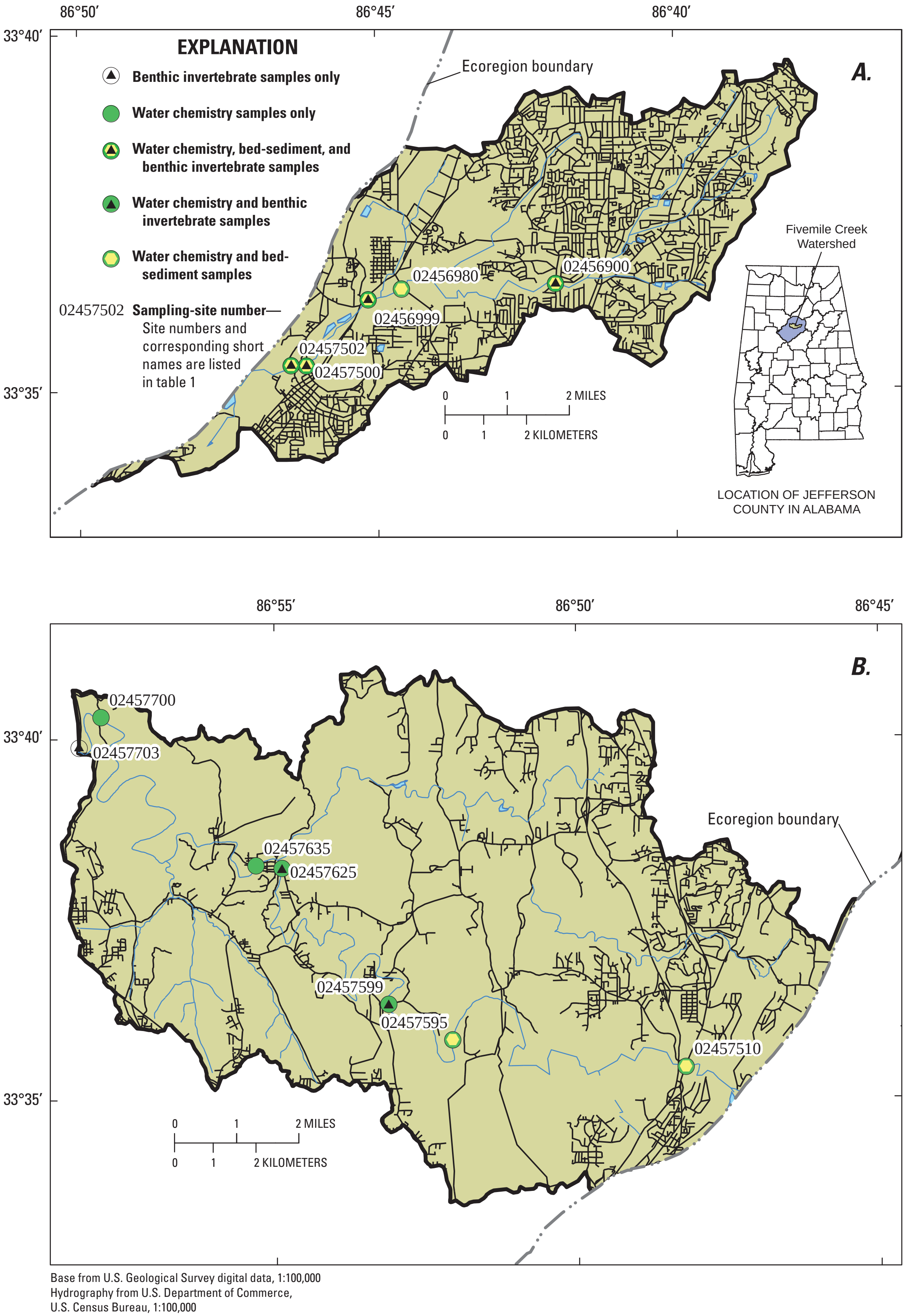

Figure 3. Locations of data-collection sites in U.S. Environmental Protection Agency Level IV (*A*) ecoregion 67f and (*B*) ecoregion 68f along Fivemile Creek in Jefferson County, Alabama, 2003–2005.

Valley and Ridge Province

The Valley and Ridge Province consists of northeast- to southwest-trending valleys and ridges. The ridges are formed by resistant sandstone and chert with steep escarpments that face northwest, and gentle slopes to the southeast (Knight, 1976). The valley floors are underlain by carbonate rocks and shale. The drainage pattern is trellis (Knight, 1976). Land-surface altitudes generally range between 300 and 1,150 feet above NGVD 29.

The Valley and Ridge Province in Jefferson County is underlain by numerous geologic formations ranging in age from Cambrian to Pennsylvanian. Major rock types are limestone, dolomite, sandstone, and shale. Deposits of economic importance in the Valley and Ridge Province in Jefferson County include limestone and dolomite in the Conasauga Formation and Ketona Dolomite of Cambrian age. The Conasauga Formation is composed of limestones, dolomites, and shales; both the carbonates and shales are highly fossiliferous (Adams and others, 1926).

Appalachian Plateaus Province

The Appalachian Plateaus Province in Jefferson County is a dissected plateau of moderate relief with dendritic drainage patterns (Knight, 1976). Land-surface altitudes generally range between 300 and 1,000 feet above NGVD 29.

Major rock types in the Appalachian Plateaus Province are soft shales, siltstones, resistant sandstone, and coal seams (Geological Survey of Alabama, 1981). Shale is the dominant rock type in most coal-bearing strata, and it contains nodules or layers of siderite (iron carbonate) and ankerite (magnesium carbonate) (Puente and Newton, 1979). Coal in the Pottsville Formation, which underlies the lower watershed, is a highly volatile, class-A bituminous coal that sometimes contains pyrite (iron sulfide) (Knight and Newton, 1977). Warrior Field coal is enriched with trace elements including (but not limited to) arsenic, molybdenum, antimony, copper, mercury, lithium, selenium, thallium, and gold (Goldhaber and others, 2000). Microscopic analyses of pyrite-bearing coals from Alabama indicate that arsenic-bearing pyrite may be more easily dissolved than arsenic-poor pyrite (Diehl and others, 2003).

Historical Overview

FMC has occupied a critical position in the history of Birmingham's development. The first public water supply for Birmingham in the 1870s was withdrawn from FMC at a point near Lawson Road in Tarrant. In the late 1880s, an aqueduct carried water from the creek to the main downtown areas of Birmingham. As the city grew, FMC was not adequate to meet the demand for water, and the aqueduct was abandoned. Deposits of limestone and coal were discovered along the creek at shallow depths. These easily acquired mineral deposits brought industrial development to this area in the days of Birmingham's early steel industry.

Coalburg was one of the first major coal mining developments in the FMC watershed. In the 1870s, John Milner bought 10,000 acres in this part of northern Jefferson County and established coal mines and a railway at Coalburg. By 1886, the mining operation consisted of 76 coke battery units and a coal-washing machine, with another 114 battery units under construction. At peak production, over 1,300 men worked the mine and coke batteries. The mining operation included a steam-engine ram that pushed coke from the ovens rather than relying on human labor (White, 1981).

Coke for steel and iron production was in high demand in the early 1900s, and soon mines dotted the hillsides. Major works including both mines and coke ovens were established at Lewisburg (Mary Lee Mines) and Brookside. Large mining operations were ongoing at Republic. Eventually 11,000 miners worked in Jefferson County, and 143 operations were documented (Lewis, 1994). During the early days of mining, environmental controls were primitive or unknown, and management practices differed substantially from modern practices. Even after the early coke ovens became obsolete, strip mines were operated in the rich coal deposits of the Warrior fields as recently as the 1990s. Persistent compounds from these past mining operations have the potential to influence water-quality conditions even today.

Railroads were a major factor in establishing the prominent role that northern Jefferson County played in the early steel industry. A railway connected the Coalburg mines to Birmingham as early as 1879 (Grieg, 1889). The Boyles Yard developed as a major rail yard during the early stages of coal transportation and is still a major transportation hub today. Railways wound their way through the valleys where grades were less severe, which commonly situated them alongside FMC. Contaminants released by spillages of hauled materials or the hazardous constituents used in railway maintenance are likely to reach the stream because of the proximity of the railways to the creek.

The use of rail transportation routes in the watershed has diminished over the years. The Mary Lee Line has been abandoned and is now being evaluated as a "rails-to-trails" route for hikers and bikers. The old Coalburg line is now long abandoned. Major highway transportation routes, however, have developed along some of these same routes. Alabama State Highway 79 has a traffic volume of approximately 36,000 vehicles a day through the watershed (Alabama Department of Transportation, 2005). Automobiles are a source of spilled oils, transmission fluids, and other similar materials. During the era of leaded fuels, automobile emissions were a source of lead, which may be persistent today near roadways.

Effects of Urbanization

Due to industrial, commercial, and residential development in the upper basin of FMC, hydrologic conditions have drastically changed since 1992 (Lee and Hedgecock, 2007). The 2001 National Land Cover Dataset (NLCD) and aerial photography (2004) indicated that the watershed upstream from Boyles Gap is approximately 75 percent developed (industrial, commercial, and residential land use), with the remaining 25 percent located in flood plains or ridge areas with a low probability for development. The 2001 NLCD, aerial photography, and field reconnaissance were used to estimate a current (2006) impervious cover of 20 percent for the portion of the FMC watershed upstream from Boyles Gap. Comparison of 1992 NLCD to these datasets also indicated that the percentages of impervious area had risen from 12 percent in 1992 to 20 percent in 2004. This growth in development has the potential to produce flood peaks of greater magnitudes and shorter durations in FMC. The changes in flow magnitude also could result in increased loading of contaminants and sediments in the creek with subsequent changes to benthic invertebrate and fish communities in surface waters. Several studies have documented the disruptive effects of urban development on stream hydrology and ecology (Booth, 1990; Richards and Host, 1994; Finkenbine and others, 2000; Wang and others, 2000).

Increases in impervious area in urban environments can cause frequent fluctuations in flow and rapid fluctuations of water levels that may lead to reductions in biodiversity. Established habitat that normally provides resources and shelter for fish and other organisms may be removed during greater stream velocities during peak flows. Floods of greater intensity and greater frequency can also interfere with life-cycle activity of aquatic organisms (Booth, 1990). Major flooding occurred at FMC in March 2000 and May 2003. The recorded stages for these floods at the USGS streamgaging station, FMC at Ketona, were 17.2 and 19.2 feet (ft) above gage datum, respectively. The higher-than-anticipated flood stages could be attributed to recent development in the basin (Lee and Hedgecock, 2007).

As the percentages of impervious surface increase in urban landscapes, the areas of land surface available to provide recharge to ground-water resources is diminished. This reduction in ground-water recharge can result in low base flow during certain seasons. This change in base flow can interfere with breeding cycles by stranding fish or by drying eggs of aquatic insects during critical periods (Finkenbine and others, 2000).

Approach and Methods

The overall approach of this investigation was to assess environmental conditions along as much of FMC as possible, with special emphasis on areas identified by the Fivemile Creek Greenway Partnership as potential public-access points to the creek. When and where possible, data-collection efforts also were designed to complement ongoing site investigations funded under the U.S. Environmental Protection Agency’s Brownfields Program. Changes in sampling design, including additions and deletions of sampling sites, were made throughout the project in response to cooperator needs and funding fluctuations.

Sampling Sites

Samples were collected from 12 sites along FMC during this investigation (fig. 3 and table 1). The 12 sites were sampled at varying frequencies and for various constituents (tables 1 and 2). For brevity of presentation, site short names are used to identify the sites in the tables, figures, and text of this report.

Many samples were collected from sites near the city of Tarrant to assess water-quality conditions in support of remediation efforts already in development. Samples occasionally were collected from various sites upstream and downstream from Tarrant. Several sites were selected near proposed or existing recreation areas. FMC at Hewitt Park and FMC at Brookside Park are public access areas along the creek, and FMC below Springdale Road is the proposed site of a constructed wetland that will be used for public education.

Changes in streamwater quality can be related to changes in streamflow, or discharge. Sources of chemical and bacterial constituents of streamwater include precipitation, ground water, point-source discharges, surface geology, and dispersed smaller sources throughout the watershed known as nonpoint-source contributions. Water quality and discharge often vary with changes in the relative contributions of the sources. For instance, storm runoff will increase stream discharge, which may dilute the effects of ground water and point sources and increase nonpoint-source contributions. In contrast, periods of low stream discharge may reflect a greater point source and ground-water contribution to overall stream conditions.

During this investigation, samples were collected from FMC during various flow conditions. By observing instantaneous discharges, valuable information can be gained about streamflow and water-quality relations at the sites. The use of continuous discharge data adds the ability to discern whether flow conditions were stable or changing over time. FMC at Ketona (USGS Station ID 02457000) is a continuous discharge gaging station located in the upper FMC watershed. The record of discharge from FMC at Ketona was used to show the temporal changes in stream discharge. Mean daily discharge for the study period (2003–2005) and instantaneous discharge from FMC at Ketona at the times of sample collection were used to compare flow conditions among the samples (fig. 4). A limitation of this approach, which should be noted, is that it may misrepresent the relative hydrologic conditions for some periods when stream inputs, especially precipitation, were different at FMC at Ketona than at other sites along FMC.

Water-Chemistry Sampling Methods

Most stream samples were composited from samples collected from multiple vertical transects evenly-spaced across the stream width. All collection bottles and compositing devices were cleaned according to appropriate protocols outlined in Wilde and others (1999). Stream samples analyzed

Table 1. Data-collection sites and number of water-quality samples in the Fivemile Creek watershed, Jefferson County, Alabama, 2003–2005.

[USGS, U.S. Geological Survey; °, degrees; ', minutes; ", seconds; mi², square mile; FMC, Fivemile Creek; —, no samples collected]

USGS station number	Station name and short name	Latitude	Longitude	Drainage area (mi²)	Major ions	Nutrients	Trace metals	Pesticides	Organic wastewater indicators
02456900	Fivemile Creek at Fivemile Road near Huffman, Alabama FMC at Fivemile Road	33°36'29"	86°42'00"	9.7	1	1	1	1	1
02456980	Fivemile Creek at Lawson Road near Tarrant City, Alabama FMC at Lawson Road	33°36'25"	86°44'35"	18.6	1	1	1	1	1
02456999	Fivemile Creek at Tarrant Park near Tarrant, Alabama [1] FMC at Hewitt Park	33°36'16"	86°45'09"	22.5	11	7	11	10	8
02457500	Fivemile Creek at Tarrant City, Alabama FMC at Huffman Road	33°35'21"	86°46'11"	25.2	2	2	2	2	2
02457502	Fivemile Creek below Springdale Road near Tarrant, Alabama FMC below Springdale Road	33°35'21"	86°46'27"	25.5	8	5	8	7	6
02457510	Fivemile Creek at Lewisburg, Alabama FMC at Lewisburg	33°35'26"	86°48'13"	32.5	8	5	8	7	5
02457595	Fivemile Creek near Republic, Alabama FMC near Republic	33°35'49"	86°52'05"	51.9	1	1	1	1	1
02457599	Fivemile Creek at Republic Ford, Alabama FMC at Republic Ford	33°36'19"	86°53'08"	57.5	2	—	2	2	2
02457625	Fivemile Creek at Brookside FMC at Brookside	33°38'12"	86°54'53"	64.4	2	1	2	2	2
02457635	Fivemile Creek at Cardiff Road Bridge at Brookside, Alabama FMC at Brookside Park	33°38'15"	86°55'19"	80.3	—	—	—	—	—
02457700	Fivemile Creek at Linn Crossing, Alabama FMC at Linn Crossing	33°40'18"	86°57'52"	96.2	1	1	1	1	1
02457703	Fivemile Creek at U.S. Highway 78 near Graysville FMC at Graysville	33°39'53"	86°58'14"	96.6	—	—	—	—	—
	Total				37	24	37	34	29

Table 1. Data-collection sites and number of water-quality samples in the Fivemile Creek watershed, Jefferson County, Alabama, 2003–2005.—Continued

[USGS, U.S. Geological Survey; °, degrees; ', minutes; ", seconds; mi², square mile; FMC, Fivemile Creek; —, no samples collected]

USGS station number	Station name and short name	Fecal indicator bacteria	Bed sediment organics	Bed sediment metals	Semivolatile organic compounds	Pheophytin *a* and chlorophyll *a*	Benthic invertebrates
02456900	Fivemile Creek at Fivemile Road near Huffman, Alabama FMC at Fivemile Road	1	1	1	—	1	1
02456980	Fivemile Creek at Lawson Road near Tarrant City, Alabama FMC at Lawson Road	1	1	1	—	1	—
02456999	Fivemile Creek at Tarrant Park near Tarrant, Alabama [1] FMC at Hewitt Park	32	2	2	1	1	2
02457500	Fivemile Creek at Tarrant City, Alabama FMC at Huffman Road	15	1	1	—	2	1
02457502	Fivemile Creek below Springdale Road near Tarrant, Alabama FMC below Springdale Road	15	1	1	1	—	1
02457510	Fivemile Creek at Lewisburg, Alabama FMC at Lewisburg	14	1	1	1	—	—
02457595	Fivemile Creek near Republic, Alabama FMC near Republic	1	1	1	—	1	—
02457599	Fivemile Creek at Republic Ford, Alabama FMC at Republic Ford	10	—	—	—	—	1
02457625	Fivemile Creek at Brookside FMC at Brookside	2	—	—	—	—	1
02457635	Fivemile Creek at Cardiff Road Bridge at Brookside, Alabama FMC at Brookside Park	6	—	—	—	—	—
02457700	Fivemile Creek at Linn Crossing, Alabama FMC at Linn Crossing	1	—	—	—	—	—
02457703	Fivemile Creek at U.S. Highway 78 near Graysville FMC at Graysville	—	—	—	—	—	1
	Total	98	8	8	3	6	8

[1] Totals include major ions (3), nutrients (3), trace metals (3), pesticides (2), organic wastewater indicators (3), fecal indicator bacteria (12), bed sediment organics (1), bed sediment metals (1), pheophytin *a* and chlorophyll *a* (1), and benthic invertebrate (1) samples stored in the National Water Information System (NWIS) under USGS station number 02457000, Fivemile Creek at Ketona, AL.

Table 2. Sampling period dates, sites, and numbers and types of samples collected from Fivemile Creek, Jefferson County, Alabama, 2003–2005.

[MI, major ions; NU, nutrients; TE, trace elements; PE, pesticides; OWC, organic wastewater compounds; FIB, fecal indicator bacteria; BEDSED, bed sediment; SVOC, semivolatile organic compounds; CHL, chlorophyll and pheophytin; BI, benthic invertebrates]

Sample period	Sample dates	Site short name	Type of sample									
			MI	NU	TE	PE	OWC	FIB	BEDSED	SVOC	CHL	BI
A	6/12/2003	FMC at Hewitt Park						1				
		FMC at Huffman Road						1				
B	6/19/2003	FMC at Hewitt Park						1				
		FMC at Huffman Road						1				
C	6/25/2003	FMC at Hewitt Park						1				
		FMC at Huffman Road						1				
D	6/26/2003	FMC at Hewitt Park						1				
		FMC at Huffman Road						1				
E	7/9/2003	FMC at Hewitt Park						1				
		FMC at Huffman Road						1				
F	7/16/2003	FMC at Fivemile Road										1
		FMC at Hewitt Park						1				1
		FMC at Huffman Road						1				1
G	7/17/2003	FMC at Hewitt Park						1				
		FMC at Huffman Road						1				
H	7/22/2003	FMC at Hewitt Park						1				
I	7/30/2003	FMC at Hewitt Park						1				
		FMC at Huffman Road						1				
J	8/12/2003	FMC at Hewitt Park						1				
		FMC at Huffman Road						1				
K	8/15/2003	FMC at Hewitt Park						1				
		FMC at Huffman Road						1				
L	8/26/2003	FMC at Hewitt Park						1				
		FMC at Huffman Road						1				
M	8/29/2003	FMC at Hewitt Park						1				
		FMC at Huffman Road						1				
N	9/9/2003	FMC at Hewitt Park						1				
		FMC at Huffman Road						1				
O	9/18/2003	FMC at Hewitt Park						1				
		FMC at Huffman Road						1				
P	10/28/2003	FMC at Hewitt Park	1	1	1	1	1	1				
		FMC at Huffman Road	1	1	1	1	1	1			1	
Q	12/15–17/2003	FMC at Fivemile Road	1	1	1	1	1	1			1	
		FMC at Lawson Road	1	1	1	1	1	1	1		1	
		FMC at Hewitt Park	1	1	1	1	1	1	1		1	
		FMC at Huffman Road	1	1	1	1	1	1	1		1	
		FMC near Republic	1	1	1	1	1	1			1	
R	12/22/2003	FMC at Fivemile Road							1			
		FMC near Republic							1			
S	6/23/2004	FMC at Hewitt Park	1	1	1		1	1				
		FMC below Springdale Road	1	1	1		1	1				
		FMC at Lewisburg	1	1	1		1	1				
T	7/28/2004	FMC at Hewitt Park	1		1	1		1				
		FMC below Springdale Road	1		1	1		1				
		FMC at Lewisburg	1		1	1		1				
U	8/31 to 9/1/2004	FMC at Hewitt Park	1		1	1		1				
		FMC below Springdale Road	1		1	1		1				
		FMC at Lewisburg	1		1	1		1				
V	11/2–3/2004	FMC at Hewitt Park	1		1	1		1				
		FMC at Lewisburg	1		1	1		1				
		FMC at Republic Ford	1		1	1	1	1				
		FMC at Brookside	1		1	1	1	1				
W	11/17–19/2004	FMC at Hewitt Park										1
		FMC below Springdale Road										1
		FMC at Republic Ford										1
		FMC at Brookside										1
		FMC at Graysville										1

Table 2. Sampling period dates, sites, and numbers and types of samples collected from Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[MI, major ions; NU, nutrients; TE, trace elements; PE, pesticides; OWC, organic wastewater compounds; FIB, fecal indicator bacteria; BEDSED, bed sediment; SVOC, semivolatile organic compounds; CHL, chlorophyll and pheophytin; BI, benthic invertebrates]

Sample period	Sample dates	Site short name	Type of sample									
			MI	NU	TE	PE	OWC	FIB	BEDSED	SVOC	CHL	BI
X	12/6–8/2004	FMC at Hewitt Park	1		1	1	1	1				
		FMC below Springdale Road	1		1	1	1	1				
		FMC at Republic Ford	1		1	1	1	1				
		FMC at Brookside	1	1	1	1	1	1				
		FMC at Linn Crossing	1	1	1	1	1	1				
Y	6/2/2005	FMC at Hewitt Park						1				
		FMC below Springdale Road						1				
		FMC at Lewisburg						1				
Z	6/6–7/2005	FMC at Hewitt Park	1	1	1	1	1	2				
		FMC below Springdale Road	1	1	1	1	1	2				
		FMC at Lewisburg	1	1	1	1	1	1				
AA	6/15/2005	FMC at Hewitt Park						1				
		FMC below Springdale Road						1				
		FMC at Lewisburg						1				
		FMC at Republic Ford						1				
BB	6/29/2005	FMC at Hewitt Park						1				
		FMC below Springdale Road						1				
		FMC at Lewisburg						1				
		FMC at Republic Ford						1				
		FMC at Brookside Park						1				
CC	7/18/2005	FMC at Hewitt Park	1	1	1	1	1					
		FMC below Springdale Road	1	1	1	1	1					
		FMC at Lewisburg	1	1	1	1	1					
DD	8/3/2005	FMC at Hewitt Park						1				
		FMC below Springdale Road						1				
		FMC at Lewisburg						1				
		FMC at Republic Ford						1				
		FMC at Brookside Park						1				
EE	8/15/2005	FMC at Hewitt Park						1				
		FMC below Springdale Road						1				
		FMC at Lewisburg						1				
		FMC at Republic Ford						1				
FF	8/22–23/2005	FMC at Hewitt Park	1	1	1	1	1	1				
		FMC below Springdale Road	1	1	1	1	1	1				
		FMC at Lewisburg	1	1	1	1	1	1				
		FMC at Republic Ford						1				
		FMC at Brookside Park						1				
GG	9/1–2/2005	FMC at Hewitt Park						1				
		FMC below Springdale Road						1				
		FMC at Lewisburg						1				
		FMC at Republic Ford						1				
		FMC at Brookside Park						1				
HH	9/12–13/2005	FMC at Hewitt Park	1	1	1	1	1	1		1		
		FMC below Springdale Road	1	1	1	1	1	1		1		
		FMC at Lewisburg	1	1	1	1	1	1		1		
		FMC at Republic Ford						1				
		FMC at Brookside Park						1				
II	9/28/2005	FMC at Hewitt Park						1				
		FMC below Springdale Road						1				
		FMC at Lewisburg						1				
		FMC at Republic Ford						1				
		FMC at Brookside Park						1				

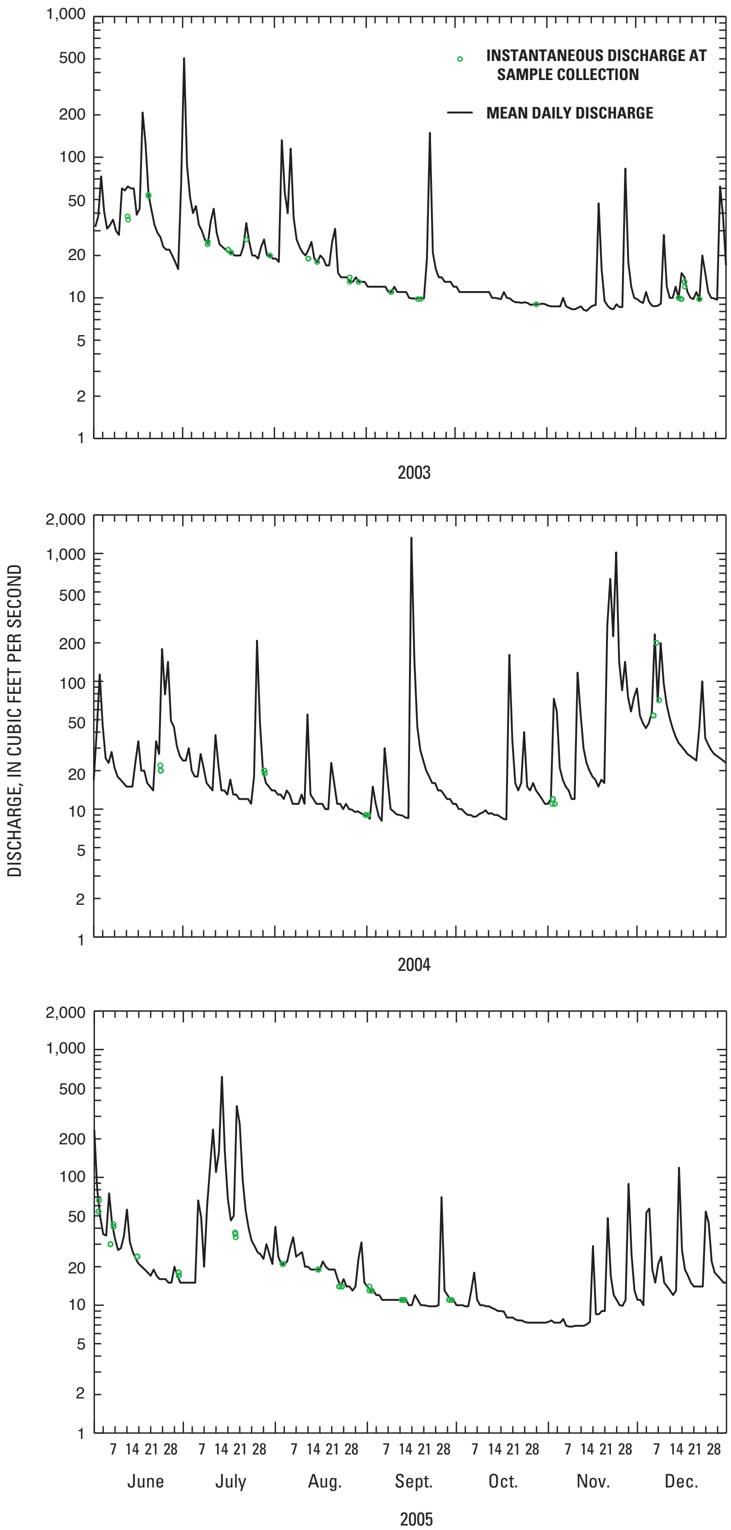

Figure 4. Mean daily and instantaneous discharge at Fivemile Creek at Ketona at time of individual sample collection from selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.

for inorganic constituents were collected using a USGS DH-81 sampler and polyethylene bottles and were composited into polyethylene churn splitters. Pesticide and wastewater samples were collected using a USGS DH-81 sampler with a Teflon bottle and composited into a 3-liter Teflon bottle. Organic wastewater samples were collected by hand-dipping a baked-glass bottle at one or more locations across the stream width. Bacteria and algal pigment (chlorophyll *a* and pheophytin *a*) samples were hand-dipped using autoclaved glass bottles at one or more locations across the stream width. Instantaneous measurements of stream discharge and several basic physical and chemical properties of the water, including temperature, specific conductance, dissolved-oxygen concentration, turbidity, pH, and alkalinity, also were recorded for each sample collected.

Temperature, specific conductance, pH, dissolved-oxygen concentration, and turbidity of streamwater were measured when water-quality samples were collected. Most of these properties were measured using a Yellow Springs Instrument (YSI) multiparameter water-quality sonde, except for a few turbidity readings, which were made with a Hach 2100P turbidimeter. Temperature can affect the solubility of many compounds in water, and extreme temperatures can interfere with aquatic life cycles. Specific conductance is the electrical conductance of an aqueous solution (Hem, 1985), and the specific conductance of streams usually is correlated to the amount of dissolved material in solution. The pH is a measure of the acidity, or hydrogen ion concentration, of the aqueous solution and affects the solubility of many compounds. Extreme pH values can increase the bioavailability of some contaminants, such as metals. Turbidity is a measure of the scattering of light due to the presence of suspended particles in the water, and higher turbidities usually are correlated with greater amounts of suspended material.

Samples analyzed for major ions, nutrients, trace elements, pesticides, and wastewater indicators were processed and preserved in the field according to procedures described in Wilde and others (1999) before being shipped to the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado, for analysis. Samples for total inorganic constituents were collected directly from the churn splitter, which was used to ensure that suspended sediment present in the sample was evenly distributed, while samples analyzed for dissolved inorganic constituents were filtered through a 0.45-micron capsule filter. Pesticide and organic wastewater indicator samples were filtered through a 0.45-micron glass-fiber filter, using stainless steel and Teflon equipment.

Bacteria samples were processed by USGS Alabama Water Science Center personnel using membrane-filtration techniques outlined in Myers and Wilde (2003). Fecal coliform bacteria were cultured on m-FC media. *Escherichia coli* (*E. coli*) were cultured on m-TEC media for all samples prior to August 3, 2005. On and after August 3, 2005, *E. coli* were cultured on modified m-TEC media.

Chlorophyll *a* and pheophytin *a* samples were passed through a 0.3-micron glass fiber filter. Filters were placed in glass screw-top bottles or plastic Petri dishes, which were wrapped in foil to prevent exposure to light. The filters were shipped on ice to the NWQL for fluorometric analysis.

Household chemical use and discharges of human wastewater can contribute a myriad of contaminants to surface-water systems. The USGS NWQL has developed a method (NWQL Schedule 1433) incorporating solid-phase extraction and capillary-column gas chromatography/mass spectrometry to rapidly assess the occurrence and concentration of 67 organic compounds commonly associated with wastewater discharges (Zaugg and others, 2002). Several of the compounds included in the method currently (2007) are unregulated but are potential or known endocrine disruptors in aquatic organisms (Zaugg and others, 2002). The occurrence of these compounds in streams may have a direct effect on aquatic community health.

The laboratory method used to analyze samples for the presence of organic wastewater compounds (OWC) differs from laboratory methods used to produce data presented in the pesticides and semivolatiles sections of this report. Concentrations of six pesticides (carbaryl, prometon, metolachlor, diazinon, dichlorvos, and chlorpyrifos) were analyzed using the organic wastewater compound method and the pesticide method. The OWC method detected low-level concentrations of carbaryl in four samples. None of the other five pesticides were detected by the organic wastewater compound method. The occurrence and concentrations of these six pesticide compounds are not included in the discussion of OWC detections because of the low numbers of detections under the OWC method and because laboratory pesticide analysis methods are accurate to lower concentrations. Ten semivolatile compounds are analyzed by both the OWC and semivolatile laboratory methods; however, the OWC method measures dissolved concentrations, whereas the semivolatile method (Fishman, 1993, NWQL schedule 1383) represents unfiltered concentrations. Results are designated by separate codes in annual data reports and USGS databases (Fishman, 1993; Zaugg and others, 2002). Semivolatiles detected by the OWC method are included in the “organic wastewater compounds” section of this report, and semivolatiles collected under the semivolatile-specific method are presented in the “semivolatile organic compounds in surface water” section of this report.

Streambed-Sediment Collection Methods

Streambed-sediment samples were collected from multiple sites along FMC and analyzed for trace element and semivolatile organic compound (SVOC) concentrations. Samples were collected from five sites (FMC at Fivemile Road, FMC at Lawson Road, FMC at Hewitt Park, FMC at Huffman Road, and FMC near Republic) during December 2003 and from three sites (FMC at Hewitt Park, FMC below Springdale Road, and FMC at Lewisburg) during November 2005. Equipment cleaning, sample collection, and sample processing followed the procedures outlined in Shelton and Capel (1994).

Samples of fine bed material were collected from depositional areas within each stream reach using Teflon scoops and spatulas. Five to 10 samples from each reach were put into clean glass bowls and homogenized to form a single sediment sample for the site. One portion of the homogenized sample was analyzed for trace elements, and the remaining portion was analyzed for SVOCs. The trace-element sample was sieved through a piece of 63-micron (µm) nylon mesh sieve cloth into a wide-mouth 500-milliliter (mL) plastic bottle until an adequate sample size was obtained. Trace-element samples were taken to the USGS Alabama Water Science Center sample processing area and allowed to settle for 2 to 3 days. After settling, the liquid was decanted and discarded, and the remaining sample was shipped to the NWQL for analysis. The SVOC portion of each sediment sample was processed through a 2.0-millimeter (mm) stainless-steel sieve into a glass jar, packed on ice, and shipped overnight to the NWQL for analysis.

Benthic Invertebrate Community Methods

Benthic invertebrates are bottom-dwelling aquatic animals (for example, insect larvae, mollusks, and worms) that occupy diverse functional niches in aquatic ecosystems. They recycle organic matter, consume smaller organisms, and are important components in the diet of fishes. Benthic invertebrates are commonly used to assess the health of aquatic communities because they are easy to collect and identify, usually abundant, more sensitive than chemical measures to water-quality changes, relatively sessile (Merritt and Cummins, 1996), and they integrate the effects of water-quality changes over periods of about 1 year.

Benthic invertebrate samples were collected during two sampling periods from sites along FMC to assess the health of the aquatic community. Samples were collected at three sites during July 2003 and at five sites during November 2004. FMC at Hewitt Park was the only site sampled during both periods. Seasonal differences in benthic invertebrate community data from a single site can be significant (Resh and Jackson, 1993; Clements, 1994). Data from the two sampling periods are presented together in tables and figures in this report, but the results are discussed separately because comparisons between the two sampling periods are tenuous at best. All of the sampling sites were affected by anthropogenic land uses such as urbanization and mining. No reference site representing undisturbed conditions was sampled as a part of this study; consequently, comparisons among sites are more qualitative than quantitative.

Benthic invertebrate samples were collected using USGS National Water-Quality Assessment (NAWQA) protocols (Cuffney and others, 1993). All richest targeted habitat (RTH) samples were collected primarily in riffle and run areas using a Slack sampler with 425-µm mesh net. Riffles, runs, and pools were used for RTH sampling at FMC at Tarrant Park during November 2004. Five 0.25-square-meter (m^2) areas were sampled and composited into one RTH sample, representing 1.25 m^2 of sampled area for each site. RTH samples were collected at all sites and were used for semi-quantitative comparisons of benthic invertebrate communities. In addition to RTH samples, invertebrates were collected from multiple instream habitats during November 2004 using a 210-µm D-frame net and visual inspection. These samples, designated as qualitative multihabitat (QMH), are designed to provide an inventory of as many taxa present at a site as possible and to provide information about the diversity of the invertebrate communities. Large or rare invertebrate specimens were preserved in separate bottles to ensure that they were identified and included in the taxa counts for the sites. QMH samples at FMC sites were collected from several types of instream habitat, including riffles, runs, pools, and woody snags.

Taxonomic ambiguities can occur when organisms cannot be identified to the same taxonomic level. For example, a taxonomic family may contain many genera, which, in turn, may contain many species. The family can be referred to as the parent taxon of the genera and species; each genus is the parent taxon of the species within it. A species can be referred to as the child taxon of the genus, family, and higher taxonomic levels to which it belongs, a genus is the child taxon of the family and higher taxonomic levels to which it belongs, and so forth up through the taxonomic hierarchy. When some individuals within a parent taxon are able to be identified to lower taxonomic levels and some are not, the parent taxon and the child taxa are ambiguous. Ambiguous taxa in datasets can be handled many ways; in this report, ambiguous taxa are treated as distinct taxa.

Benthic invertebrate samples were analyzed by EcoAnalysts, Inc., located in Moscow, Idaho. EcoAnalysts, Inc., determined taxa to the lowest possible taxonomic level. Immature or damaged specimens also were classified to the lowest possible taxonomic level based upon individual specimen attributes. If undamaged adults of the same genus occurred within the same sample and were able to be identified to the species level, the damaged and immature specimens were assumed to represent the same taxon unless distinguishing characteristics were identified. If distinguishing characteristics were identified, the immature or damaged specimens were left at the lowest level of positive identification and that taxon was counted as distinct from any ambiguous child taxa (Gary Lester, EcoAnalysts, Inc., oral commun., 2006).

EcoAnalysts, Inc., used taxonomic information to calculate several metrics, or measures, of community structure. Several of these metrics are used within this report to assess similarities and differences among the sample sites. Metrics presented in this report are calculated from RTH samples, unless otherwise noted, and include: (1) total taxa richness, (2) EPT [Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)] taxa richness, (3) chironomid taxa richness, (4) total abundance, (5) EPT abundance, (6) Chironomidae (midge) abundance, (7) dominant taxa and percentage of dominant taxon, (8) a biotic index, and (9) presence of intolerant organisms.

Taxa richness, or the total number of identified taxa, was used to describe the diversity of organisms present at each site. EPT taxa richness and chironomid taxa richness also were considered. EPT taxa richness is the number of taxa within the orders Ephemeroptera, Plecoptera, and Trichoptera that have been thought to be intolerant of organic enrichment and elevated trace-metal concentrations. The chironomids, or midges, are members of the family Chironomidae (Diptera) and are considered more tolerant of organic enrichment than the EPT taxa. Genera within the family, however, have varying levels of tolerance, and the number of distinct chironomid genera is expected to decrease in response to increasing stream perturbation (Barbour and others, 1999).

Total abundance is the number of benthic invertebrates contained in a sample, and extremely low or high total abundance may be indicative of environmental stressors (Resh and Jackson, 1993). EPT abundance is expected to decrease in response to increased stream perturbation (Barbour and others, 1999). In contrast, even though chironomid taxa richness declines in degraded streams, chironomid abundance tends to increase along with stressors such as organic enrichment and heavy-metals contamination. Healthy benthic invertebrate communities will have a fairly even distribution among Chironomidae, Ephemeroptera, Plecoptera, and Trichoptera taxa. The ADEM calculates a ratio of EPT to Chironomidae as follows: (number of EPT organisms) / (number of EPT organisms + number of chironomid organisms). Healthy communities will have ratios near 0.75 (Alabama Department of Environmental Management, 1996). The dominant taxon is the taxon with the greatest number of individual organisms present in a sample. According to the ADEM, the most dominant taxon usually accounts for no more than about 30 percent of the total abundance in healthy streams (Alabama Department of Environmental Management, 1996).

A biotic index (BI) was calculated for each of the samples. The BI is calculated from tolerance values for specific invertebrates using the formula $BI = \Sigma (x_i t_i)/n$, where x_i = number of individual organisms within a taxon, t_i = tolerance value of a taxon, and n = total number of organisms in the sample with tolerance values, as described in Section 8.6.1.1 of the ADEM's Standard Operating Procedures Manual (Alabama Department of Environmental Management, 1996). Tolerance values range from 0 to 10, with 10 being most tolerant to general contamination. Tolerance values used in this report are from Appendix X-1 of the ADEM's Standard Operating Procedures Manual (Alabama Department of Environmental Management, 1996). BI values increase as the ratio of tolerant to intolerant species increases. High BI values imply that some change in water quality has occurred that discourages intolerant species, which are defined in this report as those organisms assigned a tolerance value less than 3. The presence of intolerant species at a site indicates that the quality of water is sufficient to support them.

Data Analysis Methods

Water-chemistry data used in this report are available in published USGS Alabama Water Science Center annual data reports (Psinakis and others, 2004, 2005, 2006) or through the National Water Information System (NWIS; U.S. Geological Survey, 2006). Statistical summaries of selected water-quality properties and inorganic constituent concentrations collected during the course of this investigation are presented in appendix 1. Computed statistics include the maximum, minimum, mean, and the 95^{th}, 75^{th}, 50^{th}, 25^{th}, and 5^{th} percentiles. The nth percentile is a data value that exceeds no more than n percent of the data and is exceeded by no more than 100 minus n percent of the data (Helsel and Hirsch, 1992). Before statistics were calculated, data were censored to the highest reporting limit used for the constituent. Where more than one sample was collected, median (50^{th} percentile) values were used to compare typical water-quality conditions between sites.

An estimated concentration is reported when chemical analysis indicates the presence of a water-quality constituent at a concentration below the currently-accepted laboratory reporting limit or when the laboratory has recorded variable recoveries for that constituent in past analyses. Greater uncertainty exists in the magnitude of estimated concentrations than in the magnitude of nonestimated concentrations. In this report, estimated concentrations were treated as actual concentrations in all calculations, but are noted in text and tables by the letter “e” preceding the concentration.

Graphical methods used in this report include bar charts, stacked bar charts, and box plots. Bar charts are used to show detection frequencies and concentrations of organic wastewater compounds, aquatic invertebrate taxa richness and abundance, and biotic index values. Stacked bar charts of concentrations are used to show the contributions of subgroups of constituents. Box plots are used to show the distributions of bacterial concentrations at each site in a way that allows easy comparison among sites.

Stiff and Piper diagrams are used to display the major ionic composition of water samples. Stiff diagrams are polygons constructed from concentrations of major ion species in milliequivalents for each sample. Concentrations of cations (sodium plus potassium, magnesium, and calcium) are plotted to the left of a central vertical axis, and concentrations of anions (chloride plus fluoride, sulfate, and bicarbonate plus carbonate) are plotted to the right of the central axis. The diagram is completed by joining the concentrations with a line to form a polygon. Differences in polygon shape indicate differences in relative ionic composition among samples, while differences in size indicate greater or lesser ionic concentrations. Piper diagrams display the percentage contributions of major ions for multiple samples on one plot. The lower left triangle plot is for percentage contributions of cations, and the lower right triangle plot is for percentage contributions of anions. The upper axes display percentage contributions of cations and anions together and can show differences in the ionic composition among water samples.

Basic Physical and Chemical Properties

The temperature of streamwater varies with changes in season and weather. Water temperatures in FMC varied with season and meteorological changes as expected, with minimum measured temperatures always well above freezing and maximum temperatures about 27 degrees Celsius (appendix 1).

The specific conductance of streamwater is strongly dependent on the ionic content of the water. Conductance values in the upper FMC watershed ranged from 167 to 432 microsiemens per centimeter (µS/cm; appendix 1). Median conductance values at sites FMC at Hewitt Park and FMC below Springdale Road were 343 and 355 µS/cm, respectively. In the lower watershed, conductance values ranged from 332 to 637 µS/cm, and median values at FMC at Lewisburg and at FMC at Republic Ford were 512 and 534 µS/cm, respectively, which is somewhat higher than at the upstream sites.

The pH of natural waters can affect the solubility of metals and other contaminants. The pH values along FMC are expected to vary naturally with changes in geology. Measurements of pH at the upstream sites, within the Southern Limestone/Dolomite Valleys and Low Rolling Hills Ecoregion, indicated neutral to slightly basic conditions, with pH ranging from 7.0 to 8.7 (appendix 1). At FMC at Lewisburg and downstream sites, where the geology is less dominated by carbonate rocks, pH values ranged from 6.4 to 8.4. ADEM water-quality standards state that the pH of natural fresh waters should be between 6.0 and 8.5 (Alabama Department of Environmental Management, 2006b). Only one pH value outside of this range was measured in the FMC watershed during the course of this study; a pH value of 8.7 was measured at FMC at Fivemile Road in December 2003. No other measurements of pH were made at that location during this investigation.

Concentrations of dissolved oxygen are important to the maintenance of aquatic life. Dissolved oxygen in streams designated for fish and wildlife uses should be 5.0 milligrams per liter (mg/L) or greater (Alabama Department of Environmental Management, 2006b). The lowest dissolved-oxygen concentration measured in the FMC watershed during the course of this study was 7.0 mg/L at FMC at Lewisburg (appendix 1). Many concentrations of dissolved oxygen indicated extremely high, supersaturated oxygen conditions in the stream. Greater dissolved-oxygen levels usually indicate well-aerated healthy streams, but extremely high dissolved-oxygen levels may be caused by the presence of nuisance algal growth. Oxygen is released during photosynthesis and consumed during plant respiration and decomposition. Photosynthesis is powered by light and occurs during the day, while respiration and decomposition occur continuously. Dissolved-oxygen concentrations may decrease significantly overnight because of continuous oxygen demand and limited oxygen production. All measurements taken for this study were made during daylight hours, so the diel variation at individual sites is not known.

Turbidity, an indication of water clarity, was measured at seven sites along FMC. Sometimes measurements were made with a Hach 2100P turbidimeter, and at other times measurements were made using a YSI 6136 turbidity probe. Because of physical differences in the way each meter measures turbidity, Hach turbidimeter results are reported in nephelometric turbidity ratio units (NTRU) and YSI probe results are reported in formazin nephelometric units (FNU). The relation between these units is unique to each stream and must be established through simultaneous sampling using both methods. A relation between the two measurements was not established for FMC during this investigation.

ADEM water-quality standards state that anthropogenic additions of water to streams should not cause visible changes or interfere with beneficial uses of the stream (Alabama Department of Environmental Management, 2006b). In addition, the standards declare that turbidity should never exceed background turbidity by more than 50 nephelometric units. Measurements made using the Hach turbidimeter ranged from a maximum of 430 NTRU (FMC at Republic Ford) to a minimum of 1.5 NTRU (FMC at Hewitt Park). YSI probe measurements ranged from a maximum of 44 FNU at FMC below Springdale Road and at Lewisburg to 0.4 FNU at FMC at Hewitt Park. These turbidity measurements could be used to establish baseline conditions in the FMC watershed.

Major Ions

Major ions are those ions usually found in the greatest concentrations in natural waters. Major cations include sodium, potassium, calcium, and magnesium. Major anions include carbonate, bicarbonate, chloride, fluoride, and sulfate. Natural waters may be characterized by the relative content of the major ionic species. Concentrations of ions are influenced by geology and environmental setting, and may be influenced by anthropogenic inputs as well. For instance, chlorides and fluorides often are detected in chlorinated drinking water and may, in high concentrations, be indicative of contamination from wastewater.

In FMC, geologic and land-use differences between the upper and lower watershed sites are reflected in the major ionic composition of creek waters. Upstream sites are characterized by strongly calcium-magnesium carbonate-bicarbonate waters, reflecting the influence of the limestone/dolomite geology. Downstream sites have a more mixed water type, exhibiting a greater proportion of sodium, chloride, and sulfate ions (fig. 5). Pyrite (iron sulfite) is common in the rocks and coal seams of the Shale Hills Ecoregion, and may be a major source of sulfate ions to the lower FMC watershed.

Most streams with multiple samples showed little temporal variation in relative concentrations of major ions, but water samples from FMC at Lewisburg had variation in sodium, chloride, and sulfate (fig. 5). Stiff diagrams from two sample dates, November 2, 2004, and June 7, 2005, are included in figure 5 to illustrate temporal differences in ionic composition of water samples from FMC at Lewisburg. Samples collected at Lewisburg during the summer of 2005 contained less sodium, chloride, and sulfate than samples collected during 2004. For two of the summer 2005 samples, streamflow was elevated above base flow as observed in the continuous record of streamflow at USGS station 02457000, FMC at Ketona (fig. 4). High flows may have diluted the concentrations of sodium, chloride, and sulfate during these time periods.

Most water samples from FMC sites were calcium-magnesium bicarbonate water (fig. 6). Samples from sites FMC at Hewitt Park and below Springdale Road, two of the sites in the Limestone/Dolomite Ecoregion, were dominated by calcium and magnesium cations and carbonate and bicarbonate anions. In general, samples from the more downstream sites, within the Shale Hills Ecoregion, had greater proportions of sodium, chloride, and sulfate than did sites in the Limestone/Dolomite Ecoregion. Samples within the Shale Hills Ecoregion also exhibited greater temporal variability in ionic composition among samples from each site. Observed spatial and temporal differences in major ionic composition are reasonably explained by geologic and hydrologic conditions at the sites, and no elevated concentrations of ions associated with wastewater were noted.

Nutrients

Nutrients, which are chemical elements that are necessary for life, consist primarily of the various species of nitrogen and phosphorus. Nutrient concentrations in aquatic systems are of interest because excess concentrations can have detrimental effects on aquatic health and anthropogenic uses of the system. Eutrophication in freshwater systems is usually linked to high phosphorus concentrations and can lead to nuisance plant growth and algal blooms, which in turn can cause reduced light penetration and dissolved-oxygen concentrations, fouled water intakes, and taste and odor problems in drinking water. Likewise, excess nitrogen has been linked to eutrophication in coastal systems. Excess concentrations of nitrogen and phosphorus in streams draining to the northern Gulf of Mexico also have been linked to oxygen deficiency (hypoxia) in that area (Rabalais and others, 1996).

Sources of nutrients can be natural or anthropogenic. Natural sources of nutrients include weathering of minerals in rocks and soils and biological remineralization of organic matter. Anthropogenic nutrient sources include fertilizers, manure, faulty sanitary sewers and septic tanks, and wastewater-treatment plant outfalls. Nutrient species measured for this study were dissolved ammonia, total and dissolved ammonia plus organic nitrogen, dissolved nitrite plus nitrate, dissolved orthophosphate, and dissolved and total phosphorus. Calculated nutrients were total nitrogen, which is the sum of total ammonia plus organic nitrogen and dissolved nitrite plus nitrate, total organic nitrogen, which

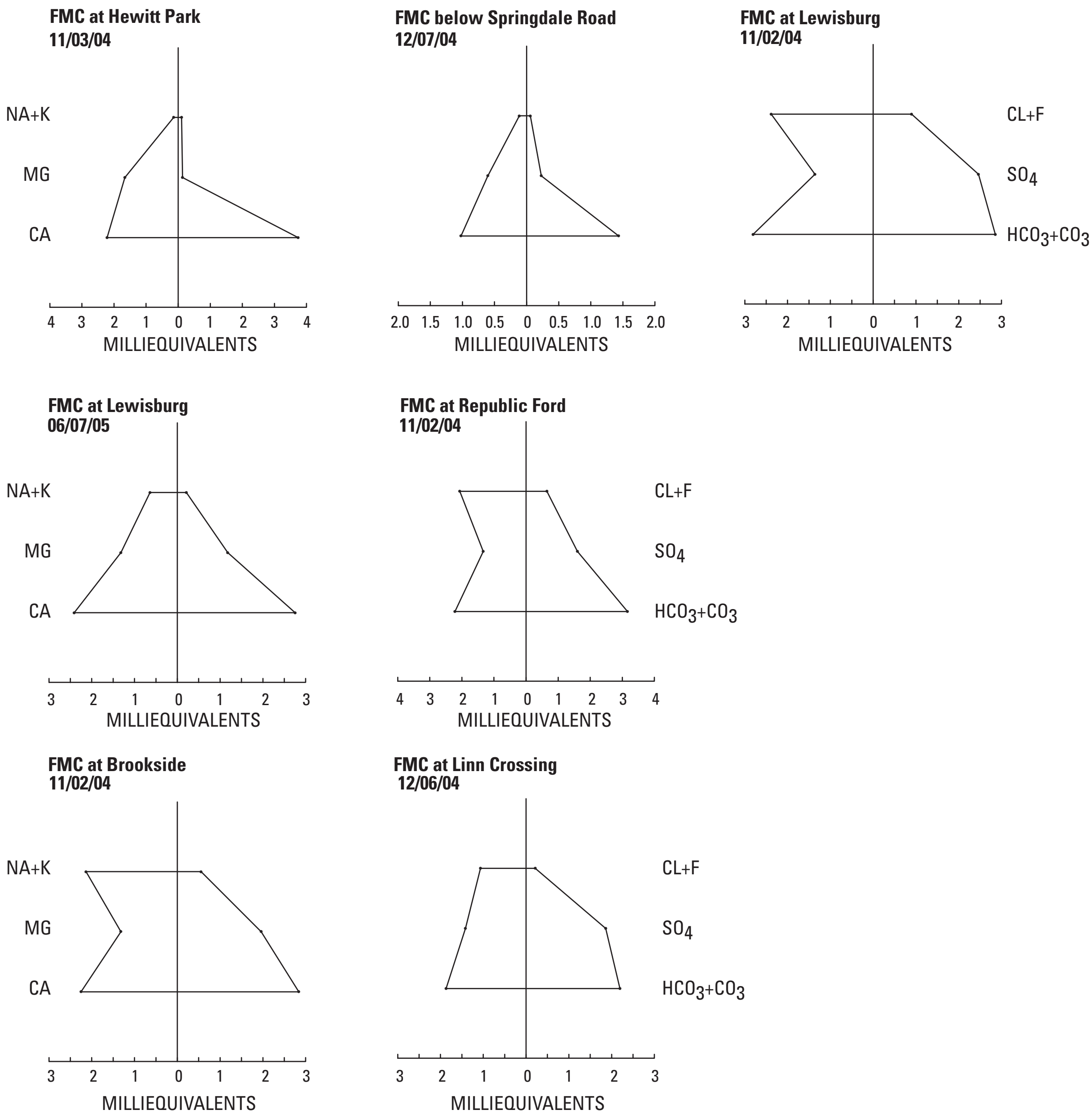

Figure 5. Stiff diagrams for selected samples in the Fivemile Creek (FMC) watershed, Jefferson County, Alabama.

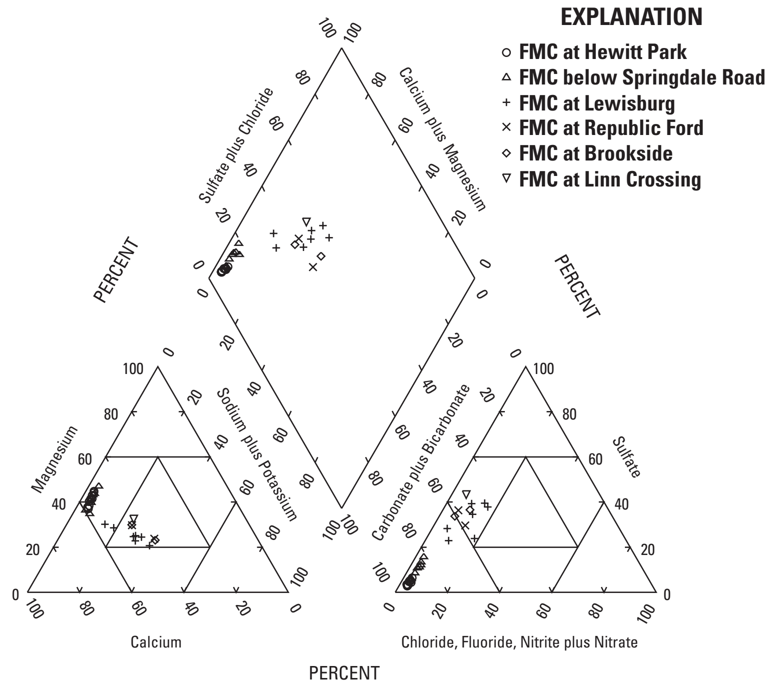

Figure 6. Piper diagrams of major ionic composition of water samples collected during 2003–2005 at selected sites in the Fivemile Creek (FMC) watershed, Jefferson County, Alabama.

is the difference in ammonia and total organic nitrogen plus ammonia, and suspended phosphorus, which is the difference in total phosphorus and dissolved phosphorus. In this report, no concentrations were estimated for the calculated nutrients when one or more components were estimated or undetected. For measured nutrient species, undetected concentrations were assumed to be zero, and estimated concentrations were used as actual concentrations.

Nutrient criteria for Alabama's rivers and streams are under development by the ADEM (Alabama Department of Environmental Management, 2006a). The USEPA has developed nutrient water-quality criteria recommendations intended as a starting point for states to develop more refined nutrient criteria (U.S. Environmental Protection Agency, 2000a). These criteria have been developed from existing nutrient data for Level III ecoregions and for larger aggregated groups of Level III ecoregions, which are designated nutrient ecoregions. Nutrient data from FMC are compared to USEPA nutrient criteria recommendations for Nutrient Ecoregion XI and Level III ecoregions 67 and 68 to assess changes from background conditions.

Nitrogen

Nitrogen concentrations in FMC generally were highest in samples from FMC at Lewisburg, FMC near Republic, and FMC at Brookside, which are located near the middle of the study area. Total nitrogen concentrations ranged from 0.91 to 3.0 mg/L (NWIS parameter code 00600; appendix 1). The greatest total nitrogen concentration (3.0 mg/L) was detected at Lewisburg, which also had the highest concentrations of all of the measured species of nitrogen. All samples at FMC at Hewitt Park, FMC below Springdale Road, FMC at Lewisburg, FMC near Republic, FMC at Brookside, and FMC at Linn Crossing exceeded the USEPA ecoregion nutrient criteria for total nitrogen (table 3; U.S. Environmental Protection Agency, 2000a).

Total organic nitrogen plus ammonia (TKN; total Kjeldahl nitrogen) concentrations ranged from less than 0.1 to 0.9 mg/L (NWIS parameter code 00625; appendix 1; fig. 7). The highest maximum concentration (0.9 mg/L) occurred at FMC at Lewisburg. TKN concentrations exceeded the appropriate USEPA ecoregion nutrient criterion (table 3) in two samples from FMC at Hewitt Park, one sample from FMC below Springdale Road, and all samples from FMC at Lewisburg, as well as in the single samples collected from FMC near Republic, FMC at Brookside, and FMC at Linn Crossing (U.S. Geological Survey, 2006; appendix 1).

Dissolved ammonia concentrations ranged from less than 0.04 to 0.26 mg/L (NWIS parameter code 00608; appendix 1). The highest maximum concentration (0.26 mg/L) and the highest median concentration (0.05 mg/L) were from FMC at Lewisburg. Dissolved ammonia concentrations at FMC at Fivemile Road, FMC at Lawson Road, FMC at Hewitt Park, FMC at Huffman Road, FMC below Springdale Road, FMC near Republic, FMC at Brookside, and FMC at Linn Crossing were less than or equal to 0.04 mg/L. The higher dissolved ammonia concentrations in three samples from FMC at Lewisburg are indicative of urban influences such as wastewater-treatment plant effluent; all other samples from FMC at Lewisburg were less than 0.04 mg/L.

Table 3. Ambient water-quality criteria recommendations for rivers and streams in Nutrient Ecoregion XI (U.S. Environmental Protection Agency, 2000a).

[mg/L, milligram per liter; µg/L, microgram per liter]

Ecoregion within Aggregate Nutrient Ecoregion XI (Central and Eastern Forested Uplands)	Total Kjeldahl nitrogen (mg/L)	Nitrite plus nitrate (mg/L)	Total nitrogen (mg/L)	Total phosphorus (mg/L)	Suspended chlorophyll *a* (µg/L)
Level III ecoregion 67—Ridge and Valley	0.169	0.23	0.214	0.01	1.063
Level III ecoregion 68—Southwestern Appalachians	0.1	0.059	0.3	0.006	2

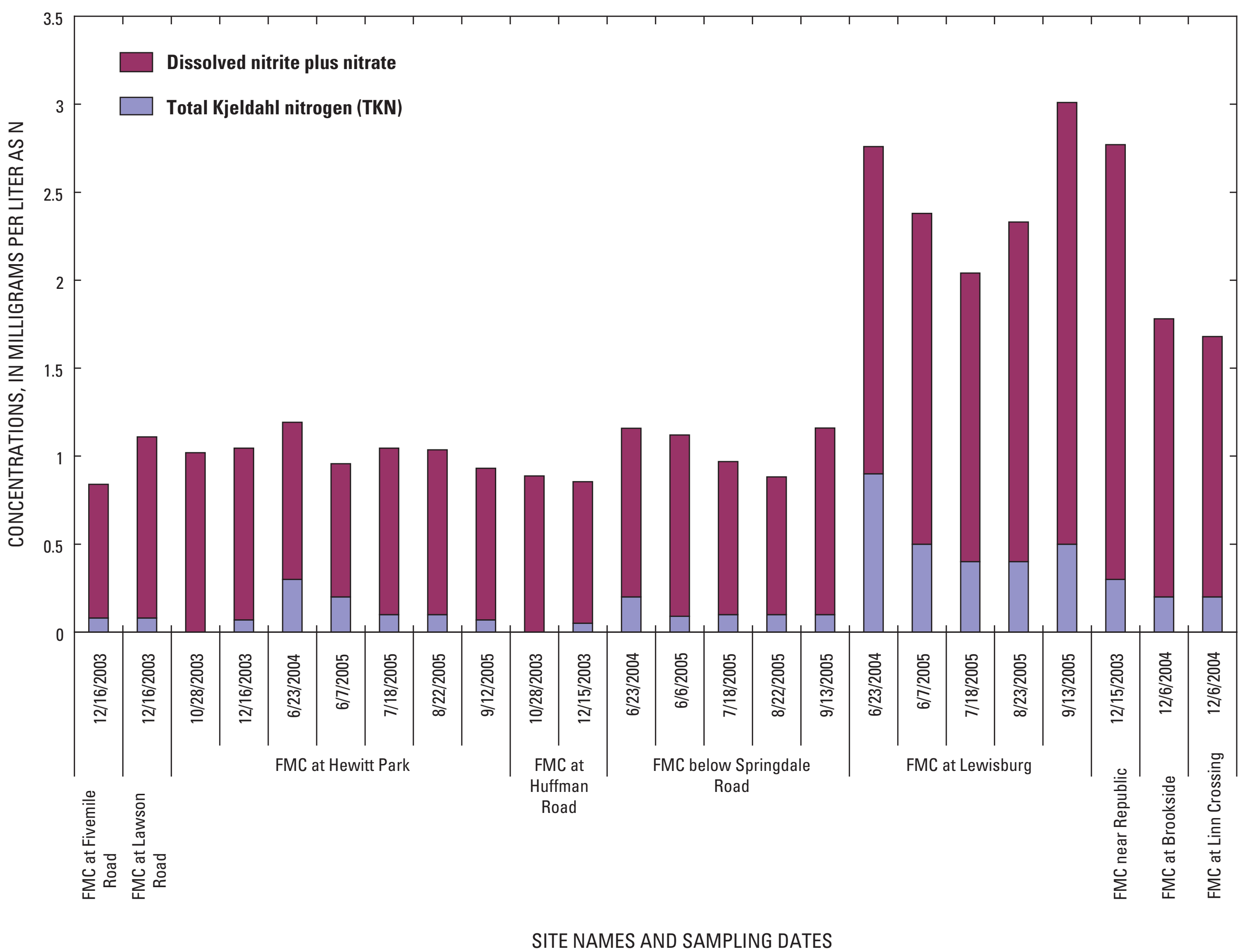

Figure 7. Concentrations of nitrite plus nitrate and total Kjeldahl nitrogen (TKN) in samples from selected sites along Fivemile Creek (FMC), Jefferson County, Alabama, 2003–2005.

Dissolved nitrite-plus-nitrate concentrations ranged from 0.76 to 2.51 mg/L (NWIS parameter code 00631; appendix 1). Nitrite-plus-nitrate concentrations exceeded the appropriate USEPA ecoregion nutrient criterion (table 3) in all of the samples. The highest maximum concentration (2.51 mg/L) and median concentration (1.88 mg/L) of nitrite plus nitrate among sites with multiple nutrient samples occurred at FMC at Lewisburg (fig. 7).

In general, nitrite concentrations were low at most sites in the upstream portion of the FMC study area; downstream sites, beginning with FMC at Lewisburg, had higher nitrite concentrations (NWIS parameter code 00613; appendix 1). Dissolved nitrite concentrations for the sites in the study area ranged from less than 0.008 mg/L to 0.12 mg/L. The highest maximum concentration (0.12 mg/L) and highest median concentration (0.04 mg/L) among sites with multiple nutrient samples occurred at FMC at Lewisburg. Single samples from FMC near Republic, at Brookside, and at Linn Crossing also had detectable concentrations of nitrite. Because nitrite generally is unstable in oxygenated water (Hem, 1985), its presence can be an indication of contamination from wastewater sources. No samples for nitrite exceeded the drinking-water standard of 1 mg/L (U.S. Environmental Protection Agency, 2002).

Dissolved nitrite-plus-nitrate nitrogen was the predominant species of the total nitrogen concentration at all sites (fig. 7). Dissolved nitrite-plus-nitrate nitrogen contributed about 68 to 94 percent of the total nitrogen concentration in most samples. TKN accounted for about 6 to 33 percent of the total nitrogen concentrations (fig. 7).

Phosphorus

Total phosphorus values ranged from 0.007 to 0.184 mg/L (NWIS parameter code 00665; appendix 1). The highest maximum concentration (0.184 mg/L) and median concentration (0.093 mg/L) of total phosphorus among sites with multiple samples occurred at FMC at Lewisburg (fig. 8). Dissolved phosphorus contributed 37 to 100 percent of the total phosphorus concentrations in samples from selected sites, and suspended phosphorus contributed 0 to 69 percent of the total phosphorus concentrations (fig. 8). Total phosphorus concentrations in about 58 percent of all samples were above nutrient

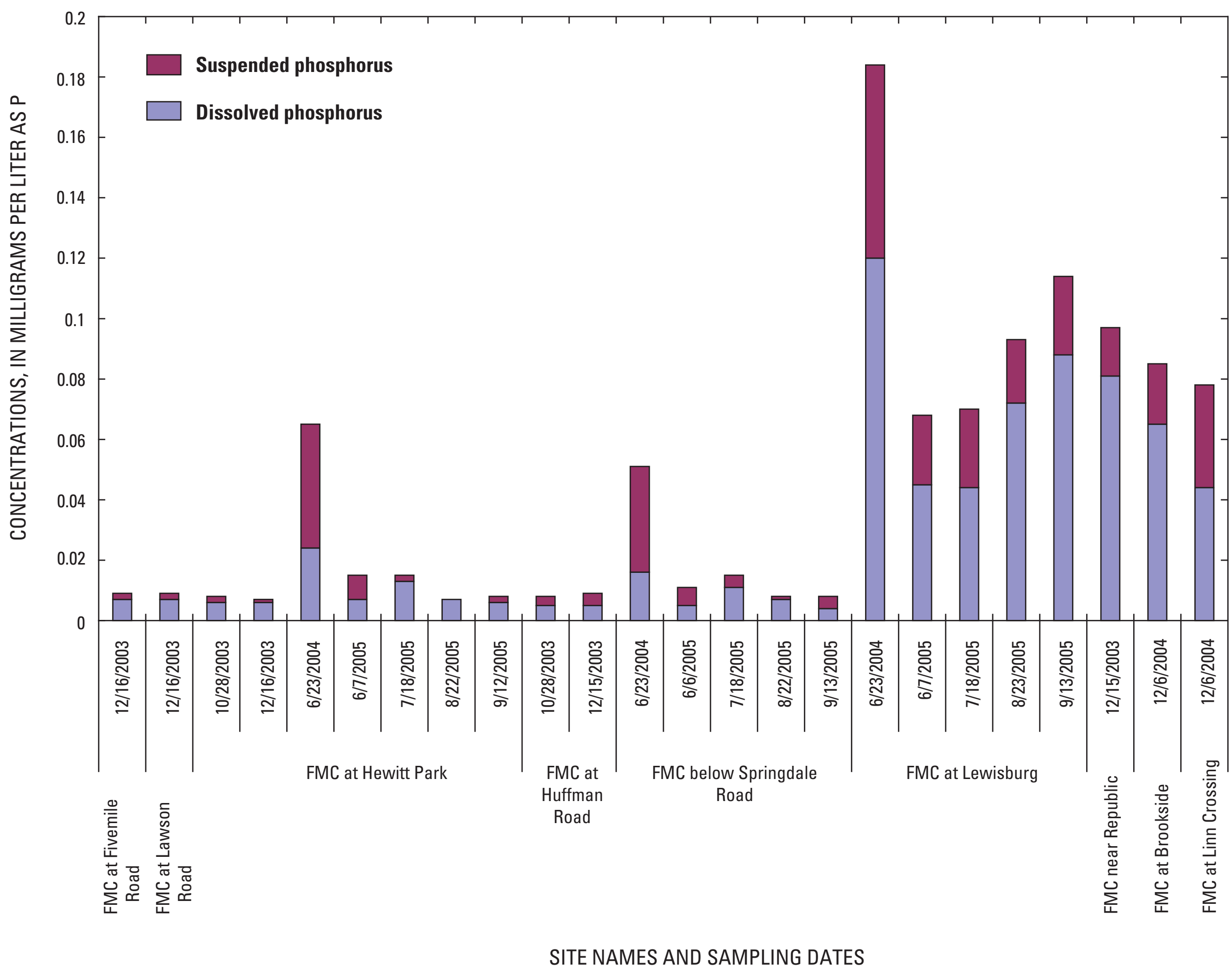

Figure 8. Concentrations of suspended and dissolved phosphorus in samples from sites in the Fivemile Creek (FMC) watershed, Jefferson County, Alabama, 2003–2005.

criteria recommendations (0.01 mg/L for Level III ecoregion 67 and 0.006 mg/L for Level III ecoregion 68; table 3), and total phosphorus concentrations measured at sites within the Southwestern Appalachians (Ecoregion 68) were an order of magnitude greater than the nutrient criterion recommended by the USEPA.

Dissolved phosphorus (parameter code 00666) concentrations ranged from 0.004 to 0.12 mg/L, and dissolved orthophosphate (parameter code 00671) concentrations ranged from less than 0.02 to 0.09 mg/L (figs. 8 and 9; appendix 1). Maximum concentrations of both dissolved phosphorus and dissolved orthophosphate were detected at FMC at Lewisburg. Median concentrations were computed for three sites in the study area (FMC at Hewitt Park, FMC below Springdale Road, and FMC at Lewisburg) because not enough samples were analyzed from other sites to compute median concentrations. The highest median concentrations for dissolved phosphorus (0.072 mg/L) and orthophosphate (0.04 mg/L) were at FMC at Lewisburg. All concentrations of orthophosphate were below the reporting limit (0.02 mg/L) for sites in the upper watershed (FMC at Fivemile Road, FMC at Lawson Road, FMC at Hewitt Park, FMC at Huffman Road, and FMC below Springdale Road) and above the reporting limit at sites in the lower watershed (FMC at Lewisburg, FMC near Republic, FMC at Brookside, and FMC at Linn Crossing) (fig. 9).

Suspended Chlorophyll *a* and Pheophytin *a*

Chlorophyll *a* is green pigment found in most plants and algae. Pheophytin *a* is one of several degradation products of chlorophyll *a*. Chlorophyll *a* often is used as a measure of living algal populations, and pheophytin *a* is used as a measure of dead algal populations. These populations can account for organic carbon in the aquatic system.

Seven samples were collected from among five sites (FMC at Fivemile Road, FMC at Lawson Road, FMC at Hewitt Park, FMC at Huffman Road, and FMC near Republic) and analyzed for suspended chlorophyll *a* concentrations. Suspended chlorophyll *a* was detected in all seven water-column samples from all five sites, with concentrations ranging from 0.25 to 0.53 µg/L (appendix 1). The maximum concentration of suspended chlorophyll *a* was detected at FMC at

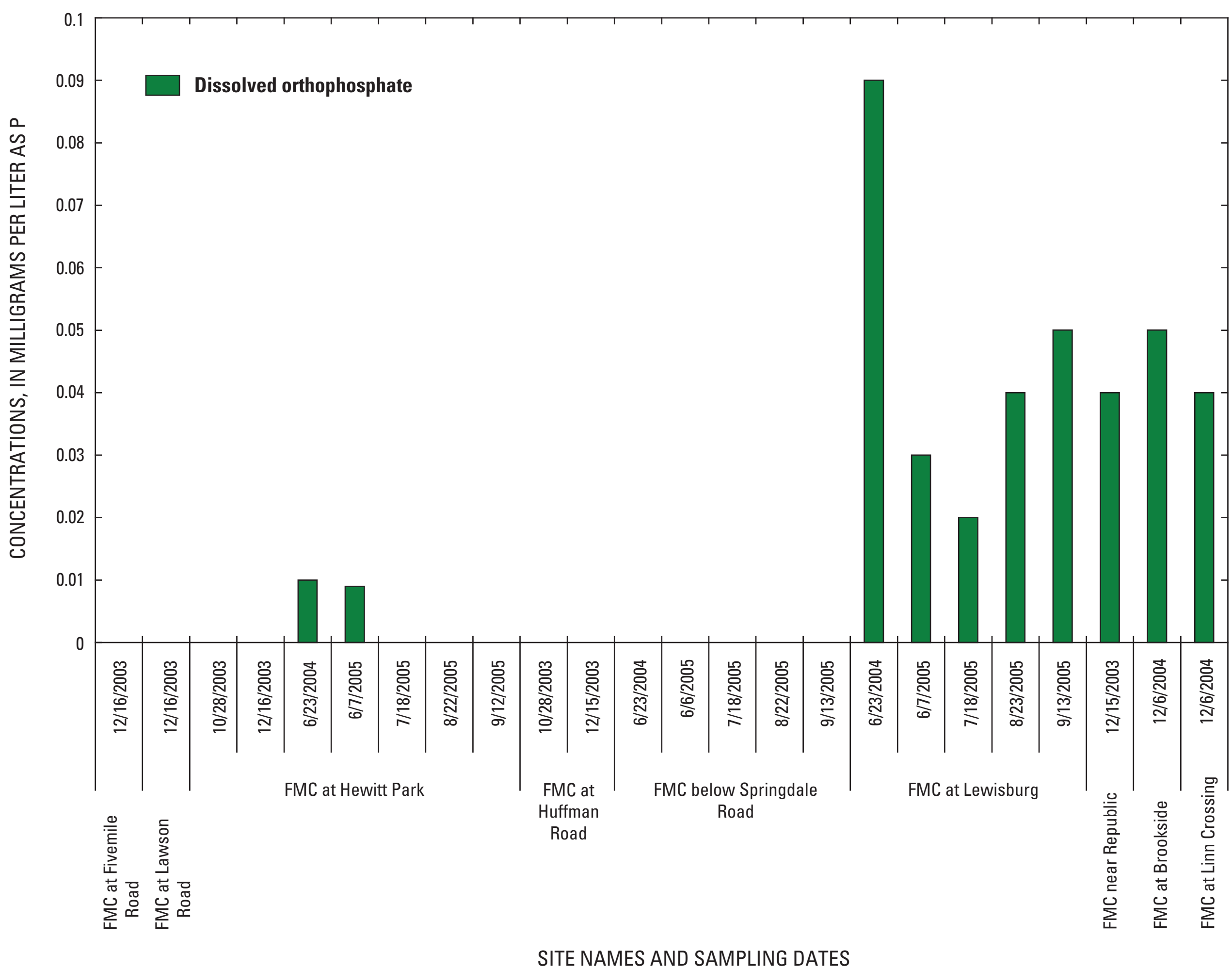

Figure 9. Concentrations of dissolved orthophosphate in samples from selected sites along Fivemile Creek (FMC), Jefferson County, Alabama, 2003–2005.

Fivemile Road (0.53 µg/L). The USEPA recommends that suspended chlorophyll *a* not exceed 1.063 or 2 µg/L, respectively, for rivers and streams in Level III ecoregions 67f and 68f within Nutrient Ecoregion XI (table 3; U.S. Environmental Protection Agency, 2000a). During this study, suspended chlorophyll *a* did not exceed these recommendations in any samples collected in the FMC watershed. Pheophytin *a* was detected in all seven water-column samples, with concentrations ranging from 0.31 to 0.69 µg/L (appendix 1). The maximum concentration of pheophytin *a* was detected at FMC near Republic. There are no USEPA recommendations for pheophytin *a* for rivers and streams in Nutrient Ecoregion XI.

Fecal Indicator Bacteria

Ninety-eight samples from FMC were analyzed for fecal coliform and *E. coli*, two types of bacteria that are indicative of fecal contamination. Samples were collected from 11 sites along FMC at varying frequencies (appendix 1). Two culture methods, m-TEC and modified m-TEC, were used to enumerate *E. coli* in samples from FMC, but in this discussion, results of the two tests are combined.

Criteria for concentrations of fecal indicator bacteria in water intended for various uses have been established by the ADEM and USEPA (table 4). The drinking-water standard of zero colonies per 100 milliliters (col/100 mL) is enforceable but applies only to finished drinking water. All other criteria in table 4 are suggested limits for bacteria concentrations in water intended for various uses. Many of these criteria are designed to be compared to the geometric mean of five or more samples collected within 30 days. Sampling frequency during most of this study did not meet this requirement, except during a few summer sampling periods. Geometric mean bacterial concentrations from these summers with greater sampling frequency are examined first; then comparisons are made between the established criteria and maximum, median, and geometric mean concentrations of all bacteria samples collected at each site. Even when sampling is not as frequent as prescribed by the criteria, comparisons of data to criteria may indicate areas where elevated levels of fecal indicator bacteria occasionally occur.

Sample collection from FMC at Hewitt Park and from FMC at Huffman Road for a few periods during summer 2003, and from FMC below Springdale Road during summer 2005 met the frequency requirements prescribed in the geometric mean criteria. Geometric means were calculated for five overlapping time periods for samples collected during summer 2003 and for one time period during summer 2005 from FMC at Hewitt Park (table 5). Geometric mean fecal-coliform concentrations ranged from 132 to 241 col/100 mL, and for three of these time periods (June 12, 2003, to July 9, 2003; July 17, 2003, to August 15, 2003; and August 12, 2003, to September 9, 2003), the concentrations were greater than the whole-body contact geometric mean criterion (200 col/100 mL; table 4). Geometric mean concentrations of *E. coli* at FMC at Hewitt Park for all of the six time periods (table 5) exceeded the whole-body contact geometric mean criterion (126 col/100 mL; table 4), but were below all other criteria. At Huffman Road, two overlapping time periods and one separate period met the sampling frequency

Table 4. Standards and criteria for concentrations of fecal bacteria for different water-use classifications.

[Alabama Department of Environmental Management (2006b); U.S. Environmental Protection Agency (1986); —, not applicable]

Type of bacteria	Drinking-water standard (colonies per 100 milliliters)	Fecal bacterial concentrations by water-use classification (colonies per 100 milliliters)				
		Outstanding Alabama Water	Public water supply	Swimming and other whole-body contact water sports	Fish and wildlife	Agriculture and industrial water supply
Fecal coliform	0	[a]200	[a]1,000		[a]1,000	
			[b](200)		[b](200)	[a]2,000
			[c]2,000	[a]200	[c]2,000	[c]4,000
Escherichia coli	0	—	—	[a]126	—	—
				[d]235 to 576		

[a]Bacteria shall not exceed a geometric mean of this value. The geometric mean shall be calculated from no less than five samples collected at a given station over a 30-day period at intervals not less than 24 hours.

[b]Values in parentheses are seasonal geometric mean limits effective during June through September to account for incidental water contact and recreational uses.

[c]Maximum bacterial concentration that is not to be exceeded in any sample.

[d]Range in single-sample maximum concentrations suggested by the U.S. Environmental Protection Agency for full-body contact in recreational waters for different frequencies of use, from designated beaches to infrequently used full-body contact recreation areas.

Table 5. Geometric mean fecal-coliform and *Escherichia coli* concentrations for periods when five samples were collected within 30 days at selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.

[shaded cells indicate geometric mean concentrations in exceedance of established criteria]

Station number	Site short name	Periods with five samples in 30 days	Geometric mean concentrations of fecal coliform for periods with five samples in 30 days (colonies per 100 milliliters)	Geometric mean concentrations of *Escherichia coli* for periods with five samples in 30 days (colonies per 100 milliliters)
02456999	FMC at Hewitt Park	6/12/2003 to 7/9/2003	241	223
		6/19/2003 to 7/17/2003	187	140
		6/25/2003 to 7/22/2003	132	130
		7/17/2003 to 8/15/2003	218	203
		8/12/2003 to 9/9/2003	225	175
		6/2/2005 to 6/29/2005	140	155
02457500	FMC at Huffman Road	6/12/2003 to 7/9/2003	130	147
		6/19/2003 to 7/17/2003	74	66
		8/12/2003 to 9/9/2003	193	131
02457502	FMC below Springdale Road	6/2/2005 to 6/29/2005	68	96

requirements of the geometric mean criteria (table 4). No fecal-coliform geometric mean criteria were exceeded at FMC at Huffman Road, but the geometric mean *E. coli* criterion for whole-body contact was exceeded during two periods (June 12, 2003, to July 9, 2003 and August 12, 2003, to September 9, 2003). Geometric mean bacterial concentrations calculated for one period (June 2 to June 29, 2005) at FMC below Springdale Road (table 5) were below geometric mean criteria for fecal coliforms and *E. coli* (table 4).

Fecal-coliform concentrations in the FMC study area ranged from 6 col/100 mL at the Fivemile Road site to 10,000 col/100 mL in a sample from below Springdale Road (fig. 10*A*; appendix 1). No samples from FMC at Brookside Park were analyzed for fecal coliform concentrations. Samples were analyzed for fecal coliform concentrations only once at four sites: FMC at Fivemile Road, FMC at Lawson Road, FMC near Republic, and FMC at Linn Crossing. All measured concentrations at these sites were below all criteria reported in table 4, except the concentration at Linn Crossing (300 col/100 mL), which exceeded the geometric mean criterion for whole-body water contact (200 col/100 mL).

Maximum fecal-coliform concentrations at all sites with multiple samples were observed during or just following higher flow conditions, and exceeded at least one criterion. The two highest fecal-coliform concentrations measured in FMC exceeded the single-sample criterion for agricultural and industrial water supply (4,000 col/100 mL; table 4). These two samples, one from FMC below Springdale Road and one from FMC at Republic Ford, were collected during high-flow conditions on December 7, 2004. The maximum concentration measured at FMC at Hewitt Park on June 23, 2004, exceeded the single-sample maximum criterion for fish and wildlife water use (2,000 col/100 mL). Maximum concentrations measured at FMC at Lewisburg and at Brookside equaled or exceeded the geometric mean criterion for fish and wildlife water use (1,000 col/100 mL), and the maximum concentration at FMC at Huffman Road, 880 col/100 mL (appendix 1), was well above the whole-body contact geometric mean criterion.

Median fecal-coliform concentrations equaled or exceeded criteria at four of the six sites with multiple samples (fig. 10*A*). Median concentrations at FMC at Huffman Road and FMC below Springdale Road were below all fecal-coliform criteria. The median fecal-coliform concentration at FMC at Brookside, 1,060 col/100 mL, exceeded the geometric mean criterion for fish and wildlife water use. Median fecal-coliform concentrations at FMC at Lewisburg and at Republic Ford exceeded the whole-body contact geometric mean criterion of 200 col/100 mL, and median concentrations at FMC at Hewitt Park equaled this criterion.

Geometric means calculated from the entire fecal-coliform dataset for each site were compared to fecal-coliform criteria. Geometric mean fecal-coliform concentrations were below the geometric mean criterion for whole-body contact recreation at three of the six sites with multiple samples. Geometric mean concentrations at FMC at Hewitt Park, at Republic Ford, and at Brookside were greater than the whole-body contact geometric mean criterion, but below all other fecal-coliform criteria (fig. 10*A*).

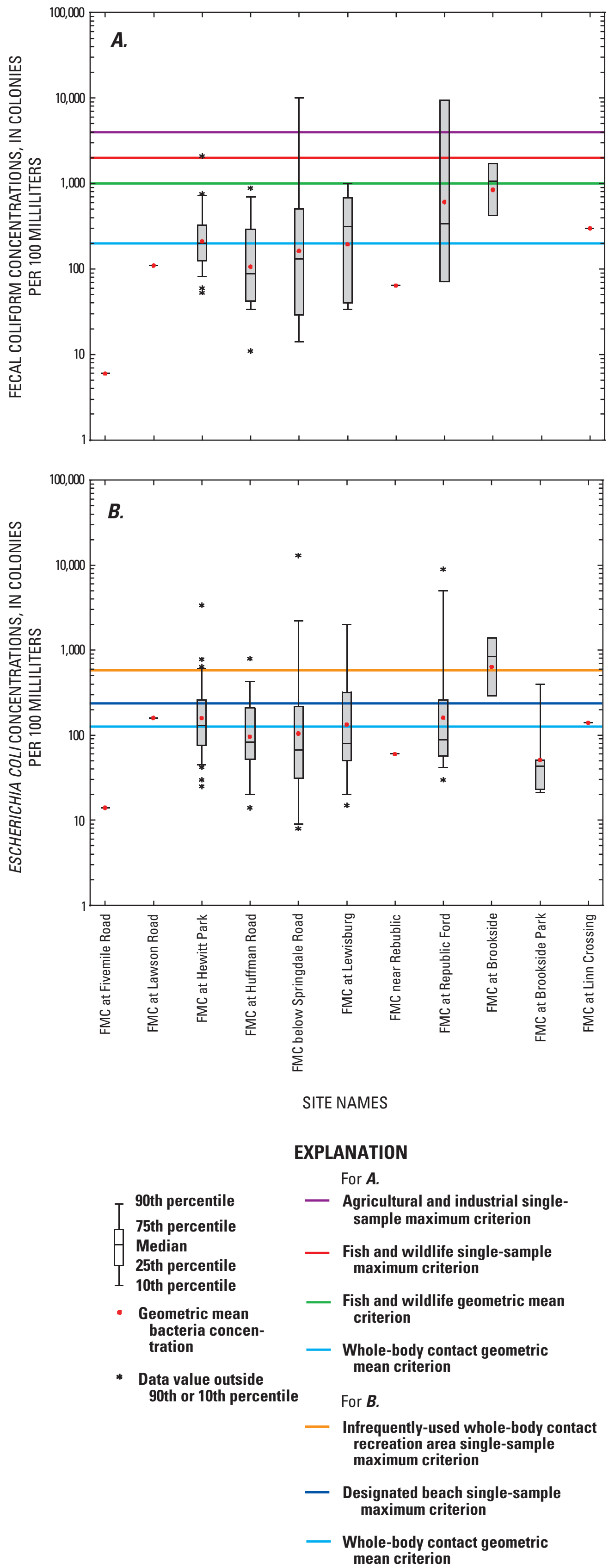

Figure 10. (*A*) Fecal coliform and (*B*) *Escherichia coli* (*E. coli*) concentrations at selected sites along Fivemile Creek (FMC), Jefferson County, Alabama, 2003–2005.

E. coli concentrations analyzed at 11 sites ranged from 8 col/100 mL at FMC below Springdale Road to 13,000 col/100 mL, also at the Springdale Road site (fig. 10*B*). Samples were analyzed for *E. coli* concentrations only once at 4 of the 11 sites: FMC at Fivemile Road, FMC at Lawson Road, FMC near Republic, and FMC at Linn Crossing. Concentrations of *E. coli* at two of these sites, FMC at Lawson Road and FMC at Linn Crossing, exceeded the geometric mean criterion for whole-body contact (126 col/100 mL; table 4; appendix 1).

Maximum *E. coli* concentrations usually occurred during high-flow conditions and exceeded the infrequently-used whole-body contact recreation area single-sample criterion at all but one site with multiple samples. The maximum concentration of *E. coli* at FMC at Brookside Park was 400 col/100 mL, below the infrequently-used whole-body contact recreation area single-sample criterion, but above the USEPA single-sample maximum criterion for designated beach areas. The two greatest *E. coli* concentrations (13,000 col/100 mL at FMC below Springdale Road and 9,000 col/100 mL at FMC at Republic Ford) occurred on the same sampling date, December 7, 2004, as the two greatest fecal-coliform concentrations.

Median *E. coli* concentrations for two of the seven sites with multiple samples exceeded *E. coli* criteria. Median *E. coli* concentrations exceeded the USEPA geometric mean criterion for whole-body contact at FMC at Hewitt Park and at Brookside (fig. 10*B*). The median *E. coli* concentration at Brookside was 845 col/100 mL, greater than the USEPA single-sample maximum criterion for infrequently-used whole-body contact recreation areas (576 col/100 mL; table 4).

Geometric mean *E. coli* concentrations were below all criteria at three of the seven sites with multiple *E. coli* samples: FMC at Huffman Road, FMC below Springdale Road, and FMC at Brookside Park. The geometric mean *E. coli* concentration at FMC at Brookside exceeded the single-sample criterion for waters infrequently used for whole-body contact recreation (576 col/100 mL; table 4; fig. 10*B*), and geometric mean *E. coli* concentrations at FMC at Hewitt Park, at Lewisburg, and at Republic Ford exceeded the geometric mean criterion for whole-body contact (126 col/100 mL).

Many maximum concentrations of fecal coliform and *E. coli* were observed during or just after storm periods. Scatter plots of all fecal indicator bacteria concentrations and measured streamflow at FMC at Ketona (USGS streamgaging station 02457000) indicate that the highest bacterial concentrations occurred during larger stream discharges (fig. 11). The majority of bacteria concentrations appeared to be only weakly related to stream discharge, indicating a mix of point and nonpoint sources of fecal contamination to the creek.

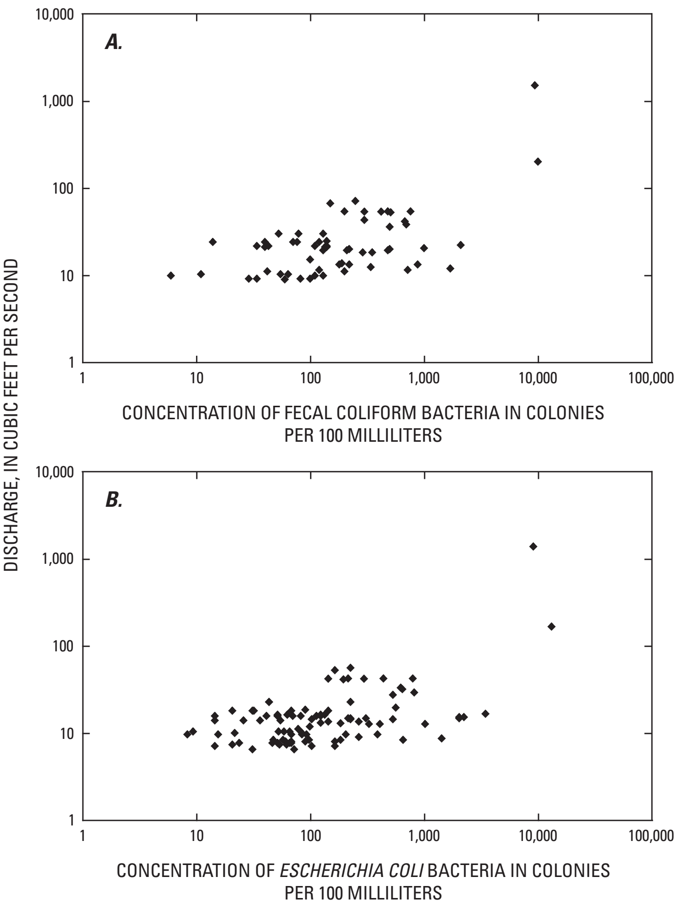

Figure 11. Relation between concentrations of (*A*) fecal coliforms and (*B*) *Escherichia coli* in samples from Fivemile Creek, Jefferson County, Alabama, and simultaneous discharge from USGS streamgaging station 02457000, Fivemile Creek at Ketona.

Organic Wastewater Compounds

Stream samples were collected to assess the occurrence of organic wastewater compounds (OWC) along FMC. Analyses of stream samples for these indicator compounds can be used to identify areas along the stream that may be receiving inputs of wastewater or may be affected by the presence of endocrine-disrupting compounds. Quality-assurance and quality-control samples were analyzed to assess the presence of contamination and variability in results. The results of quality-assurance and quality-control analyses are presented in appendix 2, and should be considered when interpreting the environmental data.

Twenty-nine water samples collected from sites along FMC were analyzed for a group of 57 organic compounds that are commonly associated with human wastewater (table 6). These OWCs can be grouped by their common uses into 11 general-use categories: (1) antioxidants, (2) detergent degradates, (3) disinfectants, (4) fire retardants, (5) flavorings or fragrances, (6) polycyclic aromatic hydrocarbons (PAHs) or combustion byproducts, (7) pesticides, (8) plastics, (9) solvents, (10) sterols or stanols, and (11) stimulants. Forty-six of the 57 OWCs, representing all 11 general-use categories, were detected in samples from FMC (tables 6 and 7). Detections for all compounds other than bromacil were estimated below minimum reporting limits. Concentrations estimated below laboratory reporting limits are treated as detections in the analysis presented herein.

Detection frequencies were calculated for the 46 detected OWCs (fig. 12). Commonly detected compounds may indicate the presence of a continuous source or sources of contamination. The most frequently detected compounds represent a variety of use categories. Caffeine, a stimulant used in a wide array of beverages, foods, and medicines, was the most commonly detected OWC, with 15 detections (table 7). Naphthalene (PAH; 37.9 percent), DEET (pesticide; 37.9 percent), phenol (disinfectant; 31.0 percent), fluoranthene (PAH; 31.0 percent), pyrene (PAH; 31.0 percent), 4-nonylphenol (detergent degradate; 27.6 percent), and bisphenol A (plastic; 26.9 percent) also were found in more than 25 percent of the samples.

Individual samples collected during this investigation are compared in terms of the number of OWCs detected and the total concentration of OWCs in each (fig. 13). Samples were collected at varying sampling times and frequencies from 10 sites along FMC (table 2). Sampling period letter designations (table 2) are used in figure 13 so that samples collected under similar flow conditions can be compared. Flow conditions within sampling periods were generally uniform, but storms occurred during periods X (December 6–8, 2004) and Z (June 6–7, 2005). Of the five samples collected during sampling period X, two samples (FMC at Brookside and at Linn Crossing) were collected before the peak of flow, two samples (FMC below Springdale Road and at Republic Ford) were collected near peak-flow conditions, and one sample (FMC at Hewitt Park) was collected after the peak flow. Of the three samples collected during sampling period Z, one sample (FMC below Springdale Road) was collected before the peak flow, and two samples (FMC at Hewitt Park and at Lewisburg) were collected after the peak flow.

The number of detected OWCs in a single sample ranged from zero in some of the samples collected from FMC at Fivemile Road, at Lawson Road, at Republic Ford, and at Linn Crossing to 32 compounds in one sample from FMC at Lewisburg (table 6; fig. 13*A*). Greater numbers of detections were noted in samples from the S (June 2004) and Z (June 2005) sampling periods. Summer thunderstorms during these periods may have washed additional OWCs into FMC. The lowest numbers of detections were from samples collected during sampling periods Q (December 2003) and X (December 2004), even though the discharge records from USGS streamgaging station 02457000 indicated discharges similar to or greater than the summer periods (fig. 4). Seasonal differences in numbers of detections may occur because of increased use of certain compounds during the summer months as well as climate factors.

Table 6. Concentrations of organic wastewater compounds in water samples collected from selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.

[all values are in micrograms per liter; PAH, polycyclic aromatic hydrocarbon; <, less than; e, estimated concentration; **bold** values indicate detections; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; DEET, *N,N*-diethyl-*m*-toluamide; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; —, compound not analyzed]

USGS station number:		02456900	02456980	02456999	02456999	02456999	02456999	02456999	02456999
Sampling site short name:		FMC at Fivemile Road	FMC at Lawson Road	FMC at Hewitt Park	FMC at Hewitt Park	FMC at Hewitt Park	FMC at Hewitt Park	FMC at Hewitt Park	FMC at Hewitt Park
Sample date:		12/16/2003	12/16/2003	10/28/2003	12/16/2003	6/23/2004	12/8/2004	6/7/2005	7/18/2005
Sample time:		1230	0800	1120	0930	1000	1030	1000	1200
General-use categories	**Organic wastewater compound**								
PAH or combustion byproduct	1-Methylnaphthalene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pesticide	1,4-Dichlorobenzene	<0.5	<0.5	<0.5	<0.5	**e0.097**	<0.5	<0.5	<0.5
PAH or combustion byproduct	2-Methylnaphthalene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PAH or combustion byproduct	2,6-Dimethylnaphthalene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sterol or stanol	3-beta-Coprostanol	<2	<2	<2	<2	<2	<2	<2	<2
Flavoring or Fragrance	3-Methyl-1H-indole	<1	<1	<1	<1	<1	<1	**e0.004**	<1
Antioxidant	3-tert-Butyl-4-hydroxyanisole	<5	<5	<5	<5	<5	<5	<5	<5
Detergent	4-Cumylphenol	<1	<1	<1	<1	<1	<1	<1	<1
Detergent	4-Nonylphenol	<5	<5	**e1.1**	<5	<5	<5	**e0.5**	<5
Detergent	4-Octylphenol	<1	<1	<1	<1	<1	<1	<1	<1
Detergent	4-tert-Octylphenol	<1	<1	<1	<1	<1	<1	<1	<1
Antioxidant	5-Methyl-1H-benzotriazole	<2	<2	<2	<2	<2	<2	<2	<2
Pesticide	9,10-Anthraquinone	<0.5	<0.5	<0.5	<0.5	**e0.09**	<0.5	**e0.11**	<0.5
Flavoring or Fragrance	Acetophenone	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Flavoring or Fragrance	AHTN	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PAH or combustion byproduct	Anthracene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PAH or combustion byproduct	Benzo[a]pyrene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pesticide	Benzophenone	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sterol or stanol	beta-Sitosterol	<2	<2	<2	<2	<2	<2	<2	<2
Sterol or stanol	beta-Stigmastanol	<2	<2	<2	<2	<2	<2	<2	<2
Plastic	Bisphenol A	<1	<1	<1	<1	**e0.18**	<1	<1	<1
Pesticide	Bromacil	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Stimulant	Caffeine	<0.5	<0.5	**e0.037**	<0.5	**e0.19**	**e0.34**	**e0.05**	<0.5
Flavoring or Fragrance	Camphor	<0.5	<0.5	<0.5	<0.5	**e0.019**	<0.5	**e0.005**	<0.5
PAH or combustion byproduct	Carbazole	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**e0.01**	<0.5
Sterol or stanol	Cholesterol	<2	<2	<2	<2	<2	<2	<2	**e0.7**
Stimulant	Cotinine	<1	<1	<1	<1	<1	<1	**e0.03**	<1
Pesticide	DEET	<0.5	<0.5	<0.5	<0.5	**e0.13**	<0.5	**e0.05**	<0.5
Detergent	Diethoxynonylphenol	<5	<5	<5	<5	<5	<5	<5	<5
Detergent	Diethoxyoctylphenol	<1	<1	<1	<1	<1	<1	<1	<1
Flavoring or Fragrance	D-Limonene	<0.5	<0.5	<0.5	<0.5	**e0.042**	<0.5	<0.5	<0.5
Detergent	Ethoxyoctylphenol	<1	<1	<1	<1	<1	<1	<1	<1
PAH or combustion byproduct	Fluoranthene	<0.5	<0.5	<0.5	<0.5	**e0.036**	<0.5	**e0.01**	<0.5
Flavoring or Fragrance	HHCB	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Flavoring or Fragrance	Indole	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**e0.004**	<0.5
Flavoring or Fragrance	Isoborneol	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Solvent	Isophorone	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Solvent	Isopropylbenzene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Flavoring or Fragrance	Isoquinoline	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Flavoring or Fragrance	Menthol	<0.5	<0.5	<0.5	<0.5	**e0.044**	<0.5	<0.5	<0.5
Pesticide	Metalaxyl	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Flavoring or Fragrance	Methyl salicylate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**e0.07**
PAH or combustion byproduct	Naphthalene	<0.5	<0.5	<0.5	<0.5	**e0.028**	<0.5	<0.5	**e0.01**
PAH or combustion byproduct	p-Cresol	<1	<1	<1	<1	<1	<1	**e0.02**	<1
Pesticide	Pentachlorophenol	<2	<2	<2	<2	<2	<2	<2	<2
PAH or combustion byproduct	Phenanthrene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Disinfectant	Phenol	<0.5	<0.5	**e0.27**	<0.5	<0.5	<0.5	**e0.21**	**e0.19**
PAH or combustion byproduct	Pyrene	<0.5	<0.5	<0.5	<0.5	**e0.034**	<0.5	**e0.007**	<0.5
Solvent	Tetrachloroethene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**e0.004**	<0.5
Disinfectant	Tribromomethane	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fire Retardant	Tributyl phosphate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Disinfectant	Triclosan	<1	<1	<1	<1	<1	<1	<1	<1
Plastic	Triethyl citrate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Plastic	Triphenyl phosphate	<0.5	<0.5	<0.5	<0.5	**e0.051**	<0.5	**e0.007**	<0.5
Plastic	Tris(2-butoxyethyl) phosphate	<0.5	<0.5	<0.5	<0.5	**e0.21**	<0.5	<0.5	<0.5
Fire Retardant	Tris(2-chloroethyl) phosphate	<0.5	<0.5	<0.5	<0.5	**e0.31**	<0.5	<0.5	<0.5
Fire Retardant	Tris(dichloroisopropyl) phosphate	<0.5	<0.5	<0.5	<0.5	**e0.079**	<0.5	**e0.03**	<0.5

Table 6. Concentrations of organic wastewater compounds in water samples collected from selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[all values are in micrograms per liter; PAH, polycyclic aromatic hydrocarbon; <, less than; e, estimated concentration; **bold** values indicate detections; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; DEET, *N*,*N*-diethyl-*m*-toluamide; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; —, compound not analyzed]

USGS station number:		02456999	02456999	02457500	02457500	02457502	02457502	02457502
Sampling site short name:		FMC at Hewitt Park	FMC at Hewitt Park	FMC at Huffman Road	FMC at Huffman Road	FMC below Springdale Road	FMC below Springdale Road	FMC below Springdale Road
Sample date:		8/22/2005	9/12/2005	10/28/2003	12/15/2003	6/23/2004	12/7/2004	6/6/2005
Sample time:		1115	1445	1000	1330	1300	1300	1130
General-use categories	**Organic wastewater compound**							
PAH or combustion byproduct	1-Methylnaphthalene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pesticide	1,4-Dichlorobenzene	<0.5	<0.5	<0.5	<0.5	**e0.085**	<0.5	<0.5
PAH or combustion byproduct	2-Methylnaphthalene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PAH or combustion byproduct	2,6-Dimethylnaphthalene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sterol or stanol	3-beta-Coprostanol	<2	<2	<2	<2	<2	<2	<2
Flavoring or Fragrance	3-Methyl-1H-indole	<1	<1	<1	<1	<1	<1	**e0.006**
Antioxidant	3-tert-Butyl-4-hydroxyanisole	<5	<5	<5	<5	<5	<5	<5
Detergent	4-Cumylphenol	<1	<1	<1	<1	<1	<1	<1
Detergent	4-Nonylphenol	<5	<5	**e1.1**	<5	<5	<5	<5
Detergent	4-Octylphenol	<1	<1	<1	<1	<1	<1	<1
Detergent	4-tert-Octylphenol	<1	<1	<1	<1	<1	<1	<1
Antioxidant	5-Methyl-1H-benzotriazole	<2	<2	<2	<2	<2	<2	<2
Pesticide	9,10-Anthraquinone	<0.5	<0.5	<0.5	<0.5	**e0.084**	<0.5	**e0.07**
Flavoring or Fragrance	Acetophenone	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Flavoring or Fragrance	AHTN	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PAH or combustion byproduct	Anthracene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PAH or combustion byproduct	Benzo[a]pyrene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pesticide	Benzophenone	**e0.05**	<0.5	<0.5	<0.5	<0.5	<0.5	**e0.01**
Sterol or stanol	beta-Sitosterol	<2	<2	<2	<2	<2	<2	**e0.4**
Sterol or stanol	beta-Stigmastanol	<2	<2	<2	<2	<2	<2	**e0.4**
Plastic	Bisphenol A	—	<1	<1	<1	**e0.19**	<1	<1
Pesticide	Bromacil	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**e0.06**
Stimulant	Caffeine	<0.5	<0.5	**e0.064**	**e0.064**	**e0.17**	**e0.08**	**e0.04**
Flavoring or Fragrance	Camphor	<0.5	<0.5	<0.5	<0.5	**e0.02**	<0.5	**e0.006**
PAH or combustion byproduct	Carbazole	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**e0.006**
Sterol or stanol	Cholesterol	<2	<2	<2	<2	<2	<2	**e0.6**
Stimulant	Cotinine	<1	<1	<1	<1	<1	<1	**e0.03**
Pesticide	DEET	<0.5	<0.5	**e0.16**	<0.5	**e0.11**	<0.5	**e0.03**
Detergent	Diethoxynonylphenol	<5	<5	<5	<5	<5	<5	<5
Detergent	Diethoxyoctylphenol	<1	<1	**e0.088**	<1	<1	<1	<1
Flavoring or Fragrance	D-Limonene	<0.5	<0.5	<0.5	<0.5	**e0.048**	<0.5	<0.5
Detergent	Ethoxyoctylphenol	<1	<1	<1	<1	<1	<1	<1
PAH or combustion byproduct	Fluoranthene	<0.5	<0.5	<0.5	<0.5	**e0.035**	<0.5	**e0.01**
Flavoring or Fragrance	HHCB	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Flavoring or Fragrance	Indole	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**e0.005**
Flavoring or Fragrance	Isoborneol	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Solvent	Isophorone	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**e0.006**
Solvent	Isopropylbenzene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Flavoring or Fragrance	Isoquinoline	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Flavoring or Fragrance	Menthol	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pesticide	Metalaxyl	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Flavoring or Fragrance	Methyl salicylate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**e0.01**
PAH or combustion byproduct	Naphthalene	<0.5	<0.5	<0.5	<0.5	**e0.036**	<0.5	**e0.03**
PAH or combustion byproduct	p-Cresol	<1	**e0.03**	<1	<1	<1	<1	**e0.04**
Pesticide	Pentachlorophenol	—	<2	<2	<2	<2	<2	<2
PAH or combustion byproduct	Phenanthrene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**e0.008**
Disinfectant	Phenol	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**e0.34**
PAH or combustion byproduct	Pyrene	<0.5	<0.5	<0.5	<0.5	**e0.035**	<0.5	**e0.006**
Solvent	Tetrachloroethene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Disinfectant	Tribromomethane	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fire Retardant	Tributyl phosphate	<0.5	<0.5	<0.5	<0.5	**e0.095**	<0.5	<0.5
Disinfectant	Triclosan	<1	<1	<1	<1	<1	<1	<1
Plastic	Triethyl citrate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Plastic	Triphenyl phosphate	<0.5	<0.5	<0.5	<0.5	**e0.05**	<0.5	**e0.006**
Plastic	Tris(2-butoxyethyl) phosphate	<0.5	<0.5	<0.5	<0.5	**e0.22**	<0.5	<0.5
Fire Retardant	Tris(2-chloroethyl) phosphate	<0.5	<0.5	<0.5	<0.5	**e0.24**	<0.5	<0.5
Fire Retardant	Tris(dichloroisopropyl) phosphate	<0.5	<0.5	<0.5	<0.5	**e0.077**	<0.5	**e0.03**

Table 6. Concentrations of organic wastewater compounds in water samples collected from selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[all values are in micrograms per liter; PAH, polycyclic aromatic hydrocarbon; <, less than; e, estimated concentration; **bold** values indicate detections; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; DEET, *N,N*-diethyl-*m*-toluamide; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; —, compound not analyzed]

USGS station number:		02457502	02457502	02457502	02457510	02457510	02457510	02457510
Sampling site short name:		FMC below Springdale Road	FMC below Springdale Road	FMC below Springdale Road	FMC at Lewisburg	FMC at Lewisburg	FMC at Lewisburg	FMC at Lewisburg
Sample date:		7/18/2005	8/22/2005	9/13/2005	6/23/2004	6/7/2005	7/18/2005	8/23/2005
Sample time:		1040	1500	0830	1400	1230	1545	0900
General-use categories	**Organic wastewater compound**							
PAH or combustion byproduct	1-Methylnaphthalene	<0.5	<0.5	<0.5	<0.5	**e0.01**	**e0.02**	<0.5
Pesticide	1,4-Dichlorobenzene	<0.5	<0.5	<0.5	**e0.1**	<0.5	<0.5	<0.5
PAH or combustion byproduct	2-Methylnaphthalene	<0.5	<0.5	<0.5	<0.5	**e0.01**	**e0.02**	<0.5
PAH or combustion byproduct	2,6-Dimethylnaphthalene	<0.5	<0.5	<0.5	<0.5	**e0.005**	<0.5	<0.5
Sterol or stanol	3-beta-Coprostanol	<2	<2	<2	<2	**e0.5**	<2	<2
Flavoring or Fragrance	3-Methyl-1H-indole	<1	<1	<1	<1	**e0.004**	<1	<1
Antioxidant	3-tert-Butyl-4-hydroxyanisole	<5	<5	<5	<5	<5	<5	<5
Detergent	4-Cumylphenol	<1	<1	<1	<1	**e0.007**	<1	<1
Detergent	4-Nonylphenol	**e0.5**	<5	**e0.8**	**e1.2**	**e0.7**	**e0.8**	<5
Detergent	4-Octylphenol	<1	<1	<1	<1	<1	<1	<1
Detergent	4-tert-Octylphenol	<1	<1	<1	<1	<1	<1	<1
Antioxidant	5-Methyl-1H-benzotriazole	<2	<2	<2	<2	**e0.2**	<2	<2
Pesticide	9,10-Anthraquinone	<0.5	<0.5	<0.5	**e0.12**	**e0.08**	**e0.03**	<0.5
Flavoring or Fragrance	Acetophenone	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Flavoring or Fragrance	AHTN	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PAH or combustion byproduct	Anthracene	<0.5	<0.5	<0.5	**e0.066**	**e0.02**	**e0.01**	<0.5
PAH or combustion byproduct	Benzo[a]pyrene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pesticide	Benzophenone	**e0.03**	<0.5	<0.5	<0.5	**e0.02**	<0.5	<0.5
Sterol or stanol	beta-Sitosterol	<2	<2	<2	<2	**e0.8**	<2	<2
Sterol or stanol	beta-Stigmastanol	<2	<2	<2	<2	**e0.9**	<2	<2
Plastic	Bisphenol A	<1	—	<1	**e0.21**	<1	<1	—
Pesticide	Bromacil	<0.5	<0.5	<0.5	**1**	**2.4**	**0.68**	<0.5
Stimulant	Caffeine	<0.5	<0.5	<0.5	**e0.2**	**e0.05**	**e0.08**	<0.5
Flavoring or Fragrance	Camphor	<0.5	<0.5	<0.5	**e0.023**	**e0.008**	<0.5	<0.5
PAH or combustion byproduct	Carbazole	<0.5	<0.5	<0.5	**e0.13**	**e0.02**	**e0.03**	**e0.04**
Sterol or stanol	Cholesterol	**e0.6**	<2	<2	<2	**e1.0**	**e0.7**	<2
Stimulant	Cotinine	<1	<1	<1	<1	<1	<1	<1
Pesticide	DEET	**e0.06**	<0.5	<0.5	**e0.12**	**e0.05**	**e0.09**	<0.5
Detergent	Diethoxynonylphenol	<5	<5	<5	**e4.7**	<5	<5	<5
Detergent	Diethoxyoctylphenol	<1	<1	<1	**e0.13**	<1	<1	<1
Flavoring or Fragrance	D-Limonene	<0.5	<0.5	<0.5	**e0.05**	<0.5	<0.5	<0.5
Detergent	Ethoxyoctylphenol	<1	<1	<1	<1	<1	<1	<1
PAH or combustion byproduct	Fluoranthene	<0.5	<0.5	<0.5	**e0.078**	**e0.04**	**e0.03**	**e0.05**
Flavoring or Fragrance	HHCB	<0.5	<0.5	<0.5	<0.5	**e0.01**	<0.5	<0.5
Flavoring or Fragrance	Indole	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Flavoring or Fragrance	Isoborneol	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Solvent	Isophorone	<0.5	<0.5	<0.5	<0.5	**e0.005**	<0.5	**e0.03**
Solvent	Isopropylbenzene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Flavoring or Fragrance	Isoquinoline	<0.5	<0.5	<0.5	**e0.14**	<0.5	<0.5	<0.5
Flavoring or Fragrance	Menthol	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pesticide	Metalaxyl	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Flavoring or Fragrance	Methyl salicylate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PAH or combustion byproduct	Naphthalene	**e0.01**	<0.5	**e0.03**	**e0.11**	**e0.1**	**e0.17**	**e0.09**
PAH or combustion byproduct	p-Cresol	<1	<1	**e0.02**	<1	**e0.02**	<1	<1
Pesticide	Pentachlorophenol	<2	—	<2	<2	**e0.08**	<2	—
PAH or combustion byproduct	Phenanthrene	<0.5	<0.5	**e0.006**	**e0.058**	**e0.02**	**e0.03**	**e0.03**
Disinfectant	Phenol	**e0.25**	<0.5	<0.5	**e0.2**	**e0.17**	**e0.23**	<0.5
PAH or combustion byproduct	Pyrene	<0.5	<0.5	<0.5	**e0.064**	**e0.04**	**e0.02**	**e0.04**
Solvent	Tetrachloroethene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Disinfectant	Tribromomethane	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fire Retardant	Tributyl phosphate	<0.5	<0.5	<0.5	<0.5	**e0.02**	<0.5	<0.5
Disinfectant	Triclosan	<1	<1	<1	<1	<1	<1	<1
Plastic	Triethyl citrate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Plastic	Triphenyl phosphate	<0.5	<0.5	<0.5	**e0.055**	**e0.007**	<0.5	<0.5
Plastic	Tris(2-butoxyethyl) phosphate	<0.5	<0.5	<0.5	**e0.27**	**e0.14**	<0.5	<0.5
Fire Retardant	Tris(2-chloroethyl) phosphate	<0.5	<0.5	<0.5	**e0.18**	<0.5	<0.5	<0.5
Fire Retardant	Tris(dichloroisopropyl) phosphate	<0.5	<0.5	<0.5	**e0.089**	**e0.03**	<0.5	<0.5

Table 6. Concentrations of organic wastewater compounds in water samples collected from selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[all values are in micrograms per liter; PAH, polycyclic aromatic hydrocarbon; <, less than; e, estimated concentration; **bold** values indicate detections; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; DEET, *N,N*-diethyl-*m*-toluamide; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; —, compound not analyzed]

USGS station number:		02457510	02457595	02457599	02457599	02457625	02457625	02457700		
Sampling site short name:		FMC at Lewisburg	FMC near Republic	FMC at Republic Ford	FMC at Republic Ford	FMC at Brookside	FMC at Brookside	FMC at Linn Crossing	Number of detections	Total concentration of all detections
Sample date:		9/13/2005	12/15/2003	11/2/2004	12/7/2004	11/2/2004	12/6/2004	12/6/2004		
Sample time:		1130	1045	1715	0900	1430	1515	1230		
General-use categories	**Organic wastewater compound**									
PAH or combustion byproduct	1-Methylnaphthalene	**e0.01**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3	0.04
Pesticide	1,4-Dichlorobenzene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3	0.282
PAH or combustion byproduct	2-Methylnaphthalene	**e0.01**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3	0.04
PAH or combustion byproduct	2,6-Dimethylnaphthalene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1	0.005
Sterol or stanol	3-beta-Coprostanol	**e0.2**	**e0.74**	<2	<2	<2	<2	<2	3	1.44
Flavoring or Fragrance	3-Methyl-1H-indole	<1	<1	<1	<1	<1	<1	<1	3	0.014
Antioxidant	3-tert-Butyl-4-hydroxyanisole	<5	<5	<5	<5	<5	<5	<5	0	0
Detergent	4-Cumylphenol	<1	<1	<1	<1	<1	<1	<1	1	0.007
Detergent	4-Nonylphenol	<5	<5	<5	<5	<5	<5	<5	8	6.7
Detergent	4-Octylphenol	<1	<1	<1	<1	<1	<1	<1	0	0
Detergent	4-tert-Octylphenol	<1	<1	<1	<1	<1	<1	<1	0	0
Antioxidant	5-Methyl-1H-benzotriazole	**e0.08**	<2	<2	<2	<2	<2	<2	2	0.28
Pesticide	9,10-Anthraquinone	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	7	0.584
Flavoring or Fragrance	Acetophenone	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0	0
Flavoring or Fragrance	AHTN	<0.5	<0.5	**e0.07**	<0.5	**e0.04**	**e0.02**	<0.5	3	0.13
PAH or combustion byproduct	Anthracene	**e0.01**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4	0.106
PAH or combustion byproduct	Benzo[a]pyrene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0	0
Pesticide	Benzophenone	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4	0.11
Sterol or stanol	beta-Sitosterol	**e0.3**	<2	<2	<2	<2	<2	<2	3	1.5
Sterol or stanol	beta-Stigmastanol	**e0.4**	<2	<2	<2	<2	<2	<2	3	1.7
Plastic	Bisphenol A	**e0.03**	<1	<1	<1	<1	<1	<1	7	0.61
Pesticide	Bromacil	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4	4.14
Stimulant	Caffeine	**e0.03**	**e0.17**	<0.5	<0.5	<0.5	**e0.14**	<0.5	15	1.705
Flavoring or Fragrance	Camphor	**e0.008**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	7	0.089
PAH or combustion byproduct	Carbazole	**e0.02**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	7	0.256
Sterol or stanol	Cholesterol	<2	**e0.95**	<2	<2	<2	<2	<2	6	4.55
Stimulant	Cotinine	<1	<1	<1	<1	<1	<1	<1	2	0.06
Pesticide	DEET	**e0.04**	**e0.09**	<0.5	<0.5	<0.5	<0.5	<0.5	11	0.93
Detergent	Diethoxynonylphenol	<5	**e4.2**	**e2.7**	<5	**e2.7**	<5	<5	4	14.3
Detergent	Diethoxyoctylphenol	**e0.05**	<1	<1	<1	<1	<1	<1	3	0.268
Flavoring or Fragrance	D-Limonene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3	0.14
Detergent	Ethoxyoctylphenol	<1	**e0.72**	<1	<1	<1	<1	<1	1	0.72
PAH or combustion byproduct	Fluoranthene	**e0.03**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	9	0.319
Flavoring or Fragrance	HHCB	<0.5	<0.5	**e0.24**	<0.5	**e0.11**	**e0.09**	<0.5	4	0.45
Flavoring or Fragrance	Indole	**e0.008**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3	0.017
Flavoring or Fragrance	Isoborneol	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0	0
Solvent	Isophorone	**e0.006**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4	0.047
Solvent	Isopropylbenzene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0	0
Flavoring or Fragrance	Isoquinoline	**e0.01**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2	0.15
Flavoring or Fragrance	Menthol	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1	0.044
Pesticide	Metalaxyl	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0	0
Flavoring or Fragrance	Methyl salicylate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2	0.08
PAH or combustion byproduct	Naphthalene	**e0.09**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	11	0.704
PAH or combustion byproduct	p-Cresol	**e0.02**	<1	<1	<1	<1	<1	<1	6	0.15
Pesticide	Pentachlorophenol	<2	<2	<2	<2	<2	<2	<2	4	0.08
PAH or combustion byproduct	Phenanthrene	**e0.02**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	7	0.172
Disinfectant	Phenol	<0.5	<0.5	**e0.38**	<0.5	<0.5	<0.5	<0.5	9	2.24
PAH or combustion byproduct	Pyrene	**e0.03**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	9	0.276
Solvent	Tetrachloroethene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1	0.004
Disinfectant	Tribromomethane	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0	0
Fire Retardant	Tributyl phosphate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2	0.115
Disinfectant	Triclosan	<1	<1	<1	<1	<1	<1	<1	0	0
Plastic	Triethyl citrate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0	0
Plastic	Triphenyl phosphate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	6	0.176
Plastic	Tris(2-butoxyethyl) phosphate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4	0.84
Fire Retardant	Tris(2-chloroethyl) phosphate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3	0.73
Fire Retardant	Tris(dichloroisopropyl) phosphate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	6	0.335

Table 7. General-use categories and summary of detections of 57 organic wastewater compounds in samples collected from selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.

[Detected compounds shown in **bold**. Green shading denotes greatest detection frequency, median concentration, or maximum concentration within the general-use category. MRL, minimum reporting limit; µg/L, micrograms per liter; ND, not detected; —, not applicable; e, estimated; K, known; S, suspected; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; PAH, polycyclic aromatic hydrocarbon; *, compound is intended to repel, rather than kill, pests]

General-use categories and compounds	Endocrine-disrupting potential	MRL (µg/L)	Number of detections	Sample size	Detection frequency (percent)	Median concentration (µg/L)	Maximum detected concentration (µg/L)	Site with maximum concentration
Antioxidants			2	29	6.9		0.2[a]	FMC at Lewisburg
3-*tert*-Butyl-4-hydroxyanisole	K	5	ND	29	—	—	—	—
5-Methyl-1H-benzotriazole	—	2	2	29	6.9	0.14	e0.2	FMC at Lewisburg
Detergent degradates			12	29	41.4		6.03[a]	FMC at Lewisburg
4-Cumylphenol	K	1	1	29	3.5	0.007	e0.007	FMC at Lewisburg
4-Nonylphenol	K	5	8	29	27.7	0.8	e1.2	FMC at Lewisburg
4-Octylphenol	K	1	ND	29	—	—	—	—
4-tert-Octylphenol	K	1	ND	29	—	—	—	—
Diethoxynonylphenol (total, NPEO2)	K	5	4	29	13.8	3.45	e4.7	FMC at Lewisburg
Diethoxyoctylphenol (OPEO2)	K	1	3	29	10.3	0.088	e0.13	FMC at Lewisburg
Ethoxyoctylphenol (OPEO1)	K	1	1	29	3.4	0.06	e0.72	FMC near Republic
Disinfectants			9	29	31.0		0.38[a]	FMC at Republic Ford
Phenol	—	0.5	9	29	31.0	0.23	e0.38	FMC at Republic Ford
Tribromomethane	—	0.5	ND	29	—	—	—	—
Triclosan	S	1	ND	29	—	—	—	—
Fire Retardants			6	29	20.7		0.412[a]	FMC below Springdale Rd.
Tributyl phosphate	—	0.5	2	29	6.9	0.0575	e0.095	FMC below Springdale Rd.
Tris(2-chloroethyl) phosphate	S	0.5	3	29	10.3	0.24	e0.31	FMC at Hewitt Park
Tris(dichloroisopropyl) phosphate	S	0.5	6	29	20.7	0.0535	e0.089	FMC at Lewisburg
Flavorings or Fragrances			11	29	37.9		0.31[a]	FMC at Republic Ford
3-Methyl-1H-indole (skatole)	—	1	3	29	10.3	0.004	e0.006	FMC below Springdale Rd.
Acetophenone	—	0.5	ND	29	—	—	—	—
HHCB	—	0.5	4	29	13.8	0.1	e0.24	FMC at Republic Ford
Camphor	—	0.5	7	29	24.1	0.008	e0.023	FMC at Lewisburg
D-Limonene	—	0.5	3	29	10.3	0.048	e0.05	FMC at Lewisburg
AHTN	—	0.5	3	29	10.3	0.04	e0.07	FMC at Republic Ford
Indole	—	0.5	3	29	10.3	0.005	e0.008	FMC at Lewisburg
Isoborneol	—	0.5	ND	29	—	—	—	—
Isoquinoline	—	0.5	2	29	6.9	0.075	e0.14	FMC at Lewisburg
Menthol	—	0.5	1	29	3.5	0.044	e0.044	FMC at Hewitt Park
Methyl salicylate	—	0.5	2	29	6.9	0.04	e0.07	FMC at Hewitt Park

Table 7. General-use categories and summary of detections of 57 organic wastewater compounds in samples collected from selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[Detected compounds shown in **bold**. Green shading denotes greatest detection frequency, median concentration, or maximum concentration within the general-use category. MRL, minimum reporting limit; µg/L, micrograms per liter; ND, not detected; —, not applicable; e, estimated; K, known; S, suspected; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; PAH, polycyclic aromatic hydrocarbon; *, compound is intended to repel, rather than kill, pests]

General-use categories and compounds	Endocrine-disrupting potential	MRL (µg/L)	Number of detections	Sample size	Detection frequency (percent)	Median concentration (µg/L)	Maximum detected concentration (µg/L)	Site with maximum concentration
PAHs or combustion byproducts			13	29	44.8		0.506[a]	FMC at Lewisburg
2-Methylnaphthalene	—	0.5	3	29	10.3	0.01	e0.02	FMC at Lewisburg
1-Methylnaphthalene	—	0.5	3	29	10.3	0.01	e0.02	FMC at Lewisburg
2,6-Dimethylnaphthalene	—	0.5	1	29	3.5	0.005	e0.005	FMC at Lewisburg
Anthracene	—	0.5	4	29	13.8	0.015	e0.066	FMC at Lewisburg
Benzo[a]pyrene	K	0.5	ND	29	—	—	—	—
Carbazole	—	0.5	7	29	24.1	0.02	e0.13	FMC at Lewisburg
Fluoranthene	—	0.5	9	29	31.0	0.035	e0.078	FMC at Lewisburg
Naphthalene	—	0.5	11	29	37.9	0.036	e0.17	FMC at Lewisburg
p-Cresol	S	1	6	29	20.7	0.02	e0.04	FMC below Springdale Rd.
Phenanthrene	—	0.5	7	29	24.1	0.02	e0.058	FMC at Lewisburg
Pyrene	—	0.5	9	29	31.0	0.034	e0.064	FMC at Lewisburg
Pesticides			12	29	41.4		2.63[a]	
Benzophenone	S	0.5	4	29	13.8	0.025	e0.05	FMC at Hewitt Park
1,4-Dichlorobenzene	S	0.5	3	29	10.3	0.097	e0.1	FMC at Lewisburg
Bromacil	—	0.5	4	29	13.8	0.84	2.4	FMC at Lewisburg
N,N-diethyl-meta-toluamide (DEET)*	—	0.5	11	29	37.9	0.09	e0.16	FMC at Huffman Rd.
Metalaxyl	—	0.5	ND	29	—	—	—	—
Pentachlorophenol	S	2	4	26	15.4	0.08	e0.08	FMC at Lewisburg
9,10-Anthraquinone*	—	0.5	7	29	24.1	0.084	e0.12	FMC at Lewisburg
Plastics			10	29	34.5		0.535[a]	FMC at Lewisburg
Bisphenol A	K	1	7	26	26.9	0.185	e0.21	FMC at Lewisburg
Triethyl citrate	—	0.5	ND	29	—	—	—	—
Triphenyl phosphate	—	0.5	6	29	20.7	0.0285	e0.055	FMC at Lewisburg
Tris(2-butoxyethyl) phosphate	—	0.5	4	29	13.8	0.215	e0.27	FMC at Lewisburg
Solvents			5	29	17.2		0.03[a]	FMC at Lewisburg
Isophorone	—	0.5	4	29	13.8	0.006	e0.03	FMC at Lewisburg
Isopropylbenzene	—	0.5	ND	29	—	—	—	—
Tetrachloroethene	—	0.5	1	29	3.5	0.004	e0.004	FMC at Hewitt Park
Sterols or stanols			7	29	24.1		3.2[a]	FMC at Lewisburg
3-beta-Coprostanol	—	2	3	29	10.3	0.5	e0.74	FMC near Republic
beta-Sitosterol	—	2	3	29	10.3	0.4	e0.8	FMC at Lewisburg
beta-Stigmastanol	—	2	3	29	10.3	0.4	e0.9	FMC at Lewisburg
Cholesterol	—	2	6	29	20.7	0.7	e1	FMC at Lewisburg
Stimulants			15	29	51.7		0.34[a]	FMC at Hewitt Park
Caffeine	—	0.5	15	29	51.7	0.08	e0.34	FMC at Hewitt Park
Cotinine	—	1	2	29	6.9	0.03	e0.03	FMC below Springdale Rd.

[a] Value represents maximum sum of compounds in this category found in a single sample.

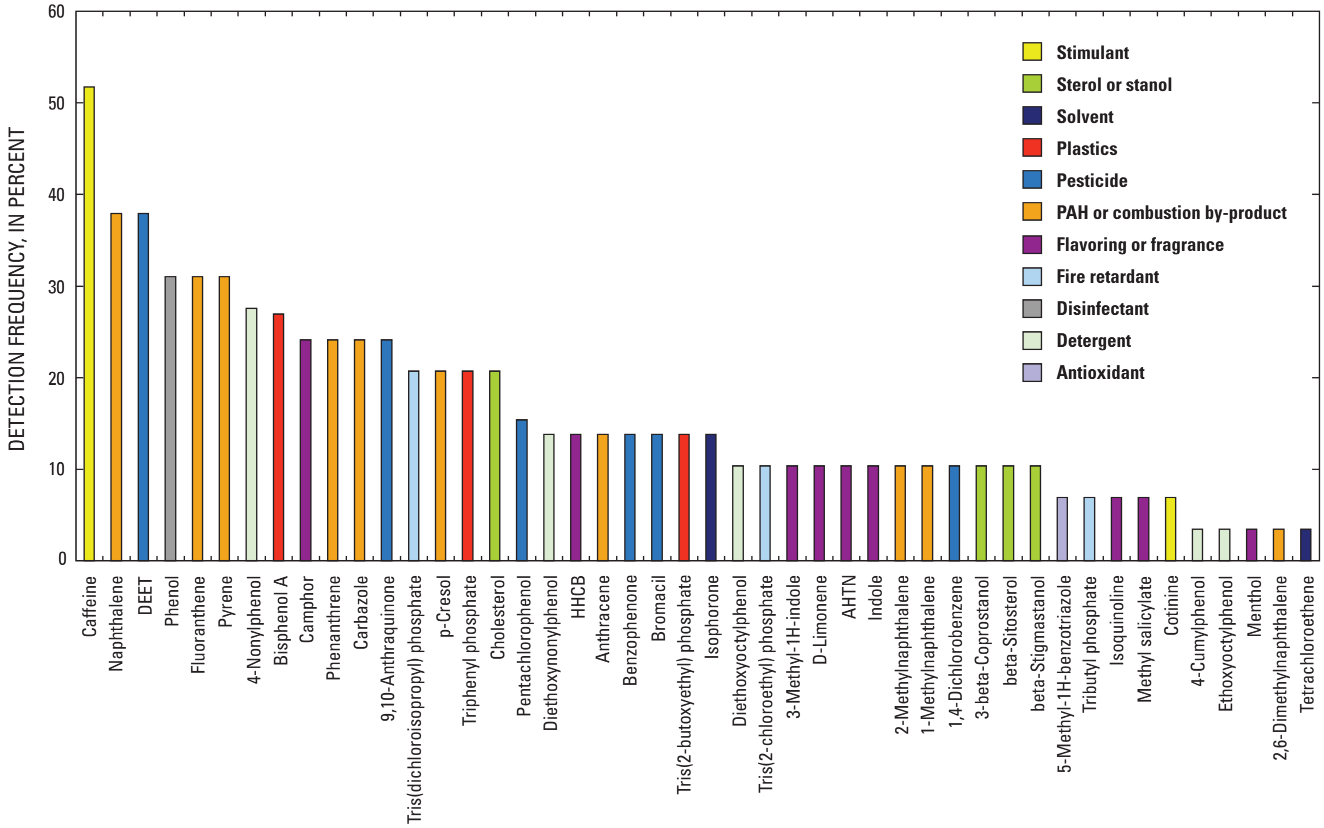

Figure 12. Detection frequencies of selected organic wastewater compounds found in samples collected from selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.

The greatest total concentrations of OWCs in single samples were measured at FMC at Lewisburg, during June 2004 (S) and June 2005 (Z), and concentrations during these time periods were much greater than total concentrations during other sampling periods at that site (fig. 13*B*). In contrast, total concentrations in samples collected from the other two sites collected during June 2004 and June 2005 (FMC at Hewitt Park and FMC below Springdale Road) were similar to total OWC concentrations from other time periods at those sites. Possible explanations for this include: (1) OWC concentrations are normally greater in the vicinity of FMC at Lewisburg, (2) the samples collected from FMC at Lewisburg were collected during hydrologic conditions that maximize concentrations of OWCs, or (3) stormflow contributions of OWCs at FMC at Lewisburg are greater than at the two upstream sites. Continuous discharge data from all sampled sites are needed to clearly distinguish between hydrologic and local effects on OWC concentrations.

Frequency of detection and magnitude of detected concentrations need to be considered when evaluating the significance of OWC data. The five most commonly detected groups of compounds in FMC were stimulants, PAHs, pesticides, detergent degradates, and flavorings or fragrances.

Most of the stimulant detections were caffeine; cotinine, a degradate of nicotine, was detected in only two samples. All detections of caffeine were reported below the minimum reporting level (MRL) of 0.5 µg/L, and accounted for 0 to 100 percent of the number of detected OWCs in individual samples (table 6). Municipal discharges and disposal of caffeinated beverages, medicines, and other products are likely sources of caffeine to streams. A study of caffeine occurrence in Switzerland found low (nanogram per liter) concentration occurrences in all but the most remote surface-water systems (Buerge and others, 2003). Wastewater-treatment plants (WWTP) have been shown to efficiently remove caffeine from their influents, but still discharge measurable concentrations of caffeine (Buerge and others, 2003; Skadsen and others, 2004). Caffeine is thought to be a suitable wastewater tracer in areas without natural plant sources, but it is slowly bio- and photodegraded in surface waters (Buerge and others, 2003). Laboratory experiments have predicted a caffeine half-life of approximately 12 days under sunny conditions (Buerge and others, 2003), indicating that detected caffeine in FMC had probably recently entered the stream environment at the time of sampling.

All but one of the analyzed PAH or combustion-byproduct compounds were detected in at least one sample from FMC. Most detections of PAHs occurred during the summer months. PAHs detected in 24 percent or more of samples were carbazole, fluoranthene, naphthalene, phenanthrene, and pyrene.

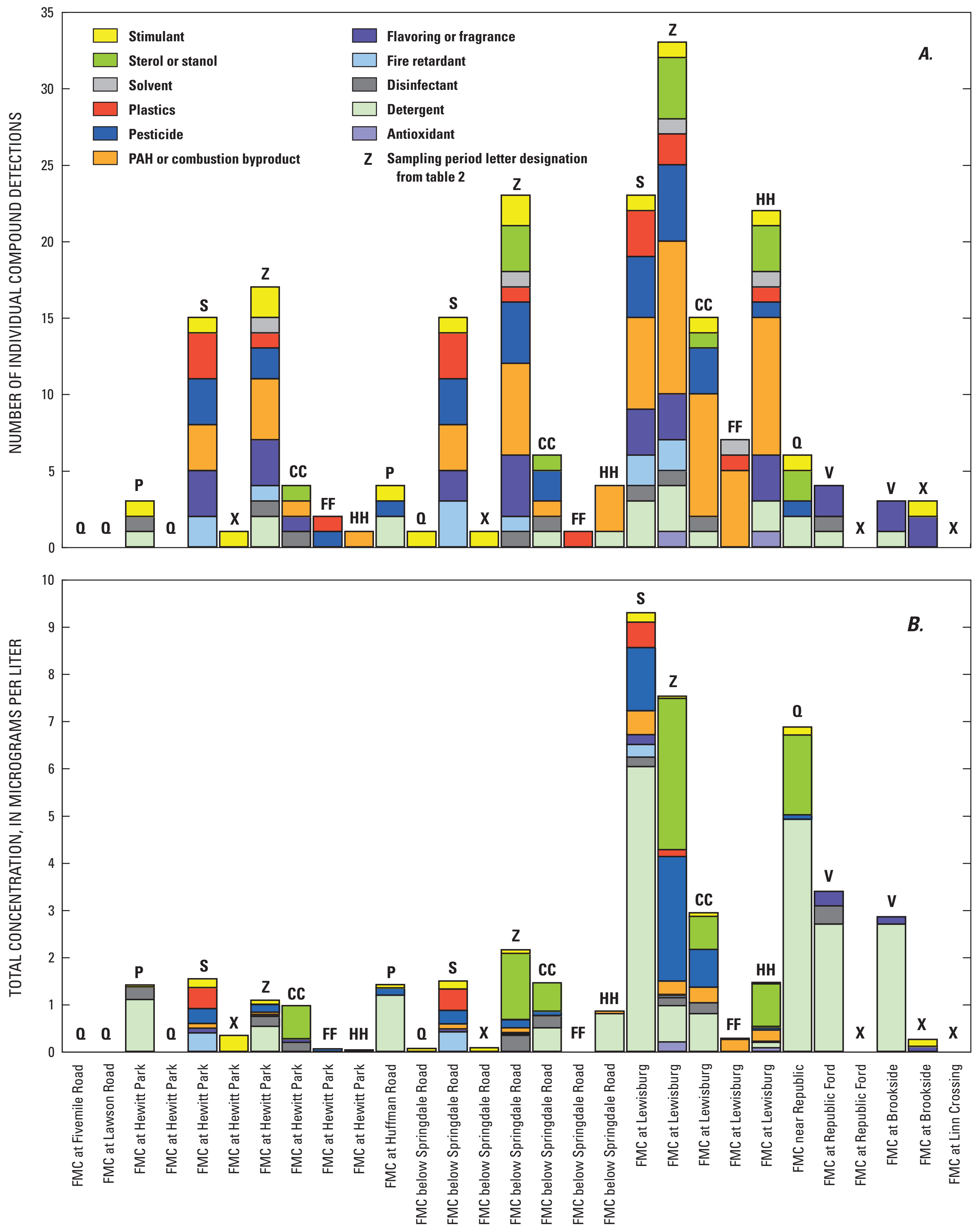

Figure 13. Summary of (*A*) number of detections and (*B*) total concentrations of general-use categories of organic wastewater compounds detected per sample at selected sites along Fivemile Creek (FMC), Jefferson County, Alabama, 2003–2005.

Naphthalene, carbazole, fluoranthene, anthracene, and pyrene were the PAHs detected at the greatest concentrations; median concentrations of naphthalene, fluoranthene, and pyrene were about 0.03 µg/L. Potential sources of PAHs in the FMC watershed include automobiles, locomotives, coke production, and industrial processes. Naphthalene is recognized by the U.S. Department of Health and Human Services, the International Agency for Research on Cancer, and the USEPA as a possible human carcinogen. The compounds 1-methylnaphthalene and 2-methylnaphthalene have caused lung problems in animal studies, but not enough data exist to determine their human carcinogenicity (U.S. Department of Health and Human Services, 2006a). The other PAH compounds detected in FMC by the NWQL method for OWCs are not known carcinogens (U.S. Department of Health and Human Services, 2006b).

The most commonly detected pesticides in FMC included the mosquito repellent, DEET, and the bird repellent, 9,10-anthraquinone. DEET was detected in almost 40 percent of the FMC samples. Most detections of DEET occurred in June, July, and August, but DEET also was detected in a few samples collected during September, October, and December. DEET was detected at least once at each of the sites where summer samples were collected: FMC at Hewitt Park, FMC at Huffman Road, FMC at Lewisburg, and FMC below Springdale Road. The pesticide 9,10-anthraquinone was detected only in summer samples. Concentrations of pesticides were generally low, with maximum concentrations for all but one compound, bromacil, estimated below minimum reporting levels.

The pesticide bromacil was the only OWC detected above the MRL, and all but one detection of bromacil was above the MRL (tables 6 and 7). Bromacil is an herbicide used to kill grass and brush, and detections of bromacil occurred exclusively in samples collected during summer months. Bromacil was detected in three samples from FMC at Lewisburg and in one sample from FMC below Springdale Road. Detected concentrations ranged from an estimated 0.06 µg/L below Springdale Road to 2.4 µg/L at Lewisburg (table 6), and were well below concentrations considered toxic to aquatic life (Turner, 2003).

Detergent degradates were the fourth most commonly detected group, but they accounted for more than 50 percent of the total OWC concentrations in 8 of the 29 samples (table 6). All of these detected compounds are known endocrine disruptors in aquatic organisms (Jobling and Sumpter, 1993; Zaugg and others, 2002). Five of the seven detergent-degradate analytes were detected in FMC. The most commonly detected detergent degradate was 4-nonylphenol (fig. 12). The detergent degradate with the maximum estimated detected concentration, 4.7 µg/L, was diethoxynonylphenol (NPEO2; table 7). Detections of detergent degradates did not exhibit a strong seasonal or hydrologic pattern (figs. 4 and 13).

Flavorings and fragrance compounds were detected in more than 35 percent of the samples collected in FMC (table 7). Camphor was the only individual compound in the group detected in more than 20 percent of samples. Camphor is used in flavorings, odorants, and ointments (Zaugg and others, 2002). Concentrations of compounds in the flavorings and fragrances group were generally low; maximum concentrations for five of the nine compounds were equal to or less than 0.05 µg/L. The greatest maximum concentration and median concentration were attributed to HHCB, a musk fragrance. More flavorings and fragrances were detected in samples collected during high streamflow periods than during low streamflow periods (figs. 4 and 13).

Cholesterol, which does not fall into one of the most commonly detected general-use categories discussed above, can be an indicator of fecal contamination but also can be derived from plants (Zaugg and others, 2002). Cholesterol was detected in six samples during this study. The greatest detections of cholesterol were 1.0 µg/L in a sample from FMC at Lewisburg, and 0.95 µg/L in a sample from FMC near Republic (table 6).

Twelve compounds known or suspected to cause endocrine disruption were detected in samples from FMC (tables 6 and 7). Five of the 12 are detergent degradates, while the other endocrine-disrupting compounds are from the fire retardants, PAHs, pesticides, and plastics categories. The single sample with the greatest concentration of endocrine disruptors was collected from FMC at Lewisburg on June 23, 2004. This sample and the June 2005 sample at Lewisburg had seven detections each of endocrine-disrupting compounds, which was the greatest number of detections in a single sample. Detections of endocrine-disrupting compounds appeared to increase during periods of increased streamflow (table 6; fig. 4), but the greatest concentrations of endocrine-disrupting compounds were detected in a variety of flow conditions.

Pesticides in Surface Water

From October 2003 through September 2005, a total of 33 surface-water samples were collected at 10 sites in the FMC study area and were analyzed for 85 pesticides and degradation products. Of the 85 pesticides, 22 were detected in 1 or more stream samples (table 8). Of the detected pesticides, 12 were herbicides, 9 were insecticides, and 1 was a fungicide (table 8; fig. 14). The detected pesticides include one carbamate, three dinitroanilines, two organochlorines, two organophosphates, two phenyl ureas, five pyrazoles, six triazenes, and one triazole. The detected pesticides include seven degradates: dieldrin, 3,4-dichloroaniline, desulfinyl fipronil, desulfinylfipronil amide, fipronil sulfide, fipronil sulfone, and 2-chloro-4-isopropylamino-6-amino-s-triazine (CIAT). Atrazine and simazine were the most frequently detected herbicides in the FMC study area. Fipronil sulfide was the most frequently detected compound from the insecticides and insecticide degradates; myclobutanil, detected in 27 percent of samples, was the only detected fungicide in the FMC study area.

Herbicides accounted for 62 percent of the number of pesticide detections in the FMC study area. These herbicides listed in order of decreasing detection frequency were

Table 8. Detected pesticide compound name and type, parameter code, minimum reporting limit, and number of and percentage of detections in samples in the Fivemile Creek watershed, Jefferson County, Alabama, 2003–2005.

[MRL, minimum reporting level, in micrograms per liter; DCPA, dacthal; CIAT, 2-chloro-4-isopropylamino-6-amino-s-triazine]

Pesticide compound	Type of pesticide compound (parent pesticide if degradate)	Parameter code	MRL	Number of detections	Percent of samples with detections
Carbamate					
Carbaryl	Insecticide	82680	0.041	10	30
Dinitroanilines					
Benfluralin	Herbicide	82673	0.01	2	6
Pendimethalin	Herbicide	82683	0.022	3	9
Trifluralin	Herbicide	82661	0.009	3	9
Organochlorines					
DCPA	Herbicide	82682	0.003	1	3
Dieldrin	Insecticide, degradate (Aldrin)	39381	0.009	5	15
Organophosphates					
Malathion	Insecticide	39532	0.027	1	3
Diazinon	Insecticide	39572	0.005	1	3
Phenyl urea					
3,4-Dichloroaniline	Herbicide, degradate (Propanil)	61625	0.004	1	9
Tebuthiuron	Herbicide	82670	0.016	17	52
Pyrazoles					
Desulfinyl fipronil	Insecticide, degradate (fipronil)	62170	0.012	12	36
Desulfinylfipronil amide	Insecticide, degradate (fipronil)	62169	0.029	13	39
Fipronil	Insecticide	62166	0.016	13	39
Fipronil sulfide	Insecticide, degradate (fipronil)	62167	0.013	17	52
Fipronil sulfone	Insecticide, degradate (fipronil)	62168	0.024	14	42
Triazenes					
CIAT	Herbicide, degradate (Atrazine)	04040	0.006	24	73
Atrazine	Herbicide	39632	0.007	33	100
Hexazinone	Herbicide	04025	0.013	1	9
Prometon	Herbicide	04037	0.010	24	73
Prometryn	Herbicide	04036	0.005	3	27
Simazine	Herbicide	04035	0.005	33	100
Triazoles					
Myclobutanil	Fungicide	61599	0.008	3	27

atrazine, simazine, CIAT, prometon, tebuthiuron, prometryn, 3,4-dichloroaniline, hexazinone, pendimethalin, trifluralin, benfluralin, and dacthal (DCPA; fig. 14). Two herbicides, atrazine and simazine, were detected in 100 percent of the surface-water samples (table 8). Atrazine and simazine are widely used as herbicides to control the growth of weeds. Atrazine is used primarily as a preemergent herbicide on corn in agricultural areas and on lawns and golf courses in urban areas. Simazine is used in urban areas for weed control along roadways and railways, along fences, and in other public areas (Hoffman and others, 2000).

Insecticides accounted for about 37 percent of the pesticide detections in the FMC study area. Fipronil sulfide was the most commonly detected insecticide-derived compound, occurring in 52 percent of the surface-water samples. Fipronil sulfide is a degradation product of fipronil, which is used as an insecticide and conventional barrier treatment for termites. Other insecticides and insecticide degradates detected in FMC listed in order of decreasing detection frequency were fipronil sulfone, desulfinylfipronil amide, fipronil, desulfinyl fipronil, carbaryl, dieldrin, diazinon, and malathion (fig. 14).

Water-quality standards and guidelines have been developed for many pesticides to protect human health and aquatic life. Eleven of the pesticides detected in this study have recommended drinking-water standards, guidelines, or health advisory levels, and 8 of the pesticides detected in this study have

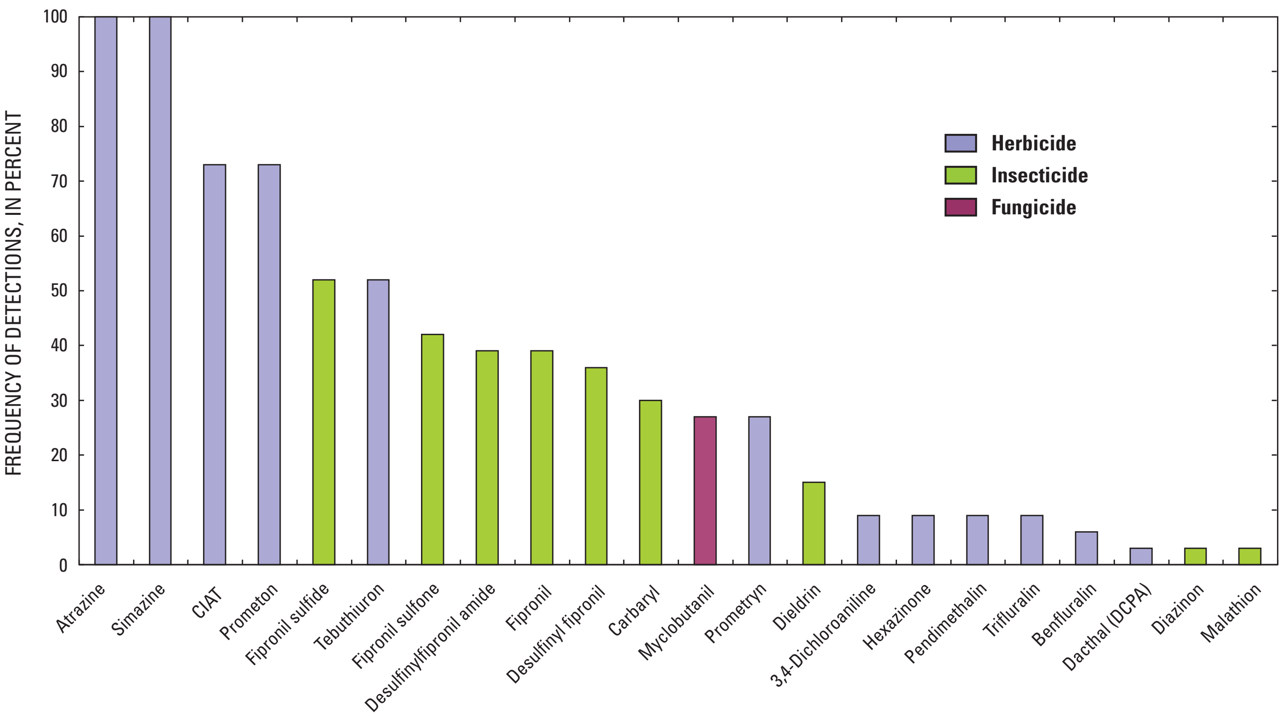

Figure 14. Frequency of detection of selected pesticides in samples collected from selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.

aquatic-life criteria established by the National Academy of Sciences and National Academy of Engineering (NAS/NAE; 1973), the USEPA (U.S. Environmental Protection Agency, 2003a, b, and c; 2004a and b), and the Canadian Council of Ministers of the Environment (2006) (table 9). Measured pesticide concentrations that exceeded water-quality standards and guidelines for pesticides to protect human health and aquatic life do not necessarily indicate that adverse effects are occurring, but rather, indicate that adverse effects may occur and that sites where water-quality standards and guidelines were exceeded may need further investigation.

Detected pesticide concentrations in FMC only exceeded one drinking-water criterion. The USEPA specific dose at 10^{-6} cancer risk, or RSD6, represents the concentration of a pesticide that corresponds to an estimated lifetime cancer risk of 1 in 1,000,000. Two estimated concentrations of one insecticide, dieldrin, exceeded the USEPA specific dose at 10^{-6} cancer risk (0.002 µg/L; table 9) in one sample collected from FMC at Hewitt Park on July 18, 2005 (e0.003 µg/L), and in one sample collected from FMC below Springdale Road on July 18, 2005 (e0.004 µg/L; table 10).

A few estimated concentrations of carbaryl and malathion exceeded aquatic-life criteria. Detected concentrations of carbaryl exceeded the NAS/NAE aquatic-life criterion (table 9) in samples collected in December 2004 from FMC below Springdale Road (e0.023 µg/L) and FMC at Republic Ford (e0.064 µg/L; table 10). The concentration of malathion measured at FMC at Lewisburg (e0.022 µg/L) on July 18, 2005, exceeded the NAS/NAE criterion.

The most commonly detected pesticide compounds in FMC were the herbicides atrazine and simazine, which were detected in all of the samples collected. Concentrations of atrazine at sites in the FMC study area ranged from 0.01 to 0.8 µg/L. The highest concentration of atrazine occurred in December 2004 at FMC below Springdale Road. All concentrations of atrazine were below water-quality standards or guidelines (table 9). Concentrations of simazine at sites in the FMC study area ranged from 0.011 to 0.816 µg/L with the highest concentration occurring in December 2004 at FMC below Springdale Road. All concentrations of simazine were below water-quality standards or guidelines (tables 9 and 10).

Several other herbicides also were detected frequently in the FMC study area. The herbicides CIAT and prometon were each detected in 73 percent of the samples and were detected at five and seven of the sites, respectively. All concentrations of CIAT detected in the FMC study area were estimated. Concentrations of CIAT at sites in the FMC study area ranged from less than the MRL of 0.006 µg/L to an estimated concentration of 0.018 µg/L in December 2004 at FMC below Springdale Road. Concentrations of prometon at sites in the FMC study area ranged from less than the MRL of 0.01 to 0.021 µg/L. The highest concentration of prometon was detected in a sample collected in July 2004 from FMC below Springdale Road. The herbicide tebuthiuron was detected in 52 percent of the samples and detected at eight sites. Concentrations of tebuthiuron at sites in the FMC study area ranged from less than the MRL of 0.016 to 0.827 µg/L. The highest concentration of tebuthiuron was detected in a sample

Table 9. Water-quality standards, guidelines, and maximum concentrations of pesticides detected in surface-water samples from the Fivemile Creek watershed, Jefferson County, Alabama, 2003–2005.

[Concentrations in micrograms per liter; FMC, Fivemile Creek; MCL, maximum contaminant level; HAL, health advisory level; USEPA, U.S. Environmental Protection Agency; NAS/NAE, National Academy of Sciences and National Academy of Engineering; —, no standard of guideline has been established; e, estimated value; DCPA, dacthal; e0.064, concentration in red indicates standard or guideline exceeded]

Pesticide compound	Type of pesticide compound (parent pesticide if degradate)	Maximum concentration detected in the FMC study	Drinking-water guidelines			Aquatic-life criteria		
			USEPA drinking-water standard or MCL[a]	USEPA lifetime HAL[a]	USEPA specific dose at 10^{-6} cancer risk (RSD6)[a]	USEPA water-quality criteria—aquatic life[b]	Canadian water-quality guideline—aquatic life[c]	NAS/NAE maximum recommended concentration[d]
Carbamate								
Carbaryl	Herbicide	e0.064	—	700	—	—	0.2	0.02
Dinitroaniline								
Trifluralin	Herbicide	e0.005	—	5	5	—	0.2	—
Organochlorines								
DCPA	Herbicide	e0.002	—	70	—	—	—	—
Dieldrin	Insecticide, degradate (Aldrin)	e0.004	—	—	0.002	0.24[e], 0.056[f]	—	0.005
Organophosphates								
Malathion	Insecticide	e0.022	—	100	—	0.1[f]	—	0.008
Diazinon	Insecticide	e0.004	—	0.6	—	0.1[g]	—	0.009
Phenyl urea								
Tebuthiuron	Herbicide	0.827	—	500	—	—	1.6	—
Triazenes								
Atrazine	Herbicide	0.8	3	—	—	1,500[h]	1.8	—
Hexazinone	Herbicide	0.016	—	400	—	—	—	—
Prometon	Herbicide	0.021	—	100	—	—	—	—
Simazine	Herbicide	0.816	4	4	—	—	10	10

[a] U.S. Environmental Protection Agency (2004a).

[b] U.S. Environmental Protection Agency (2004b).

[c] Canadian Council of Ministers of the Environment (2006).

[d] National Academy of Sciences and National Academy of Engineering (1973).

[e] Criterion maximum concentration for aquatic life (U.S. Environmental Protection Agency, 2004b).

[f] Criterion continuous concentration for aquatic life (U.S. Environmental Protection Agency, 2004b).

[g] Criterion maximum and continuous concentration for aquatic life (U.S. Environmental Protection Agency, 2003b,c).

[h] Criterion maximum concentration for aquatic life (U.S. Environmental Protection Agency, 2003a).

Table 10. Pesticides detected in the Fivemile Creek watershed, Jefferson County, Alabama, 2003–2005.

[Concentrations in micrograms per liter; MRL, minimum reporting limit; CIAT, 2-chloro-4-isopropylamino-6-amino-s-triazine; —, no data; DCPA, dacthal; <, less than; e, estimated concentration; detections are in **bold**; shaded values indicate that concentrations exceed water-quality standards or criteria]

Compound	MRL	Site short name and number and sample collection dates											
		FMC at Fivemile Road 02456900	FMC at Lawson Road 02456980	FMC at Hewitt Park 02456999									
		12/16/2003	12/16/2003	10/28/2003	12/16/2003	7/28/2004	9/1/2004	11/3/2004	12/8/2004	6/7/2005	7/18/2005	8/22/2005	9/12/2005
3,4-Dichloroaniline	<0.004	—	—	—	—	—	—	—	—	<0.004	<0.004	<0.004	<0.004
Atrazine	<0.007	**0.015**	**0.012**	**0.011**	**0.011**	**0.044**	**0.018**	**0.016**	**0.194**	**0.027**	**0.024**	**0.012**	**0.012**
Benfluralin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**e0.006**	<0.01	<0.01	<0.01
Carbaryl	<0.041	<0.041	**e0.004**	<0.041	**e0.006**	<0.041	<0.041	<0.041	<0.041	**e0.007**	<0.041	<0.041	<0.041
CIAT	<0.006	<0.006	<0.006	**e0.004**	<0.006	**e0.01**	**e0.009**	**e0.006**	**e0.01**	**e0.011**	**e0.012**	**e0.009**	**e0.01**
DCPA	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Desulfinyl fipronil	<0.012	<0.012	<0.012	<0.012	<0.012	**e0.004**	<0.012	<0.012	<0.012	**e0.004**	**e0.005**	**e0.005**	**e0.004**
Diazinon	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Dieldrin	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	**e0.001**	**e0.003**	<0.009	<0.009
Desulfinylfipronil amide	<0.029	<0.029	<0.029	<0.029	<0.029	**e0.004**	<0.029	<0.029	<0.029	**e0.007**	**e0.006**	**e0.005**	**e0.005**
Fipronil sulfide	<0.013	**e0.007**	**e0.005**	**e0.004**	**e0.004**	**e0.004**	<0.013	<0.013	<0.013	**e0.006**	**e0.006**	**e0.006**	**e0.005**
Fipronil sulfone	<0.024	<0.024	<0.024	**e0.005**	<0.024	**e0.006**	<0.024	<0.024	<0.024	**e0.007**	**e0.007**	**e0.007**	**e0.006**
Fipronil	<0.016	**e0.007**	**e0.003**	<0.016	**e0.003**	**e0.009**	<0.016	<0.016	<0.016	**e0.01**	**e0.008**	**e0.006**	**e0.006**
Hexazinone	<0.013	—	—	—	—	—	—	—	—	<0.013	<0.013	<0.013	<0.013
Malathion	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027
Myclobutanil	<0.008	—	—	—	—	—	—	—	—	**e0.006**	**e0.006**	<0.008	<0.008
Pendimethalin	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	**e0.01**	<0.022	<0.022	<0.022
Prometon	<0.01	**0.005**	**0.006**	**0.006**	**0.007**	**0.017**	**0.011**	<0.01	<0.01	**e0.009**	**e0.007**	**e0.008**	**e0.007**
Prometryn	<0.005	—	—	—	—	—	—	—	—	<0.005	<0.005	<0.005	<0.005
Simazine	<0.005	**0.052**	**0.059**	**0.011**	**0.051**	**0.028**	**0.017**	**0.033**	**0.191**	**0.021**	**0.018**	**0.013**	**0.015**
Tebuthiuron	<0.016	<0.016	<0.016	**e0.009**	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	**e0.009**	**0.019**
Trifluralin	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	**e0.005**	<0.009	<0.009	<0.009

Table 10. Pesticides detected in the Fivemile Creek watershed, Jefferson County, Alabama, 2003–2005.—Continued

[Concentrations in micrograms per liter; MRL, minimum reporting limit; CIAT, 2-chloro-4-isopropylamino-6-amino-s-triazine; —, no data; DCPA, dacthal; <, less than; e, estimated concentration; detections are in **bold**; shaded values indicate that concentrations exceed water-quality standards or criteria]

Compound	MRL	Site short name, number, and sample collection dates								
		FMC at Huffman Road 02457500		FMC below Springdale Road 02457502						
		10/28/2003	12/15/2003	7/28/2004	8/31/2004	12/7/2004	6/6/2005	7/18/2005	8/22/2005	9/13/2005
3,4-Dichloroaniline	<0.004	—	—	—	—	—	<0.004	<0.004	<0.004	<0.004
Atrazine	<0.007	**0.012**	**0.013**	**0.043**	**0.02**	**0.8**	**0.029**	**0.022**	**0.013**	**0.012**
Benfluralin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Carbaryl	<0.041	<0.041	**e0.006**	<0.041	<0.041	**e0.023**	**e0.01**	<0.041	<0.041	<0.041
CIAT	<0.006	<0.006	<0.006	**e0.012**	**e0.009**	**e0.018**	**e0.012**	**e0.01**	**e0.009**	**e0.01**
DCPA	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	**e0.002**	<0.003	<0.003	<0.003
Desulfinyl fipronil	<0.012	<0.012	<0.012	**e0.005**	<0.012	<0.012	**e0.005**	**e0.004**	**e0.005**	**e0.007**
Diazinon	<0.005	<0.005	**e0.004**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Dieldrin	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	**e0.002**	**e0.004**	<0.009	<0.009
Desulfinylfipronil amide	<0.029	<0.029	<0.029	**e0.004**	<0.029	<0.029	**e0.007**	**e0.005**	**e0.006**	**e0.014**
Fipronil sulfide	<0.013	**e0.004**	**e0.004**	<0.013	<0.013	<0.013	**e0.006**	**e0.006**	**e0.006**	**0.013**
Fipronil sulfone	<0.024	**e0.005**	<0.024	**e0.006**	<0.024	<0.024	**e0.007**	**e0.006**	**e0.007**	**e0.013**
Fipronil	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	**e0.009**	**e0.007**	<0.016	**e0.016**
Hexazinone	<0.013	—	—	—	—	—	<0.013	<0.013	<0.013	<0.013
Malathion	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027
Myclobutanil	<0.008	—	—	—	—	—	<0.008	**e0.005**	<0.008	<0.008
Pendimethalin	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	**e0.009**	<0.022	<0.022	<0.022
Prometon	<0.01	**0.006**	**0.007**	**0.021**	**0.014**	<0.01	**0.012**	**e0.007**	**e0.009**	**0.01**
Prometryn	<0.005	—	—	—	—	—	<0.005	<0.005	<0.005	<0.005
Simazine	<0.005	**0.012**	**0.067**	**0.026**	**0.018**	**0.816**	**0.018**	**0.016**	**0.015**	**0.015**
Tebuthiuron	<0.016	**e0.008**	<0.016	<0.016	<0.016	<0.016	**0.018**	<0.016	**e0.011**	<0.016
Trifluralin	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	**e0.004**	<0.009	<0.009	<0.009

Table 10. Pesticides detected in the Fivemile Creek watershed, Jefferson County, Alabama, 2003–2005.—Continued

[Concentrations in micrograms per liter; MRL, minimum reporting limit; CIAT, 2-chloro-4-isopropylamino-6-amino-s-triazine; —, no data; DCPA, dacthal; <, less than; e, estimated concentration; detections are in **bold**; shaded values indicate that concentrations exceed water-quality standards or criteria]

Compound name		Site short name, number, and sample collection dates											
		FMC at Lewisburg 02457510						FMC near Republic 02457595	FMC at Republic Ford 02457599		FMC at Brookside 02457625		FMC at Linn Crossing 02457700
	MRL	7/28/2004	8/31/2004	11/2/2004	6/7/2005	7/18/2005	9/13/2005	12/15/2003	11/2/2004	12/7/2004	11/2/2004	12/6/2004	12/6/2004
3,4-Dichloroaniline	<0.004	—	—	—	**e0.01**	<0.004	<0.004	—	—	—	—	—	—
Atrazine	<0.007	**0.038**	**0.017**	**0.013**	**0.019**	**0.019**	**0.01**	**0.016**	**0.013**	**0.058**	**0.013**	**0.028**	**0.012**
Benfluralin	<0.01	<0.01	<0.01	<0.01	**e0.005**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Carbaryl	<0.041	<0.041	<0.041	<0.041	**e0.01**	**e0.006**	<0.041	**e0.007**	<0.041	**e0.064**	<0.041	<0.041	<0.041
CIAT	<0.006	**e0.007**	**e0.007**	<0.006	**e0.009**	**e0.009**	**e0.009**	**e0.005**	**e0.003**	**e0.004**	<0.006	<0.006	<0.006
DCPA	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Desulfinyl fipronil	<0.012	<0.012	<0.012	<0.012	**e0.004**	**e0.005**	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012
Diazinon	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Dieldrin	<0.009	<0.009	<0.009	<0.009	**e0.002**	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009
Desulfinylfipronil amide	<0.029	<0.029	<0.029	<0.029	**e0.006**	**e0.005**	**e0.014**	<0.029	<0.029	<0.029	<0.029	<0.029	<0.029
Fipronil sulfide	<0.013	<0.013	<0.013	<0.013	**e0.006**	**e0.006**	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013
Fipronil sulfone	<0.024	<0.024	<0.024	<0.024	**e0.006**	**e0.007**	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024
Fipronil	<0.016	<0.016	<0.016	<0.016	**e0.008**	**e0.007**	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016
Hexazinone	<0.026	—	—	—	<0.013	<0.013	**0.016**	—	—	—	—	—	—
Malathion	<0.027	<0.027	<0.027	<0.027	<0.027	**e0.022**	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027
Myclobutanil	<0.008	—	—	—	<0.008	<0.008	<0.008	—	—	—	—	—	—
Pendimethalin	<0.022	<0.022	<0.022	<0.022	**e0.011**	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022
Prometon	<0.01	**0.02**	**0.014**	<0.01	**0.014**	**0.011**	**0.01**	**0.01**	<0.01	<0.01	<0.01	<0.01	<0.01
Prometryn	<0.005	—	—	—	0.026	0.006	0.008	—	—	—	—	—	—
Simazine	<0.005	**0.021**	**0.012**	**0.019**	**0.015**	**0.015**	**0.013**	**0.068**	**0.037**	**0.087**	**0.034**	**0.033**	**0.023**
Tebuthiuron	<0.016	**0.076**	**0.038**	**0.022**	**0.827**	**0.09**	**0.034**	**0.019**	<0.016	**e0.016**	**0.018**	**e0.015**	**e0.013**
Trifluralin	<0.009	<0.009	<0.009	<0.009	**e0.004**	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009

collected in June 2005 from FMC at Lewisburg. The remaining herbicides pendimethalin, prometryn, trifluralin, benfluralin, dacthal (DCPA), 3,4-dichloroaniline, and hexazinone were detected in less than 30 percent of the samples and were detected at three or fewer sites.

Many insecticides and insecticide degradates were detected frequently in the FMC study area. Fipronil sulfide, detected at six sites, was the most frequently detected insecticide-derived compound with detections in 52 percent of samples. All but one reported concentration of fipronil sulfide were less than the MRL of 0.013 µg/L. The greatest detected concentration of fipronil sulfide reported was equal to the MRL, and was measured in a sample collected from FMC below Springdale Road in September 2005. Fipronil sulfone was detected in 42 percent of samples and was detected at four sites. Concentrations of fipronil sulfone at sites in the FMC study area were less than the MRL of 0.024 µg/L. The highest estimated concentration of fipronil sulfone, 0.013 µg/L, occurred in September 2005 at FMC below Springdale Road. The insecticide fipronil and its degradate, desulfinylfipronil amide, were each detected in 39 percent of the samples and detected at five and three of the sites, respectively. Concentrations of fipronil and desulfinylfipronil amide in the FMC study area were all equal to or less than their MRLs. The insecticide degradate desulfinyl fipronil was detected in 36 percent of the samples and was detected at three sites. Concentrations of desulfinyl fipronil in the FMC study area were all equal to or less than the MRL. The insecticide carbaryl was detected in 30 percent of the samples and was detected at seven sites with concentrations at sites in the FMC study area ranging from less than the MRL of 0.041 to an estimated concentration of 0.064 µg/L. The highest concentration of carbaryl was detected in a sample collected in December 2004 at FMC at Republic Ford. The insecticide dieldrin was detected in 15 percent of the samples and was detected at three sites. The highest concentration of dieldrin was in a sample from FMC below Springdale Road at an estimated concentration of 0.004 µg/L in July 2005. The insecticides malathion and diazinon were detected in 3 percent of the samples and were detected at one site each. Concentrations of malathion and diazinon in the FMC study area were all equal to or less than their respective MRLs.

The fungicide myclobutanil was detected in 27 percent of the samples and was detected at two sites. Concentrations of myclobutanil at sites in the FMC study area were all less than the MRL of 0.008 µg/L. The highest estimated concentrations of myclobutanil were detected in samples in June and July 2005 from FMC at Hewitt Park.

Trace Elements in Surface Water

Trace and major elements commonly are found in surface water and may occur naturally due to geochemical weathering of rocks and soil. Trace elements, such as arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc, generally are present in water in concentrations less than 25 µg/L (Hem, 1985). Major elements such as iron, manganese, and aluminum commonly are found in greater concentrations and are frequently detected in the water column. High frequencies of detection of trace and major elements do not necessarily imply anthropogenic sources; however, industrial and municipal discharges, as well as urban land-use activities, often account for elevated concentrations above natural background levels.

Laboratory methods for arsenic, chromium, cobalt, iron, and selenium changed during this study. The new methods were implemented in approximately August 2005 for these trace elements and allow detections to be reported at lower concentrations. For each of these five elements, there was an MRL in effect before the method change, and a new, lower MRL in effect after the new method was implemented. Values reported as non-detects, as less than the higher MRL, could be similar in magnitude to values reported as detections under the new, lower MRL. To maximize the available information, all concentrations reported as detections were left uncensored in detection frequency summaries in this report. For the calculation of summary statistics, however, all values below the greater MRL were considered to be non-detections.

From October 2003 through September 2005, a total of 37 surface-water samples were collected at 10 sites in the FMC study area and analyzed for 18 trace elements. Of the 18 trace elements, 16 were detected in 1 or more stream samples (table 11; appendix 1). The 16 detected trace elements listed in order of decreasing detection frequency were: aluminum, barium, cobalt, copper, manganese, uranium, nickel, zinc, molybdenum, iron, antimony, arsenic, selenium, chromium, lead, and cadmium. Concentrations of beryllium and silver were below detection levels in all samples. Maximum concentrations for seven of the trace elements measured during this study occurred at FMC at Lewisburg.

Water-quality standards and guidelines have been developed for many trace metals to protect human health and aquatic life. Fifteen of the 18 trace metals analyzed in this study have recommended maximum concentration levels established by the USEPA (U.S. Environmental Protection Agency, 2003d, 2004a) and ADEM (Alabama Department of Environmental Management, 2005a, 2005b, 2006b; table 12).

Table 11. Concentrations of trace elements reported in water samples collected from Fivemile Creek, Jefferson County, Alabama, 2003–2005.

[Concentrations in micrograms per liter; minimum reporting levels are given below each trace element name in parentheses; shading indicates a detection; <, less than; e, estimated concentration]

Site short name	Site number	Sample date	Sample time	Hardness	Aluminum (1.6)	Antimony (0.2)	Arsenic (1.9 0.12[a])	Barium (0.2)	Beryllium (0.06)	Cadmium (0.04)	Chromium (0.8 0.04[a])
FMC at Fivemile Road	02456900	12/16/2003	1230	200	2.5	<0.2	<1.9	21.4	<0.06	<0.04	<0.8
FMC at Lawson Road	02456980	12/16/2003	0800	210	1.6	<0.2	<1.9	25.6	<0.06	<0.04	<0.8
FMC at Hewitt Park	02456999	10/28/2003	1120	190	6.4	<0.2	<1.9	27.3	<0.06	<0.04	<0.8
	02456999	12/16/2003	0930	210	1.6	<0.2	<1.9	26.4	<0.06	<0.04	<0.8
	02456999	6/23/2004	1000	130	8.3	e0.2	<1.9	27.4	<0.06	<0.04	<0.8
	02456999	7/28/2004	1400	180	5.7	e0.1	<1.9	32.7	<0.06	<0.04	<0.8
	02456999	9/1/2004	0830	190	6	<0.2	<1.9	30.5	<0.06	<0.04	<0.8
	02456999	11/3/2004	0800	190	6.7	<0.2	<1.9	32	<0.06	<0.04	<0.8
	02456999	12/8/2004	1030	150	5	<0.2	<1.9	28.3	<0.06	<0.04	<0.8
	02456999	6/7/2005	1000	170	6.1	0.2	<1.9	29.4	<0.06	<0.04	<0.8
	02456999	7/18/2005	1200	170	6.2	<0.2	<1.9	33.7	<0.06	<0.04	<0.8
	02456999	8/22/2005	1115	190	4	<0.2	<1.9	30.3	<0.06	<0.04	<0.8
	02456999	9/12/2005	1445	190	1.8	<0.2	0.3	60.7	<0.06	<0.04	0.2
FMC at Huffman Road	02457500	10/28/2003	1000	190	2.4	<0.2	<1.9	29.7	<0.06	<0.04	e0.5
	02457500	12/15/2003	1330	190	2	<0.2	<1.9	26	<0.06	<0.04	<0.8
FMC below Springdale Road	02457502	6/23/2004	1300	160	9.2	0.2	<1.9	30.4	<0.06	<0.04	<0.8
	02457502	7/28/2004	1115	200	5.7	e0.2	<1.9	36.1	<0.06	<0.04	<0.8
	02457502	8/31/2004	1545	200	6.7	<0.2	e1.1	32.6	<0.06	<0.04	<0.8
	02457502	12/7/2004	1300	81	16.3	e0.1	e1.1	17.8	<0.06	<0.04	<0.8
	02457502	6/6/2005	1130	140	33.9	<0.2	<1.9	24.5	<0.06	<0.04	<0.8
	02457502	7/18/2005	1040	180	7	<0.2	e1.6	35.8	<0.06	<0.04	<0.8
	02457502	8/22/2005	1500	190	6.5	<0.2	<1.9	31.7	<0.06	<0.04	e0.4
	02457502	9/13/2005	0830	220	3.6	e0.1	0.5	31.6	<0.06	<0.04	0.2
FMC at Lewisburg	02457510	6/23/2004	1400	140	16.4	0.4	3.4	58.7	<0.06	e0.02	1.2
	02457510	7/28/2004	0815	190	14	0.4	2.8	60.2	<0.06	e0.03	1.2
	02457510	8/31/2004	1315	190	37.9	0.3	4.1	112	<0.06	e0.03	2.1
	02457510	11/2/2004	1130	210	35.5	0.3	3.4	115	<0.06	<0.04	2
	02457510	6/7/2005	1230	190	15.7	0.4	<1.9	50.9	<0.06	<0.04	<0.8
	02457510	7/18/2005	1545	180	23.4	0.3	2.2	49.9	<0.06	<0.04	<0.8
	02457510	8/23/2005	0900	190	31.8	0.3	2.5	116	<0.06	e0.03	1.3
	02457510	9/13/2005	1130	190	36.9	0.4	3.6	126	<0.06	0.41	1.3
FMC near Republic	02457595	12/15/2003	1045	190	23.9	e0.1	3	37.7	<0.06	<0.04	e0.5
FMC at Republic Ford	02457599	11/2/2004	1715	180	18	0.2	e1.8	53.9	<0.06	e0.03	e0.4
	02457599	12/7/2004	0900	120	21	e0.2	<1.9	31.8	<0.06	<0.04	<0.8
FMC at Brookside	02457625	11/2/2004	1430	180	13.7	0.2	e1.7	57.3	<0.06	e0.03	<0.8
	02457625	12/6/2004	1515	170	15.9	e0.2	<1.9	42.9	<0.06	<0.04	e0.4
FMC at Linn Crossing	02457700	12/6/2004	1230	160	77.9	e0.1	<1.9	40.4	<0.06	e0.03	<0.8

Table 11. Concentrations of trace elements reported in water samples collected from Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[Concentrations in micrograms per liter; minimum reporting levels are given below each trace element name in parentheses; shading indicates a detection; <, less than; e, estimated concentration]

Site short name	Site number	Sample date	Sample time	Cobalt (0.014)	Copper (0.4)	Iron (6.4 6.0[b])	Lead (0.08)	Manganese (0.2)	Molybdenum (0.4)	Nickel (0.06)	Selenium (2.6 0.08[a])	Silver (0.2)	Uranium (0.04)	Zinc (0.6)
FMC at Fivemile Road	02456900	12/16/2003	1230	0.146	e0.2	e3.6	<0.08	2.6	<0.4	0.13	<2.6	<0.2	0.26	e0.5
FMC at Lawson Road	02456980	12/16/2003	0800	0.151	e0.2	e4.3	<0.08	14.4	<0.4	0.12	<2.6	<0.2	0.3	e0.6
FMC at Hewitt Park	02456999	10/28/2003	1120	0.165	e0.3	<6.4	<0.08	4.8	e0.2	0.39	<2.6	<0.2	0.38	12.7
	02456999	12/16/2003	0930	0.161	e0.3	<6.4	<0.08	5.4	<0.4	0.18	<2.6	<0.2	0.31	0.8
	02456999	6/23/2004	1000	0.172	1.2	8.2	<0.08	4.6	0.7	0.61	<2.6	<0.2	0.19	1.2
	02456999	7/28/2004	1400	0.221	0.8	e4.8	<0.08	6	0.6	1.77	<2.6	<0.2	0.34	1.4
	02456999	9/1/2004	0830	0.161	0.5	e4.8	<0.08	3.9	e0.2	0.84	e1.6	<0.2	0.32	<0.6
	02456999	11/3/2004	0800	0.12	0.5	e5	<0.08	4	0.4	<0.06	<2.6	<0.2	0.33	1.1
	02456999	12/8/2004	1030	0.124	0.6	7	<0.08	7.3	e0.3	1.63	<2.6	<0.2	0.23	0.9
	02456999	6/7/2005	1000	0.109	0.6	11	<0.08	8.8	0.6	1.21	<2.6	<0.2	0.19	0.9
	02456999	7/18/2005	1200	0.12	0.6	<6	<0.08	6.5	0.6	1.44	<2.6	<0.2	0.28	0.9
	02456999	8/22/2005	1115	0.119	0.5	e3	e0.05	6.6	e0.2	2.46	<2.6	<0.2	0.25	1.2
	02456999	9/12/2005	1445	0.091	1.4	<6	<0.08	7.8	e0.4	2.16	0.1	<0.2	0.05	2.9
FMC at Huffman Road	02457500	10/28/2003	1000	0.138	e0.3	<6.4	<0.08	7.2	e0.2	0.49	<2.6	<0.2	0.38	3.5
	02457500	12/15/2003	1330	0.164	0.4	9.3	<0.08	10.7	e0.3	0.2	<2.6	<0.2	0.32	1.9
FMC below Springdale Road	02457502	6/23/2004	1300	0.24	1.2	e5.7	<0.08	5.4	1.3	0.84	<2.6	<0.2	0.56	1.1
	02457502	7/28/2004	1115	0.387	1.1	e3.9	<0.08	8.4	1.7	2.7	<2.6	<0.2	0.99	1.7
	02457502	8/31/2004	1545	0.237	0.8	e5.1	<0.08	6.5	1.1	1.35	3.7	<0.2	0.81	0.6
	02457502	12/7/2004	1300	0.131	1.2	47	e0.06	6.7	0.5	1.18	<2.6	<0.2	0.22	1.2
	02457502	6/6/2005	1130	0.214	2.2	e3	<0.08	5.8	0.6	2.03	<2.6	<0.2	0.32	4.4
	02457502	7/18/2005	1040	0.146	0.5	<6	<0.08	8.3	0.7	1.52	<2.6	<0.2	0.32	1.1
	02457502	8/22/2005	1500	0.142	0.7	7	0.15	11.7	0.6	2.38	<2.6	<0.2	0.37	0.9
	02457502	9/13/2005	0830	0.166	0.7	<6	<0.08	9.6	0.8	2.07	0.3	<0.2	0.58	1.3
FMC at Lewisburg	02457510	6/23/2004	1400	0.278	1.7	24.7	<0.08	26.6	4.7	0.97	3	<0.2	0.42	2.3
	02457510	7/28/2004	0815	0.41	2.1	27.6	<0.08	34.6	4	2.81	3.6	<0.2	0.98	1.9
	02457510	8/31/2004	1315	0.357	1.7	17.1	e0.04	22.9	6.4	1.78	7.8	<0.2	0.74	1.4
	02457510	11/2/2004	1130	0.325	1.5	29	<0.08	22.4	3.3	0.58	5.9	<0.2	0.86	2.2
	02457510	6/7/2005	1230	0.384	1.7	13	<0.08	28.7	1.9	2.43	e1.5	<0.2	0.57	3.9
	02457510	7/18/2005	1545	0.297	0.8	11	0.11	25.3	1.6	2.26	e2.2	<0.2	0.57	2.4
	02457510	8/23/2005	0900	0.252	2	27	e0.07	18.7	2.7	3.05	4.6	<0.2	0.42	1.9
	02457510	9/13/2005	1130	0.239	2.1	28	e0.07	19.2	3.4	2.54	5.4	<0.2	0.46	5.2
FMC near Republic	02457595	12/15/2003	1045	0.366	1	39.3	<0.08	76.3	5.2	1.41	4.7	<0.2	0.53	2.4
FMC at Republic Ford	02457599	11/2/2004	1715	0.27	2	32	e0.07	16.3	2.5	1.05	e1.9	<0.2	0.5	7.6
	02457599	12/7/2004	0900	0.315	1.2	51	0.14	39.8	0.9	2.04	<2.6	<0.2	0.31	1.5
FMC at Brookside	02457625	11/2/2004	1430	0.304	1.7	30	e0.05	16.3	2.4	0.96	e1.8	<0.2	0.44	4.1
	02457625	12/6/2004	1515	0.566	1.1	20	<0.08	59.5	1.2	3.16	<2.6	<0.2	0.44	3.3
FMC at Linn Crossing	02457700	12/6/2004	1230	1.53	1.2	6	<0.08	108	0.9	5.69	<2.6	<0.2	0.37	5.2

[a] New reporting level for all samples collected after August 2005.

[b] New reporting level for all samples collected after September 2004.

Table 12. Standards, criteria, and maximum concentrations for trace and major elements in surface-water samples from Fivemile Creek, Jefferson County, Alabama, 2003–2005.

[USEPA, U.S. Environmental Protection Agency; ADEM, Alabama Department of Environmental Management; **bold** indicates USEPA priority pollutant; all concentrations except hardness in micrograms per liter; hardness concentrations in milligrams per liter; <, less than; e, 2.718; LN, natural log; CF, conversion factor]

Trace element	Maximum concentration measured in Fivemile Creek	Primary Drinking Water Standard	Secondary Drinking Water Standard	ADEM acute aquatic-life criterion[a]	ADEM chronic aquatic-life criterion[a]
Aluminum	77.9	—	200[d] 50–200[b]	—	—
Antimony	0.4	6	—	—	—
Arsenic	4.1	50[b,c]	—	340	150
Barium	126	2,000[b,c]	—	—	—
Beryllium	<0.06	4[b,c]	—	—	—
Cadmium	0.41	5[b,c]	—	$=(e^{((1.0166*LN(Hardness))-3.924)})$ (CF); where CF=1.136672–[LN(Hardness) (0.041838)]	$=e^{((0.7409*LN(Hardness))-4.719)}$ (CF); where CF=1.101672–[LN(hardness)(0.041838)]
Chromium	2.1	100[b,c]	—	$=e^{((0.8190*LN(Hardness))+3.7256)}$ (CF); where CF=0.316	$=e^{((0.819*LN(Hardness))+0.6848)}$ (CF); where CF=0.860
Cobalt	1.53	—	—	—	—
Copper	2.2	1,300[b]	1,000[b,d]	$=e^{((0.9422*LN(Hardness))-1.7)}$ (CF); where CF=0.960	$=e^{((0.8545*LN(Hardness))-1.702)}$ (CF); where CF=0.960
Iron	51	—	300[b,d]	—	—
Lead	0.15	15[b,c]	—	$=e^{((1.273*LN(Hardness))-1.46)}$ (CF); where CF=1.46203–[LN(hardness)(0.145712)]	$=e^{((1.273*LN(Hardness))-4.705)}$ (CF); where CF=1.46203–[LN(hardness)(0.145712)]
Manganese	108	—	50[b,d]	—	—
Molybdenum	6.4	—	—	—	—
Nickel	5.69	100[c]	—	$=e^{((0.846*LN(Hardness))+2.255)}$ (CF); where CF=0.998	$=e^{((0.846*LN(Hardness))+0.0584)}$ (CF); where CF=0.997
Selenium	7.8	50[b,c]	—	20	5.0
Silver	<0.2	—	100[b,d]	$=e^{((1.72*LN(Hardness))-6.59)}$ (CF); where CF=0.85	—
Uranium	0.99	—	—	—	—
Zinc	12.7	—	5,000[b,d]	$=e^{((0.8473*LN(Hardness))+0.884)}$ (CF); where CF=0.978	$=e^{((0.8473*LN(Hardness))+0.884)}$ (CF); where CF=0.986

[a] Alabama Water Quality Criteria (Alabama Department of Environmental Management, 2006b).

[b] U.S. Environmental Protection Agency (2003d, 2004a).

[c] Alabama Primary Drinking Water Standards (Alabama Department of Environmental Management, 2005a).

[d] Alabama Secondary Drinking Water Standards (Alabama Department of Environmental Management, 2005b).

Antimony, arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver, and zinc are USEPA priority pollutants because of their potential harmful effects on human health or aquatic life. Drinking-water standards apply to finished drinking water only. Primary drinking-water standards are enforceable; secondary drinking-water standards are suggested limits to avoid problems with taste, odor, and color. Aquatic-life criteria are intended to protect aquatic organisms and are enforceable. Aquatic-life criteria for trace elements are sometimes computed by equations based on the hardness of the water because some trace elements are more lethal to fish and invertebrates in soft water than in hard water (Alabama Department of Environmental Management, 2006b; table 12). Values greater than acute and chronic toxicity limits calculated from the equations indicate that the trace-element concentrations can be acutely or chronically toxic to fish and other aquatic organisms. In the following discussion, descriptions of the potential environmental effects of metals concentrations are largely derived from information provided on the USEPA's Region 5 Superfund Toxicity Profiles web page (U.S. Environmental Protection Agency, 2006).

Few trace-element concentrations measured in FMC were above established standards or criteria. No primary drinking-water standards were exceeded. Some detections of aluminum and manganese were above secondary drinking-water standards. The concentration of aluminum, 77.9 µg/L, at FMC at Linn Crossing in December 2004 was above the lower end of the range of National Secondary Drinking Water Regulations recommended by the USEPA (tables 11 and 12). Three concentrations of manganese measured in the FMC study area exceeded the secondary drinking-water standard of 50 µg/L. Manganese exceeded the standard in one sample each from FMC near Republic in December 2003 and FMC at Brookside and FMC at Linn Crossing in December 2004. Concentrations of cadmium and selenium exceeded ADEM chronic aquatic-life criteria in a few samples. The cadmium concentration in a sample from FMC at Lewisburg in September 2005 was above the chronic aquatic-life criterion (0.40 µg/L for sample hardness of 190 mg/L). Samples from FMC at Lewisburg in August 2004, November 2004, and September 2005 had selenium concentrations above the chronic aquatic-life criterion of 5.0 µg/L.

Aluminum is one of the most abundant elements in the earth's crust, but it is not generally present in natural water at concentrations greater than a few tenths of a milligram per liter (Hem, 1985). Fish have been observed to be more sensitive to aluminum toxicity than aquatic invertebrates (U.S. Environmental Protection Agency, 2006). Elevated concentrations of aluminum have been observed in acid water from mine drainage and in runoff and lakes of regions affected by acidic precipitation (Driscoll, 1985). Concentrations of aluminum at sites in the FMC study area ranged from 1.6 to 77.9 µg/L (table 11, appendix 1). The highest concentration of aluminum was detected in a sample collected in December 2004 from FMC at Linn Crossing and exceeded the USEPA National Secondary Drinking Water Regulations (50–200 µg/L; table 12).

Antimony is a USEPA priority pollutant that can be toxic to plants and animals. In addition to natural occurrences of antimony in bedrock and streambed sediment, antimony salts are used in the fireworks, rubber, textile, ceramic, glass, and paint industries (National Academy of Sciences and National Academy of Engineering, 1973). Concentrations of antimony at sites in the FMC study area ranged from less than the MRL of 0.2 to 0.4 µg/L (table 11, appendix 1). Concentrations of 0.4 µg/L of antimony were detected in samples collected in June and July 2004, June 2005, and September 2005 from FMC at Lewisburg.

Arsenic is listed as a USEPA priority pollutant and is recognized as a potential carcinogen. Arsenic and its compounds are used as pesticides, herbicides, insecticides, and various alloys. Arsenic is a carcinogen, teratogen, and possible mutagen (causing mutations in genes and DNA) in mammals. Aquatic organisms also can be affected by carcinogens and mutagens. Effects include behavioral impairments, growth reduction, and metabolic failure. Aquatic bottom feeders are the most susceptible of the aquatic organisms to the effects of arsenic. In plants, arsenic has been shown to cause wilting, chlorosis, browning, dehydration, mortality, and inhibition of light activity (U.S. Environmental Protection Agency, 2006). About 68 percent of samples had arsenic concentrations below the old MRL of 1.9 µg/L. Detected concentrations of arsenic at sites in the FMC study area ranged from 0.3 to 4.1 µg/L (table 11, appendix 1). The highest concentration of arsenic was detected in a sample collected in August 2004 from FMC at Lewisburg. All concentrations of arsenic were below drinking-water standards and aquatic-life criteria.

Barium is an alkaline-earth metal that is present in most surface water and ground water, as well as in treated drinking water (Hem, 1985). Concentrations of barium at sites in the FMC study area ranged from 17.8 to 126 µg/L (table 11, appendix 1). The highest concentration of barium was detected in a sample collected in September 2005 from FMC at Lewisburg. All concentrations of barium were below drinking-water-quality standards.

Detectable concentrations of cadmium in surface or ground water not associated with human activity are rare. Cadmium is a USEPA priority pollutant and is known to bioaccumulate in plants and animals. Cadmium is a carcinogen and a teratogen, potentially causes mutations, and can have severe sub-lethal and lethal effects at low environmental concentrations. Cadmium affects respiratory function, enzyme levels, muscle contractions, growth, and reproduction. Cadmium accumulates in the livers and kidneys of fish. Crustaceans appear to be more sensitive to cadmium than fish and mollusks (U.S. Environmental Protection Agency, 2006). Concentrations of cadmium at sites in the FMC study area ranged from less than the MRL of 0.04 to 0.41 µg/L (table 11, appendix 1). The highest concentration of cadmium was detected in a sample collected in September 2005 from FMC at Lewisburg and exceeded the ADEM chronic aquatic-life criterion. All other concentrations of cadmium were below water-quality standards or criteria.

Chromium is a transition metal that may be present in surface water as trivalent cations or hexavalent anions (Hem, 1985). Hexavalent chromium is listed as a USEPA priority pollutant, and the primary drinking-water standard has been established at 100 µg/L (U.S. Environmental Protection Agency, 1991). The toxicity of chromium to aquatic life varies with the valence state and form of chromium, oxidation-reduction and pH relations, and synergistic or antagonistic effects of other constituents. Chromium exhibits no significant biomagnifications in aquatic food webs. Chromium can cause a wide range of adverse effects in the aquatic community such as reduced ability to reproduce (fecundity) and survive, inhibition of growth, and abnormal movement patterns. In addition, fish have demonstrated reduced disease resistance, morphological changes, and chromosomal changes when exposed to chromium. Most of the toxic effects are found in the lower trophic levels. Primary toxic effects result from direct exposure of algae, benthic invertebrates, and embryos and fingerlings of freshwater fish and amphibians to chromium (U.S. Environmental Protection Agency, 2006). Eighty-four percent of samples had chromium concentrations less than the old MRL of 0.8 µg/L. Detected concentrations of chromium at sites along FMC ranged from 0.2 to 2.1 µg/L (table 11, appendix 1), with the highest concentration of chromium collected in a water sample in August 2004 from FMC at Lewisburg. All concentrations of chromium were below drinking-water standards and aquatic-life criteria.

Cobalt is a transition metal that usually is present in streams only in very small concentrations (Hem, 1985). Cobalt can be found in various ores and is used in alloys. Compounds of cobalt are used in the production of inks, paints, and varnishes. Uncontaminated water should contain no more than a few micrograms per liter of cobalt (Hem, 1985). Concentrations of cobalt at sites in the FMC study area ranged from 0.091 to 1.53 µg/L (table 11, appendix 1). The highest concentration of cobalt was detected in a sample collected in December 2004 from FMC at Linn Crossing. No water-quality standards or criteria exist for cobalt.

Copper is a macronutrient for the growth of plants and animals, but is identified by the USEPA as a priority pollutant because even small concentrations of copper in surface water can be toxic to aquatic life. The toxicity of copper is a function of the total hardness of water because copper ions form complexes with anions that contribute to water hardness. Copper is highly toxic to amphibians, and adverse effects have been observed in tadpoles and embryos exposed to high concentrations of copper. The potential for bioconcentration is low in fish but high in mollusks (U.S. Environmental Protection Agency, 2006). Copper strongly adsorbs to organic matter, clay, and carbonates, which reduces its bioavailability. Concentrations of copper at sites in the FMC study area ranged from 0.2 µg/L, which was estimated below the MRL (0.4 µg/L), to 2.2 µg/L. The highest concentration of copper was measured in a water sample collected in June 2005 from FMC below Springdale Road. All concentrations of copper were below water-quality standards or criteria.

Although iron is one of the most abundant elements in the earth's outer crust, concentrations of iron in water generally are small (Hem, 1985). Iron is an objectionable constituent in water supplies because of unpleasant taste or staining of plumbing fixtures and laundry. Although iron is an essential element in the metabolism of plants and animals, elevated concentrations of iron can be acutely or chronically toxic to aquatic organisms. Ferric hydroxide precipitates can interfere with respiratory processes of aquatic fauna or adversely affect bottom-dwelling organisms by degrading aquatic microhabitats. Concentrations of iron at sites in the FMC study area ranged from less than the MRL of 6.0 to 51 µg/L (table 11, appendix 1). The highest concentration of iron was detected in a sample collected in December 2004 from FMC at Republic Ford. All concentrations of iron were below drinking-water-quality standards.

Although lead is widely dispersed in the environment, natural sources (sedimentary rocks in particular) release small concentrations of lead to water because of the low solubility of lead hydroxyl carbonates (Hem, 1985). Sources of lead include shale and other sedimentary rocks and also human activities, including combustion of leaded gasoline and coal. Lead is a USEPA priority pollutant that can be acutely or chronically toxic to humans (particularly children) and aquatic life. Lead pipe was used in water-distribution systems prior to the beginning of the 20th century and is still present in many old buildings. Lead is a carcinogen and has adverse effects on reproduction, liver and thyroid function, and disease resistance in humans (U.S. Environmental Protection Agency, 2006). Potential ecological effects typically result from direct exposure of algae, invertebrates, fingerlings of fish, and amphibians to lead. Exposure to high levels of lead can result in a wide range of effects including neurological degeneration and reproductive problems. Ordinarily, lead partitions to sediments, but becomes more bioavailable under low pH, hardness, and organic-matter-content conditions (U.S. Environmental Protection Agency, 2006). Concentrations of lead at sites in the FMC study area ranged from less than the MRL of 0.08 to 0.15 µg/L (table 11, appendix 1), with the highest concentration of lead detected in a sample collected in August 2005 from FMC below Springdale Road. All concentrations of lead were below water-quality standards or criteria.

Although manganese is an essential element in plant metabolism, it is an undesirable impurity in water supplies because water that contains appreciable concentrations of manganese can deposit black oxide stains and have an unpleasant taste and odor. Concentrations of manganese at sites in the FMC study area ranged from 2.6 to 108 µg/L (table 11, appendix 1). Concentrations of manganese in single samples from FMC near Republic, FMC at Brookside, and FMC at Linn Crossing exceeded the USEPA National Secondary Drinking Water Regulation (50 µg/L; table 12).

Molybdenum is a transition metal and an essential element in animal and plant nutrition, particularly in legumes (Hem, 1985). Molybdenum is an essential micronutrient for the growth of algae, and certain species may concentrate molybdenum by a factor of as much as 15 (National Academy of Sciences and National Academy of Engineering, 1973). Molybdenum is used extensively as an alloy in steel. It is generally present in fossil fuels and can be spread in the environment by the burning of fossil fuels (Hem, 1985). Concentrations of molybdenum at sites in the FMC study area ranged from less than the MRL of 0.4 to 6.4 µg/L (table 11, appendix 1) with the highest concentration of molybdenum detected in a sample collected in August 2004 from FMC at Lewisburg. No drinking-water-quality standards or aquatic-life criteria for molybdenum are listed by the USEPA or ADEM.

Nickel is a USEPA priority pollutant that can adversely affect humans and aquatic organisms. Nickel is an important industrial metal that is used extensively in the production of stainless steel. Substantial amounts of nickel can be contributed to the environment by waste disposal (Hem, 1985) and atmospheric emissions. Nickel ions are toxic, particularly to plant life, and can exhibit synergism when present with other metallic ions (National Academy of Sciences and National Academy of Engineering, 1973). Nickel also is a carcinogen and a mutagen. Mollusks and crustaceans are more sensitive to nickel than are other organisms (U.S. Environmental Protection Agency, 2006). Concentrations of nickel at sites in the FMC study area ranged from less than the MRL of 0.06 to 5.69 µg/L (table 11, appendix 1), with the highest concentration of nickel occurring in December 2004 from FMC at Linn Crossing. All concentrations of nickel were below water-quality standards or criteria.

Selenium is a nonmetallic trace element that is listed as a primary pollutant by the USEPA. Selenium is an essential macronutrient for plants and animals but can be toxic in excessive amounts. Selenium is a rare element, and concentrations of selenium in natural waters seldom exceed 1 µg/L (Hem, 1985). Anthropogenic sources of selenium include coal burning and the mining and smelting of sulfide ores. Selenium is found in highest quantities in sulfide ores such as pyrite. Selenium undergoes bioconcentration, bioaccumulation, and biomagnification as trophic levels increase and also causes growth reduction in green algae at elevated concentrations. Adverse effects in aquatic organisms include neurological disorders, liver damage, reproductive failure, reduced movement rates, and chromosomal aberrations (U.S. Environmental Protection Agency, 2006). Concentrations of selenium at sites in the FMC study area ranged from 0.1 to 7.8 µg/L (table 11, appendix 1), with the highest concentration of selenium detected in a sample collected in August 2004 from FMC at Lewisburg. Concentrations of selenium exceeded the chronic aquatic-life criterion (5.0 µg/L) in three samples from FMC at Lewisburg.

Uranium is a naturally occurring element found in low concentrations within rock, soil, and water. Concentrations of uranium occur in substances such as phosphate rock deposits, lignite, and monazite sands in uranium-rich ores. Uranium is present in concentrations between 0.1 and 10 µg/L in most natural waters (Hem, 1985). Concentrations of uranium at sites in the FMC study area ranged from 0.05 to 0.99 µg/L (table 11, appendix 1). The highest concentration of uranium was detected in a sample collected in July 2004 from FMC below Springdale Road. Water-quality standards or criteria have not been established for concentrations of uranium.

Zinc, a USEPA priority pollutant, is an essential micronutrient for plant and animal metabolism that can be acutely or chronically toxic to aquatic organisms. Adverse synergistic effects can occur when zinc is present with cadmium, copper, or other metals, and zinc is known to biomagnify through the aquatic food chain (National Academy of Sciences and National Academy of Engineering, 1973). Many aquatic organisms have adverse effects from exposure to elevated zinc levels. These effects include reduced growth, lower survival rates, and lower reproduction rates. In aquatic environments, zinc tends to be partitioned into sediments and is less frequently dissolved as hydrated zinc ions and organic and inorganic complexes. Elevated zinc can cause a wide range of problems in mammals (U.S. Environmental Protection Agency, 2006). Concentrations of zinc at sites in the FMC study area ranged from less than the MRL of 0.6 to 12.7 µg/L (table 11, appendix 1) with the highest concentration of zinc occurring in the October 2003 sample from FMC at Hewitt Park. All concentrations of zinc were below water-quality standards or criteria.

Semivolatile Organic Compounds in Surface Water

Surface-water samples were collected and analyzed for 57 semivolatile organic compounds (SVOC) at three sites along FMC (tables 13 and 14). The samples were collected in September 2005 at FMC at Hewitt Park, FMC below Springdale Road, and FMC at Lewisburg. Only 10 compounds were detected in surface water from these three FMC sites, and all of the detected compounds were below the method detection limits and assigned estimated concentrations (table 14). Complete analytical results for these analyses are available in the report “Water Resources Data, Alabama, Water Year 2005” (Psinakis and others, 2006).

No SVOCs were detected at FMC at Hewitt Park. Two compounds, acenaphthene (estimated concentration 0.004 µg/L) and naphthalene (estimated concentration 0.03 µg/L), were detected in water from FMC below Springdale Road (table 14). Ten of the 57 compounds were detected at FMC at Lewisburg. All of the compounds were detected at low levels and are reported as estimated concentrations. The SVOCs identified in FMC are typical for streams affected by industrial sources, and compounds such as acenaphthene, naphthalene, acenaphthylene, 9H-fluorene, and phenanthrene are polycyclic aromatic hydrocarbons (PAHs) typically associated with coal operations and coal tar.

Table 13. Analytes for semivolatile organic analyses in Fivemile Creek, Jefferson County, Alabama.

[<, less than; method detection levels in micrograms per liter]

Analyte	Method detection level
1,2-Diphenylhydrazine	< 2.2
2,4,6-Trichlorophenol	< 1.4
2,4-Dichlorophenol	< 2.5
2,4-Dimethylphenol	< 2.0
2,4-Dinitrophenol	< 3.3
2,4-Dinitrotoluene	< 1.4
2,6-Dinitrotoluene	< 2.3
2-Chloronaphthalene	< 1.0
2-Chlorophenol	< 1.0
2-Methyl-4,6-dinitrophenol	< 1.8
2-Nitrophenol	< 1.4
3,3'-Dichlorobenzidine	< 0.9
4-Bromophenyl phenyl ether	< 2.1
4-Chloro-3-methylphenol	< 1.6
4-Chlorophenyl phenyl ether	< 1.2
4-Nitrophenol	< 2.4
9H-Fluorene	< 1.2
Acenaphthene	< 1.9
Acenaphthylene	< 1.8
Anthracene	< 2.0
Benzidine	< 1,000
Benzo[a]anthracene	< 1.6
Benzo[a]pyrene	< 1.3
Benzo[b]fluoranthene	< 1.9
Benzo[ghi]perylene	< 1.6
Benzo[k]fluoranthene	< 1.4
Benzyl n-butyl phthalate	< 1.8
Bis(2-chloroethoxy)methane	< 1.0
Bis(2-chloroethyl) ether	< 1.0

Analyte	Method detection level
Bis(2-chloroisopropyl) ether	< 1.0
Bis(2-ethylhexyl) phthalate	< 1.8
Chrysene	< 1.2
Dibenzo[a,h]anthracene	< 2.2
Diethyl phthalate	< 1.6
Dimethyl phthalate	< 1.0
Di-n-butyl phthalate	< 1.7
Di-n-octyl phthalate	< 2.3
Fluoranthene	< 1.4
Hexachlorobenzene	< 1.0
Hexachlorocyclopentadiene	< 1.2
Indeno[1,2,3-cd]pyrene	< 1.8
Isophorone	< 2.2
Nitrobenzene	< 1.4
N-Nitroso-dimethylamine	< 1.6
N-Nitroso-di-n-propylamine	< 1.6
N-Nitroso-diphenylamine	< 1.9
Pentachlorophenol	< 1.8
Phenanthrene	< 1.0
Phenol	< 1.6
Pyrene	< 1.6
1,2,4-Trichlorobenzene	< 1.2
1,2-Dichlorobenzene	< 1.5
1,3-Dichlorobenzene	< 1.2
1,4-Dichlorobenzene	< 1.4
Hexachlorobutadiene	< 1.2
Hexachloroethane	< 1.6
Naphthalene	< 1.6

Table 14. Concentrations of semivolatile organic compounds detected in surface water from Fivemile Creek, Jefferson County, Alabama, 2003–2005.

[Values are in micrograms per liter; <, less than; e, estimated value]

Station number	Station short name	Sample date	2,4-Dimethylphenol, water unfiltered recoverable	9H-Fluorene, water unfiltered recoverable	Acenaphthene, water unfiltered recoverable	Acenaphthylene, water unfiltered recoverable	Bis(2-chloroethyl) ether, water unfiltered recoverable
02456999	FMC at Hewitt Park	9/12/2005	<2	<1.2	<1.9	<1.8	<1
02457502	FMC below Springdale Rd.	9/13/2005	<2	<1.2	e0.004	<1.8	<1
02457510	FMC at Lewisburg	9/13/2005	e0.04	e0.03	e0.04	e0.03	e0.007

Station number	Station short name	Sample date	Fluoranthene, water unfiltered recoverable	Nitrobenzene, water unfiltered recoverable	Phenanthrene, water unfiltered recoverable	Pyrene, water unfiltered recoverable	Naphthalene, water unfiltered recoverable
02456999	FMC at Hewitt Park	9/12/2005	<1.4	<1.4	<1	<1.6	<1.6
02457502	FMC below Springdale Rd.	9/13/2005	<1.4	<1.4	<1	<1.6	e0.03
02457510	FMC at Lewisburg	9/13/2005	e0.05	e0.02	e0.03	e0.04	e0.1

Semivolatile Organic Compounds and Trace Elements in Streambed-Sediment Samples

Eight streambed-sediment samples were collected in either December 2003 or November 2005 from seven sites along FMC, and analyzed for a group of SVOCs (tables 15 and 16) and a group of trace elements (table 17). Forty-nine of 98 SVOCs were detected in streambed-sediment samples from FMC (table 15); all concentrations for eight of these SVOCs were below the highest MRLs used in this study for the respective compounds (table 16). Forty-five of 47 trace elements were detected at one or more sites in FMC (table 17).

Occurrence of Semivolatile Organic Compounds in Streambed Sediment

SVOCs can be divided by chemical composition into many classes. Classes of SVOCs detected in FMC included PAHs, alkylated PAHs (alkyl-PAHs), azaarenes, organochlorines, phenols, phthalates, quinones, sulfurous-PAHs, and chloroaromatics (table 15). Many of these SVOCs have been designated as priority pollutants by the USEPA (table 15), are toxic to humans and aquatic life, and are associated with industrial activities and processes. Other SVOC classes analyzed for but not detected include bromo-ethers, chloro-ethers, cyclic ketones, nitro-aromatics, and nitrosoamines.

PAHs can be found in streambed sediments all over the world (Hites and others, 1980). The presence of PAHs in the environment is primarily anthropogenic. PAHs are found naturally in petroleum products and also are released during combustion. PAHs enter the water, soil, and air through fuel spills, tar coatings, coal and other fossil-fuel usage, road dust, and from the atmospheric deposition of combustion products (Prahl and others, 1984; Wakeham and others, 1980). Typically, urban areas may have high concentrations of PAHs because of transportation-related sources such as vehicle exhaust, paving materials, and releases of fuel or oil. Natural sources of PAHs include forest fires, which may contribute small amounts of PAHs. Many PAHs are listed as USEPA priority pollutants (tables 15 and 16).

All 8 streambed-sediment samples from FMC contained concentrations of multiple PAH compounds, and all 16 analyzed PAH compounds were detected in several samples. The least number of PAH compounds was detected in the FMC at Hewitt Park sample collected in November 2005 (table 16). All of the 16 PAH SVOCs analyzed were detected in samples from FMC at Fivemile Road, FMC at Huffman Road, FMC below Springdale Road, FMC at Lewisburg, and FMC near Republic and in the December 2003 sample from FMC at Hewitt Park. Fluoranthene had the highest concentration (9,700 µg/kg) of all PAH SVOCs detected. Maximum concentrations for 12 of the 16 PAH compounds were measured in the sample from FMC at Lewisburg.

All of the eight streambed-sediment samples contained multiple alkyl-PAH compounds. The least number of alkyl-PAH compounds was detected in the FMC at Hewitt Park sample collected in November 2005 (table 16). The greatest number (10) of alkyl-PAH compounds in a single sample was detected in samples collected from FMC at Huffman Road, FMC at Lewisburg, and FMC near Republic. The maximum detected concentration (950 µg/kg) of a single alkyl-PAH compound was measured for 4,5-methylenephenanthrene at FMC at Lewisburg in November 2005. Maximum concentrations of 7 of the 10 detected alkyl-PAH compounds were detected in the FMC at Lewisburg sample.

Table 15. Semivolatile organic compounds analyzed in streambed-sediment samples collected from locations along Fivemile Creek, Jefferson County, Alabama, 2003–2005.

[SVOC, semivolatile organic compound; PAH, polycyclic aromatic hydrocarbon; shading indicates priority pollutant; **bold**, indicates compound detected in Fivemile Creek; Y, yes; N, no]

Compound name	SVOC class	Priority pollutant[a]	Minimum reporting level (micrograms per liter)
1,2,4-Trichlorobenzene	chloroaromatic	Y	50
1,2-Dichlorobenzene	chloroaromatic	Y	50
1,2-Dimethylnaphthalene	alkyl-PAH	N	50
1,3-Dichlorobenzene	chloroaromatic	Y	50
1,4-Dichlorobenzene	chloroaromatic	Y	50
1,6-Dimethylnaphthalene	alkyl-PAH	N	50
1-Methyl-9H-fluorene	alkyl-PAH	N	50
1-Methylphenanthrene	alkyl-PAH	N	50
1-Methylpyrene	alkyl-PAH	N	50
2,2'-Biquinoline	azaarene	N	50
2,3,6-Trimethylnaphthalene	alkyl-PAH	N	50
2,4,6-Trimethylphenol	phenol	N	50
2,4-Dinitrotoluene	nitroaromatic	Y	50
2,6-Dimethylnaphthalene	alkyl-PAH	N	50
2,6-Dinitrotoluene	nitroaromatic	Y	50
2-Chloronaphthalene	chloroaromatic	Y	50
2-Chlorophenol	phenol	Y	50
2-Ethylnaphthalene	alkyl-PAH	N	50
2-Methylanthracene	alkyl-PAH	N	50
3,5-Dimethylphenol	phenol	N	50
4,5-Methylenephenanthrene	alkyl-PAH	N	50
4-Bromophenyl phenyl ether	bromoether	Y	50
4-Chloro-3-methylphenol	phenol	Y	50
4-Chlorophenyl phenyl ether	chloroether	Y	50
9,10-Anthraquinone	quinone	N	50
9H-Fluorene	PAH	Y	50
Acenaphthene	PAH	Y	50
Acenaphthylene	PAH	Y	50
Acridine	azaarene	N	50
Aldrin	organochlorine pesticide	Y	1.0
alpha-Endosulfan	organochlorine pesticide	Y	1.0
alpha-HCH	organochlorine pesticide	Y	1.0
Anthracene	PAH	Y	50
Azobenzene	nitroaromatic	N	50
Benzo[a]anthracene	PAH	Y	50
Benzo[a]pyrene	PAH	Y	50
Benzo[b]fluoranthene	PAH	Y	50
Benzo[c]cinnoline	azaarene	N	50
Benzo[ghi]perylene	PAH	Y	50
Benzo[k]fluoranthene	PAH	Y	50
Benzyl n-butyl phthalate	phthalate	Y	50
beta-HCH	organochlorine pesticide	Y	1.0
Bis(2-chloroethoxy)methane	chloroether	Y	50
Bis(2-chloroethyl) ether	chloroether	Y	50
Bis(2-ethylhexyl) phthalate	phthalate	Y	50
C8-Alkylphenol	phenol	N	50
Carbazole	azaarene	N	50
Chloroneb	organochlorine pesticide	N	5.0
Chrysene	PAH	Y	50
***cis*-Chlordane**	organochlorine pesticide	N	1.0

Table 15. Semivolatile organic compounds analyzed in streambed-sediment samples collected from locations along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[SVOC, semivolatile organic compound; PAH, polycyclic aromatic hydrocarbon; shading indicates priority pollutant; **bold**, indicates compound detected in Fivemile Creek; Y, yes; N, no]

Compound name	SVOC class	Priority pollutant[a]	Minimum reporting level (micrograms per liter)
cis-Nonachlor	organochlorine pesticide	N	1.0
cis-Permethrin	organochlorine pesticide	N	5.0
DCPA	organochlorine pesticide	N	5.0
Dibenzo[a,h]anthracene	PAH	Y	50
Dibenzothiophene	sulfurous-PAH	N	50
Dieldrin	organochlorine pesticide	Y	1.0
Diethyl phthalate	phthalate	Y	50
Dimethyl phthalate	phthalate	Y	50
Di-n-butyl phthalate	phthalate	Y	50
Di-n-octyl phthalate	phthalate	Y	50
Endrin	organochlorine pesticide	Y	2.0
Fluoranthene	PAH	Y	50
Heptachlor	organochlorine pesticide	Y	1.0
Heptachlor epoxide	organochlorine pesticide	Y	1.0
Hexachlorobenzene	organochlorine pesticide	Y	50
Indeno[1,2,3-cd]pyrene	PAH	Y	50
Isodrin	organochlorine pesticide	N	1.0
Isophorone	cyclic ketone	Y	50
Isoquinoline	azaarene	N	50
Lindane	organochlorine pesticide	Y	1.0
Mirex	organochlorine pesticide	N	1.0
Naphthalene	PAH	Y	50
Nitrobenzene	nitroaromatic	Y	50
N-Nitrosodi-n-propylamine	nitrosoamine	Y	50
N-Nitrosodiphenylamine	nitrosoamine	Y	50
o,p'-DDD	organochlorine pesticide	N	1.0
o,p'-DDE	organochlorine pesticide	N	1.0
o,p'-DDT	organochlorine pesticide	N	2.0
o,p'-Methoxychlor	organochlorine pesticide	N	5.0
Oxychlordane	organochlorine pesticide	N	1.0
p,p'-DDD	organochlorine pesticide	Y	1.0
p,p'-DDE	organochlorine pesticide	Y	1.0
p,p'-DDT	organochlorine pesticide	Y	2.0
p,p'-Methoxychlor	organochlorine pesticide	N	5.0
PCBs	PCB	Y	50
p-Cresol	phenol	N	50
Pentachloroanisole	organochlorine pesticide	N	50
Pentachloronitrobenzene	chloroaromatic	N	50
Pentachlorophenol	phenol	Y	50
Phenanthrene	PAH	Y	50
Phenanthridine	azaarene	N	50
Phenol	phenol	Y	50
Pyrene	PAH	Y	50
Quinoline	azaarene	N	50
Toxaphene	organochlorine pesticide	Y	50
***trans*-Chlordane**	organochlorine pesticide	N	1.0
***trans*-Nonachlor**	organochlorine pesticide	N	1.0
trans-Permethrin	organochlorine pesticide	N	5.0

[a] U.S. Environmental Protection Agency, 2004b.

Table 16. Concentrations of semivolatile organic compounds in streambed-sediment samples collected from selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.

[FMC, Fivemile Creek; concentrations in micrograms per kilogram; shading indicates reported detections; e, estimated concentration; <, less than; PAHs, polycyclic aromatic hydrocarbons; alkyl-PAHs, alkylated PAHs]

Station number:			**02456900**	**02456980**	**02456999**	**02456999**	**02457500**	**02457502**	**02457510**	**02457595**		
Station short name:			**FMC at Fivemile Road**	**FMC at Lawson Road**	**FMC at Hewitt Park**	**FMC at Hewitt Park**	**FMC at Huffman Road**	**FMC below Springdale Road**	**FMC at Lewisburg**	**FMC near Republic**		
Sample date:			**12/22/2003**	**12/17/2003**	**12/17/2003**	**11/7/2005**	**12/17/2003**	**11/7/2005**	**11/7/2005**	**12/22/2003**		
Sample start time:			**1030**	**1230**	**1100**	**1030**	**1430**	**1200**	**1330**	**1330**		
	Minimum reporting level	**Number of detections**									**Minimum**	**Maximum**
						PAHs						
Anthracene	50	8	94	e37	e49	e25	1,500	96	2,000	1,100	e25	2,000
Benzo[a]anthracene	50	8	510	180	170	e52	2,800	480	5,800	2,900	e52	5,800
Benzo[a]pyrene	50	8	650	210	170	70	2,700	610	4,800	2,400	70	4,800
Benzo[b]fluoranthene	50	8	880	260	200	110	2,100	940	6,400	2,500	110	6,400
Benzo[ghi]perylene	50	8	540	160	130	e54	1,700	e310	e3,100	1,600	e54	e3,100
Benzo[k]fluoranthene	50	8	590	200	150	62	1,600	340	2,600	1,700	62	2,600
Chrysene	50	8	830	250	200	68	2,600	640	5,400	2,900	68	5,400
Fluoranthene	50	8	1,400	470	400	120	5,000	610	9,700	4,400	120	9,700
Indeno[1,2,3-cd]pyrene	50	8	640	200	160	e62	1,700	330	3,000	1,700	e62	3,000
Phenanthrene	50	8	560	180	210	e46	5,200	200	3,100	1,700	e46	5,200
Pyrene	50	8	1,100	340	290	88	7,000	690	6,900	3,200	88	7,000
9H-Fluorene	50	7	e30	e8	e16	<57	370	e27	540	220	e8	540
Acenaphthene	50	7	e20	<50	e10	e16	480	e12	280	110	e10	480
Acenaphthylene	50	7	e30	e13	e9	<57	e80	e26	1,100	830	e9	1,100
Dibenzo[a,h]anthracene	50	7	150	66	57	<57	430	e59	e340	570	<57	570
Naphthalene	50	7	e20	<50	e10	e8.1	140	e30	1,100	240	e8.1	1,100
Total number of PAH compounds detected per sample			16	14	16	13	16	16	16	16		

Table 16. Concentrations of semivolatile organic compounds in streambed-sediment samples collected from selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[FMC, Fivemile Creek; concentrations in micrograms per kilogram; shading indicates reported detections; e, estimated concentration; <, less than; PAHs, polycyclic aromatic hydrocarbons; alkyl-PAHs, alkylated PAHs]

Station number:			**02456900**	**02456980**	**02456999**	**02456999**	**02457500**	**02457502**	**02457510**	**02457595**		
Station short name:			**FMC at Fivemile Road**	**FMC at Lawson Road**	**FMC at Hewitt Park**	**FMC at Hewitt Park**	**FMC at Huffman Road**	**FMC below Springdale Road**	**FMC at Lewisburg**	**FMC near Republic**		
Sample date:			**12/22/2003**	**12/17/2003**	**12/17/2003**	**11/7/2005**	**12/17/2003**	**11/7/2005**	**11/7/2005**	**12/22/2003**		
Sample start time:			**1030**	**1230**	**1100**	**1030**	**1430**	**1200**	**1330**	**1330**		
	Minimum reporting level	**Number of detections**									**Minimum**	**Maximum**
Alkyl-PAHs												
2,6-Dimethylnaphthalene	50	8	68	e12	e14	e31	180	e44	270	110	e12	270
4,5-Methylenephenanthrene	50	8	66	e18	e21	e23	710	e36	950	440	e18	950
1-Methylphenanthrene	50	7	e28	e10	e12	<57	540	e43	580	310	e10	580
1-Methylpyrene	50	7	e40	e20	e19	<57	630	85	570	270	e19	630
2-Methylanthracene	50	6	e24	e15	e18	<57	380	<61	640	340	e15	640
1,6-Dimethylnaphthalene	50	5	<65	<50	<50	e16	e91	e21	150	71	e16	150
2,3,6-Trimethylnaphthalene	50	5	<65	<50	<50	e20	e53	e17	130	68	e17	130
1,2-Dimethylnaphthalene	50	4	<65	<50	<50	<57	e40	e12	e53	e23	e12	<65
1-Methyl-9H-fluorene	50	4	<65	<50	<50	<57	100	e16	150	84	e16	150
2-Ethylnaphthalene	50	4	<65	<50	<50	<57	120	e16	80	e22	e16	120
Total number of alkyl-PAH compound detections per sample			5	5	5	4	10	9	10	10		
Azaarenes												
Carbazole	50	8	110	e32	e28	e17	120	e58	390	170	e17	390
Acridine	50	7	e64	e30	e20	<57	e71	e31	280	120	e20	280
Phenanthridine	50	7	e24	e17	e17	<57	e37	e22	e65	e44	e17	e65
Isoquinoline	50	4	e26	<50	e22	<57	e47	<61	<71	e30	e22	<71
2,2'-Biquinoline	50	3	<65	<50	e46	<57	e99	<61	210	<65	e46	210
Quinoline	50	1	<65	<50	<50	<57	<100	<61	<71	e17	e17	<100
Total number of azaarene compounds detected per sample			4	3	5	1	5	3	4	5		

Table 16. Concentrations of semivolatile organic compounds in streambed-sediment samples collected from selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[FMC, Fivemile Creek; concentrations in micrograms per kilogram; shading indicates reported detections; e, estimated concentration; <, less than; PAHs, polycyclic aromatic hydrocarbons; alkyl-PAHs, alkylated PAHs]

Station number:			**02456900**	**02456980**	**02456999**	**02456999**	**02457500**	**02457502**	**02457510**	**02457595**		
Station short name:			**FMC at Fivemile Road**	**FMC at Lawson Road**	**FMC at Hewitt Park**	**FMC at Hewitt Park**	**FMC at Huffman Road**	**FMC below Springdale Road**	**FMC at Lewisburg**	**FMC near Republic**		
Sample date:			**12/22/2003**	**12/17/2003**	**12/17/2003**	**11/7/2005**	**12/17/2003**	**11/7/2005**	**11/7/2005**	**12/22/2003**		
Sample start time:			**1030**	**1230**	**1100**	**1030**	**1430**	**1200**	**1330**	**1330**		
	Minimum reporting level	**Number of detections**									**Minimum**	**Maximum**
Organochlorines												
PCBs	50	3	<50	<50	<50	<50	e83	e130	<50	e34	<50	e130
cis-Chlordane	1.0	3	e0.96	<1	<1	<1	1.1	<1	<1	e0.56	e0.56	1.1
Dieldrin	1.0	3	e0.81	<1	<1	<1	1.2	<1	<1	e0.55	e0.55	1.2
trans-Chlordane	1.0	3	1.1	<1	<1	<1	1.3	<1	<1	e0.56	e0.56	1.3
trans-Nonachlor	1.0	3	1.3	<1	<1	<1	1.4	<1	<1	e0.45	e0.45	1.4
p,p'-DDE	1.0	1	<1	<1	<1	<1	e0.71	<1	<1	<1	e0.71	<1
p,p'-DDT	2.0	1	<2	<2	<2	<2	<2	<2	<2	2.6	<2	2.6
Total number of organochlorine compounds detected per sample			4	0	0	0	6	1	0	6		
Phenols												
p-Cresol	50	7	e33	e23	e23	<57	e45	e26	e110	e28	e23	e110
Phenol	50	3	<65	<50	<50	e20	<100	e37	120	<65	e20	120
C8-Alkylphenol	50	2	<65	<50	<50	<57	<100	e24	e38	<65	e24	<100
3,5-Dimethylphenol	50	1	<65	<50	<50	<57	<100	<61	e36	<65	e36	<100
Pentachlorophenol	50	1						e110			—	e110
Total number of phenol compounds detected per sample			1	1	1	1	1	4	4	1		

Table 16. Concentrations of semivolatile organic compounds in streambed-sediment samples collected from selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[FMC, Fivemile Creek; concentrations in micrograms per kilogram; shading indicates reported detections; e, estimated concentration; <, less than; PAHs, polycyclic aromatic hydrocarbons; alkyl-PAHs, alkylated PAHs]

Station number:			**02456900**	**02456980**	**02456999**	**02456999**	**02457500**	**02457502**	**02457510**	**02457595**		
Station short name:			**FMC at Fivemile Road**	**FMC at Lawson Road**	**FMC at Hewitt Park**	**FMC at Hewitt Park**	**FMC at Huffman Road**	**FMC below Springdale Road**	**FMC at Lewisburg**	**FMC near Republic**		
Sample date:			**12/22/2003**	**12/17/2003**	**12/17/2003**	**11/7/2005**	**12/17/2003**	**11/7/2005**	**11/7/2005**	**12/22/2003**		
Sample start time:			**1030**	**1230**	**1100**	**1030**	**1430**	**1200**	**1330**	**1330**		
	Minimum reporting level	**Number of detections**									**Minimum**	**Maximum**
Phthalates												
Bis(2-ethylhexyl) phthalate	50	4	590	—	—	<68	740	e130	360	—	<68	740
Di-n-octyl phthalate	50	2	<65	<50	<50	<57	e64	e30	<71	<65	e30	<71
Total number of phthalate compounds detected per sample			1	0	0	0	2	2	1	0		
Quinone												
9,10-Anthraquinone	50	8	220	78	58	e47	350	120	480	250	e47	480
Sulfurous-PAH												
Dibenzothiophene	50	5	e25	<50	<50	<57	330	e17	200	94	e17	330
Chloroaromatic												
1,2,4-Trichlorobenzene	50	1	<65	<50	<50	<57	<100	<61	e13	<65	e13	<100

Azaarenes are nitrogen analogues of PAHs, and they usually are found in water in association with sediment (Steinheimer and Ondrus, 1986). As a class, azaarenes are contributors to the biological activity of fossil-fuel combustion products. Azaarenes are believed to be formed during combustion or pyrolysis processes involving fossil fuels (Steinheimer and Ondrus, 1986). As with PAHs, some azaarenes are carcinogenic. All eight streambed-sediment samples analyzed contained concentrations of azaarene compounds (table 16). Seven of the samples contained multiple azaarene compounds. Only one azaarene compound was detected in the FMC at Hewitt Park sample collected in November 2005. December 2003 samples from FMC at Hewitt Park, FMC at Huffman Road, and FMC near Republic contained five of the six detected azaarene compounds. Carbazole had the highest detected concentration (390 µg/kg) of all azaarene compounds.

Organochlorine compounds degrade slowly in the environment and are routinely detected in environmental samples, even though they are no longer used in the United States. The USEPA has listed many organochlorine compounds as priority pollutants because they cause a variety of adverse health effects in wildlife (Nowell and others, 1999; table 15). Organochlorines are hydrophobic, which means that they do not dissolve readily in water, and are mostly associated with sediments or tissue in aquatic systems. Most organochlorine compounds are anthropogenic, and many organochlorines are pesticides, such as DDT and chlordanes, that were used widely in the 1950s–60s. Some organochlorine pesticides were restricted or banned in the United States during the 1970s–80s. Organochlorine polychlorinated biphenyls (PCBs) were used for a variety of applications, mostly as insulators in electrical transformers and equipment. PCBs are measured and reported as a group rather than as individual compounds, and are counted as a single constituent in the discussion presented below.

Only 7 of 32 organochlorine compounds analyzed for were detected, and only 4 of the 8 streambed-sediment samples from FMC contained concentrations of organochlorine SVOCs (table 16). No organochlorines were detected in samples from FMC at Lawson Road, FMC at Hewitt Park, and FMC at Lewisburg. Only PCBs were detected at FMC below Springdale Road. Sediment samples from FMC at Huffman Road and FMC near Republic each had six organochlorine compounds detected, the greatest number in a single sample (table 16). All of the organochlorine compounds detected in streambed-sediment samples, except PCBs, are organochlorine pesticides or related compounds.

All of the eight streambed-sediment samples analyzed contained concentrations of phenol SVOCs, and two samples contained multiple phenol compounds (table 16). Of the eight phenol compounds analyzed, only five were detected (tables 15 and 16). Phenol had the highest concentration (120 µg/kg) of all phenol compounds detected, and p-cresol was the most frequently detected phenol compound (table 16). Samples collected from FMC at Fivemile Road, FMC at Lawson Road, FMC at Hewitt Park, FMC at Huffman Road, and FMC near Republic contained only one phenol compound each. The greatest number (four) of phenol compounds was detected in samples collected from FMC below Springdale Road and FMC at Lewisburg.

Phthalate SVOCs often are associated with urban activities. Phthalates are aromatic esters widely used as solvents, plasticizers, and insect repellents (Budavari and others, 1989). They are used in a variety of industrial applications and in inks, adhesives, and resins. Some of the phthalates are environmentally persistent and have become widespread contaminants (Manahan, 1992). Phthalates are thought to be endocrine disrupters; Jobling and others (1995) found that some phthalates are weakly estrogenic. The USEPA considers some phthalates to be possible carcinogens. Of the eight streambed-sediment samples analyzed, four contained concentrations of phthalate compounds (table 16). No phthalate compounds were detected in samples from FMC at Lawson Road, FMC at Hewitt Park, or FMC near Republic. Only two phthalate compounds, bis(2-ethylhexyl) phthalate and di-n-octyl phthalate, were detected at sites in FMC. Samples from FMC at Huffman Road and FMC below Springdale Road contained concentrations of both phthalate compounds. The maximum detected concentrations of bis(2-ethylhexyl) phthalate (740 µg/kg) and di-n-octyl phthalate (e64 µg/kg) occurred in the FMC at Huffman Road sample.

Single compounds from three additional classes of SVOCs—quinones, sulfurous-PAHs, and chloroaromatics—were detected in streambed-sediment samples from FMC. The quinone compound, 9,10-anthraquinone was detected in all samples (table 16). The sulfurous-PAH, dibenzothiophene, was detected in the FMC at Fivemile Road, FMC at Huffman Road, FMC below Springdale Road, FMC at Lewisburg, and FMC near Republic samples. The chloroaromatic compound, 1,2,4-trichlorobenzene, was detected only in the FMC at Lewisburg sample.

Occurrence of Trace Elements in Streambed Sediment

Multiple trace elements were detected in all eight streambed-sediment samples analyzed from the seven sites (table 17). Gold and tantalum were the only analyzed trace elements not detected at least once. Seven elements (europium, gold, holmium, neodymium, tantalum, tin, and ytterbium) were analyzed in samples collected in 2003 but not in samples from 2005. Rubidium and cesium were added to the analysis for the 2005 samples but were not analyzed in the 2003 samples. Aluminum concentrations were not determined in 2005 because of matrix interference.

Forty-one of the 47 trace elements were detected in every sample collected from FMC for which they were analyzed (table 17). Twelve of the trace elements have been designated as priority pollutants by the USEPA (U.S. Environmental Protection Agency, 2004b). Because the priority pollutants can be detrimental to aquatic life, their relative concentrations among

Table 17. Concentrations of trace elements in streambed-sediment samples collected from selected sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.

[Concentrations in micrograms per gram; **bold** indicates trace elements designated as priority pollutants by the U.S. Environmental Protection Agency; —, no data; <, less than]

Station number:	02456900	02456980	02456999	02456999	02457500	02457502	02457510	02457595			
Station short name:	FMC at Fivemile Road	FMC at Lawson Road	FMC at Hewitt Park	FMC at Hewitt Park	FMC at Huffman Road	FMC below Springdale Road	FMC at Lewisburg	FMC near Republic			
Sample date:	12/22/2003	12/17/2003	12/17/2003	11/7/2005	12/17/2003	11/7/2005	11/7/2005	12/22/2003			
Sample time:	1030	1230	1100	1030	1430	1200	1330	1330	Minimum	Maximum	Median
Aluminum	46,000	43,000	47,000	—	42,000	—	—	64,000	42,000	64,000	46,000
Antimony	0.93	0.81	0.81	0.62	3.3	1	1.2	1.2	0.62	3.3	0.965
Arsenic	15	15	14	12	14	18	12	20	12	20	14.5
Barium	250	230	240	219	200	352	181	500	181	500	235
Beryllium	1.9	1.4	1.8	1.6	1.5	1.6	1.3	2	1.3	2	1.6
Bismuth	<1	<1	<1	0.27	<1	0.41	0.32	<1	0.27	0.41	0.32
Cadmium	0.41	0.37	0.33	0.28	2.4	0.64	0.75	0.36	0.28	2.4	0.39
Calcium	36,000	12,000	18,000	33,500	55,000	31,700	43,800	13,000	12,000	55,000	32,600
Cerium	74	72	76	73.1	63	68.5	67.6	75	63	76	72.55
Cesium	—	—	—	3.4	—	5.4	3	—	3	5.4	3.4
Chromium	53	48	53	46.9	56	61.9	51.2	68	46.9	68	53
Cobalt	18	14	15	12.2	12	17.2	12.3	16	12	18	14.5
Copper	25	28	28	23.4	40	33	29.2	32	23.4	40	28.6
Europium	1.3	1.2	1.4	—	1	—	—	1.4	1	1.4	1.3
Gallium	12	11	12	10	10	11	9.6	16	9.6	16	11
Gold	<1	<1	<1	—	<1	—	—	<1	—	—	—
Holmium	1	<1	1	—	<1	—	—	<1	1	1	1
Iron	30,000	28,000	28,000	24,000	26,000	26,000	24,000	33,000	24,000	33,000	27,000
Lanthanum	32	32	36	31.3	28	28.3	26.6	37	26.6	37	31.65
Lead	42	41	39	28.1	200	47.2	75.9	41	28.1	200	41.5
Lithium	29	28	31	24.8	28	34.1	24	43	24	43	28.5
Magnesium	6,200	5,700	6,100	5,760	21,000	7,890	12,100	6,000	5,700	21,000	6,150
Manganese	1,600	2,100	1,800	1,960	1,300	1,730	1,050	1,000	1,000	2,100	1,665
Mercury	0.09	0.09	0.09	0.08	0.15	0.15	0.16	0.13	0.08	0.16	0.11
Molybdenum	0.78	0.9	0.9	0.78	1.6	1.2	0.98	1.4	0.78	1.6	0.94
Neodymium	30	29	31	—	24	—	—	33	24	33	30
Nickel	26	23	25	22.4	24	28	22.2	26	22.2	28	24.5
Niobium	11	11	12	11	11	13	15	12	11	15	11.5
Phosphorus	820	680	720	650	640	1,100	560	740	560	1,100	700
Potassium	9,500	7,500	8,200	7,190	8,000	9,950	7,000	16,000	7,000	16,000	8,100
Rubidium	—	—	—	45.5	—	61.9	38.8	—	38.8	61.9	45.5
Scandium	8.8	8.2	9	8.4	8.1	8.9	7.6	13	7.6	13	8.6
Selenium	0.59	0.71	0.59	0.71	0.89	5.1	0.71	3.4	0.59	5.1	0.71
Silver	0.21	0.20	0.22	<3	0.32	<3	<3	0.22	0.2	0.32	0.22
Sodium	550	480	780	571	560	1,600	606	1,600	480	1,600	588.5
Strontium	48	33	39	41	53	81.1	43	71	33	81.1	45.5
Sulfur	700	600	500	600	1,000	1,800	700	800	500	1,800	700
Tantalum	<1	<1	<1	—	<1	—	—	<1	—	—	—
Thallium	<1	<1	<1	0.5	<1	0.52	0.5	<1	0.5	0.52	0.5
Thorium	9.8	9.9	10	10.2	8.6	9.3	9.4	11	8.6	11	9.85
Tin	2.4	2.7	3.2	—	20	—	—	4.4	2.4	20	3.2
Titanium	2,800	2,800	3,000	3,400	2,700	3,400	3,300	3,100	2,700	3,400	3,050
Uranium	3.2	3.4	3.4	2.9	3	2.7	2.6	3.7	2.6	3.7	3.1
Vanadium	63	64	64	52	56	53.8	50.1	94	50.1	94	59.5
Ytterbium	2.5	2.2	2.4	—	1.9	—	—	2.2	1.9	2.5	2.2
Yttrium	24	20	24	33	18	26.1	24.2	20	18	33	24
Zinc	150	110	130	114	1,000	292	236	200	110	1,000	175

the eight samples collected in FMC were examined in detail. At FMC at Hewitt Park and FMC at Lawson Road, concentrations of eight and nine of the priority pollutants, respectively, were below the respective element's median concentration reported for this study. The lowest concentrations of six priority pollutants (antimony, cadmium, copper, lead, mercury, and thallium) were present in the streambed-sediment sample collected from FMC at Hewitt Park in November 2005. In contrast, concentrations of 10 and 9 of the priority pollutants at FMC below Springdale Road and FMC near Republic, respectively, were greater than their study median concentrations. Maximum concentrations of six priority pollutants (antimony, cadmium, copper, lead, silver, and zinc) were detected in the sample collected from FMC at Huffman Road in December 2003.

Comparison of Concentrations of Organochlorine Compounds, Polycyclic Aromatic Hydrocarbon Compounds, and Trace Elements in Streambed-Sediment Samples with Standards and Guidelines

Concentrations of organochlorine compounds, PAH compounds, and trace elements in streambed-sediment samples from the FMC study area were compared with two types of consensus-based sediment-quality guidelines (SQGs; table 18), which were developed to distinguish between sediments with little or no toxicity and those with probable toxic effects on sediment-dwelling organisms. Threshold-effect concentrations (TECs) define a level below which toxic effects are not likely to be observed, while probable-effect concentrations (PECs) define a level above which toxic effects are likely to be observed (MacDonald and others, 2000). MacDonald and others (2000) determined SQGs for multiple semivolatile compounds and eight trace elements, and tested the guidelines against datasets of sediment quality and toxicity. The SQGs predicted toxicity better for some substances than for others, with the most useful guidelines being TECs and PECs that correctly defined lack of toxicity or toxicity, respectively, in at least 75 percent of cases. All SQGs available for substances analyzed in FMC are used in this report, but the SQGs that did not meet the 75-percent accuracy criterion are identified (table 18).

Detections of SVOCs in streambed sediment collected from FMC were compared to SQGs. PAH-compound concentrations detected in streambed-sediment samples exceeded PECs at three sites: FMC at Huffman Road, FMC at Lewisburg, and FMC near Republic (table 18). Concentrations of nine PAH-compounds exceeded their respective PECs. Anthracene, benzo[a]anthracene, benzo[a]pyrene, chrysene, fluoranthene, phenanthrene, and pyrene concentrations were higher than PECs in the samples from FMC at Huffman Road, FMC at Lewisburg, and FMC near Republic. The naphthalene and 9H-fluorene concentrations in the sample from FMC at Lewisburg also were higher than the PEC. Concentrations of multiple individual PAH compounds exceeded TECs in every sample except one from FMC at Hewitt Park in 2005, and the calculated total concentrations of PAH compounds exceeded the TEC for total PAHs in all samples except the two from FMC at Hewitt Park. Total PAH-compound concentrations exceeded the PEC in the FMC at Huffman Road and FMC at Lewisburg samples. No organochlorine-compound concentrations in streambed-sediment samples exceeded PECs in any of the samples, but estimated concentrations of PCBs exceeded the TEC at FMC at Huffman Road in 2003 and FMC below Springdale Road in 2005.

Trace-element concentrations can be elevated in streambed sediments as a result of anthropogenic activities, such as mining or industrial or urban development, or as a result of natural geologic factors. Data from previous studies have shown that median concentrations of chromium, copper, lead, nickel, and zinc were higher at sites downstream from urban areas than at non-urban sites (Rice, 1999).

SQGs were exceeded for seven of the eight trace elements (table 18, fig. 15). Concentrations of mercury were below the TEC, indicating that adverse effects on stream biota caused by mercury were rare at the sampled sites in FMC. All but one measured concentration of cadmium, at FMC at Huffman Road, were below the TEC. Only two concentrations of trace elements measured in sediment from FMC, lead (200 µg/g) and zinc (1,000 µg/g) in the FMC at Huffman Road sample, exceeded their respective PECs, indicating probable detrimental effects on in-stream biota. Concentrations of arsenic and chromium were between the TEC and PEC at all sites, which may indicate occasional detrimental effects on aquatic biota. Most sediment samples from FMC contained concentrations of multiple trace elements above the TECs, indicating that occasional detrimental effects on aquatic life are likely along FMC.

Table 18. Comparison of semivolatile organic compounds and trace-element concentrations in streambed-sediment samples from Fivemile Creek, Jefferson County, Alabama, to consensus-based sediment-quality guidelines from MacDonald and others, 2000.

[µg/kg, micrograms per kilogram; µg/g, micrograms per gram; e, estimated concentration; <, less than; —, no data; TEC, threshold-effect concentration; PEC, probable-effect concentration; Plain text indicates concentration below TEC; bold italic indicates concentration between TEC and PEC; shaded bold italic indicates concentration above PEC; PAH, polycyclic aromatic hydrocarbon; PCB, polychlorinated biphenyl; p,p'-DDE, p,p'-1,1-dichloro-2,2-bis(chlorophenyl) ethene; p,p'-DDT, p,p'-1,1,1-trichloro-2,2-bis(chlorophenyl)ethane]

Station number:			**02456900**	**02456980**	**02456999**	**02456999**	**02457500**	**02457502**	**02457510**	**02457595**
Station short name:			**FMC at Fivemile Road**	**FMC at Lawson Road**	**FMC at Hewitt Park**	**FMC at Hewitt Park**	**FMC at Huffman Road**	**FMC below Springdale Road**	**FMC at Lewisburg**	**FMC near Republic**
Sample date:			**12/22/2003**	**12/17/2003**	**12/17/2003**	**11/7/2005**	**12/17/2003**	**11/7/2005**	**11/7/2005**	**12/22/2003**
Sample start time:			**1030**	**1230**	**1100**	**1030**	**1430**	**1200**	**1330**	**1330**
	TEC	**PEC**								
Polycyclic aromatic hydrocarbons										
Anthracene, µg/kg	57.2	845	***94***	e37	e 49	e25	***1,500***	***96***	***2,000***	***1,100***
Benzo[a]anthracene, µg/kg	108	1,050	***510***	***180***	***170***	e52	***2,800***	***480***	***5,800***	***2,900***
Benzo[a]pyrene, µg/kg	150	1,450	***650***	***210***	***170***	70	***2,700***	***610***	***4,800***	***2,400***
Chrysene, µg/kg	166	1,290	***830***	***250***	***200***	68	***2,600***	***640***	***5,400***	***2,900***
Fluoranthene, µg/kg	423	2,230	***1,400***	***470***	400	120	***5,000***	***610***	***9,700***	***4,400***
Phenanthrene, µg/kg	204	1,170	***560***	180	***210***	e46	***5,200***	200	***3,100***	***1,700***
Pyrene, µg/kg	195	1,520	***1,100***	***340***	***290***	88	***7,000***	***690***	***6,900***	***3,200***
9H-Fluorene, µg/kg	77.4[a,b]	536[a]	e30	e8	e16	<57	370	e27	***540***	***220***
Dibenzo[a,h]anthracene, µg/kg	33[b]	—	***150***	***66***	***57***	***<57***	430	***e59***	***e340***	***570***
Naphthalene, µg/kg	176	561	e20	<50	e10	e8.1	140	e30	***1,100***	***240***
Total PAHs, µg/kg	1,610	22,800	***5,294***	***1,696***	1,497	346	***27,740***	***3,326***	***39,340***	***19,630***
Organochlorines										
PCBs, µg/kg	59.8	676	<50	<50	<50	<50	***e83***	***e130***	<50	e34
cis-Chlordane, µg/kg	3.24[c]	17.6[c,f]	e0.96	<1	<1	<1	1.10	<1	<1	e0.56
Dieldrin, µg/kg	1.9	61.8	e0.81	<1	<1	<1	1.20	<1	<1	e0.55
trans-Chlordane, µg/kg	3.24[c]	17.6[c,f]	1.10	<1	<1	<1	1.30	<1	<1	e0.56
p,p'-DDE, µg/kg	3.16[d]	31.3[d]	<1	<1	<1	<1	e0.71	<1	<1	<1
p,p'-DDT, µg/kg	4.16[e]	62.9[e]	<2	<2	<2	<2	<2	<2	<2	2.60
Trace elements										
Arsenic, µg/g	9.79[b]	33.00	***15***	***15***	***14***	***12***	***14***	***18***	***12***	***20***
Cadmium, µg/g	0.99	4.98	0.41	0.37	0.33	0.28	***2.40***	0.64	0.75	0.36
Chromium, µg/g	43.4[b]	111.0	***53.0***	***48.0***	***53.0***	***46.9***	***56.0***	***61.9***	***51.2***	***68.0***
Copper, µg/g	31.6	149.0	25.0	28.0	28.0	23.4	***40.0***	***33.0***	29.2	***32.0***
Lead, µg/g	35.8	128.0	***42.0***	***41.0***	***39.0***	28.1	***200.0***	***47.2***	***75.9***	***41.0***
Mercury, µg/g	0.18[b]	1.06	0.09	0.09	0.09	0.08	0.15	0.15	0.16	0.13
Nickel, µg/g	22.7[b]	48.6	***26.0***	***23.0***	***25.0***	22.4	***24.0***	***28.0***	22.2	***26.0***
Zinc, µg/g	121	459	***150***	110	***130***	114	***1,000***	***292***	***236***	***200***

[a] Sediment-quality guideline is for fluorene.

[b] Sediment-quality guideline correctly predicted lack of toxicity in less than 75 percent of samples.

[c] Sediment-quality guideline is for chlordane.

[d] Sediment-quality guideline is for the sum of DDE (1,1-dichloro-2,2-bis(chlorophenyl)ethene).

[e] Sediment-quality guideline is for the sum of DDT (1,1,1-trichloro-2,2-bis(chlorophenyl)ethane).

[f] Sediment-quality guideline correctly predicted toxicity in less than 75 percent of samples.

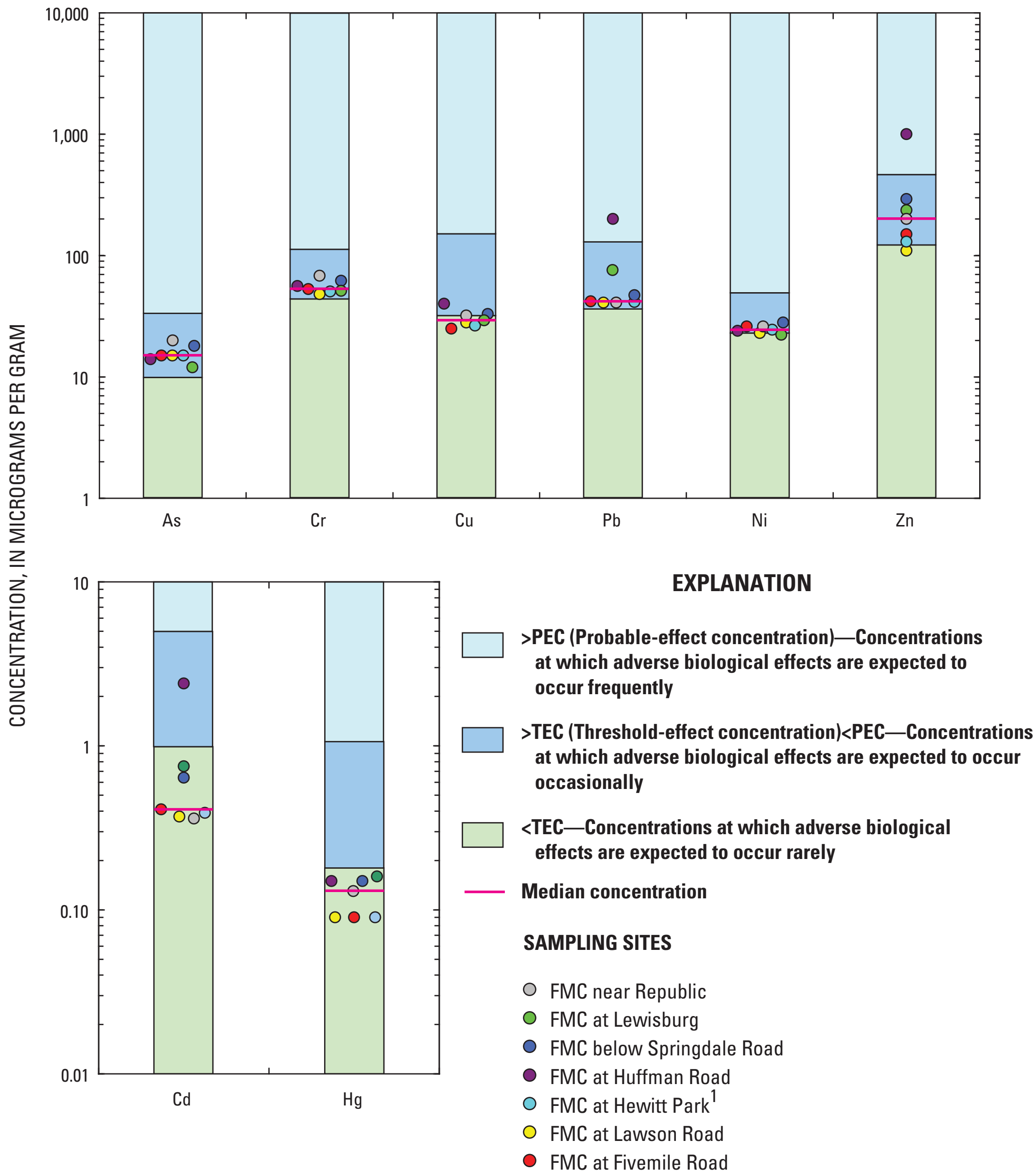

Figure 15. Concentrations of selected trace elements in streambed sediment, sediment-quality guidelines, and median concentrations in the Fivemile Creek, Jefferson County, Alabama, study area. [[1], value shown is average of detected concentrations in 2003 and 2005 samples for the site.]

Benthic Invertebrate Communities

Benthic invertebrate communities respond to the integrated effects of chemical and physical stream properties, and samples of the benthic invertebrate communities along FMC were important indicators of the stream's suitability as habitat for aquatic biota. Analysis of samples at selected sites along FMC identified 137 benthic invertebrate taxa, including 14 ambiguous parent taxa (appendix 3). For computation of metrics in this report, ambiguous parent taxa are counted as distinct taxa. For richest targeted habitat (RTH) samples, total taxa richness ranged from a high of 37 taxa at FMC at Hewitt Park in November 2004, to only 13 taxa at FMC at Brookside in November 2004 (table 19, appendix 3, fig. 16). Total taxa richness was fairly uniform in RTH samples collected in July 2003, ranging from 25 distinct taxa at FMC at Huffman Road to 21 distinct taxa at FMC at Hewitt Park. Taxa richness in samples from Hewitt Park in 2004 was nearly double the measured richness in 2003, indicating that changes in benthic invertebrate communities across years or seasons may occur.

Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness was greatest at FMC at Graysville (12 EPT taxa) in 2004 and lowest at Hewitt Park (4 EPT taxa) in 2003 (fig. 16). EPT taxa are expected to decrease in response to increased stream perturbation, but reference site data are needed to determine if any of these sites have unexpectedly small numbers of EPT taxa. Nine EPT taxa were detected at Hewitt Park in 2004, indicating that annual, seasonal, or sampling variations may exceed observed differences in benthic invertebrate communities between sites.

Chironomids, or midges, are usually considered more tolerant of organic enrichment and heavy metals contamination than the EPT taxa (Resh and Jackson, 1993; Alabama Department of Environmental Management, 1996), but because this tolerance is not universal within the family Chironomidae, the number of chironomid taxa is generally expected to

Table 19. Calculated metrics for invertebrate samples collected in July 2003 and November 2004 at selected sites along Fivemile Creek, Jefferson County, Alabama.

[USGS, U.S. Geological Survey; FMC, Fivemile Creek; EPT, Ephemeroptera, Plecoptera, Trichoptera; %, percent; ADEM, Alabama Department of Environmental Management]

Site:	FMC at Fivemile Road	FMC at Hewitt Park	FMC at Hewitt Park	FMC at Huffman Road	FMC below Springdale Road	FMC at Republic Ford	FMC at Brookside	FMC at Graysville
USGS station number:	**02456900**	**02456999**	**02456999**	**02457500**	**02457502**	**02457599**	**02457625**	**02457700**
Sample date:	**07/16/2003**	**07/16/2003**	**11/17/2004**	**07/16/2003**	**11/18/2004**	**11/19/2004**	**11/18/2004**	**11/19/2004**
Species richness	23	21	37	25	26	17	13	20
EPT richness	5	4	9	5	8	8	8	12
Chironomidae richness	10	8	14	11	5	4	0	3
Total abundance	1,252	3,732	427.2	3,720	698	66	59	238
EPT abundance	552	2,364	252	1,944	570	49	41	226
EPT abundance relative to total abundance	44.1%	63.3%	59.0%	52.3%	81.7%	74.2%	69.5%	95.0%
Chironomidae abundance	592	900.4	63.6	1,512.6	56	5	0	5
Chironomidae abundance relative to total abundance	47.3%	24.1%	14.9%	40.7%	8.0%	7.6%	0.0%	2.1%
Ratio of EPT to Chironomidae	0.48	0.72	0.80	0.56	0.91	0.91	1.00	0.98
ADEM biotic index	5.47	5.11	4.51	5.3	4.33	5.34	4.94	3.98
Percent of individuals with ADEM tolerance value	99.76	99.87	99.69	99.82	100	100	100	99.79
Number of intolerant taxa	1.0	1.0	5.0	1.0	5.0	1.0	1.0	1.0
Abundance of intolerant organisms	4.0	96.0	64.8	36.0	286.0	4.0	7.0	18.0
Intolerant organism abundance relative to total abundance	0.3%	2.6%	15.2%	1.0%	41.0%	6.1%	11.9%	7.6%

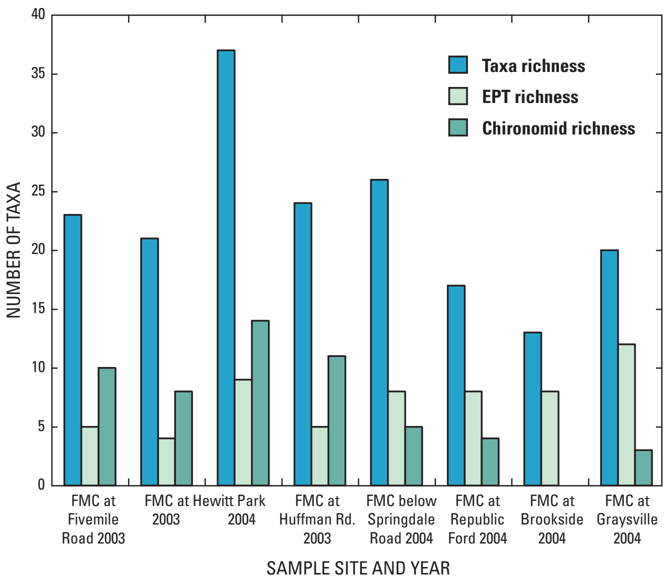

Figure 16. Total taxa richness, Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness, and chironomid taxa richness in richest targeted habitat (RTH) samples collected at selected sites along Fivemile Creek, Jefferson County, Alabama, 2003 and 2004.

decrease with increasing stream impairment (Barbour and others, 1999). No chironomid taxa were identified in the sample from FMC at Brookside. Chironomid taxa richness at other sampled sites in FMC ranged from a low of 3 taxa at Graysville to a high of 14 taxa in the 2004 sample from Hewitt Park. In samples collected during November 2004, chironomid richness was highest at FMC at Hewitt Park and decreased downstream. The incidence of past mining activity and mining wastes is greater in the lower portion of the watershed (ecoregion 68f), and heavy-metals contamination would be expected to be greater in those areas.

Dominant taxa at FMC sampling sites were usually mayflies, caddisflies, and chironomids (table 20). At all sites except Fivemile Road and Hewitt Park, the first dominant taxon accounted for more than 30 percent of the total benthic invertebrate abundance, which indicates possible community imbalance and environmental stressors. *Isonychia* sp., a fairly intolerant (ADEM tolerance value = 3.5; Alabama Department of Environmental Management, 1996) mayfly genus (appendix 3), represented more than half of the total abundance at Graysville, and the second and third dominant taxa at that site accounted for another quarter of the total invertebrates. Domination of the benthic invertebrate community by such a small number of taxa is often indicative of environmental stress (Alabama Department of Environmental Management, 1996). The Brookside site was dominated by *Stenonema mediopunctatum*,[1] another moderately intolerant mayfly, but the second most common taxon at the site was the highly tolerant (ADEM tolerance value = 7.1; Alabama Department of Environmental Management, 1996) tubificid worms. The *Cheumatopsyche* and *Hydropsyche* caddisfly genera are members of the family Hydropsychidae, also known as the hydropsychid caddisflies. Species of hydropsychid caddisflies, which filter their food from the water column, were in the top three most abundant taxa at five of the sites. Hydropsychid caddisflies commonly dominate communities that receive large quantities of fine particulate organic matter (Alabama Department of Environmental Management, 1996), and their prevalence at several sites along FMC suggests that organic enrichment is occurring along the stream.

Total abundance of individual invertebrates varied greatly among the RTH samples, which were collected in riffle habitat (table 19, fig. 17). The greatest total abundances were observed at FMC at Hewitt Park (3,732 individuals) and Huffman Road (3,720 individuals) in 2003. Total abundance in RTH samples collected in 2004 was reduced in comparison to July 2003 samples at FMC at Hewitt Park where samples were collected both years. Total abundances in the RTH samples collected in November 2004 from FMC at Republic Ford and FMC at Brookside were 66 and 59 individuals, respectively, much less than in samples from other sites. The lower abundances suggest that benthic invertebrate communities at these two sites may be stressed.

Qualitative-multihabitat (QMH) samples were intended to document the taxa present within all habitats in each sampling reach. QMH samples were only collected in November 2004, and total abundance in the QMH samples was relatively high, ranging from 946 at FMC at Hewitt Park to 4,607 at FMC at Brookside (appendix 3). These results indicate that sampling in a variety of habitats may be desirable when trying to characterize and compare sites.

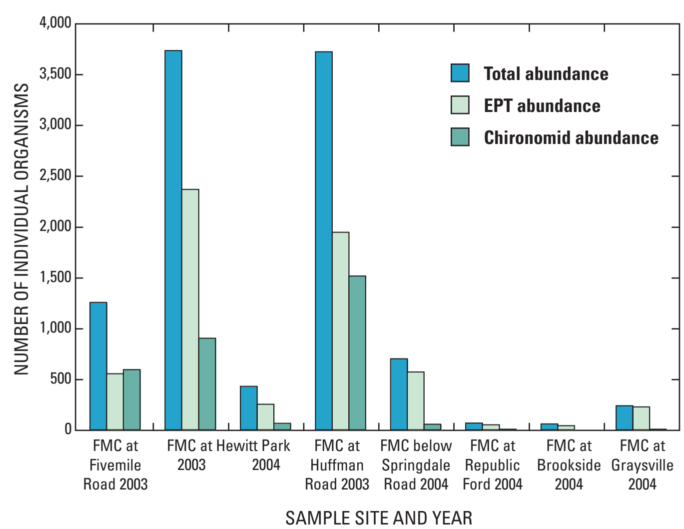

Figure 17. Total, EPT, and chironomid abundance at selected sites along Fivemile Creek, Jefferson County, Alabama, July 2003 and November 2004. [EPT, Ephemeroptera, Plecoptera, and Trichoptera]

[1] All members of the *Stenonema* genus except *Stenonema femoratum* now have been assigned to the genus *Macaffertium*. *Stenonema* was the correct genus at the time of sample analysis and is used in this report.

Table 20. Three most abundant invertebrate taxa and their respective cumulative percentages of total abundance at selected sites in Fivemile Creek, Jefferson County, Alabama, July 2003 and November 2004.

Station short name, number, and date of sample	1st Dominant Taxon Scientific name Common group name	2nd Dominant Taxon Scientific name Common group name	3rd Dominant Taxon Scientific name Common group name	Percentage of total abundance in first dominant taxon	Percentage of total abundance in first and second dominant taxa	Percentage of total abundance in first, second, and third dominant taxa
FMC at Fivemile Rd. 02456900 07/16/2003	*Baetis flavistriga* mayfly	*Cricotopus* sp. chironomid	*Cricotopus bicinctus* gr. chironomid	26.2	43.13	59.42
FMC at Hewitt Park 02457000 07/16/2003	*Hydropsyche sparna*[1] caddisfly	*Cheumatopsyche* sp. caddisfly	*Baetis flavistriga* mayfly	29.58	49.2	60.45
FMC at Hewitt Park 02456999 11/17/2004	*Cheumatopsyche* sp. caddisfly	*Simulium* sp. black fly	*Chimarra obscura* caddisfly	19.1	37.08	50
FMC at Huffman Rd. 02457500 07/16/2003	*Baetis flavistriga* mayfly	*Cricotopus* sp. chironomid	*Cricotopus bicinctus* gr. chironomid	34.52	50	60.65
FMC below Springdale Rd. 02457502 11/18/2004	*Chimarra obscura* caddisfly	*Cheumatopsyche* sp. caddisfly	*Baetis flavistriga* mayfly	36.1	60.17	68.19
FMC at Republic Ford 02457599 11/19/2004	*Cheumatopsyche* sp. caddisfly	*Isonychia* sp. mayfly	*Baetis flavistriga* mayfly	30.3	40.91	50
FMC at Brookside 02457625 11/18/2004	*Stenonema mediopunctatum*[2] mayfly	*Tubificidae* worm	*Cheumatopsyche* sp. caddisfly	32.2	47.46	59.32
FMC at Graysville 02457700 11/19/2004	*Isonychia* sp. mayfly	*Stenonema mediopunctatum*[2] mayfly	*Cheumatopsyche* sp. caddisfly	51.26	64.71	73.53

[1] Wiggins, 1996.

[2] All members of the *Stenonema* genus except *Stenonema femoratum* now have been assigned to the genus *Macaffertium*. *Stenonema* was the correct genus at the time of sample analysis and is used in this report.

According to the ADEM, good biotic condition is indicated by evenly distributed abundance among the EPT taxa and the chironomid taxa (Alabama Department of Environmental Management, 1996). Abundance of EPT organisms ranged from 44.1 percent of total abundance at FMC at Fivemile Road to 95.0 percent of total abundance at FMC at Graysville (table 19). The relative abundance of organisms in the generally intolerant EPT orders is expected to decrease in response to stream perturbation (Barbour and others, 1999). EPT organisms account for a minimum of about 50 percent of total abundance in samples from sites along FMC, indicating that these intolerant organisms are not limited by the presence of environmental stressors. No chironomid organisms were identified in the sample from FMC at Brookside. Chironomid abundance at the other sites ranged from 2.1 percent of total abundance at FMC at Graysville to 47.3 percent of total abundance at FMC at Fivemile Road. Calculated ratios of EPT to chironomid abundance indicate poor biotic conditions at several of the sites along FMC. At FMC at Fivemile Road and at Huffman Road, ratios indicate that more chironomids are present than are members of the EPT taxa, which can indicate organic enrichment or contamination from heavy metals (Alabama Department of Environmental Management, 1996). Ratios calculated for FMC below Springdale Road, at Republic Ford, at Brookside, and at Graysville indicate that EPT organisms greatly outnumber chironomid organisms. The imbalance between EPT and chironomid abundances indicates poor biotic conditions at these four sites as well.

Biotic-index (BI) values represent the average tolerance of the invertebrate community to degraded water quality. Lower BI values at a site indicate the presence of less tolerant, more sensitive invertebrate communities, and suggest that water-quality conditions at the site are adequate to support such a community. BI values ranged from 3.98 at FMC at Graysville to 5.47 at FMC at Fivemile Road (table 19). During July 2003, BI values were similar among the three sites sampled, ranging from 5.11 at FMC at Hewitt Park to 5.47 at FMC at Fivemile Road (fig. 18). During November 2004,

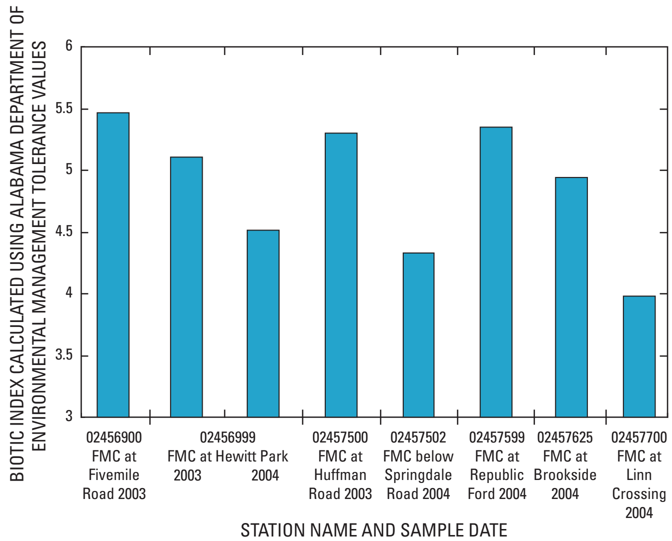

Figure 18. Biotic index values calculated for samples collected during July 2003 and November 2004 from selected sites along Fivemile Creek, Jefferson County, Alabama.

more variability was observed among the sites. The greatest BI values measured in 2004 RTH samples were from FMC at Republic Ford and FMC at Brookside. When compared to relations between BI values and water quality observed in North Carolina Piedmont streams (table 21), the ranges observed in this study indicate very good to excellent water quality along FMC.

The number of intolerant taxa is expected to decrease in response to increasing stream perturbation (Barbour and others, 1999), but the absence of an intolerant taxon does not necessarily indicate that its environmental needs are not met in the stream (Johnson and others, 1993). All RTH samples collected along FMC had at least one intolerant taxon present (table 19). Samples from FMC at Hewitt Park in 2004 and from FMC below Springdale Road each had five intolerant taxa present. Intolerant organisms accounted for fairly low percentages of total abundance at most sites. The greatest percentage of intolerant organisms in an RTH sample (41.0 percent) was from FMC below Springdale Road. Though the presence of historical mining operations in the lower watershed is one explanation for the reduced numbers of intolerant taxa at the more downstream sites, ecoregion and habitat differences might also account for the reduced numbers.

Table 21. North Carolina biotic index values and associated water-quality conditions (Alabama Department of Environmental Management, 1996).

Piedmont biotic index values	Water-quality conditions
0.00–5.18	Excellent
5.19–5.78	Very good
5.79–6.48	Good–Fair
6.49–7.48	Fair
7.49–10.00	Poor

Summary

The U.S. Geological Survey (USGS), in cooperation with the City of Tarrant, the Freshwater Land Trust, and the Jefferson County Commission, conducted a water-quality assessment of Fivemile Creek (FMC) during 2003–2005. Samples were collected from 12 sites along FMC and were analyzed for a variety of biological and chemical indicators of water-quality condition. Data collected during this assessment were compared to available standards, criteria, and guidelines to evaluate the suitability of the creek for human body-contact recreation and as habitat for aquatic organisms.

In most cases, properties of FMC measured at the time of sampling indicated water-quality conditions adequate for recreational and aquatic-life uses. Temperatures varied with season and meteorological conditions, never dropping below freezing. Specific conductance values ranged from 167 to 637 microsiemens per centimeter (μS/cm), with slightly greater values recorded at the more downstream sites. Values of pH generally indicated neutral to slightly basic conditions, ranging from 6.4 to 8.7 units. One recorded pH value was outside the range recommended by the Alabama Department of Environmental Management; this value was measured at FMC at Fivemile Road. Dissolved-oxygen measurements indicated well-aerated to super-saturated conditions along the stream. Turbidity measurements ranged from 1.5 to 430 nephelometric turbidity ratio units and from 0.4 to 44 formazin nephelometric units, and could be used as a baseline for evaluating changes in optical properties of the stream.

Major ionic composition in FMC has been strongly influenced by the geology of the watershed. Limestone and dolomite present in the upper watershed have given the stream a strong calcium-magnesium bicarbonate signature. Downstream from ecoregion 67f, the proportions of sodium, chloride, and sulfate ions were greater than upstream.

High nutrient concentrations can fuel nuisance algal growth and cause changes in the ecological communities of streams. The U.S. Environmental Protection Agency (USEPA) nutrient ecoregion criteria recommendations can be used to prioritize the location of nutrient-control efforts in the watershed. The highest concentrations of most nitrogen and phosphorus species were measured at the FMC at Lewisburg site, but the concentrations exceeded ecoregion criteria at many of the sites along FMC.

Total nitrogen concentrations ranged from 0.91 to 3.0 milligrams per liter (mg/L) and exceeded the USEPA's respective ecoregion total nitrogen criterion for all samples at FMC at Hewitt Park, FMC below Springdale Road, FMC at Lewisburg, FMC near Republic, FMC at Brookside, and FMC at Linn Crossing. Total Kjeldahl nitrogen (TKN) concentrations ranged from less than 0.1 to 0.9 mg/L and exceeded the USEPA's respective ecoregion criterion for TKN in two samples from FMC at Hewitt Park, one sample from FMC below Springdale Road, all samples from FMC at Lewisburg, and in the single samples collected from FMC near Republic, FMC at

Brookside, and FMC at Linn Crossing. Dissolved ammonia concentrations ranged from less than 0.04 to 0.26 mg/L. The maximum concentration (0.26 mg/L) and the highest median concentration (0.05 mg/L) were from FMC at Lewisburg. The high dissolved ammonia concentrations at FMC at Lewisburg are indicative of urban influences. Dissolved nitrite-plus-nitrate concentrations ranged from 0.76 to 2.51 mg/L. Nitrite-plus-nitrate concentrations exceeded the USEPA's respective ecoregion nutrient criterion in 100 percent of the samples from FMC. The highest maximum concentration (2.51 mg/L) and median concentration (1.88 mg/L) of nitrite plus nitrate occurred at FMC at Lewisburg.

Total phosphorus values ranged from 0.007 to 0.184 mg/L. The highest maximum concentration (0.184 mg/L) and median concentration (0.093 mg/L) of total phosphorus among sites with multiple samples occurred at FMC at Lewisburg. About 58 percent of total phosphorus concentrations of all samples were above the respective ecoregion nutrient criterion. Total phosphorus concentrations in samples collected from FMC at Hewitt Park, FMC at Springdale Road, FMC at Lewisburg, FMC near Republic, FMC at Brookside, and FMC at Linn Crossing exceeded the total phosphorus criterion for the respective ecoregion. Dissolved phosphorus concentrations ranged from 0.004 to 0.12 mg/L, and dissolved orthophosphate concentrations ranged from less than 0.02 to 0.09 mg/L. Maximum and highest median concentrations for dissolved phosphorus (0.12 mg/L and 0.072 mg/L, respectively) and orthophosphate (0.09 mg/L and 0.04 mg/L, respectively) were observed at FMC at Lewisburg.

Suspended chlorophyll *a* was measured and detected in seven samples collected from among five sites (FMC at Fivemile Road, FMC at Lawson Road, FMC at Hewitt Park, FMC at Huffman Road, and FMC near Republic). Suspended chlorophyll *a* concentrations ranged from 0.25 to 0.53 µg/L. The maximum concentration of suspended chlorophyll *a* was detected at FMC at Fivemile Road (0.53 µg/L). For rivers and streams in Level III ecoregions 67f and 68f within Nutrient Ecoregion XI, the USEPA recommends that suspended chlorophyll *a* not exceed 1.063 or 2 µg/L, respectively (U.S. Environmental Protection Agency, 2000a). During this study, suspended chlorophyll *a* did not exceed these recommendations in any samples collected in the FMC watershed.

Ninety-eight samples from FMC were analyzed for fecal coliform and *E. coli*, two types of bacteria that are indicative of fecal contamination. Samples were collected from 11 sites along FMC at varying frequencies. Sample results were compared to criteria established by the Alabama Department of Environmental Management (ADEM) and USEPA to protect human and aquatic health. The highest concentrations of fecal indicator bacteria measured in FMC occurred during elevated streamflow; most bacterial concentrations, however, showed little or no relation to streamflow, indicating a mix of point and nonpoint sources of fecal contamination.

Fecal-coliform concentrations from FMC sites ranged from 6 colonies per 100 milliliters (col/100 mL) at FMC at Fivemile Road to 10,000 col/100 mL in a sample from FMC below Springdale Road. Concentrations of fecal coliform exceeded criteria for human whole-body contact in some samples collected from seven sites on FMC: FMC at Hewitt Park, FMC at Huffman Road, FMC below Springdale Road, FMC at Lewisburg, FMC at Republic Ford, FMC at Brookside, and FMC at Linn Crossing. Fish and wildlife criteria were equaled or exceeded by fecal-coliform concentrations measured at five FMC sites: FMC at Hewitt Park, FMC below Springdale Road, FMC at Lewisburg, FMC at Republic Ford, and FMC at Brookside. At two sites, FMC below Springdale Road and FMC at Republic Ford, fecal-coliform concentrations exceeded the single-sample criterion for agricultural and industrial water supply (4,000 col/100 mL).

E. coli concentrations ranged from 8 col/100 mL at FMC below Springdale Road to 13,000 col/100 mL, also at the Springdale Road site. Maximum *E. coli* concentrations usually were in samples collected during high-flow conditions and exceeded the single-sample infrequently-used whole-body contact recreation area criterion (576 col/100 mL) at all but one site (FMC at Brookside Park) with multiple samples. Median *E. coli* concentrations for two of the seven sites with multiple samples, FMC at Hewitt Park and FMC at Brookside, exceeded the USEPA's geometric mean criterion for whole-body contact (126 col/100 mL). The median *E. coli* concentration at Brookside, 845 col/100 mL, also exceeded USEPA's single-sample maximum criterion for infrequently-used whole-body contact recreation areas.

Discharges of wastewater can contribute a wide array of contaminants to streams, including many that are harmful to aquatic life. Twenty-nine samples were collected from sites along FMC and analyzed by the USGS National Water Quality Laboratory for the presence of 57 organic wastewater compounds. All detections of organic wastewater compounds were estimated below laboratory reporting limits except for several detections of the herbicide bromacil. Forty-six organic wastewater compounds were detected in FMC samples, representing 11 general-use categories. The most commonly detected categories were stimulants, polycyclic aromatic hydrocarbons (PAHs), pesticides, detergent degradates, and flavorings or fragrances. The number of compounds detected in a single sample ranged from 32 compounds from FMC at Lewisburg to no detections in some samples from FMC at Fivemile Road, FMC at Lawson Road, FMC at Republic Ford, and FMC at Linn Crossing. Caffeine, a stimulant, was the most commonly detected compound, and was present in approximately 50 percent of the samples. Other compounds found in more than 25 percent of the samples were DEET, naphthalene, phenol, fluoranthene, pyrene, 4-nonylphenol, and bisphenol A. Diethoxynonylphenol, bromacil, 4-nonylphenol, and cholesterol were the compounds detected or estimated in the highest concentrations. Twelve of the detected organic wastewater compounds are known or suspected to cause endocrine disruption. The greatest number and concentration of endocrine-disrupting compounds were detected at FMC at Lewisburg during high streamflow events.

A total of 33 surface-water samples were collected at 10 sites in the FMC study area and analyzed for 85 pesticides and degradates. Of the 85 compounds, 22 were detected in one or more stream samples. Of the 22 detected pesticides, 12 were herbicides, 9 were insecticides, and 1 was a fungicide. Atrazine and simazine were the most frequently detected herbicides. Fipronil sulfide was the most frequently detected insecticide-derived compound, and myclobutanil was the only detected fungicide.

Eleven of the pesticides detected in this study have recommended drinking-water standards, guidelines, or health advisory levels, and 8 of the pesticides detected in this study have aquatic-life criteria established by the USEPA, the National Academy of Sciences and National Academy of Engineering (NAS/NAE), and the Canadian Council of Ministers of the Environment. Estimated concentrations of one insecticide, dieldrin, exceeded the USEPA specific dose at 10^{-6} cancer risk in one sample from FMC at Hewitt Park collected on July 18, 2005, and in one sample from FMC below Springdale Road on July 18, 2005. A few estimated concentrations of carbaryl and malathion exceeded aquatic-life criteria. Estimated concentrations of carbaryl exceeded the NAS/NAE aquatic-life criterion in samples collected in December 2004 from FMC below Springdale Road (0.023 µg/L) and FMC at Republic Ford (0.064 µg/L). The estimated concentration of malathion measured at FMC at Lewisburg (0.022 µg/L) on July 18, 2005, exceeded the NAS/NAE criterion. Measured pesticide concentrations that exceeded water-quality standards and guidelines for pesticides to protect human health and aquatic life do not necessarily indicate that adverse effects are occurring, but rather, indicate that adverse effects may occur and that sites where water-quality standards and guidelines were exceeded may need further investigation.

A total of 37 surface-water samples were collected at 10 sites in the FMC study area and analyzed for 18 trace elements. Of the 18 trace elements, 16 were detected in one or more stream samples. Concentrations of beryllium and silver were below detection levels in all samples. The concentration of aluminum in a sample from FMC at Linn Crossing and concentrations of manganese in single samples collected from FMC near Republic, FMC at Brookside, and FMC at Linn Crossing exceeded secondary drinking-water standards. The concentration of cadmium in a sample from FMC at Lewisburg exceeded the chronic aquatic-life criterion established by ADEM.

Surface-water samples from three sites along FMC were analyzed for 57 semivolatile organic compounds (SVOCs). No SVOCs were detected at FMC at Hewitt Park. Two SVOCs were detected in the sample from FMC below Springdale Road, and 10 SVOCs were detected at FMC at Lewisburg. All detected SVOC concentrations were estimated below the method detection limits.

Streambed-sediment samples were collected at seven sites along FMC, and analyzed for 98 SVOCs and 47 trace elements. Forty-nine SVOCs were detected in streambed-sediment samples. Forty-five trace elements were detected at one or more FMC sites.

Concentrations of SVOCs and trace elements in sediment were compared to sediment-quality guidelines designed to evaluate toxicity to sediment-dwelling organisms. Sediment-quality guidelines have been established for 15 individual SVOCs, 8 trace elements, total PAHs, and polychlorinated biphenyls. Concentrations of PAH compounds and trace elements detected in streambed-sediment samples exceeded probable-effect concentrations (PECs) at three sites: FMC at Huffman Road, FMC at Lewisburg, and FMC near Republic. Concentrations of nine PAH compounds exceeded their respective PECs. Anthracene, benzo[a]anthracene, benzo[a]pyrene, chrysene, fluoranthene, phenanthrene, and pyrene concentrations were higher than PECs in the samples from FMC at Huffman Road, FMC at Lewisburg, and FMC near Republic. The naphthalene and 9H-fluorene concentrations in the sample from FMC at Lewisburg also were higher than the PEC. Total PAH-compound concentrations exceeded the PEC in the FMC at Huffman Road and FMC at Lewisburg samples. Concentrations of multiple individual PAH compounds exceeded threshold-effect concentrations (TECs) in every sample except one from FMC at Hewitt Park in 2005. No organochlorine-compound concentrations in streambed-sediment samples exceeded PECs, but estimated concentrations of polychlorinated biphenyls (PCBs) exceeded the TEC at FMC at Huffman Road in 2003 and at FMC below Springdale Road in 2005. Lead and zinc were the only trace elements with concentrations higher than their PECs. Most streambed-sediment samples from FMC contained concentrations of multiple trace elements above the TECs, suggesting that occasional detrimental effects on aquatic life are likely.

The limited benthic invertebrate community data collected as part of this watershed assessment indicate that possible stream impairment exists at some of the sites. The low total abundance, low chironomid abundance, and relatively high biotic-index values at FMC at Brookside and FMC at Republic Ford during 2004 indicate poor water quality or the presence of some other environmental stressors. FMC at Graysville had greater Ephemeroptera, Plecoptera, and Trichoptera abundance and a lower biotic-index value than sites directly upstream, indicating better water quality than the upstream sites, but the abundance at FMC at Graysville was dominated by a few taxa, indicating possible impairment. Lower numbers of intolerant taxa at FMC at Republic Ford, Brookside, and Graysville than at the upstream sites FMC at Hewitt Park and FMC below Springdale Road in November 2004 also suggest that water-quality differences exist among the sites. Nearby historical mining sites may be a factor in the benthic invertebrate community impairment evident at the three downstream sites. A more structured study based on available water-chemistry data and incorporating hypotheses formed by this limited benthic invertebrate community collection could better determine differences in and effects of land use in benthic invertebrate communities in FMC.

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Appendixes

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.-

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02456900, Fivemile Creek at Fivemile Road near Huffman, Alabama, December 2003									
00010	Water temperature, °C	1	13.1	—	—	—	—	—	—	—
00095	Specific conductance, µS/cm at 25 °C	1	308	—	—	—	—	—	—	—
00400	pH	1	8.7	—	—	—	—	—	—	—
00300	Dissolved oxygen, mg/L	1	14.7	—	—	—	—	—	—	—
00930	Sodium, wf, mg/L	1	2.13	—	—	—	—	—	—	—
00935	Potassium, wf, mg/L	1	0.75	—	—	—	—	—	—	—
00915	Calcium, wf, mg/L	1	45.2	—	—	—	—	—	—	—
00925	Magnesium, wf, mg/L	1	19.9	—	—	—	—	—	—	—
00940	Chloride, wf, mg/L	1	3.70	—	—	—	—	—	—	—
00950	Fluoride, wf, mg/L	1	<0.17	—	—	—	—	—	—	—
00945	Sulfate, wf, mg/L	1	5.27	—	—	—	—	—	—	—
00623	Ammonia plus organic nitrogen, wf, mg/L as N	1	<0.10	—	—	—	—	—	—	—
00625	Ammonia plus organic nitrogen, wu, mg/L as N	1	<0.10	—	—	—	—	—	—	—
00608	Ammonia, wf, mg/L as N	1	<0.04	—	—	—	—	—	—	—
00631	NO2+NO3, wf, mg/L as N	1	0.76	—	—	—	—	—	—	—
00613	Nitrite, wf, mg/L as N	1	<0.008	—	—	—	—	—	—	—
00671	Orthophosphate, mg/L as P	1	<0.020	—	—	—	—	—	—	—
00666	Phosphorus, wf, mg/L	1	0.007	—	—	—	—	—	—	—
00665	Phosphorus, wu, mg/L	1	0.009	—	—	—	—	—	—	—
62360	Pheophytin *a*, µg/L	1	0.51	—	—	—	—	—	—	—
70953	Chlorophyll *a*, µg/L	1	0.53	—	—	—	—	—	—	—
31633	*Escherichia coli*, colonies per 100 mL	1	14	—	—	—	—	—	—	—
31625	Fecal coliform, colonies per 100 mL	1	6	—	—	—	—	—	—	—
01106	Aluminum, wf, µg/L	1	2.5	—	—	—	—	—	—	—
01095	Antimony, wf, µg/L	1	<0.20	—	—	—	—	—	—	—

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02456900, Fivemile Creek at Fivemile Road near Huffman, Alabama, December 2003—Continued									
01000	Arsenic, wf, µg/L	1	<1.9	—	—	—	—	—	—	—
01005	Barium, wf, µg/L	1	21.4	—	—	—	—	—	—	—
01010	Beryllium, wf, µg/L	1	<0.060	—	—	—	—	—	—	—
01025	Cadmium, wf, µg/L	1	<0.040	—	—	—	—	—	—	—
01030	Chromium, wf, µg/L	1	<0.80	—	—	—	—	—	—	—
01035	Cobalt, wf, µg/L	1	0.146	—	—	—	—	—	—	—
01040	Copper, wf, µg/L	1	0.2	—	—	—	—	—	—	—
01046	Iron, wf, µg/L	1	<6.4	—	—	—	—	—	—	—
01049	Lead, wf, µg/L	1	<0.08	—	—	—	—	—	—	—
01056	Manganese, wf, µg/L	1	2.6	—	—	—	—	—	—	—
01060	Molybdenum, wf, µg/L	1	<0.4	—	—	—	—	—	—	—
01065	Nickel, wf, µg/L	1	0.13	—	—	—	—	—	—	—
01145	Selenium, wf, µg/L	1	<2.6	—	—	—	—	—	—	—
01075	Silver, wf, µg/L	1	<0.2	—	—	—	—	—	—	—
01090	Zinc, wf, µg/L	1	<0.6	—	—	—	—	—	—	—
22703	Uranium, wf, µg/L	1	0.26	—	—	—	—	—	—	—
	02456980, Fivemile Creek at Lawson Road near Tarrant City, Alabama, December 2003									
00010	Water temperature, °C	1	9.6	—	—	—	—	—	—	—
00095	Specific conductance, µS/cm at 25 °C	1	340	—	—	—	—	—	—	—
00400	pH	1	8.1	—	—	—	—	—	—	—
00300	Dissolved oxygen, mg/L	1	11.2	—	—	—	—	—	—	—
00930	Sodium, wf, mg/L	1	2.74	—	—	—	—	—	—	—
00935	Potassium, wf, mg/L	1	0.80	—	—	—	—	—	—	—
00915	Calcium, wf, mg/L	1	47.1	—	—	—	—	—	—	—
00925	Magnesium, wf, mg/L	1	22.7	—	—	—	—	—	—	—
00940	Chloride, wf, mg/L	1	4.34	—	—	—	—	—	—	—

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02456980, Fivemile Creek at Lawson Road near Tarrant City, Alabama, December 2003—Continued									
00950	Fluoride, wf, mg/L	1	<0.17	—	—	—	—	—	—	—
00945	Sulfate, wf, mg/L	1	5.69	—	—	—	—	—	—	—
00623	Ammonia plus organic nitrogen, wf, mg/L as N	1	<0.10	—	—	—	—	—	—	—
00625	Ammonia plus organic nitrogen, wu, mg/L as N	1	<0.10	—	—	—	—	—	—	—
00608	Ammonia, wf, mg/L as N	1	<0.04	—	—	—	—	—	—	—
00631	NO2+NO3, wf, mg/L as N	1	1.03	—	—	—	—	—	—	—
00613	Nitrite, wf, mg/L as N	1	<0.008	—	—	—	—	—	—	—
00671	Orthophosphate, mg/L as P	1	<0.020	—	—	—	—	—	—	—
00666	Phosphorus, wf, mg/L	1	0.007	—	—	—	—	—	—	—
00665	Phosphorus, wu, mg/L	1	0.009	—	—	—	—	—	—	—
62360	Pheophytin *a*, µg/L	1	0.36	—	—	—	—	—	—	—
70953	Chlorophyll *a*, µg/L	1	0.28	—	—	—	—	—	—	—
31633	*Escherichia coli*, colonies per 100 mL	1	160	—	—	—	—	—	—	—
31625	Fecal coliform, colonies per 100 mL	1	110	—	—	—	—	—	—	—
01106	Aluminum, wf, µg/L	1	1.6	—	—	—	—	—	—	—
01095	Antimony, wf, µg/L	1	<0.20	—	—	—	—	—	—	—
01000	Arsenic, wf, µg/L	1	<1.9	—	—	—	—	—	—	—
01005	Barium, wf, µg/L	1	25.6	—	—	—	—	—	—	—
01010	Beryllium, wf, µg/L	1	<0.060	—	—	—	—	—	—	—
01025	Cadmium, wf, µg/L	1	<0.040	—	—	—	—	—	—	—
01030	Chromium, wf, µg/L	1	<0.80	—	—	—	—	—	—	—
01035	Cobalt, wf, µg/L	1	0.151	—	—	—	—	—	—	—
01040	Copper, wf, µg/L	1	0.2	—	—	—	—	—	—	—
01046	Iron, wf, µg/L	1	<6.4	—	—	—	—	—	—	—
01049	Lead, wf, µg/L	1	<0.080	—	—	—	—	—	—	—

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02456980, Fivemile Creek at Lawson Road near Tarrant City, Alabama, December 2003—Continued									
01056	Manganese, wf, µg/L	1	14.4	—	—	—	—	—	—	—
01060	Molybdenum, wf, µg/L	1	<0.4	—	—	—	—	—	—	—
01065	Nickel, wf, µg/L	1	0.12	—	—	—	—	—	—	—
01145	Selenium, wf, µg/L	1	<2.6	—	—	—	—	—	—	—
01075	Silver, wf, µg/L	1	<0.2	—	—	—	—	—	—	—
01090	Zinc, wf, µg/L	1	<0.6	—	—	—	—	—	—	—
22703	Uranium, wf, µg/L	1	0.30	—	—	—	—	—	—	—
	02456999, Fivemile Creek at Tarrant Park near Tarrant, Alabama, June 2003 to November 2005									
00010	Water temperature, °C	33	23.1	10.5	20.2	23.0	22.0	20.9	19.6	12.6
00095	Specific conductance, µS/cm at 25 °C	33	432	237	336	388	354	343	325	266
00400	pH	33	8.4	7.0	7.8	8.3	8.0	7.9	7.6	7.0
00300	Dissolved oxygen, mg/L	33	12.4	7.1	9.8	12	10.4	9.8	9.2	7.3
63676	Turbidity, NTRU	5	24	1.5	—	—	—	—	—	—
63680	Turbidity, FNU	5	43	0.4	—	—	—	—	—	—
00930	Sodium, wf, mg/L	11	2.88	1.90	2.50	2.88	2.67	2.52	2.36	1.90
00935	Potassium, wf, mg/L	11	1.70	0.76	1.10	1.70	1.30	1.08	0.78	0.76
00915	Calcium, wf, mg/L	11	45.4	32.0	40.4	45.4	42.2	41.6	37.5	32.0
00925	Magnesium, wf, mg/L	11	22.3	13.0	18.7	22.3	21.4	20.2	16.4	13.0
00452	Carbonate, wf, mg/L	4	2	0	—	—	—	—	—	—
00453	Bicarbonate, wf, mg/L	4	215	179	—	—	—	—	—	—
00940	Chloride, wf, mg/L	11	4.32	2.81	3.54	4.32	3.77	3.55	3.19	2.81
00950	Fluoride, wf, mg/L	11	<0.17	<0.17	—	<0.17	<0.17	<0.17	<0.17	<0.17
00945	Sulfate, wf, mg/L	11	9.50	5.20	6.80	9.50	8.18	6.62	5.71	5.20
00623	Ammonia plus organic nitrogen, wf, mg/L as N	7	0.10	<0.10	—	0.10	<0.10	<0.10	<0.10	<0.10
00625	Ammonia plus organic nitrogen, wu, mg/L as N	7	0.30	<0.10	—	0.30	0.20	<0.10	<0.10	<0.10

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
02456999, Fivemile Creek at Tarrant Park near Tarrant, Alabama, June 2003 to November 2005—Continued										
00608	Ammonia, wf, mg/L as N	7	<0.040	<0.040	—	<0.040	<0.040	<0.040	<0.040	<0.040
00631	NO2+NO3, wf, mg/L as N	7	1.02	0.76	0.91	1.02	0.98	0.94	0.86	0.76
00613	Nitrite, wf, mg/L as N	7	<0.008	<0.008	—	<0.008	<0.008	<0.008	<0.008	<0.008
00600	Total nitrogen, mg/L	3	1.2	0.91	—	—	—	—	—	—
00671	Orthophosphate, mg/L as P	7	<0.020	<0.020	—	<0.020	<0.020	<0.020	<0.020	<0.020
00666	Phosphorus, wf, mg/L	7	0.024	0.006	0.010	0.024	0.013	0.007	0.006	0.006
00665	Phosphorus, wu, mg/L	7	0.065	0.007	0.018	0.065	0.015	0.008	0.007	0.007
62360	Pheophytin *a*, µg/L	2	0.33	0.31	—	—	—	—	—	—
70953	Chlorophyll *a*, µg/L	2	0.37	0.29	—	—	—	—	—	—
90902	*Escherichia coli*, modif m colonies per 100 mL	6	120	25	70	120	102	66	40	25
31633	*Escherichia coli*, colonies per 100 mL	25	3,400	30	380	2,600	520	200	95	34
31625	Fecal coliform, colonies per 100 mL	24	2,100	53	324	1,800	338	200	122	55
01106	Aluminum, wf, µg/L	11	8.3	1.6	5.3	8.3	6.4	6.0	4.0	1.6
01095	Antimony, wf, µg/L	11	0.20	<0.20	—	0.20	<0.20	<0.20	<0.20	<0.20
01000	Arsenic, wf, µg/L	11	<1.9	<1.9	—	<1.9	<1.9	<1.9	<1.9	<1.9
01005	Barium, wf, µg/L	11	60.7	26.4	32.6	60.7	32.7	30.3	27.4	26.4
01010	Beryllium, wf, µg/L	11	<0.060	<0.060	—	<0.060	<0.060	<0.060	<0.060	<0.060
01025	Cadmium, wf, µg/L	11	<0.040	<0.040	—	<0.040	<0.040	<0.040	<0.040	<0.040
01030	Chromium, wf, µg/L	11	<0.80	<0.80	—	<0.80	<0.80	<0.80	<0.80	<0.80
01035	Cobalt, wf, µg/L	11	0.221	0.091	0.142	0.221	0.165	0.124	0.119	0.091
01040	Copper, wf, µg/L	11	1.4	0.3	0.7	1.4	0.8	0.6	0.5	0.3
01046	Iron, wf, µg/L	11	11.0	<6.4	—	11.0	7.0	<6.4	<6.4	<6.4
01049	Lead, wf, µg/L	11	<0.080	<0.080	—	<0.080	<0.080	<0.080	<0.080	<0.080
01056	Manganese, wf, µg/L	11	8.8	3.9	6	8.8	7.3	6.0	4.6	3.9
01060	Molybdenum, wf, µg/L	11	0.7	<0.4	0.443*	0.7	0.6	<0.4	<0.4	<0.4

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02456999, Fivemile Creek at Tarrant Park near Tarrant, Alabama, June 2003 to November 2005—Continued									
01065	Nickel, wf, µg/L	11	2.46	<0.060	1.167*	2.46	1.77	1.21	0.39	0.18
01145	Selenium, wf, µg/L	11	<2.6	<2.6	—	<2.6	<2.6	<2.6	<2.6	<2.6
01075	Silver, wf, µg/L	11	<0.2	<0.2	—	<0.2	<0.2	<0.2	<0.2	<0.2
01090	Zinc, wf, µg/L	11	12.7	<0.6	2.205*	12.7	1.4	1.1	0.9	0.8
22703	Uranium, wf, µg/L	11	0.38	0.050	0.26	0.38	0.33	0.28	0.19	0.05
	02457500, Fivemile Creek at Tarrant City, Alabama, June 2003 to December 2003									
00010	Water temperature, °C	16	23.2	11.0	20.8	23.2	23	22	20.7	11.0
00095	Specific conductance, µS/cm at 25 °C	16	423	276	341	423	358	340	328	276
00400	pH	16	8.4	7.4	7.9	8.4	8.1	7.9	7.8	7.4
00300	Dissolved oxygen, mg/L	16	13.400	8.7	10.3	13.4	11.1	10.2	9.0	8.7
00930	Sodium, wf, mg/L	2	2.78	2.66	—	—	—	—	—	—
00935	Potassium, wf, mg/L	2	0.99	0.95	—	—	—	—	—	—
00915	Calcium, wf, mg/L	2	44.0	42.3	—	—	—	—	—	—
00925	Magnesium, wf, mg/L	2	20.7	20.0	—	—	—	—	—	—
00940	Chloride, wf, mg/L	2	4.18	3.97	—	—	—	—	—	—
00950	Fluoride, wf, mg/L	2	<0.17	<0.17	—	—	—	—	—	—
00945	Sulfate, wf, mg/L	2	9.04	6.54	—	—	—	—	—	—
00623	Ammonia plus organic nitrogen, wf, mg/L as N	2	<0.10	<0.10	—	—	—	—	—	—
00625	Ammonia plus organic nitrogen, wu, mg/L as N	2	<0.10	<0.10	—	—	—	—	—	—
00608	Ammonia, wf, mg/L as N	2	<0.040	<0.040	—	—	—	—	—	—
00631	NO2+NO3, wf, mg/L as N	2	0.89	0.81	—	—	—	—	—	—
00613	Nitrite, wf, mg/L as N	2	<0.008	<0.008	—	—	—	—	—	—
00671	Orthophosphate, mg/L as P	2	<0.020	<0.020	—	—	—	—	—	—
00666	Phosphorus, wf, mg/L	2	0.005	0.005	—	—	—	—	—	—
00665	Phosphorus, wu, mg/L	2	0.009	0.008	—	—	—	—	—	—

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02457500, Fivemile Creek at Tarrant City, Alabama, June 2003 to December 2003—Continued									
62360	Pheophytin *a*, µg/L	2	0.49	0.39	—	—	—	—	—	—
70953	Chlorophyll *a*, µg/L	2	0.44	0.25	—	—	—	—	—	—
31633	*Escherichia coli*, colonies per 100 mL	15	800	14	171	800	210	82	52	14
31625	Fecal coliform, colonies per 100 mL	14	880	11	219	880	338	88	41	11
01106	Aluminum, wf, µg/L	2	2.4	2.0	—	—	—	—	—	—
01095	Antimony, wf, µg/L	2	<0.20	<0.20	—	—	—	—	—	—
01000	Arsenic, wf, µg/L	2	<1.9	<1.9	—	—	—	—	—	—
01005	Barium, wf, µg/L	2	29.7	26.0	—	—	—	—	—	—
01010	Beryllium, wf, µg/L	2	<0.060	<0.060	—	—	—	—	—	—
01025	Cadmium, wf, µg/L	2	<0.040	<0.040	—	—	—	—	—	—
01030	Chromium, wf, µg/L	2	<0.80	<0.80	—	—	—	—	—	—
01035	Cobalt, wf, µg/L	2	0.164	0.138	—	—	—	—	—	—
01040	Copper, wf, µg/L	2	0.4	0.3	—	—	—	—	—	—
01046	Iron, wf, µg/L	2	9.3	<6.4	—	—	—	—	—	—
01049	Lead, wf, µg/L	2	<0.08	<0.08	—	—	—	—	—	—
01056	Manganese, wf, µg/L	2	10.7	7.2	—	—	—	—	—	—
01060	Molybdenum, wf, µg/L	2	<0.4	<0.4	—	—	—	—	—	—
01065	Nickel, wf, µg/L	2	0.49	0.20	—	—	—	—	—	—
01145	Selenium, wf, µg/L	2	<2.6	<2.6	—	—	—	—	—	—
01075	Silver, wf, µg/L	2	<0.2	<0.2	—	—	—	—	—	—
01090	Zinc, wf, µg/L	2	3.5	1.9	—	—	—	—	—	—
22703	Uranium, wf, µg/L	2	0.38	0.32	—	—	—	—	—	—
	02457502, Fivemile Creek below Springdale Road near Tarrant, Alabama, June 2004 to November 2005									
00010	Water temperature, °C	15	27.7	17.0	22.4	27.7	24.1	23.0	20.8	17.0
00095	Specific conductance, µS/cm at 25 °C	15	397	167	343	397	380	355	332	167
00400	pH	15	8.2	7.0	8	8.2	8.1	8.1	7.9	7.0

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02457502, Fivemile Creek below Springdale Road near Tarrant, Alabama, June 2004 to November 2005—Continued									
00300	Dissolved oxygen, mg/L	14	11.4	7.9	9.7	11.4	10.5	9.7	9.0	7.9
63676	Turbidity, NTRU	1	210	—	—	—	—	—	—	—
63680	Turbidity, FNU	4	44	1.1	—	—	—	—	—	—
00930	Sodium, wf, mg/L	8	3.25	1.45	2.58	3.25	3.04	2.76	2.12	1.45
00935	Potassium, wf, mg/L	8	1.97	0.89	1.36	1.97	1.80	1.27	1.03	0.89
00915	Calcium, wf, mg/L	8	48.9	20.5	39.1	48.9	45.7	41.1	34.1	20.5
00925	Magnesium, wf, mg/L	8	24.0	7.34	18	24.0	22.8	18.7	14.9	7.34
00452	Carbonate, wf, mg/L	4	2	0	—	—	—	—	—	—
00453	Bicarbonate, wf, mg/L	4	227	195	—	—	—	—	—	—
00940	Chloride, wf, mg/L	8	4.78	1.85	3.63	4.78	4.29	3.62	3.25	1.85
00950	Fluoride, wf, mg/L	8	<0.17	<0.17	—	<0.17	<0.17	<0.17	<0.17	<0.17
00945	Sulfate, wf, mg/L	8	30.5	10.1	17.1	30.5	20.0	17.8	10.5	10.1
00623	Ammonia plus organic nitrogen, wf, mg/L as N	5	0.10	<0.10	—	—	—	0.08	—	—
00625	Ammonia plus organic nitrogen, wu, mg/L as N	5	0.20	<0.10	—	—	—	0.10	—	—
00608	Ammonia, wf, mg/L as N	5	<0.04	<0.04	—	—	—	0.04	—	—
00631	NO2+NO3, wf, mg/L as N	5	1.06	0.78	—	—	—	0.96	—	—
00613	Nitrite, wf, mg/L as N	5	<0.008	<0.008	—	—	—	0.01	—	—
00600	Total nitrogen, mg/L	4	1.20	0.92	—	—	—	1.10	—	—
00671	Orthophosphate, mg/L as P	5	<0.020	<0.020	—	—	—	0.02	—	—
00666	Phosphorus, wf, mg/L	5	0.016	0.004	—	—	—	0.01	—	—
00665	Phosphorus, wu, mg/L	5	0.051	0.008	—	—	—	0.01	—	—
90902	*Escherichia coli*, modif m colonies per 100 mL	6	68	8	37	68	66	36	9	8
31633	*Escherichia coli*, colonies per 100 mL	8	13,000	31	2,020	13,000	1,725	200	72	31
31625	Fecal coliform, colonies per 100 mL	7	10,000	14	1,600	10,000	500	130	29	14
01106	Aluminum, wf, µg/L	8	33.9	3.6	11.1	34	14.5	6.85	5.90	3.60

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02457502, Fivemile Creek below Springdale Road near Tarrant, Alabama, June 2004 to November 2005—Continued									
01095	Antimony, wf, µg/L	8	0.20	<0.20	—	0.20	<0.20	<0.20	<0.20	<0.20
01000	Arsenic, wf, µg/L	8	<1.9	<1.9	—	<1.9	<1.9	<1.9	<1.9	<1.9
01005	Barium, wf, µg/L	8	36.1	17.8	30.1	36.1	35.0	31.6	26	17.8
01010	Beryllium, wf, µg/L	8	<0.060	<0.060	—	<0.060	<0.060	<0.060	<0.060	<0.060
01025	Cadmium, wf, µg/L	8	<0.040	<0.040	—	<0.040	<0.040	<0.040	<0.040	<0.040
01030	Chromium, wf, µg/L	8	<0.80	<0.80	—	<0.80	<0.80	<0.80	<0.80	<0.80
01035	Cobalt, wf, µg/L	8	0.387	0.131	0.208	0.387	0.239	0.190	0.143	0.131
01040	Copper, wf, µg/L	8	2.2	0.5	1.0	2.2	1.2	1	0.7	0.5
01046	Iron, wf, µg/L	8	47	<6.4	—	47	<6.4	<6.4	<6.4	<6.4
01049	Lead, wf, µg/L	8	0.15	<0.080	—	0.15	<0.080	<0.080	<0.080	<0.080
01056	Manganese, wf, µg/L	8	11.7	5.4	7.8	11.7	9.3	7.5	6	5.4
01060	Molybdenum, wf, µg/L	8	1.7	0.5	0.9	1.7	1.2	0.8	0.6	0.5
01065	Nickel, wf, µg/L	8	2.7	0.84	1.76	2.70	2.30	1.78	1.22	0.84
01145	Selenium, wf, µg/L	8	3.7	<2.6	—	3.70	<2.6	<2.6	<2.6	<2.6
01075	Silver, wf, µg/L	8	<0.2	<0.2	—	<0.2	<0.2	<0.2	<0.2	<0.2
01090	Zinc, wf, µg/L	8	4.4	0.6	1.5	4.4	1.6	1.2	0.95	0.6
22703	Uranium, wf, µg/L	8	0.99	0.22	0.52	0.99	0.75	0.47	0.32	0.22
	02457510, Fivemile Creek at Lewisburg, Alabama, June 2004 to November 2005									
00010	Water temperature, °C	15	27.6	19.8	24.4	27.6	26.2	25.2	22.2	19.8
00095	Specific conductance, µS/cm at 25 °C	15	637	358	495	637	537	512	439	358
00400	pH	15	8.4	7.1	7.9	8.4	8.1	8.0	7.9	7.1
00300	Dissolved oxygen, mg/L	15	11.4	7.0	8.9	11.4	9.6	8.7	7.9	7.0
63676	Turbidity, NTRU	1	3.3	—	—	—	—	—	—	—
63680	Turbidity, FNU	3	44	1.6	—	—	—	—	—	—
00930	Sodium, wf, mg/L	8	52.1	12.1	30.9	52.1	38.9	32.6	19.1	12.1
00935	Potassium, wf, mg/L	8	7.50	3.29	4.80	7.50	5.26	4.49	3.95	3.29

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median 95 %	Median 75%	Median 50%	Median 25%	Median 5%
	02457510, Fivemile Creek at Lewisburg, Alabama, June 2004 to November 2005—Continued									
00915	Calcium, wf, mg/L	8	56.2	36.9	48.6	56.2	50.2	49.7	47.6	36.9
00925	Magnesium, wf, mg/L	8	16.9	10.8	15.5	16.9	16.5	16.0	15.7	10.8
00452	Carbonate, wf, mg/L	3	0.7	0.0	—	—	—	—	—	—
00453	Bicarbonate, wf, mg/L	3	178	168	—	—	—	—	—	—
00940	Chloride, wf, mg/L	8	31.0	6.84	21.47	31.0	30.8	23.3	12.2	6.84
00950	Fluoride, wf, mg/L	8	0.95	0.37	0.68	0.95	0.82	0.69	0.51	0.37
00945	Sulfate, wf, mg/L	8	118	46.2	78.3	118	99.8	74.8	57.1	46.2
00623	Ammonia plus organic nitrogen, wf, mg/L as N	5	0.50	0.30	—	—	—	0.4	—	—
00625	Ammonia plus organic nitrogen, wu, mg/L as N	5	0.90	0.40	—	—	—	0.5	—	—
00608	Ammonia, wf, mg/L as N	5	0.26	<0.040	—	—	—	0.05	—	—
00618	Nitrate, wf, mg/L as N	5	2.48	1.62	—	—	—	1.82	—	—
00631	NO2+NO3, wf, mg/L as N	5	2.51	1.64	—	—	—	1.88	—	—
00613	Nitrite, wf, mg/L as N	5	0.120	0.020	—	—	—	0.04	—	—
00600	Total nitrogen, mg/L	5	3.0	2.0	—	—	—	2.4	—	—
00671	Orthophosphate, mg/L as P	5	0.090	0.020	—	—	—	0.04	—	—
00666	Phosphorus, wf, mg/L	5	0.120	0.044	—	—	—	0.072	—	—
00665	Phosphorus, wu, mg/L	5	0.184	0.068	—	—	—	0.093	—	—
90902	*Escherichia coli*, modif m colonies per 100 mL	6	80	15	50	80	68	53	30	15
31633	*Escherichia coli*, colonies per 100 mL	7	2,000	20	763	2,000	2,000	320	180	20
31625	Fecal coliform, colonies per 100 mL	6	1,000	34	400	1,000	760	315	38	34
01106	Aluminum, wf, µg/L	8	37.9	14.0	26.4	37.9	36.6	27.6	15.9	14.0
01095	Antimony, wf, µg/L	8	0.40	0.30	0.35	0.40	0.40	0.35	0.30	0.30
01000	Arsenic, wf, µg/L	8	4.1	<1.9	2.974*	4.1	3.4	2.8	2.2	2.2
01005	Barium, wf, µg/L	8	126	50	86	126	116	86	53	50
01010	Beryllium, wf, µg/L	8	<0.060	<0.060	—	<0.060	<0.060	<0.060	<0.060	<0.060

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02457510, Fivemile Creek at Lewisburg, Alabama, June 2004 to November 2005—Continued									
01025	Cadmium, wf, µg/L	8	0.41	<0.040	—	0.41	<0.040	<0.040	<0.040	<0.040
01030	Chromium, wf, µg/L	8	2.10	<0.80	1.337*	2.1	1.3	1.2	<0.80	<0.80
01035	Cobalt, wf, µg/L	8	0.410	0.239	0.318	0.410	0.377	0.311	0.259	0.239
01040	Copper, wf, µg/L	8	2.1	0.8	1.7	2.1	2.1	1.7	1.6	0.8
01046	Iron, wf, µg/L	8	29	11	22	29	28	26	14	11
01049	Lead, wf, µg/L	8	0.11	<0.080	—	0.11	<0.080	<0.080	<0.080	<0.080
01056	Manganese, wf, µg/L	8	34.6	18.7	24.8	34.6	28.2	24.1	20.0	18.7
01060	Molybdenum, wf, µg/L	8	6.4	1.6	3.5	6.4	4.5	3.4	2.1	1.6
01065	Nickel, wf, µg/L	8	3.05	0.58	2.05	3.05	2.74	2.34	1.17	0.58
01145	Selenium, wf, µg/L	8	7.8	<2.6	4.281*	7.8	5.4	3.6	<2.6	<2.6
01075	Silver, wf, µg/L	8	<0.2	<0.2	—	<0.2	<0.2	<0.2	<0.2	<0.2
01090	Zinc, wf, µg/L	8	5.2	1.4	2.6	5.2	3.5	2.2	1.9	1.4
22703	Uranium, wf, µg/L	8	0.98	0.42	0.63	0.98	0.83	0.57	0.43	0.42
	02457595, Fivemile Creek near Republic, Alabama, December 2003									
00010	Water temperature, °C	1	6.9	—	—	—	—	—	—	—
00095	Specific conductance, µS/cm at 25 °C	1	578	—	—	—	—	—	—	—
00400	pH	1	8.1	—	—	—	—	—	—	—
00300	Dissolved oxygen, mg/L	1	13.1	—	—	—	—	—	—	—
00930	Sodium, wf, mg/L	1	58.4	—	—	—	—	—	—	—
00935	Potassium, wf, mg/L	1	3.40	—	—	—	—	—	—	—
00915	Calcium, wf, mg/L	1	47.2	—	—	—	—	—	—	—
00925	Magnesium, wf, mg/L	1	18.2	—	—	—	—	—	—	—
00940	Chloride, wf, mg/L	1	20.7	—	—	—	—	—	—	—
00950	Fluoride, wf, mg/L	1	0.73	—	—	—	—	—	—	—
00945	Sulfate, wf, mg/L	1	98.1	—	—	—	—	—	—	—
00623	Ammonia plus organic nitrogen, wf, mg/L as N	1	0.30	—	—	—	—	—	—	—

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02457595, Fivemile Creek near Republic, Alabama, December 2003—Continued									
00625	Ammonia plus organic nitrogen, wu, mg/L as N	1	0.30	—	—	—	—	—	—	—
00608	Ammonia, wf, mg/L as N	1	<0.040	—	—	—	—	—	—	—
00618	Nitrate, wf, mg/L as N	1	2.45	—	—	—	—	—	—	—
00631	NO2+NO3, wf, mg/L as N	1	2.47	—	—	—	—	—	—	—
00613	Nitrite, wf, mg/L as N	1	0.020	—	—	—	—	—	—	—
00600	Total nitrogen, mg/L	1	2.7	—	—	—	—	—	—	—
00671	Orthophosphate, mg/L as P	1	0.040	—	—	—	—	—	—	—
00666	Phosphorus, wf, mg/L	1	0.081	—	—	—	—	—	—	—
00665	Phosphorus, wu, mg/L	1	0.097	—	—	—	—	—	—	—
62360	Pheophytin *a*, µg/L	1	0.69	—	—	—	—	—	—	—
70953	Chlorophyll *a*, µg/L	1	0.38	—	—	—	—	—	—	—
31633	*Escherichia coli*, colonies per 100 mL	1	60	—	—	—	—	—	—	—
31625	Fecal coliform, colonies per 100 mL	1	64	—	—	—	—	—	—	—
01106	Aluminum, wf, µg/L	1	23.9	—	—	—	—	—	—	—
01095	Antimony, wf, µg/L	1	<0.20	—	—	—	—	—	—	—
01000	Arsenic, wf, µg/L	1	3.0	—	—	—	—	—	—	—
01005	Barium, wf, µg/L	1	37.7	—	—	—	—	—	—	—
01010	Beryllium, wf, µg/L	1	<0.060	—	—	—	—	—	—	—
01025	Cadmium, wf, µg/L	1	<0.040	—	—	—	—	—	—	—
01030	Chromium, wf, µg/L	1	<0.80	—	—	—	—	—	—	—
01035	Cobalt, wf, µg/L	1	0.366	—	—	—	—	—	—	—
01040	Copper, wf, µg/L	1	1.0	—	—	—	—	—	—	—
01046	Iron, wf, µg/L	1	39.3	—	—	—	—	—	—	—
01049	Lead, wf, µg/L	1	<0.080	—	—	—	—	—	—	—
01056	Manganese, wf, µg/L	1	76.3	—	—	—	—	—	—	—
01060	Molybdenum, wf, µg/L	1	5.2	—	—	—	—	—	—	—
01065	Nickel, wf, µg/L	1	1.41	—	—	—	—	—	—	—

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02457595, Fivemile Creek near Republic, Alabama, December 2003—Continued									
01145	Selenium, wf, µg/L	1	4.7	—	—	—	—	—	—	—
01075	Silver, wf, µg/L	1	<0.2	—	—	—	—	—	—	—
01090	Zinc, wf, µg/L	1	2.4	—	—	—	—	—	—	—
22703	Uranium, wf, µg/L	1	0.53	—	—	—	—	—	—	—
	02457599, Fivemile Creek at Republic Ford, Alabama, November 2004 to September 2005									
00010	Water temperature, °C	8	26.6	16.2	23.5	26.6	25.8	24.1	22.4	16.2
00095	Specific conductance, µS/cm at 25 °C	8	581	332	513	581	574	534	490	332
00400	pH	8	8.2	6.4	7.8	8.2	8.1	7.9	7.6	6.4
00300	Dissolved oxygen, mg/L	8	11.1	7.8	9.1	11.1	9.9	8.8	8.5	7.8
63676	Turbidity, NTRU	2	430	2.8	—	—	—	—	—	—
63680	Turbidity, FNU	2	2.8	1.8	—	—	—	—	—	—
00930	Sodium, wf, mg/L	2	44.5	16.1	—	—	—	—	—	—
00935	Potassium, wf, mg/L	2	5.07	3.15	—	—	—	—	—	—
00915	Calcium, wf, mg/L	2	44.4	27.9	—	—	—	—	—	—
00925	Magnesium, wf, mg/L	2	16.2	11.2	—	—	—	—	—	—
00940	Chloride, wf, mg/L	2	22.0	6.17	—	—	—	—	—	—
00950	Fluoride, wf, mg/L	2	0.55	0.23	—	—	—	—	—	—
00945	Sulfate, wf, mg/L	2	77.0	54.0	—	—	—	—	—	—
90902	*Escherichia coli*, modif m colonies per 100 mL	6	110	53	77	110	99	73	56	53
31633	*Escherichia coli*, colonies per 100 mL	4	9,000	30	—	—	—	—	—	—
31625	Fecal coliform, colonies per 100 mL	3	9,400	71	—	—	—	—	—	—
01106	Aluminum, wf, µg/L	2	21.0	18.0	—	—	—	—	—	—
01095	Antimony, wf, µg/L	2	0.20	<0.20	—	—	—	—	—	—
01000	Arsenic, wf, µg/L	2	<1.9	<1.9	—	—	—	—	—	—
01005	Barium, wf, µg/L	2	53.9	31.8	—	—	—	—	—	—

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02457599, Fivemile Creek at Republic Ford, Alabama, November 2004 to September 2005—Continued									
01010	Beryllium, wf, µg/L	2	<0.060	<0.060	—	—	—	—	—	—
01025	Cadmium, wf, µg/L	2	<0.040	<0.040	—	—	—	—	—	—
01030	Chromium, wf, µg/L	2	<0.80	<0.80	—	—	—	—	—	—
01035	Cobalt, wf, µg/L	2	0.315	0.270	—	—	—	—	—	—
01040	Copper, wf, µg/L	2	2.0	1.2	—	—	—	—	—	—
01046	Iron, wf, µg/L	2	51	32	—	—	—	—	—	—
01049	Lead, wf, µg/L	2	0.14	<0.080	—	—	—	—	—	—
01056	Manganese, wf, µg/L	2	39.8	16.3	—	—	—	—	—	—
01060	Molybdenum, wf, µg/L	2	2.5	0.9	—	—	—	—	—	—
01065	Nickel, wf, µg/L	2	2.04	1.05	—	—	—	—	—	—
01145	Selenium, wf, µg/L	2	<2.6	<2.6	—	—	—	—	—	—
01075	Silver, wf, µg/L	2	<0.2	<0.2	—	—	—	—	—	—
01090	Zinc, wf, µg/L	2	7.6	1.5	—	—	—	—	—	—
22703	Uranium, wf, µg/L	2	0.50	0.31	—	—	—	—	—	—
	02457625, Fivemile Creek at Brookside, Alabama, November 2004 to December 2004									
00010	Water temperature, °C	2	22.1	14.3	—	—	—	—	—	—
00095	Specific conductance, µS/cm at 25 °C	2	483	431	—	—	—	—	—	—
00400	pH	2	8.1	6.6	—	—	—	—	—	—
00300	Dissolved oxygen mg/L	2	9.8	8.9	—	—	—	—	—	—
63676	Turbidity, NTRU	1	9.7	—	—	—	—	—	—	—
00930	Sodium, wf, mg/L	2	46.1	24.7	—	—	—	—	—	—
00935	Potassium, wf, mg/L	2	5.05	3.53	—	—	—	—	—	—
00915	Calcium, wf, mg/L	2	45.1	41.9	—	—	—	—	—	—
00925	Magnesium, wf, mg/L	2	16.9	16.0	—	—	—	—	—	—
00940	Chloride, wf, mg/L	2	18.7	7.94	—	—	—	—	—	—

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02457625, Fivemile Creek at Brookside, Alabama, November 2004 to December 2004—Continued									
00950	Fluoride, wf, mg/L	2	0.53	0.27	—	—	—	—	—	—
00945	Sulfate, wf, mg/L	2	94.1	72.0	—	—	—	—	—	—
00623	Ammonia plus organic nitrogen, wf, mg/L as N	1	0.20	—	—	—	—	—	—	—
00625	Ammonia plus organic nitrogen, wu, mg/L as N	1	0.20	—	—	—	—	—	—	—
00608	Ammonia, wf, mg/L as N	1	0.040	—	—	—	—	—	—	—
00618	Nitrate, wf, mg/L as N	1	1.55	—	—	—	—	—	—	—
00631	NO2+NO3, wf, mg/L as N	1	1.58	—	—	—	—	—	—	—
00613	Nitrite, wf, mg/L as N	1	0.040	—	—	—	—	—	—	—
00600	Total nitrogen, mg/L	1	1.8	—	—	—	—	—	—	—
00671	Orthophosphate, mg/L as P	1	0.050	—	—	—	—	—	—	—
00666	Phosphorus, wf, mg/L	1	0.065	—	—	—	—	—	—	—
00665	Phosphorus, wu, mg/L	1	0.085	—	—	—	—	—	—	—
31633	*Escherichia coli*, colonies per 100 mL	2	1,400	290	—	—	—	—	—	—
31625	Fecal coliform, colonies per 100 mL	2	1,700	420	—	—	—	—	—	—
01106	Aluminum, wf, µg/L	2	15.9	13.7	—	—	—	—	—	—
01095	Antimony, wf, µg/L	2	0.20	<0.20	—	—	—	—	—	—
01000	Arsenic, wf, µg/L	2	<1.9	<1.9	—	—	—	—	—	—
01005	Barium, wf, µg/L	2	57.3	42.9	—	—	—	—	—	—
01010	Beryllium, wf, µg/L	2	<0.060	<0.060	—	—	—	—	—	—
01025	Cadmium, wf, µg/L	2	<0.040	<0.040	—	—	—	—	—	—
01030	Chromium, wf, µg/L	2	<0.80	<0.80	—	—	—	—	—	—
01035	Cobalt, wf, µg/L	2	0.566	0.304	—	—	—	—	—	—
01040	Copper, wf, µg/L	2	1.7	1.1	—	—	—	—	—	—
01046	Iron, wf, µg/L	2	30	20	—	—	—	—	—	—
01049	Lead, wf, µg/L	2	<0.08	<0.08	—	—	—	—	—	—
01056	Manganese, wf, µg/L	2	59.5	16.3	—	—	—	—	—	—
01060	Molybdenum, wf, µg/L	2	2.4	1.2	—	—	—	—	—	—

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02457625, Fivemile Creek at Brookside, Alabama, November 2004 to December 2004—Continued									
01065	Nickel, wf, µg/L	2	3.16	0.96	—	—	—	—	—	—
01145	Selenium, wf, µg/L	2	<2.6	<2.6	—	—	—	—	—	—
01075	Silver, wf, µg/L	2	<0.2	<0.2	—	—	—	—	—	—
01090	Zinc, wf, µg/L	2	4.1	3.3	—	—	—	—	—	—
22703	Uranium, wf, µg/L	2	0.44	0.44	—	—	—	—	—	—
	02457635, Fivemile Creek at Cardiff Road Bridge at Brookside, Alabama, June 2005 to September 2005									
00010	Water temperature, °C	4	27.5	24.3	—	—	—	—	—	—
00095	Specific conductance, µS/cm at 25 °C	5	575	446	—	—	—	—	—	—
00400	pH	5	8.3	7.7	—	—	—	—	—	—
00300	Dissolved oxygen, mg/L	5	13.5	7.9	—	—	—	—	—	—
63680	Turbidity, FNU	3	3.8	1.5	—	—	—	—	—	—
90902	*Escherichia coli*, modif m colonies per 100 mL	5	51	21	—	—	—	—	—	—
31633	*Escherichia coli*, colonies per 100 mL	1	400	—	—	—	—	—	—	—
	02457700, Fivemile Creek at Linn Crossing, Alabama, December 2004									
00010	Water temperature, °C	1	13.5	—	—	—	—	—	—	—
00095	Specific conductance, µS/cm at 25 °C	1	421	—	—	—	—	—	—	—
00400	pH	1	7.5	—	—	—	—	—	—	—
00300	Dissolved oxygen, mg/L	1	10.6	—	—	—	—	—	—	—
63676	Turbidity, NTRU	1	12	—	—	—	—	—	—	—
00930	Sodium, wf, mg/L	1	22.7	—	—	—	—	—	—	—
00935	Potassium, wf, mg/L	1	3.08	—	—	—	—	—	—	—
00915	Calcium, wf, mg/L	1	37.5	—	—	—	—	—	—	—
00925	Magnesium, wf, mg/L	1	17.2	—	—	—	—	—	—	—
00940	Chloride, wf, mg/L	1	7.14	—	—	—	—	—	—	—
00950	Fluoride, wf, mg/L	1	0.23	—	—	—	—	—	—	—
00945	Sulfate, wf, mg/L	1	89.4	—	—	—	—	—	—	—

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02457700, Fivemile Creek at Linn Crossing, Alabama, December 2004—Continued									
00623	Ammonia plus organic nitrogen, wf, mg/L as N	1	0.10	—	—	—	—	—	—	—
00625	Ammonia plus organic nitrogen, wu, mg/L as N	1	0.20	—	—	—	—	—	—	—
00608	Ammonia, wf, mg/L as N	1	<0.040	—	—	—	—	—	—	—
00618	Nitrate, wf, mg/L as N	1	1.44	—	—	—	—	—	—	—
00631	NO2+NO3, wf, mg/L as N	1	1.48	—	—	—	—	—	—	—
00613	Nitrite, wf, mg/L as N	1	0.030	—	—	—	—	—	—	—
00600	Total nitrogen, mg/L	1	1.6	—	—	—	—	—	—	—
00671	Orthophosphate, mg/L as P	1	0.040	—	—	—	—	—	—	—
00666	Phosphorus, wf, mg/L	1	0.044	—	—	—	—	—	—	—
00665	Phosphorus, wu, mg/L	1	0.078	—	—	—	—	—	—	—
31633	*Escherichia coli*, colonies per 100 mL	1	140	—	—	—	—	—	—	—
31625	Fecal coliform, colonies per 100 mL	1	300	—	—	—	—	—	—	—
01106	Aluminum, wf, µg/L	1	77.9	—	—	—	—	—	—	—
01095	Antimony, wf, µg/L	1	<0.20	—	—	—	—	—	—	—
01000	Arsenic, wf, µg/L	1	<1.9	—	—	—	—	—	—	—
01005	Barium, wf, µg/L	1	40.4	—	—	—	—	—	—	—
01010	Beryllium, wf, µg/L	1	<0.060	—	—	—	—	—	—	—
01025	Cadmium, wf, µg/L	1	<0.040	—	—	—	—	—	—	—
01030	Chromium, wf, µg/L	1	<0.80	—	—	—	—	—	—	—
01035	Cobalt, wf, µg/L	1	1.53	—	—	—	—	—	—	—
01040	Copper, wf, µg/L	1	1.2	—	—	—	—	—	—	—
01046	Iron, wf, µg/L	1	6	—	—	—	—	—	—	—
01049	Lead, wf, µg/L	1	<0.08	—	—	—	—	—	—	—
01056	Manganese, wf, µg/L	1	108	—	—	—	—	—	—	—
01060	Molybdenum, wf, µg/L	1	0.9	—	—	—	—	—	—	—

Appendix 1. Summary of Descriptive Statistics of Selected Water-Quality Properties and Inorganic Constituents for Selected Surface-Water Sites along Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[NWIS, National Water Information System; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, value not calculated; wf, filtered water; wu, unfiltered water; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; NTU, nephelometric turbidity units; FNU, formazin nephelometric units; mL, milliliters; modif m, modified m-TEC; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95 %	75%	50%	25%	5%
	02457700, Fivemile Creek at Linn Crossing, Alabama, December 2004—Continued									
01065	Nickel, wf, µg/L	1	5.69	—	—	—	—	—	—	—
01145	Selenium, wf, µg/L	1	<2.6	—	—	—	—	—	—	—
01075	Silver, wf, µg/L	1	<0.2	—	—	—	—	—	—	—
01090	Zinc, wf, µg/L	1	5.2	—	—	—	—	—	—	—
22703	Uranium, wf, µg/L	1	0.37	—	—	—	—	—	—	—

Appendix 2. Quality-Assurance and Quality-Control Samples for Organic Wastewater Compounds

In addition to regular stream samples, field blanks and replicate stream samples were analyzed for organic wastewater compound (OWC) concentrations to assess contamination introduced during sampling procedures and to assess reproducibility of results. Field blanks are samples of certified organic compound-free water that are processed in the field with exactly the same procedures as stream samples. One replicate stream sample was spiked to determine the effects of the native water (matrix) on detection of the OWCs. During the course of this investigation, three field blanks were analyzed for OWC concentrations. Six OWCs were detected once each in field blank, and most detections were at concentrations estimated (e) below the laboratory minimum reporting levels (table 2–1). Benzophenone (e0.007 µg/L), DEET (e0.01 µg/L), and phenol (e0.13 µg/L) were detected in a blank field-processed at FMC at Hewitt Park on June 7, 2005. Two detergent degradates, diethoxynonylphenol (e2.4 µg/L) and ethoxyoctylphenol (e0.6 µg/L), and one flavoring/fragrance compound, acetophenone (0.62 µg/L), were detected in a field blank processed at FMC at Huffman Road on December 15, 2003.

All concentrations of benzophenone, DEET, phenol, diethoxynonylphenol, and ethoxyoctylphenol in field blanks were estimated below the laboratory minimum reporting limits. Environmental concentrations for these compounds, however, also were estimated below laboratory reporting limits. Concentrations present in environmental samples at levels equal to or less than concentrations reported in field blanks are considered highly suspect and were censored out of the OWC dataset used in this report.

The concentration of acetophenone reported in the blank from Huffman Road was above the minimum reporting level (MRL) in effect at the time of collection. Concentrations of detections above the MRL are more certain than concentrations estimated below the MRL, and detections in field blanks of concentrations above the MRL indicate the presence of contamination. Detections of this magnitude in field blanks usually require more stringent censoring of affected environmental data; however, acetophenone was not detected in the environmental samples collected during this study.

Results of replicate samples collected during the study for two sites indicated low variability in results (table 2–2). Only three OWCs—4-nonylphenol, caffeine, and p-cresol—were detected in replicates. The concentration of the detergent degradate, 4-nonylphenol, was estimated to be 0.8 µg/L, well below the detection limit of 5 µg/L, in one replicate at FMC at Hewitt Park on September 12, 2005, and was not detected in the other replicate. Concentrations of caffeine were estimated below reporting limits in both samples collected on December 15, 2003, and concentrations of p-cresol were estimated below reporting limits in both samples collected on September 12, 2005. Estimated concentrations reported for caffeine and p-cresol in the replicate samples agreed within 0.01 µg/L.

One spike of an environmental sample was processed to assess any interference between the native water (matrix) and the detection of OWCs (table 2–2). Matrix spike recoveries for each of the OWCs were calculated as follows:

$$\text{Recovery (\%)} = \frac{\text{(detected concentration in spike)} - \text{(detected concentration in unspiked sample)}}{\text{Expected concentration in spike}} * 100$$

Matrix spike recoveries ranged from 50 percent for the antioxidant, 3-tert-butyl-4-hydroxyanisole, to a maximum of 203 percent for the detergent degradate, diethoxynonylphenol. Recoveries for six compounds were more than 25 percent greater or less than expected. The six compounds were 3-tert-butyl-4-hydroxyanisole, diethoxynonylphenol, d-limonene, indole, tetrachloroethene, and tris(2-butoxyethyl) phosphate. Reported concentrations of these compounds may be affected by interference and may be greater or less than actual concentrations.

Table 2–1. Concentrations of selected organic wastewater compounds in field blanks processed in the Fivemile Creek watershed, Jefferson County, Alabama, 2003–2005.

[FMC, Fivemile Creek; all values are in micrograms per liter; <, less than; e, estimated concentration; —, value not reported; shaded indicates detection; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; DEET, *N*,*N*-diethyl-*m*-toluamide; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran]

USGS station number:	**02456999**	**02456999**	**02457500**
Station short name:	**FMC at Hewitt Park**	**FMC at Hewitt Park**	**FMC at Huffman Road**
Date of sample:	**6/7/2005**	**8/23/2005**	**12/15/2003**
Time of sample:	**8:30**	**7:30**	**13:00**
Compound name			
1,4-Dichlorobenzene	<0.5	<0.5	<0.5
1-Methylnaphthalene	<0.5	<0.5	<0.5
2,6-Dimethylnaphthalene	<0.5	<0.5	<0.5
2-Methylnaphthalene	<0.5	<0.5	<0.5
3-beta-Coprostanol	<2	<2	<2
3-Methyl-1H-indole	<1	<1	<1
3-tert-Butyl-4-hydroxyanisole	<5	<5	<5
4-Cumylphenol	<1	<1	<1
4-Nonylphenol	<5	<5	<5
4-Octylphenol	<1	<1	<1
4-tert-Octylphenol	<1	<1	<1
5-Methyl-1H-benzotriazole	<2	<2	<2
9,10-Anthraquinone	<0.5	<0.5	<0.5
Acetophenone	<0.5	<0.5	0.62
AHTN	<0.5	<0.5	<0.5
Anthracene	<0.5	<0.5	<0.5
Benzo[a]pyrene	<0.5	<0.5	<0.5
Benzophenone	e0.007	<0.5	<0.5
beta-Sitosterol	<2	<2	<2
beta-Stigmastanol	<2	<2	<2
Bisphenol A	<1	—	<1
Bromacil	<0.5	<0.5	<0.5
Caffeine	<0.5	<0.5	<0.5
Camphor	<0.5	<0.5	<0.5
Carbaryl	<0.041	<0.041	<0.041
Carbazole	<0.5	<0.5	<0.5
Chlorpyrifos	<0.005	<0.005	<0.005
Cholesterol	<2	<2	<2
Cotinine	<1	<1	<1
DEET	e0.01	<0.5	<0.5
Diazinon	<0.005	<0.005	<0.005
Dichlorvos	<0.012	<0.012	<1
Diethoxynonylphenol	<5	<5	e2.4
Diethoxyoctylphenol	<1	<1	<1
D-Limonene	<0.5	<0.5	<0.5
Ethoxyoctylphenol	<1	<1	e0.6
Fluoranthene	<0.5	<0.5	<0.5
HHCB	<0.5	<0.5	<0.5
Indole	<0.5	<0.5	<0.5
Isoborneol	<0.5	<0.5	<0.5
Isophorone	<0.5	<0.5	<0.5
Isopropylbenzene	<0.5	<0.5	<0.5
Isoquinoline	<0.5	<0.5	<0.5
Menthol	<0.5	<0.5	<0.5
Metalaxyl	<0.5	<0.5	<0.5
Methyl salicylate	<0.5	<0.5	<0.5
Metolachlor	<0.006	<0.006	<0.013
Naphthalene	<0.5	<0.5	<0.5
p-Cresol	<1	<1	<1
Pentachlorophenol	<2	—	<2
Phenanthrene	<0.5	<0.5	<0.5
Phenol	e0.13	<0.5	<0.5
Prometon	<0.01	<0.01	<0.005
Pyrene	<0.5	<0.5	<0.5
Tetrachloroethene	<0.5	<0.5	<0.5
Tribromomethane	<0.5	<0.5	<0.5
Tributyl phosphate	<0.5	<0.5	<0.5
Triclosan	<1	<1	<1
Triethyl citrate	<0.5	<0.5	<0.5
Triphenyl phosphate	<0.5	<0.5	<0.5
Tris(2-butoxyethyl) phosphate	<0.5	<0.5	<0.5
Tris(2-chloroethyl) phosphate	<0.5	<0.5	<0.5
Tris(dichloroisopropyl) phosphate	<0.5	<0.5	<0.5

Table 2–2. Concentrations of selected organic wastewater compounds in replicate and spike samples and calculated spike recoveries for samples collected from Fivemile Creek, Jefferson County, Alabama, 2003–2005.

[USGS, U.S. Geological Survey; NWQL, National Water Quality Laboratory; µg/L, microgram per liter; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; —, compound not included in sample fortification solution; DEET, *N,N*-diethyl-*m*-toluamide; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; <, less than; dates given in month/day/year format; e, estimated; bold value indicates detection in stream samples]

USGS station number:	02457500	02457500	02456999	02456999	02456999	LS 1433 field spike mixture NWQL lot number: WWS1SP134A NWIS-I lot number: 90412	Matrix spike recovery, in percent
Station short name:	FMC at Huffman Road	FMC at Huffman Road	FMC at Hewitt Park	FMC at Hewitt Park	FMC at Hewitt Park		
Date:	12/15/2003	12/15/2003	9/12/2005	9/12/2005	9/12/2005	NWQL certificate date: December 10, 2004	
Time:	13:30	13:31	14:45	15:15	15:16	Sample fortification	
Sample type:	Sample (µg/L)	Replicate (µg/L)	Sample (µg/L)	Replicate (µg/L)	Spike (µg/L)	Spike concentration* (µg/L)	
Compound name							
1,4-Dichlorobenzene	<0.5	<0.5	<0.5	<0.5	e0.77	0.8	96
1-Methylnaphthalene	<0.5	<0.5	<0.5	<0.5	0.83	0.8	104
2,6-Dimethylnaphthalene	<0.5	<0.5	<0.5	<0.5	0.8	0.8	100
2-Methylnaphthalene	<0.5	<0.5	<0.5	<0.5	0.79	0.8	99
3-beta-Coprostanol	<2	<2	<2	<2	e3.8	3.2	119
3-Methyl-1H-indole	<1	<1	<1	<1	e0.7	0.8	88
3-tert-Butyl-4-hydroxyanisole	<5	<5	<5	<5	e0.4	0.8	50
4-Cumylphenol	<1	<1	<1	<1	e0.9	0.8	112
4-Nonylphenol	<5	<5	<5	**e0.8**	e6.2	6.4	84
4-Octylphenol	<1	<1	<1	<1	e0.7	0.8	88
4-tert-Octylphenol	<1	<1	<1	<1	e0.9	0.8	112
5-Methyl-1H-benzotriazole	<2	<2	<2	<2	5	6.4	78
9,10-Anthraquinone	<0.5	<0.5	<0.5	<0.5	0.8	0.8	100
Acetophenone	<0.5	<0.5	<0.5	<0.5	0.86	0.8	108
AHTN	<0.5	<0.5	<0.5	<0.5	0.82	—	—
Anthracene	<0.5	<0.5	<0.5	<0.5	0.76	0.8	95
Benzo[a]pyrene	<0.5	<0.5	<0.5	<0.5	0.62	0.8	78
Benzophenone	<0.5	<0.5	<0.5	<0.5	0.93	0.8	116
beta-Sitosterol	<2	<2	<2	<2	2.5	3.2	78
beta-Stigmastanol	<2	<2	<2	<2	e2.7	3.2	84
Bisphenol A	<1	<1	<1	<1	e0.7	0.8	88
Bromacil	<0.5	<0.5	<0.5	<0.5	3.6	3.2	112
Caffeine	**e0.064**	**e0.071**	<0.5	<0.5	0.87	0.8	109
Camphor	<0.5	<0.5	<0.5	<0.5	0.89	0.8	111
Carbazole	<0.5	<0.5	<0.5	<0.5	0.78	0.8	98
Cholesterol	<2	<2	<2	<2	e3.6	3.2	112
Cotinine	<1	<1	<1	<1	3.2	3.2	100
DEET	<0.5	<0.5	<0.5	<0.5	0.97	0.8	121

Table 2–2. Concentrations of selected organic wastewater compounds in replicate and spike samples and calculated spike recoveries for samples collected from Fivemile Creek, Jefferson County, Alabama, 2003–2005.—Continued

[USGS, U.S. Geological Survey; NWQL, National Water Quality Laboratory; µg/L, microgram per liter; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; —, compound not included in sample fortification solution; DEET, *N,N*-diethyl-*m*-toluamide; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; <, less than; dates given in month/day/year format; e, estimated; bold value indicates detection in stream samples]

USGS station number:	02457500	02457500	02456999	02456999	02456999	LS 1433 field spike mixture NWQL lot number: WWS1SP134A NWIS-I lot number: 90412	Matrix spike recovery, in percent
Station short name:	FMC at Huffman Road	FMC at Huffman Road	FMC at Hewitt Park	FMC at Hewitt Park	FMC at Hewitt Park		
Date:	12/15/2003	12/15/2003	9/12/2005	9/12/2005	9/12/2005	NWQL certificate date: December 10, 2004	
Time:	13:30	13:31	14:45	15:15	15:16	Sample fortification	
Sample type:	Sample (µg/L)	Replicate (µg/L)	Sample (µg/L)	Replicate (µg/L)	Spike (µg/L)	Spike concentration* (µg/L)	
Compound name							
Diethoxynonylphenol	<5	<5	<5	<5	e13	6.4	203
Diethoxyoctylphenol	<1	<1	<1	<1	e0.5	0.47	106
D-Limonene	<0.5	<0.5	<0.5	<0.5	e0.55	0.8	69
Ethoxyoctylphenol	<1	<1	<1	<1	e1.7	1.6	106
Fluoranthene	<0.5	<0.5	<0.5	<0.5	0.8	0.8	100
HHCB	<0.5	<0.5	<0.5	<0.5	0.78	—	—
Indole	<0.5	<0.5	<0.5	<0.5	0.56	0.8	70
Isoborneol	<0.5	<0.5	<0.5	<0.5	0.85	0.8	106
Isophorone	<0.5	<0.5	<0.5	<0.5	0.87	0.8	109
Isopropylbenzene	<0.5	<0.5	<0.5	<0.5	e0.66	0.8	82
Isoquinoline	<0.5	<0.5	<0.5	<0.5	0.7	0.8	88
Menthol	<0.5	<0.5	<0.5	<0.5	0.82	0.8	102
Metalaxyl	<0.5	<0.5	<0.5	<0.5	0.92	0.8	115
Methyl salicylate	<0.5	<0.5	<0.5	<0.5	0.75	0.8	94
Naphthalene	<0.5	<0.5	<0.5	<0.5	0.82	0.8	102
p-Cresol	<1	<1	**e0.03**	**e0.02**	e0.7	0.8	85
Pentachlorophenol	<2	<2	<2	<2	e3.2	3.2	100
Phenanthrene	<0.5	<0.5	<0.5	<0.5	0.81	0.8	101
Phenol	<0.5	<0.5	<0.5	<0.5	0.85	0.8	106
Pyrene	<0.5	<0.5	<0.5	<0.5	0.79	0.8	99
Tetrachloroethene	<0.5	<0.5	<0.5	<0.5	e0.54	0.8	68
Tribromomethane	<0.5	<0.5	<0.5	<0.5	e0.68	0.8	85
Tributyl phosphate	<0.5	<0.5	<0.5	<0.5	0.77	0.8	96
Triclosan	<1	<1	<1	<1	e0.8	0.8	100
Triethyl citrate	<0.5	<0.5	<0.5	<0.5	0.7	0.8	88
Triphenyl phosphate	<0.5	<0.5	<0.5	<0.5	0.92	0.8	115
Tris(2-butoxyethyl) phosphate	<0.5	<0.5	<0.5	<0.5	e1.1	0.8	138
Tris(2-chloroethyl) phosphate	<0.5	<0.5	<0.5	<0.5	1	0.8	125
Tris(dichloroisopropyl) phosphate	<0.5	<0.5	<0.5	<0.5	0.85	0.8	106

Appendix 3. Abundance and Alabama Department of Environmental Management Tolerance Values of Benthic Invertebrate Taxa Found at Selected Sites along Fivemile Creek, Jefferson County, Alabama, July 2003 and November 2004.

[RTH, richest targeted habitat; QMH, qualitative multihabitat; L/R, large/rare organisms; shading indicates taxa found; —, taxa not found; [1], tolerance value for taxonomic class used; [2], tolerance value for taxonomic family used; [3], tolerance value for taxonomic subfamily used; [4], tolerance value for taxonomic tribe used; [5], higher reported tolerance value used; [6], abundance corrected for subsampling; [7], taxonomy from Wiggins, 1996]

		RTH								QMH					L/R		
Sampling station		**FMC at Fivemile Rd**	**FMC at Hewitt Park**	**FMC at Hewitt Park**	**FMC at Huffman Rd**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Republic Ford**	**FMC at Grays-ville**	**FMC at Hewitt Prk**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Republic Ford**	**FMC at Grays-ville**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Grays-ville**
USGS station number		02456900	02456999	02456999	02457500	02457502	02457625	02457599	02457700	02456999	02457502	02457625	02457599	02457700	02457502	02457625	02457700
Date		07/16/2003	07/16/2003	11/17/2004	07/16/2003	11/18/2004	11/18/2004	11/19/2004	11/19/2004	11/17/2004	11/18/2004	11/18/2004	11/19/2004	11/19/2004	11/18/2004	11/18/2004	11/19/2004
Percent subsampled		25.00	8.33	83.33	8.33	50.00	100.00	100.00	100.00	43.67	37.45	7.29	16.67	33.33	100.00	100.00	100.00
Taxon	**ADEM tolerance value 1996**																
PLATYHELMINTHES																	
Turbellaria	NA	4	2	1	3	—	—	—	2	2	2	—	6	1	—	—	—
NEMERTEA																	
Prostoma sp.	NA	—	—	—	—	—	—	—	—	1	—	1	2	1	—	—	—
MOLLUSCA																	
Gastropoda																	
Planorbidae																	
Micromenetus sp. [2]	6.3	2	—		—												
Micromenetus dilatatus [2]	6.3	—	—	—	—	—	—	—	—	—	3	1	1	—	—	—	—
Ancylidae	7.1	—	—	—	—	1	—	—	—	—	—	2	—	—	—	—	—
Ferrissia sp.	6.6	—	1		—												
Pleuroceridae	3.4	—	—	3	—	1	—	—	—	—	—	—	—	—	—	—	—
Elimia sp.	7	—	—	—	—	1	—	—	—	5	5	—	1	—	1	—	—
Bivalvia	NA	—	—	—	—	—	—	—	—	—	—	—	—	4	—	—	—
Veneroida																	
Corbiculidae																	
Corbicula sp.	6.1	—	—	—	1	4	4	5	—	—	2	4	3	10	1	—	—
Sphaeriidae	7.6	1	—	—	—	—	—	—	—	—	—	—	1	3	—	—	—
ANNELIDA																	
Oligochaeta	8.4	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
Haplotaxida																	
Tubificina																	
Enchytraeidae	9.8	—	—	—	—	—	3	—	—	—	2	—	—	3	—	—	—
Naididae	6.1	10	3	7	1	2	—	—	—	29	16	—	12	—	—	—	—
Tubificidae	7.1	—	—	—	—	—	9	4	—	13	61	3	9	16	—	—	—
Lumbricina [1]	8.4	1	2	—	8	—	—	—	—	—	—	—	—	2	—	—	—
Lumbriculida																	
Lumbriculidae	7	—	—	2	—	—	1	—	—	2	10	2	—	2	—	—	—

Appendix 3. Abundance and Alabama Department of Environmental Management Tolerance Values of Benthic Invertebrate Taxa Found at Selected Sites along Fivemile Creek, Jefferson County, Alabama, July 2003 and November 2004.—Continued

[RTH, richest targeted habitat; QMH, qualitative multihabitat; L/R, large/rare organisms; shading indicates taxa found; —, taxa not found; [1], tolerance value for taxonomic class used; [2], tolerance value for taxonomic family used; [3], tolerance value for taxonomic subfamily used; [4], tolerance value for taxonomic tribe used; [5], higher reported tolerance value used; [6], abundance corrected for subsampling; [7], taxonomy from Wiggins, 1996]

		RTH								QMH					L/R		
Sampling station		**FMC at Fivemile Rd**	**FMC at Hewitt Park**	**FMC at Hewitt Park**	**FMC at Huffman Rd**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Republic Ford**	**FMC at Grays-ville**	**FMC at Hewitt Prk**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Republic Ford**	**FMC at Grays-ville**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Grays-ville**
USGS station number		02456900	02456999	02456999	02457500	02457502	02457625	02457599	02457700	02456999	02457502	02457625	02457599	02457700	02457502	02457625	02457700
Date		07/16/2003	07/16/2003	11/17/2004	07/16/2003	11/18/2004	11/18/2004	11/19/2004	11/19/2004	11/17/2004	11/18/2004	11/18/2004	11/19/2004	11/19/2004	11/18/2004	11/18/2004	11/19/2004
Percent subsampled		25.00	8.33	83.33	8.33	50.00	100.00	100.00	100.00	43.67	37.45	7.29	16.67	33.33	100.00	100.00	100.00
Taxon	**ADEM tolerance value 1996**																
ARTHROPODA																	
Chelicerata																	
Arachnida																	
Acari	NA	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
Hygrobates sp.	NA	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Oribatei	NA	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Crustacea																	
Malacostraca																	
Amphipoda																	
Crangonyctidae																	
Crangonyx sp.	7.9	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—
Gammaridae																	
Gammarus sp.	9.1	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Decapoda																	
Cambaridae	6.6	—	—	—	1	—	—	—	—	—	—	1	—	1	1	—	—
Orconectes sp.	2.6	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
Isopoda																	
Asellidae																	
Lirceus sp.	7.9	—	—	—	—	3	—	1	—	9	7	—	—	—	—	—	—
Ostracoda	NA	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—
Hexapoda																	
Insecta																	
Ephemeroptera																	
Baetidae																	
Baetis sp.	4.5	—	—	—	—	—	—	5	—	1	—	—	1	7	—	—	—
Baetis flavistriga	4.5	82	35	11	107	28	1	6	—	16	7	—	11	5	—	—	—
Baetis intercalaris	4.5	7	9	—	20	—	1	—	5	—	—	3	—	9	—	—	—
Centroptilum sp.	6.6	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
Caenidae																	
Caenis sp.	7.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Caenis latipennis	7.4	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—

Appendix 3. Abundance and Alabama Department of Environmental Management Tolerance Values of Benthic Invertebrate Taxa Found at Selected Sites along Fivemile Creek, Jefferson County, Alabama, July 2003 and November 2004.—Continued

[RTH, richest targeted habitat; QMH, qualitative multihabitat; L/R, large/rare organisms; shading indicates taxa found; —, taxa not found; [1], tolerance value for taxonomic class used; [2], tolerance value for taxonomic family used; [3], tolerance value for taxonomic subfamily used; [4], tolerance value for taxonomic tribe used; [5], higher reported tolerance value used; [6], abundance corrected for subsampling; [7], taxonomy from Wiggins, 1996]

		RTH								QMH					L/R		
Sampling station		**FMC at Fivemile Rd**	**FMC at Hewitt Park**	**FMC at Hewitt Park**	**FMC at Huffman Rd**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Republic Ford**	**FMC at Grays-ville**	**FMC at Hewitt Prk**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Republic Ford**	**FMC at Grays-ville**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Grays-ville**
USGS station number		**02456900**	**02456999**	**02456999**	**02457500**	**02457502**	**02457625**	**02457599**	**02457700**	**02456999**	**02457502**	**02457625**	**02457599**	**02457700**	**02457502**	**02457625**	**02457700**
Date		**07/16/2003**	**07/16/2003**	**11/17/2004**	**07/16/2003**	**11/18/2004**	**11/18/2004**	**11/19/2004**	**11/19/2004**	**11/17/2004**	**11/18/2004**	**11/18/2004**	**11/19/2004**	**11/19/2004**	**11/18/2004**	**11/18/2004**	**11/19/2004**
Percent subsampled		**25.00**	**8.33**	**83.33**	**8.33**	**50.00**	**100.00**	**100.00**	**100.00**	**43.67**	**37.45**	**7.29**	**16.67**	**33.33**	**100.00**	**100.00**	**100.00**
Taxon	**ADEM tolerance value 1996**																
Heptageniidae	4	—	—	—	—	—	—	—	—	—	—	—	6	—	—	—	—
Stenacron sp.	3.6	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—
Stenacron interpunctatum	3.6	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	—
Stenonema sp.	3.5	—	—	—	—	—	—	—	5	1	—	26	3	28	—	—	—
Stenonema femoratum	3.5	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Stenonema mediopunctatum	3.5	—	—	—	—	—	19	4	32	—	—	7	13	9	—	—	—
Stenonema terminatum	3.5	—	—	—	—	—	—	—	1	—	—	—	—	6	—	—	—
Isonychiidae																	
Isonychia sp.	3.5	—	—	7	—	25	5	7	122	12	13	113	24	72	—	—	—
Leptohyphidae																	
Tricorythodes sp.	5.1	—	—	—	—	—	—	—	—	1	—	7	2	17	—	1	—
Odonata																	
Zygoptera																	
Coenagrionidae	7.2	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—
Argia sp.	8.2	—	—	1	—	—	—	1	2	1	3	7	5	4	—	—	—
Calopterygidae																	
Hetaerina sp.	5.6	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—
Anisoptera																	
Gomphidae	5	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—
Dromogomphus spinosus	5.9	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—
Erpetogomphus designatus	4	—	—	—	—	—	—	—	1	—	—	2	1	1	—	—	—
Gomphus sp.	5.8	—	—	—	—	—	—	—	—	—	—	—	1	2	—	—	—
Gomphus modestus	5.8	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—

Appendix 3. Abundance and Alabama Department of Environmental Management Tolerance Values of Benthic Invertebrate Taxa Found at Selected Sites along Fivemile Creek, Jefferson County, Alabama, July 2003 and November 2004.—Continued

[RTH, richest targeted habitat; QMH, qualitative multihabitat; L/R, large/rare organisms; shading indicates taxa found; —, taxa not found; [1], tolerance value for taxonomic class used; [2], tolerance value for taxonomic family used; [3], tolerance value for taxonomic subfamily used; [4], tolerance value for taxonomic tribe used; [5], higher reported tolerance value used; [6], abundance corrected for subsampling; [7], taxonomy from Wiggins, 1996]

		RTH								QMH					L/R		
Sampling station		**FMC at Fivemile Rd**	**FMC at Hewitt Park**	**FMC at Hewitt Park**	**FMC at Huffman Rd**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Republic Ford**	**FMC at Grays-ville**	**FMC at Hewitt Prk**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Republic Ford**	**FMC at Grays-ville**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Grays-ville**
USGS station number		**02456900**	**02456999**	**02456999**	**02457500**	**02457502**	**02457625**	**02457599**	**02457700**	**02456999**	**02457502**	**02457625**	**02457599**	**02457700**	**02457502**	**02457625**	**02457700**
Date		**07/16/2003**	**07/16/2003**	**11/17/2004**	**07/16/2003**	**11/18/2004**	**11/18/2004**	**11/19/2004**	**11/19/2004**	**11/17/2004**	**11/18/2004**	**11/18/2004**	**11/19/2004**	**11/19/2004**	**11/18/2004**	**11/18/2004**	**11/19/2004**
Percent subsampled		**25.00**	**8.33**	**83.33**	**8.33**	**50.00**	**100.00**	**100.00**	**100.00**	**43.67**	**37.45**	**7.29**	**16.67**	**33.33**	**100.00**	**100.00**	**100.00**
Taxon	**ADEM tolerance value 1996**																
Hagenius brevistylus	4	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Corduliidae																	
Macromia sp.	6.2	—	—	—	—	—	—	—	—	—	—	2	—	1	—	—	—
Plecoptera																	
Perlidae	1.7	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Taeniopterygidae																	
Taeniopteryx sp.	5.4	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
Megaloptera																	
Corydalidae																	
Corydalus sp.	5.2	—	—	—	—	—	—	1	1	—	—	1	3	—	—	1	4
Trichoptera																	
Brachycentridae																	
Micrasema sp.	0.6	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Glossosomatidae																	
Glossosoma sp.	1.6	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Hydropsychidae	3.1	—	—	5	—	—	—	—	—	4	—	—	—	2	—	—	—
Cheumatopsyche sp.	6.2	44	61	68	26	84	7	20	21	33	44	41	104	34	1	1	—
Hydropsyche sp.	4.3	—	—	10	6	3	—	—	9	—	1	5	5	8	—	—	—
Hydropsyche betteni	4.3	—	—	—	—	4	1	2	9	—	1	1	1	—	—	—	—
Hydropsyche morosa gr. [7]	4.3	—	—	—	—	—	—	—	12	—	—	1	—	5	—	—	—
Hydropsyche scalaris	4.3	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Hydropsyche sparna [7]	4.3	4	92	26	—	10	1	3	—	19	4	—	—	—	—	—	—
Diplectrona sp.	2.2	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Hydroptilidae	3.1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Hydroptila sp.	6.2	1	—	—	3	—	—	—	—	—	—	—	1	3	—	—	—
Leptoceridae																	

Appendix 3. Abundance and Alabama Department of Environmental Management Tolerance Values of Benthic Invertebrate Taxa Found at Selected Sites along Fivemile Creek, Jefferson County, Alabama, July 2003 and November 2004.—Continued

[RTH, richest targeted habitat; QMH, qualitative multihabitat; L/R, large/rare organisms; shading indicates taxa found; —, taxa not found; [1], tolerance value for taxonomic class used; [2], tolerance value for taxonomic family used; [3], tolerance value for taxonomic subfamily used; [4], tolerance value for taxonomic tribe used; [5], higher reported tolerance value used; [6], abundance corrected for subsampling; [7], taxonomy from Wiggins, 1996]

		RTH								QMH					L/R		
Sampling station		FMC at Fivemile Rd	FMC at Hewitt Park	FMC at Hewitt Park	FMC at Huffman Rd	FMC below Spring-dale Rd	FMC at Brookside	FMC at Republic Ford	FMC at Grays-ville	FMC at Hewitt Prk	FMC below Spring-dale Rd	FMC at Brookside	FMC at Republic Ford	FMC at Grays-ville	FMC below Spring-dale Rd	FMC at Brookside	FMC at Grays-ville
USGS station number		02456900	02456999	02456999	02457500	02457502	02457625	02457599	02457700	02456999	02457502	02457625	02457599	02457700	02457502	02457625	02457700
Date		07/16/2003	07/16/2003	11/17/2004	07/16/2003	11/18/2004	11/18/2004	11/19/2004	11/19/2004	11/17/2004	11/18/2004	11/18/2004	11/19/2004	11/19/2004	11/18/2004	11/18/2004	11/19/2004
Percent subsampled		25.00	8.33	83.33	8.33	50.00	100.00	100.00	100.00	43.67	37.45	7.29	16.67	33.33	100.00	100.00	100.00
Taxon	ADEM tolerance value 1996																
Mystacides sp.	2.7	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
Philopotimidae																	
Chimarra aterrima	2.8	—	—	36	—	5	—	—	—	11	4	—	—	—	—	—	—
Chimarra obscura	2.8	—	—	46	—	126	6	2	8	8	31	5	1	8	2	—	—
Polycentropodidae																	
Polycentropus sp.	3.5	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
Lepidoptera																	
Pyralidae																	
Petrophila sp.	2.1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Coleoptera																	
Elmidae																	
Ancyronyx variegata	6.5	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Dubiraphia sp.	5.9	—	—	—	—	—	—	—	—	—	1	1	—	2	—	—	—
Macronychus glabratus	4.6	—	—	—	—	—	—	—	—	—	—	7	—	—	—	—	—
Microcylloepus pusillus	2.1	—	5		1												
Microcylloepus sp.	2.1	—	—	—	—	2	—	—	—	3	—	3	3	3	—	—	—
Oulimnius latiusculus	1.8	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—
Stenelmis sp.	5.1	1	6	3	2	8	—	—	—	24	7	13	6	1	—	—	—
Hydrophilidae																	
Berosus sp.	8.4	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Psephenidae																	
Psephenus herricki	2.4	—	—	3	—	3	—	—	—	2	1	—	—	—	—	—	—
Diptera																	
Nematocera																	
Ceratopogonidae																	
Bezzia/Palpomyia sp. [5]	6.9	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
Chironomidae																	

Appendix 3. Abundance and Alabama Department of Environmental Management Tolerance Values of Benthic Invertebrate Taxa Found at Selected Sites along Fivemile Creek, Jefferson County, Alabama, July 2003 and November 2004.—Continued

[RTH, richest targeted habitat; QMH, qualitative multihabitat; L/R, large/rare organisms; shading indicates taxa found; —, taxa not found; [1], tolerance value for taxonomic class used; [2], tolerance value for taxonomic family used; [3], tolerance value for taxonomic subfamily used; [4], tolerance value for taxonomic tribe used; [5], higher reported tolerance value used; [6], abundance corrected for subsampling; [7], taxonomy from Wiggins, 1996]

		RTH								QMH					L/R		
Sampling station		**FMC at Fivemile Rd**	**FMC at Hewitt Park**	**FMC at Hewitt Park**	**FMC at Huffman Rd**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Republic Ford**	**FMC at Grays-ville**	**FMC at Hewitt Prk**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Republic Ford**	**FMC at Grays-ville**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Grays-ville**
USGS station number		02456900	02456999	02456999	02457500	02457502	02457625	02457599	02457700	02456999	02457502	02457625	02457599	02457700	02457502	02457625	02457700
Date		07/16/2003	07/16/2003	11/17/2004	07/16/2003	11/18/2004	11/18/2004	11/19/2004	11/19/2004	11/17/2004	11/18/2004	11/18/2004	11/19/2004	11/19/2004	11/18/2004	11/18/2004	11/19/2004
Percent subsampled		25.00	8.33	83.33	8.33	50.00	100.00	100.00	100.00	43.67	37.45	7.29	16.67	33.33	100.00	100.00	100.00
Taxon	**ADEM tolerance value 1996**																
Chironominae																	
Chironomini	6.1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Apedilum sp. [3]	6.1	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Chironomus sp.	9.6	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Cryptochironomus sp.	6.4	—	—	—	—	—	—	—	—	—	5	5	2	2	—	—	—
Dicrotendipes sp.	8.1	1	—	—	—	—	—	—	—	—	—	2	5	—	—	—	—
Dicrotendipes neomodestus	8.1	—	—	—	—	—	—	—	—	—	1	—	1	2	—	—	—
Paracladopelma sp.	5.5	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Paratendipes sp.	5.1	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—
Phaenopsectra sp.	6.5	—	—	1	—	—	—	—	—	1	3	2	1	—	—	—	—
Polypedilum sp.	5.8	27	12	—	15	—	—	—	1	—	—	6	—	7	—	—	—
Polypedilum aviceps	5.8	—	—	21	—	2	—	—	—	44	5	—	—	—	—	—	—
Polypedilum fallax gr.	5.8	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—
Polypedilum flavum	5.8	—	—	2	—	—	—	—	—	—	1	14	22	7	—	—	—
Polypedilum halterale gr.	5.8	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
Polypedilum illinoense gr.	5.8	—	—	—	—	—	—	—	—	4	—	4	1	3	—	—	—
Polypedilum scalaenum gr.	5.8	—	—	—	—	—	—	—	—	1	2	8	2	4	—	—	—
Pseudochironomus sp.	5.4	—	—	—	—	—	—	—	—	1	2	—	—	—	—	—	—
Rheotanytarsus sp.	5.9	—	8		9												
Rheotanytarsus exiguus gr.	5.9	—	—	3	—	—	—	—	—	5	4	9	7	—	—	—	—

Appendix 3. Abundance and Alabama Department of Environmental Management Tolerance Values of Benthic Invertebrate Taxa Found at Selected Sites along Fivemile Creek, Jefferson County, Alabama, July 2003 and November 2004.—Continued

[RTH, richest targeted habitat; QMH, qualitative multihabitat; L/R, large/rare organisms; shading indicates taxa found; —, taxa not found; [1], tolerance value for taxonomic class used; [2], tolerance value for taxonomic family used; [3], tolerance value for taxonomic subfamily used; [4], tolerance value for taxonomic tribe used; [5], higher reported tolerance value used; [6], abundance corrected for subsampling; [7], taxonomy from Wiggins, 1996]

		RTH								QMH					L/R		
Sampling station		FMC at Fivemile Rd	FMC at Hewitt Park	FMC at Hewitt Park	FMC at Huffman Rd	FMC below Spring-dale Rd	FMC at Brookside	FMC at Republic Ford	FMC at Grays-ville	FMC at Hewitt Prk	FMC below Spring-dale Rd	FMC at Brookside	FMC at Republic Ford	FMC at Grays-ville	FMC below Spring-dale Rd	FMC at Brookside	FMC at Grays-ville
USGS station number		02456900	02456999	02456999	02457500	02457502	02457625	02457599	02457700	02456999	02457502	02457625	02457599	02457700	02457502	02457625	02457700
Date		07/16/2003	07/16/2003	11/17/2004	07/16/2003	11/18/2004	11/18/2004	11/19/2004	11/19/2004	11/17/2004	11/18/2004	11/18/2004	11/19/2004	11/19/2004	11/18/2004	11/18/2004	11/19/2004
Percent subsampled		25.00	8.33	83.33	8.33	50.00	100.00	100.00	100.00	43.67	37.45	7.29	16.67	33.33	100.00	100.00	100.00
Taxon	**ADEM tolerance value 1996**																
Rheotanytarsus pellucidus gr.	5.9	—	—	1	—	—	—	—	—	3	5	—	—	—	—	—	—
Sergentia sp. [4]	6.1	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
Tanytarsus sp.	6.8	6	—	—	1	—	—	—	—	4	10	1	6	1	—	—	—
Tribelos sp.	6.3	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
Orthocladiinae																	
Brillia sp.	5.2	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
Cardiocladius sp.	5.9	—	15	3	5	6	—	1	—	—	—	—	—	—	—	—	—
Corynoneura sp.	6	—	—	1	—	1	—	—	—	25	4	4	10	2	—	—	—
Cricotopus sp.	5.8	53	24	9	48	18	—	—	—	7	9	—	—	—	—	—	—
Cricotopus bicinctus gr.	5.8	51	10	1	33	—	—	—	—	2	6	—	2	—	—	—	—
Cricotopus trifascia gr.	5.8	—	—		2												
Nanocladius sp.	7.1	—	—	—	—	—	—	2	3	—	1	3	1	1	—	—	—
Orthocladius Complex [2]	4.7	5	3	1	3	—	—	—	—	—	—	—	—	—	—	—	—
Parakiefferiella sp.	5.4	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Parametriocnemus sp.	3.7	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
Pseudosmittia sp.	2	1	—		—												
Rheocricotopus sp.	7.3	—	2	1	1	—	—	—	—	1	2	—	1	—	—	—	—
Thienemanniella sp.	5.9	1	1	5	3	—	—	—	—	58	5	3	10	4	—	—	—
Tvetenia bavarica gr.	3.6	—	—	2	—	1	—	—	—	5	1	—	1	—	—	—	—
Tvetenia discoloripes gr.	3.6	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—
Tanypodinae																	
Pentaneurini [2]	6.6	—	—	—	—	—	—	—	—	—	3	—	—	1	—	—	—
Ablabesmyia sp.	7.2	1	—	—	—	—	—	1	—	1	—	6	—	1	—	—	—

Appendix 3. Abundance and Alabama Department of Environmental Management Tolerance Values of Benthic Invertebrate Taxa Found at Selected Sites along Fivemile Creek, Jefferson County, Alabama, July 2003 and November 2004.—Continued

[RTH, richest targeted habitat; QMH, qualitative multihabitat; L/R, large/rare organisms; shading indicates taxa found; —, taxa not found; [1], tolerance value for taxonomic class used; [2], tolerance value for taxonomic family used; [3], tolerance value for taxonomic subfamily used; [4], tolerance value for taxonomic tribe used; [5], higher reported tolerance value used; [6], abundance corrected for subsampling; [7], taxonomy from Wiggins, 1996]

		RTH								QMH					L/R		
Sampling station		**FMC at Fivemile Rd**	**FMC at Hewitt Park**	**FMC at Hewitt Park**	**FMC at Huffman Rd**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Republic Ford**	**FMC at Grays-ville**	**FMC at Hewitt Prk**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Republic Ford**	**FMC at Grays-ville**	**FMC below Spring-dale Rd**	**FMC at Brookside**	**FMC at Grays-ville**
USGS station number		**02456900**	**02456999**	**02456999**	**02457500**	**02457502**	**02457625**	**02457599**	**02457700**	**02456999**	**02457502**	**02457625**	**02457599**	**02457700**	**02457502**	**02457625**	**02457700**
Date		**07/16/2003**	**07/16/2003**	**11/17/2004**	**07/16/2003**	**11/18/2004**	**11/18/2004**	**11/19/2004**	**11/19/2004**	**11/17/2004**	**11/18/2004**	**11/18/2004**	**11/19/2004**	**11/19/2004**	**11/18/2004**	**11/18/2004**	**11/19/2004**
Percent subsampled		**25.00**	**8.33**	**83.33**	**8.33**	**50.00**	**100.00**	**100.00**	**100.00**	**43.67**	**37.45**	**7.29**	**16.67**	**33.33**	**100.00**	**100.00**	**100.00**
Taxon	**ADEM tolerance value 1996**																
Ablabesmyia mallochi	7.2	—	—	—	—	—	—	—	—	—	8	—	4	3	—	—	—
Labrundinia sp.	5.9	—	—	—	—	—	—	—	—	—	1	2	—	1	—	—	—
Nilotanypus sp.	3.9	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Nilotanypus fimbriatus	3.9	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—
Paramerina sp.	4.3	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Pentaneura sp.	4.7	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Thienemannimyia gr. sp.	6.2	2	—	2	6	—	—	1	1	3	3	2	2	2	—	—	—
Zavrelimyia sp.	9.1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Simuliidae																	
Simulium sp.	4	7	17	64	5	7	—	—	—	33	6	—	3	—	—	—	—
Tipulidae																	
Antocha sp.	4.3	—	1	2	1	2	—	—	—	—	—	—	—	—	—	—	—
Tipula sp.	7.3	—	—	—	—	—	—	—	1	—	—	3	1	3	—	—	—
Brachycera																	
Athericidae																	
Atherix sp.	2.1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
Empididae	7.6	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—
Hemerodromia sp.	7.6	—	2	1	—	1	—	—	—	2	1	—	1	1	—	—	—
Wiedemannia sp. [2]	7.6	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
NEMATODA	6	1	—	—	—	—	—	—	—	1	—	—	1	2	—	—	—
Total organisms identified in subsample		313	311	356	310	349	59	66	238	413	322	341	326	333	7	3	5
Corrected abundance [6]		1,252	3,732	427	3,720	698	59	66	238	946	860	4,607	1,932	990	—	—	—

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