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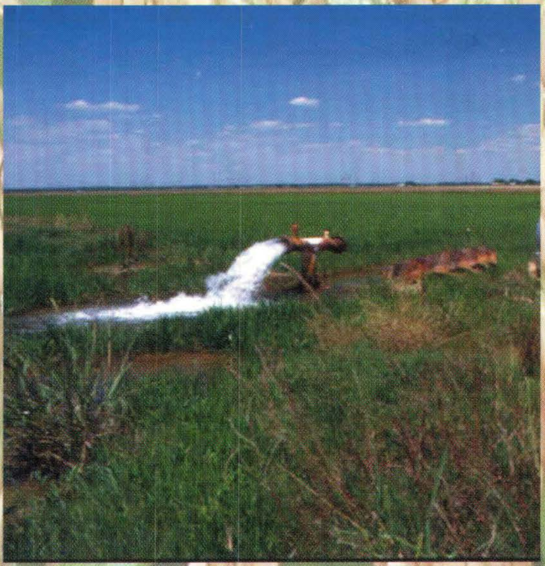
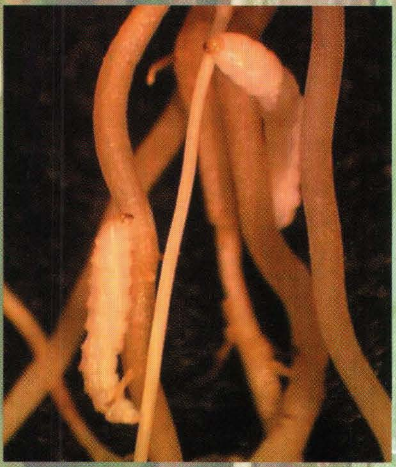
ENVIRONMENTAL SETTING, WATER QUALITY, AND ECOLOGICAL INDICATORS OF SURFACE-WATER QUALITY IN THE MERMENTAU RIVER BASIN, SOUTHWESTERN LOUISIANA, 1998-2001

Water-Resources Investigations Report 03-4185





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

Front cover:

Background: Mature rice plants (*Oryza sativa*) in the Mermentau River Basin, southwestern Louisiana
(Photograph by Dennis K. Demcheck, U.S. Geological Survey)

Top left: Rice water weevil, adult (*Lissorhoptrus oryzophilus*) on rice stalk
(Photograph provided by Kelly V. Tindall, Department of Entomology, Louisiana State University, Baton Rouge, Louisiana)

Top right: Ground water for rice field irrigation in the Mermentau River Basin, southwestern Louisiana
(Photograph by Dennis K. Demcheck, U.S. Geological Survey)

Lower left: Rice water weevil, larva (*Lissorhoptrus oryzophilus*) on rice roots
(Photograph provided by Kelly V. Tindall, Department of Entomology, Louisiana State University, Baton Rouge, Louisiana)

Lower right: Hydropsychidae, larva, net-spinning caddisfly
(Photograph provided by Elaine Esteban, Department of Biology, California State University, Chico, California)

Environmental Setting, Water Quality, and Ecological Indicators of Surface-Water Quality in the Mermentau River Basin, Southwestern Louisiana, 1998-2001

By Stanley C. Skrobialowski, Scott V. Mize, and Dennis K. Demcheck

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U.S. GEOLOGICAL SURVEY
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National Water-Quality Assessment Program

Baton Rouge, Louisiana

2004

U.S. DEPARTMENT OF THE INTERIOR
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Information regarding the National Water-Quality Assessment (NAWQA) Program is available on the Internet via the World Wide Web. You may connect to the NAWQA Home Page using the Universal Resource Locator (URL) at:

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FOREWORD

The U.S. Geological Survey (USGS) is committed to serve the Nation with accurate and timely scientific information that helps enhance and protect the overall quality of life, and facilitates effective management of water, biological, energy, and mineral resources. Information on the quality of the Nation's water resources is of critical interest to the USGS because it is so integrally linked to the long-term availability of water that is clean and safe for drinking and recreation and that is suitable for industry, irrigation, and habitat for fish and wildlife. Escalating population growth and increasing demands for the multiple water uses make water availability, now measured in terms of quantity *and* quality, even more critical to the long-term sustainability of our communities and ecosystems.

The USGS implemented the National Water-Quality Assessment (NAWQA) Program to support national, regional, and local information needs and decisions related to water-quality management and policy. Shaped by and coordinated with ongoing efforts of other Federal, State, and local agencies, the NAWQA Program is designed to answer: What is the condition of our Nation's streams and ground water? How are the conditions changing over time? How do natural features and human activities affect the quality of streams and ground water, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues. NAWQA results can contribute to informed decisions that result in practical and effective water-resource management and strategies that protect and restore water quality.

Since 1991, the NAWQA Program has implemented interdisciplinary assessments in more than 50 of the Nation's most important river basins and aquifers, referred to as Study Units. Collectively, these Study Units account for more than 60 percent of the overall water use and population served by public water supply, and are representative of the Nation's major hydrologic landscapes, priority ecological resources, and agricultural, urban, and natural sources of contamination.

Each assessment is guided by a nationally consistent study design and methods of sampling and analysis. The assessments thereby build local knowledge about water-quality issues and trends in a particular stream or aquifer while providing an understanding of how and why water quality varies regionally and nationally. The consistent, multi-scale approach helps to determine if certain types of water-quality issues are isolated or pervasive, and allows direct comparisons of how human activities and natural processes affect water quality and ecological health in the Nation's diverse geographic and environmental settings. Comprehensive assessments on pesticides, nutrients, volatile organic compounds, trace metals, and aquatic ecology are developed at the national scale through comparative analysis of the Study-Unit findings.

The USGS places high value on the communication and dissemination of credible, timely, and relevant science so that the most recent and available knowledge about water resources can be applied in management and policy decisions. We hope this NAWQA publication will provide you the needed insights and information to meet your needs, and thereby foster increased awareness and involvement in the protection and restoration of our Nation's waters.

The NAWQA Program recognizes that a national assessment by a single program cannot address all water-resource issues of interest. External coordination at all levels is critical for a fully integrated understanding of watersheds and for cost-effective management, regulation, and conservation of our Nation's water resources. The Program, therefore, depends extensively on the advice, cooperation, and information from other Federal, State, interstate, Tribal, and local agencies, non-government organizations, industry, academia, and other stakeholder groups. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Associate Director for Water

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CONVERSION FACTORS, DATUMS, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
foot per second (ft/s)	0.3048	meter per second (m/s)
yard (yd)	0.9144	meter (m)
mile (mi)	1.609	kilometer (km)
acre	4,047	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
million gallons per day (Mgal/d)	3, 785	cubic meters per day (m^3/d)

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) as follows: °F = (1.8 x °C) + 32.

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Horizontal coordinate information is referenced to the North American Datum of 1983.

Abbreviated water-quality units:
micrograms per liter (μg/L)
micrograms per kilogram (μg/kg)
microsiemens per centimeter at 25 degrees Celsius (μS/cm)
milligrams per liter (mg/L)
organisms per square meter (organisms/m^2)

Environmental Setting, Water Quality, and Ecological Indicators of Surface-Water Quality in the Mermentau River Basin, Southwestern Louisiana, 1998-2001

By Stanley C. Skrobialowski, Scott V. Mize, *and* Dennis K. Demcheck

ABSTRACT

The U.S. Geological Survey collected data from 29 wells and 24 surface-water sites in the Mermentau River Basin, 1998-2001, to better understand ground-water and surface-water quality; aquatic invertebrate communities; and habitat conditions, in relation to land use. This study was a part of the National Water-Quality Assessment Program, which was designed to assess water quality as it relates to various land uses. Water-quality data were evaluated with criteria established for the protection of drinking water and aquatic life, and bed-sediment data were compared to aquatic-life criteria. Water-quality and ecological data were analyzed statistically in relation to drainage area and agricultural land-use intensity.

Concentrations of nutrients and major inorganic ions in ground water and surface water generally were highest in the southeastern part of the study area where soils contain thick loess deposits. Peak concentrations of nutrients in surface water occurred March-May at two sites with high agricultural intensity; the lowest concentrations occurred August-January. The greatest potential for eutrophic conditions in surface water, based on nutrient concentrations, existed March-May, at about the same time or shortly after ricefields were drained. Secondary Maximum Contaminant Levels established by the U.S. Environmental Protection Agency (USEPA) were exceeded for sulfate, chloride, iron, or manganese in samples from 20 wells, and for iron or manganese in samples from all surface-water sites.

Fewer pesticides were detected in ground water than in surface water. In 11 of the 29 wells sampled, at least one pesticide or pesticide degradation product was detected. The most frequently detected pesticides or pesticide degradation products in ground water were the herbicides bentazon and atrazine. Concentrations of 47 pesticides and degradation products were detected in surface water. At least 3 pesticides were detected in all surface-water samples. In 72 percent of the samples at least 5 hydrophylic pesticides were detected, and in more than 70 percent of the samples at least 3 hydrophobic pesticides were detected. Although atrazine concentrations in three samples collected in the spring exceeded 3 µg/L (micrograms per liter), the USEPA Maximum Contaminant Level of 3 µg/L was not exceeded because it is based on an annual average of quarterly samples. Concentrations larger than 3.0 µg/L were not detected in samples collected during other times of the year. Tebuthiuron was detected at all surface-water sites; the largest concentration (6.33 µg/L) was detected at a site on Bayou des Cannes, and was the only detection that exceeded the criterion (1.6 µg/L) for the protection of aquatic life. Malathion was detected at 16 surface-water sites; the largest concentration (0.113 µg/L) was detected at a site on Bayou Lacassine, and was the only detection that exceeded the criterion (0.1 µg/L) for the protection of aquatic life. Concentrations of fipronil exceeded numeric targets for acute total maximum daily loads (2.3 µg/L) at 3 sites and chronic total maximum daily loads (4.6 µg/L) at 14 sites. Maximum pesticide concentrations in surface water usually occurred in the spring at about the same time or shortly after ricefields were drained.

Concentrations of DDE in bed sediment at two sites exceeded interim freshwater sediment quality guidelines for the protection of aquatic life. Fipronil sulfide and desulfinylfipronil were detected at all 17 sites from which bed-sediment samples were collected, but there are no current (2002) guidelines with which to evaluate the environmental effects of fipronil and degradation products.

Two methods were used to group the ecological data-collection sites: (1) Sites were grouped before data collection (according to the study design) using drainage

area and agricultural land-use intensity, and (2) sites were grouped statistically after data collection using canonical correspondence analysis (CCA) and classification (cluster analysis) techniques on surface-water quality, habitat, and aquatic invertebrate data. Aquatic invertebrate communities were used as ecological indicators of surface-water quality and habitat conditions at these sites. The CCA identified four significant environmental variables (instream cover score, percentage of open canopy, concentrations of dissolved oxygen, and maximum concentrations of dissolved fipronil) that described the distribution of aquatic invertebrate communities among ecological data-collection sites. Results from the CCA were used in a cluster analysis to identify four site groups that had similar water quality, habitat, and aquatic invertebrate characteristics. Environmental variables and biological metrics within the study-design (*a priori*, before sampling) and CCA-assigned (*posteriori*, after sampling) site groups were compared.

Median values of 17 water-quality variables were lowest at sites in the northern part of the study area, where less than 45 percent of a drainage area is used for rice cultivation. Median values of 11 water-quality variables were highest at sites in the southeastern part of the study area, where the percentage of a drainage area used for rice cultivation varies. Median values of turbidity, and concentrations of total ammonia plus organic nitrogen, nitrate, total phosphorus, and dissolved fipronil, were highest at sites in the north-central part of the study area. Possible explanations for the differences in water quality among ecological data-collection sites may be the differences in (1) general soil composition and drainage characteristics, and (2) percentage of land used for agriculture in these basins.

Habitat characteristics including channel size and morphology, water clarity, open canopy, and substrate differed between streams in the northern and southern parts of the study area. Stream habitat ratings were based on the total of 10 habitat parameter scores, using the Rapid Bioassessment Protocols habitat characterization. Scores increase as habitat quality increases. Ratings were suboptimal (102-154) to optimal (155-200) for 16 of the 19 ecological data-collection sites. Three sites were rated marginal (49-101). Differences in channel size, bank stability, and pool substrate may account for some differences in aquatic invertebrate communities between site groups distinguished by agricultural intensity.

Organisms tolerant of turbidity, organic enrichment, and low dissolved-oxygen concentrations were common in the study area and dominated the aquatic invertebrate community. Metrics for aquatic invertebrate communities were significantly different ($p \leq 0.05$) among agricultural land-use intensity site groups and CCA site groups in (1) percentage of noninsects, (2) abundance of midge taxa, (3) abundance of feeding groups, and (4) number of tolerant organisms. Dominance and diversity metrics were significantly different ($p \leq 0.05$) among CCA site groups. In this report, the maximum concentration of dissolved fipronil was the only significant environmental variable related to consistent decreases in relative abundance of many species, notably midges. Low species abundance in this report was associated with lower concentrations of fipronil degradation products than of the parent compound fipronil.

INTRODUCTION

The National Water-Quality Assessment (NAWQA) Program is a long-term program of the U.S. Geological Survey (USGS) designed to describe the status and trends in the quality of the Nation's surface- and ground-water resources and to provide an understanding of the natural and human factors that can affect the quality of these resources (Gilliom and others, 1995). The program is interdisciplinary and integrates biological, chemical, and physical data to assess the Nation's water quality at local, regional, and national scales. Assessing the quality of water in every part of the Nation would not be practical; therefore, NAWQA Program studies are conducted in a set of areas called study units. The Acadian-Pontchartrain (ACAD) is one such Study Unit, and consists of all or parts of 39 parishes in southern Louisiana and 5 counties in southwestern Mississippi (Demas and others, 1999). The 26,000-mi^2 ACAD Study Unit includes the Mermentau River Basin, a distinctive agricultural area in southwestern Louisiana. Water-quality and ecological data are needed to describe interactions between ground- and surface-water components of the hydrologic cycle and to determine the effects of agricultural land use on water quality in the Mermentau River Basin.

Purpose and Scope

This report characterizes ground-water and surface-water quality and ecological indicators (aquatic invertebrate communities and habitat conditions) for selected sites in the Mermentau River Basin. Bed-sediment quality also is characterized at selected sites. The environmental setting, including agricultural, industrial, water-availability and use, and hydrologic characteristics of the Mermentau River Basin are described. This report (1) describes the occurrence and distribution of selected nutrients, major inorganic ions, trace elements, and pesticides in ground water and surface water, suspended sediment in surface water, and selected pesticides in bed sediment; (2) characterizes stream habitat conditions at selected sites; and (3) assesses responses of aquatic invertebrate communities to surface-water quality and habitat conditions among selected sites. This report relates agricultural intensity (the percentage of land used for rice cultivation) to pesticide concentrations in water, aquatic community composition, and stream habitat characteristics.

The study area encompasses the Mermentau River Basin. Ground-water samples were collected once from 29 wells (19-230 ft deep) in the study area during January 2000-January 2001 (fig. 1). Surface-water samples were collected from 3 sites during November 1998-September 1999; 17 sites during October 1999-September 2000; and 18 sites during October 2000-September 2001 (fig. 2, table 1). Ecological (habitat and aquatic invertebrate) data were collected in 2001 for 18 surface-water sites in the Mermentau River Basin and an additional site in the adjacent Calcasieu River Basin (fig. 3, table 1). Data from the additional site were used for comparison only, and the site was not intended to represent water quality in the Calcasieu River Basin. The additional site was used to compare conditions at a relatively undisturbed site with those at the agricultural sites in the Mermentau River Basin. The Calcasieu River Basin site was the best approximation to a large-basin, low agricultural-intensity site that was available. There were few suitable sites in the Mermentau River Basin with large basins and low agricultural intensity for comparison. Bed-sediment samples were collected under low-flow conditions from 17 surface-water sites August-September 2000. Stream-habitat characteristics were documented and aquatic invertebrate samples were collected March-April 2001 for all 19 surface-water sites sampled in 2001.

Acknowledgments

The authors thank Keith Fontenot, Ronnie Levy, and Eddie Eskew of the Louisiana Cooperative Extension Service, Louisiana State University Agricultural Center for their cooperation in evaluating the extent of rice cultivation in the Mermentau River Basin. The authors also thank the many owners of domestic wells for allowing access to their property and wells. Appreciation is extended to the following USGS employees: Stephen D. Porter and Lawrence R. Deweese for project development and support and critical study design review; Thomas F. Cuffney for reviewing the design of the study; Patricia J. D'Arconte for assistance with GIS support; Stephen D. Porter, Lawrence R. Deweese, Jeffrey A. Brantly, Van G. Bergeron, C. Paul Frederick, Kevin J. Grimsley, Cindy G. Sibley, Lane B. Simmons, and William B. Snee for assistance in data collection; and Stephen D. Porter, Lawrence R. DeWeese, Douglas A. Harned, and Thomas F. Cuffney for providing critical reviews that improved the quality of the report.

ENVIRONMENTAL SETTING

The Mermentau River Basin is located in the Western Gulf Coastal Plains ecoregion of southwestern Louisiana (Omernik, 1987). The area also is called coastal prairie or wet prairie (Brown, 1972). Historically, the area was a tallgrass prairie similar in many ways to the tallgrass prairie in the midwestern United States (Allain and others, 2000).

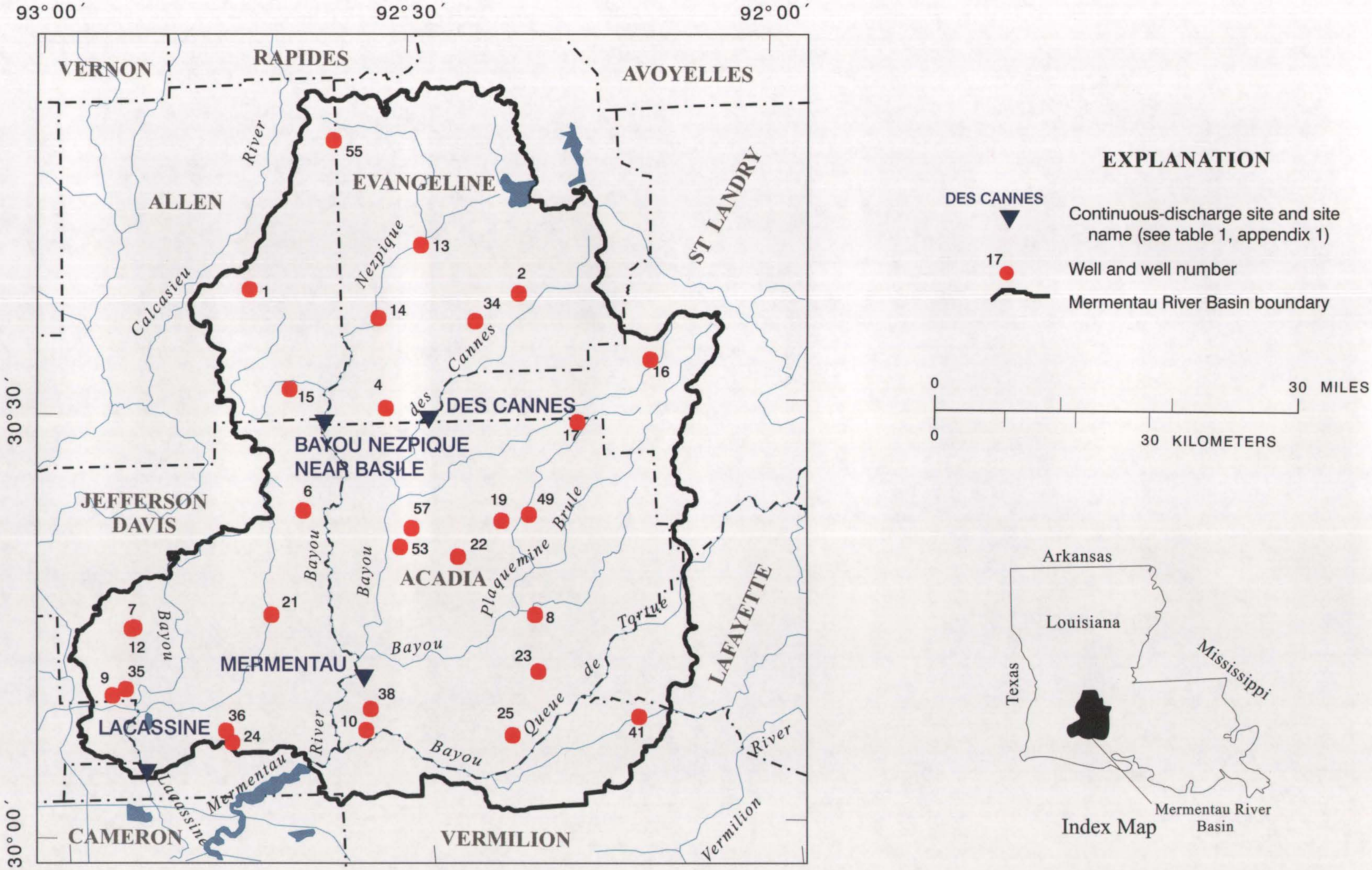
Soils in the Mermentau River Basin (fig. 4) consist of a thick loess in the eastern part of the study area (fig. 4), the area most used for soybean production (fig. 2). Most of the central and southern parts of the basin, however, consist of clayey and loamy alluvial deposits which are ideally suited for rice cultivation. Rice cultivation within the last 100 years has caused leaching of salts and fine clays to form a hardpan underlying ricefields (Lovelace, 1999). Alluvial soils in the northwestern part of the basin contain more silt and sand and consist of loamy and silty deposits and loamy fluvial deposits than other parts of the basin. The streambed substrate in the tributaries and main channel of the Mermentau River is silt or clay. The substrate in the mainstem and smaller tributaries also can be a soft flocculent muck rich in organic matter.

The area drained by the upper Calcasieu River Basin (fig. 3) is located in the Western Gulf Coastal Plains ecoregion, is primarily forested, and has geomorphic features and hydrology typical of an upland basin. The streams drain an area of rolling pine hills with sandy soils. Ground-water contributions to the stream during the late summer result in orange-red iron oxide coatings on the sandy substrate.

Land Use

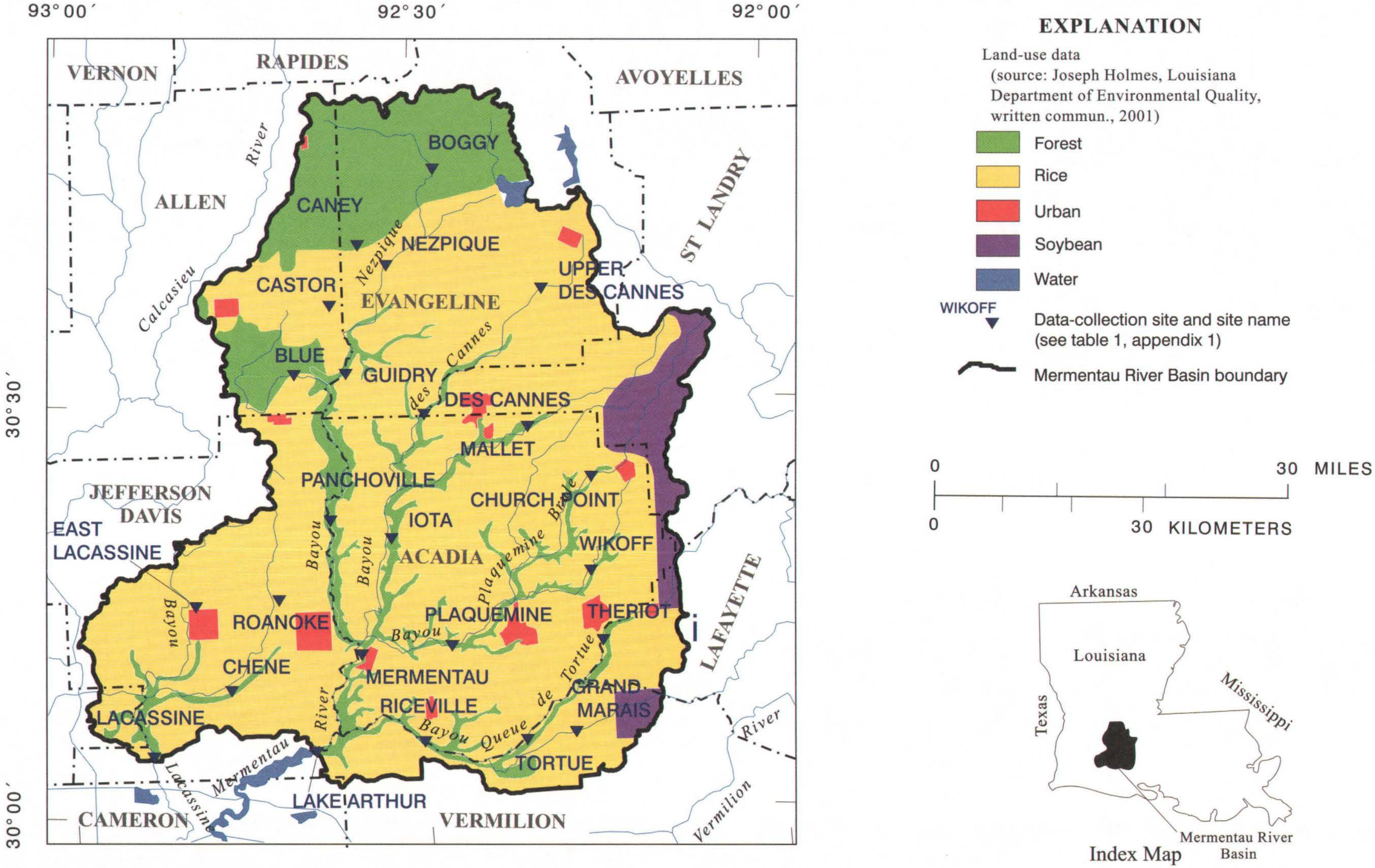
Most land in the Mermentau River Basin has been altered for agricultural crops such as rice, soybeans, and sugarcane, and for pasture (fig. 3). Other land uses include crawfish farming and oil and gas exploration and production. The northwestern part of the basin is mostly forested and land in the remainder of the basin is used predominantly for rice agriculture.

Forest consisting of mixed pine-hardwoods in the upper basin changes to water tupelo and cypress riparian zones as the land flattens toward the lower basin. The mid-to-lower reaches of the Mermentau River are bordered by a water tupelo and cypress riparian zone that



Map credit: Modified from Official Map of Louisiana, Department of Transportation and Development, 1986

Figure 1. Continuous-discharge surface-water sites and ground-water wells sampled in the Mermentau River Basin, southwestern Louisiana, 1998-2001.



Map credit: Modified from Official Map of Louisiana, Department of Transportation and Development, 1986

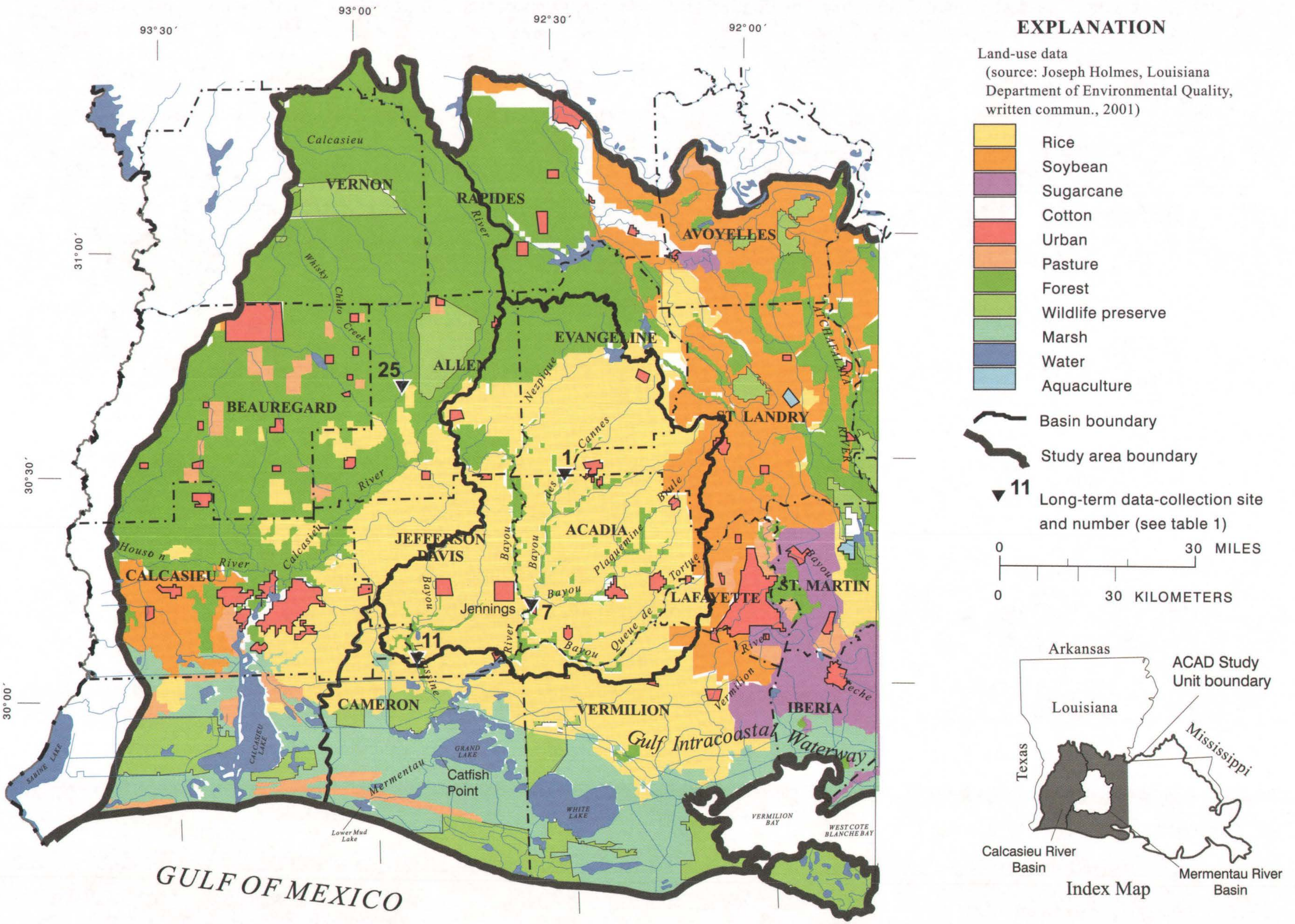
Figure 2. Land use and location of surface-water data-collection sites in the Mermentau River Basin, southwestern Louisiana, 1998-2001.

Table 1. Surface-water and ecological data-collection sites in the Mermentau River Basin and adjacent Calcasieu River Basin, southwestern Louisiana, 1998-2001

[Basin size: A drainage area greater than or equal to 70 square miles represents a large basin, and a drainage area smaller than 70 square miles represents a small basin. Agricultural land-use intensity: A basin in which the land used for rice cultivation is at least 45 percent of the drainage area is considered high agricultural intensity, and less than 45 percent is considered low agricultural intensity. All sites are short-term except sites 1, 7, 11, and 25, which are long-term. X, sampled]

Site number (fig. 2)	Abbreviated site name[1]	U.S. Geological Survey station number	Drainage area (square miles)	Basin size	Drainage area used for rice (percent)	Agricultural land-use intensity	Sampling period		
							[2]Nov. 1998-Sept. 1999	[3]Oct. 1999-Sept. 2000	[4]Oct. 2000-Sept. 2001
			Mermentau River Basin						
1	Des Cannes	08010000	142	Large	95	High	X	X	X
2	Wikoff	08010500	63	Small	54	High		X	X
3	Plaquemine	08011020	320	Large	64.7	High		X	X
4	Boggy	08011500	65	Small	0	Low			X
5	Castor	08011800	33	Small	42.4	Low			X
6	Nezpique	08011860	166	Large	21.7	Low		X	X
7	Mermentau	08012150	1,381	Large	66.5	High	X	X	X
8	Riceville	08012300	236	Large	76.3	High		X	
9	Lake Arthur	08012400	1,702	Large	69	High		X	
10	Chene	08012447	100	Large	97	High		X	
11	Lacassine	08012470	296	Large	89.5	High	X	X	X
12	Tortue	300446092214200	97	Large	74.2	High		X	X
13	Grand Marais	300514092173500	26	Small	38.5	Low			X
14	Theriot	301154092145900	37	Small	62.2	High			X
15	East Lacassine	301520092491800	15	Small	100	High		X	X
16	Roanoke	301538092421900	56	Small	100	High		X	
17	Iota	301959092323400	333	Large	50	High		X	
18	Panchoville	302128092373800	550	Large	45	High		X	
19	Church Point	302403092152300	74	Large	25.7	Low		X	X
20	Mallet	302749092203500	91	Large	86.8	High		X	X
21	Guidry	303206092360000	381	Large	36.6	Low		X	X
22	Blue	303209092401800	80	Large	53.8	High			X
23	Upper Des Cannes	303755092190400	46	Small	91.3	High			X
24	Caney	304130092344100	18	Small	0	Low			X
			Calcasieu River Basin (additional site)						
[6]25	Whisky	08014500	504	Large	[5]8	Low	X	[2]X	X

[1] Complete site name is listed in appendix 1.
[2] Water-quality samples only.
[3] Water-quality and bed-sediment samples, except as noted.
[4] Water-quality and ecological samples and data.
[5] Estimated value.
[6] Shown in figure 3.



Map credit: Modified from Official Map of Louisiana, Department of Transportation and Development, 1986

Figure 3. Land use and long-term water-quality data-collection sites in southwestern Louisiana, 1998-2001.

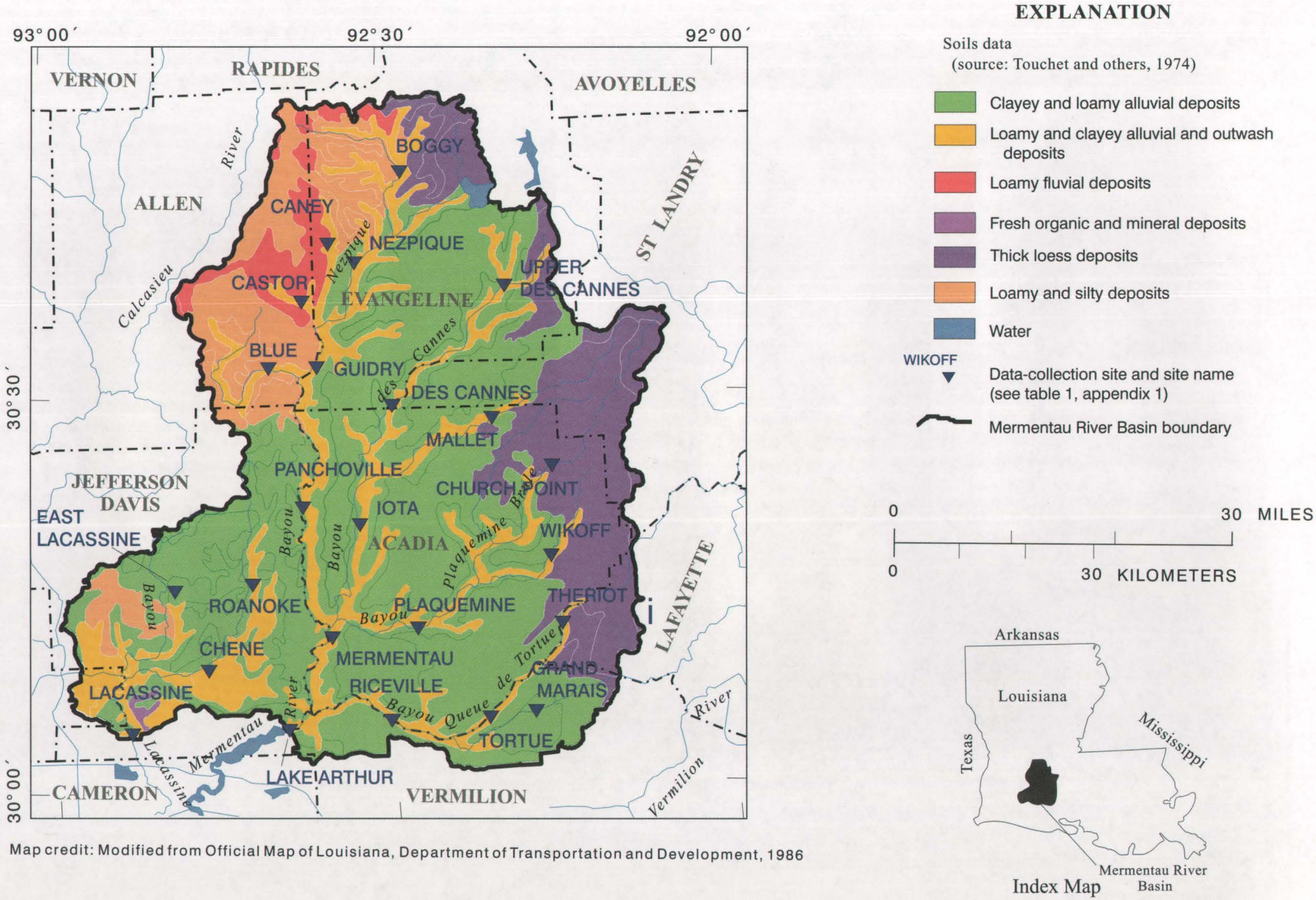


Figure 4. Soils and location of surface-water data-collection sites in the Mermentau River Basin, southwestern Louisiana 1998-2001.

typically is flooded more than half of the year. Banks along the tributaries generally are low with water tupelo and cypress extending into the streams. Along parts of the lower reaches, banks are not discernible as the water extends into a bottomland hardwood flood plain. In places, the flood plain abruptly ends at ricefield levees or roadways.

Rice is the most important agricultural crop produced in the basin. Total rice acreage in the seven parishes (Acadia, Allen, Evangeline, Jefferson Davis, Lafayette, St. Landry, and Vermilion) of the Mermentau River Basin was almost 400,000 acres in 1998 and about 340,000 acres in 2000 (Louisiana Cooperative Extension Service, 1998, 2000). Soybeans are rotated periodically with rice in the basin, but areas where this occurs are shown only as rice acreage in figure 3 because rice is the most frequently cultivated crop. Although sugarcane is grown in the southwestern part of the basin, the acreage is too small and scattered to be delineated in figure 3.

Rice cultivation practices in the Mermentau River Basin use substantial amounts of ground water and surface water. Aerial application of seed on flooded fields is the predominant method of planting rice in the basin. The flooding of ricefields also suppresses red rice, a wild variety with no commercial value, and allows crawfish farming in the ricefields (Linscombe and others, 1999). After the aerial seeding of rice, the water is retained on the field for about 1 to 2 days and released. The field is allowed to drain only long enough for the young seedlings to become anchored, about 3 to 5 days. Releases of ricefield water (called tailwater) into the streams result in very high turbidities during March through May. The field is then reflooded until the rice nears maturity. Rice typically is harvested in July and August. A second rice crop may be harvested in September and October from volunteers of the first harvest, depending on prices and the climate for the particular year.

About 30,000-40,000 acres in the Mermentau River Basin were used for crawfish farming in 2000. Two species are grown commercially, the red swamp crawfish and the white river crawfish. There are two basic methods for growing crawfish: permanent ponds and rotational ponds. Permanent ponds are dedicated solely for the production of crawfish and generally are located east of the Mermentau River Basin. Rotational ponds are the most common method of crawfish production in the basin. In this aquacultural practice rice and crawfish are double-cropped annually. Typically, rice is planted in March and April. Land is reflooded and, by June, the flooded fields are stocked with crawfish. Rice is harvested by August, land is reflooded in October, and crawfish are harvested in November through April (Avery and Lorio, 1999).

The primary industry affecting water quality in the Mermentau River Basin is oil and gas exploration and production (Demas and others, 1999). The first oil well in Louisiana was drilled near Jennings, Louisiana, in September 1901, soon after the first great gusher in America, at Spindletop, Texas, in January 1901 (Spearing, 1995). Since then, oil and gas production facilities and their associated pipelines have become major and conspicuous features of the landscape of the area. Most facilities are quite small, occupying only a few acres or less. Although oil and gas production from the fields in the basin is declining, wells, pipelines, and oil and gas production and distribution facilities are located throughout the area. Individual oil wells among rice fields are separated from the fields by low earthen berms.

Water Availability and Use

Ground water and surface water are used for rice cultivation and crawfish farming in the Mermentau River Basin (fig. 5). Rice farmers in the southern part of the basin rely on surface water for irrigation, whereas farmers in the northern part of the basin rely on ground water. The 540 Mgal/d combined ground- and surface-water withdrawals for rice irrigation in 2000 was 87 percent of the total water used in the basin (B.P. Sargent, U.S. Geological Survey, written commun., 2002). More than 80 percent of the water used for rice irrigation was from ground-water sources in the Chicot aquifer system.

A drought occurred throughout southwestern Louisiana in 1998-2000. May 1998 was one of the driest Mays in more than 100 years. The drought was classified as mild in 1998 and intensified to severe conditions during the latter half of 1999. Conditions further intensified to extreme through October 2000, then subsided in November 2000, one of the wettest Novembers on record (John M. Grymes, III, Louisiana State Climatologist, written commun., 2002). The drought caused rice farmers to use more ground water or forego planting.

Hydrology

The Mermentau River Basin has a drainage area of about 3,800 mi^2 (Sloss, 1971), and includes most of a seven-parish area (fig. 3). The Mermentau River begins at the confluence of three major tributaries: Bayou Nezpique, Bayou des Cannes, and Bayou Plaquemine Brule (fig. 1). Downstream from the confluence, Bayou Lacassine enters the Mermentau River from the west,

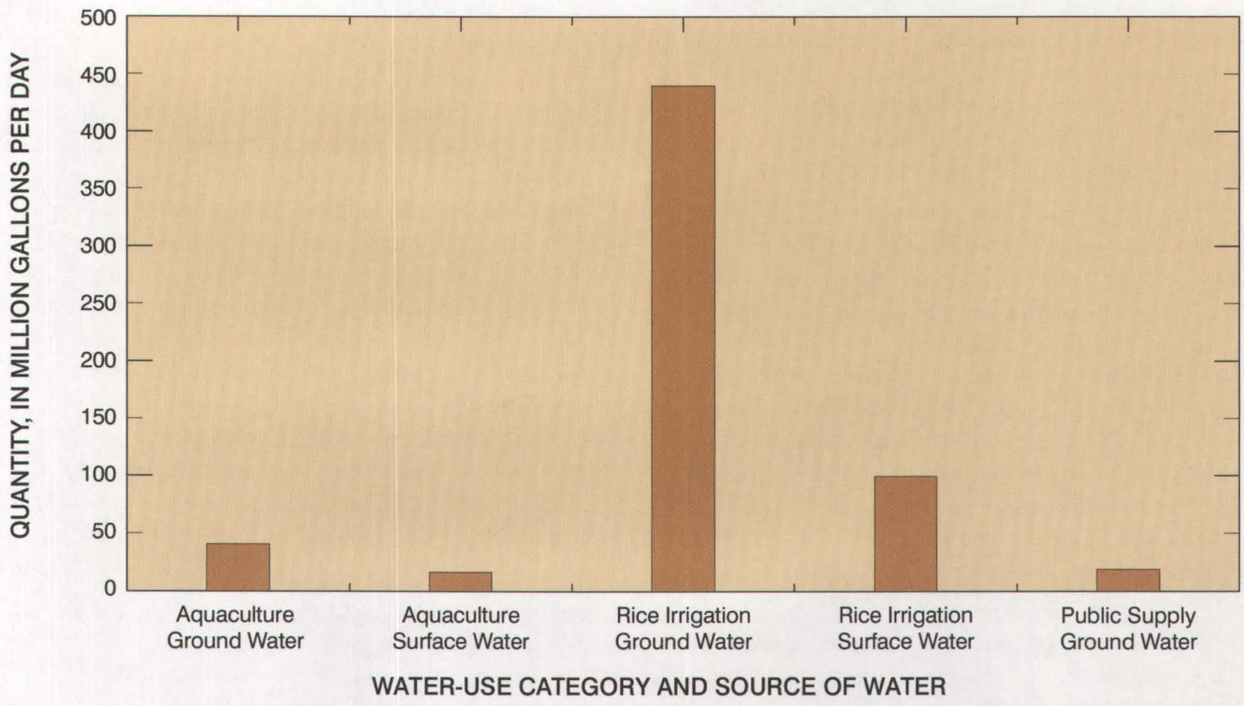


Figure 5. Sources and quantities of water used in the Mermentau River Basin, southwestern Louisiana, 2000.

and Bayou Queue de Tortue enters the river from the east. The five bayous divide the Mermentau River Basin into a series of broad, flat areas ideal for agriculture. These areas are separated by bottomland hardwood riparian corridors that vary in width from only a hundred feet to several miles. Land-surface elevations are less than 100 ft above NGVD 29 in most of the basin and less than 25 ft above NGVD 29 along the Mermentau River mainstem. Thus, the Mermentau River Basin is characterized by a low gradient and dendritic river system that drains to the Gulf of Mexico.

Hydrology in the Mermentau River Basin is complicated by the extensive use of ground water for irrigation and by modifications for agriculture and navigation. Water used to flood ricefields may enter the Chicot aquifer system, be reused downstream for agriculture, or drain to the Gulf of Mexico. During the study described in this report, a dam was constructed upstream from one of the long-term surface-water sites, Des Cannes, because a train derailed and spilled chemicals (National Transportation Safety Board, 2002). Modifications of streams for navigation and water-control structures are common in the basin.

The Mermentau River Basin is characterized by free-flowing streams in the north. The low gradient and low topographic relief in the southern part of the basin create both bidirectional (downstream and upstream) and interbasin flow, with water velocities typically less than 1 ft/s. The river is tidally affected, and most upstream (negative) flow occurs in the summer and fall. Negative flow can be caused by natural events such as storms and sustained winds from the south in conjunction with unusually high tides. These negative flows can be increased in magnitude and duration during low-discharge periods, such as occurred during the drought of 1999-2000 (fig. 6). Pumping of surface water for irrigation may cause bidirectional flow, but typically only in the smaller tributaries.

The naturally low gradient and human-made canals and waterways allow interbasin flows. The primary flow route is the Gulf Intracoastal Waterway (GIWW), constructed in 1940 (fig. 3). The GIWW crosses the Mermentau River north of Grand Lake and is a major route for east-west barge traffic along the Gulf Coast. A complex series of gates and locks is operated by the U.S. Army Corps of Engineers (USACE) to manage the waterway. The GIWW hydraulically connects the Mermentau River Basin with the Calcasieu River Basin to the west and the Teche-Vermilion Basin to the east.

In the 1970's, the natural mouth of the Mermentau River was bypassed with the construction of a separate 4.6-mi navigation channel from Lower Mud Lake to the Gulf of Mexico. This navigation channel, the GIWW, and other hydrologic modifications throughout southwestern Louisiana are managed by numerous water-control structures. One such structure is on the Mermentau

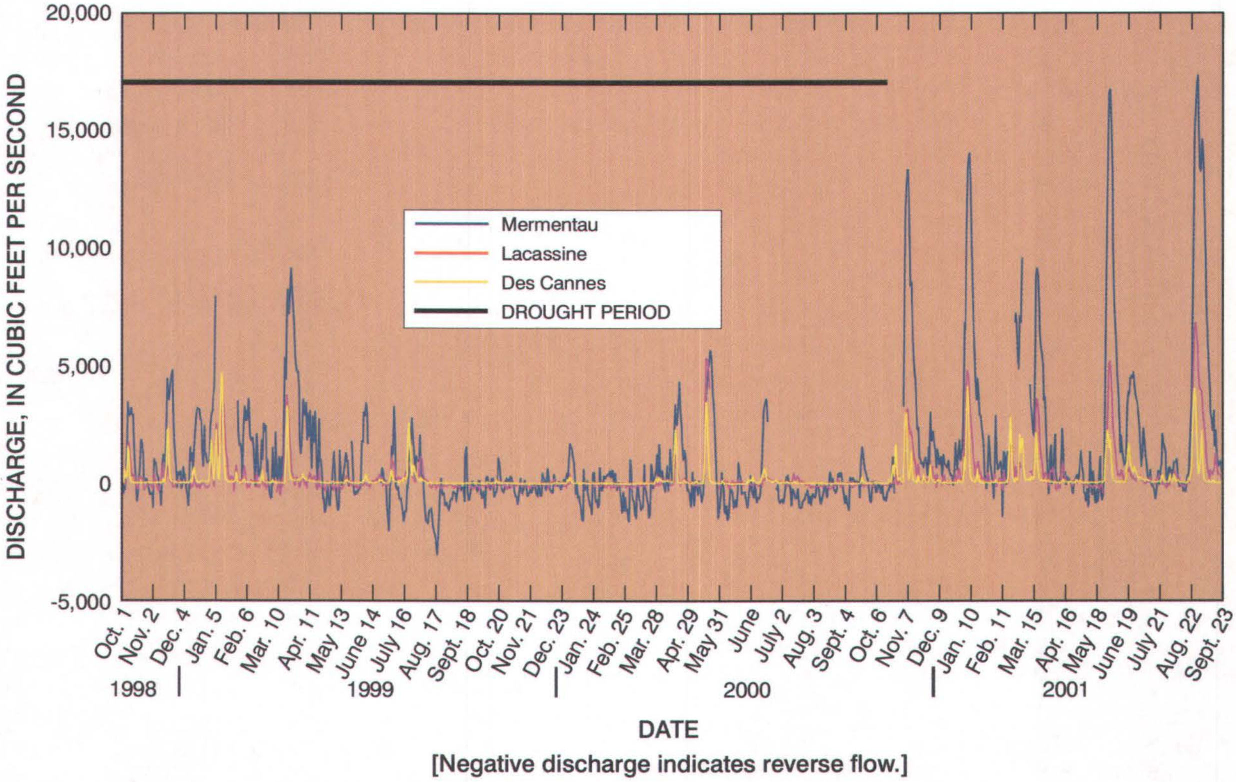


Figure 6. Discharge for selected sites in the Mermentau River Basin, southwestern Louisiana, 1998-2001.

River south of Grand Lake at Catfish Point. The purposes of the gated control structure are to reduce northward movement of saltwater and to maintain a sufficient freshwater stage for farmers, especially rice farmers, in the Mermentau River Basin. The USACE maintains the stage on the mainstem of the Mermentau River at about 2 ft above NGVD 1929 (Steven Schinetsky, U.S. Army Corps of Engineers, oral commun., 2002), sometimes by closing the control structure at Catfish Point. The river upstream from Catfish Point appears to cease flowing during periods of closure.

On May 27, 2000, a train with 17 cars of hazardous materials and residues derailed about 0.5 mi upstream from Des Cannes and 2 mi west of Eunice, Louisiana (National Transportation Safety Board, 2002). The derailment resulted in the release of hazardous materials to a ditch and pond draining to Bayou des Cannes. No chemicals spilled directly into the bayou. Because an earthen dam was constructed about 100 yd upstream from the Des Cannes site, streamflow data from nearby Bayou Nezpique near Basile (a continuous-discharge site only) were used to augment streamflow data from the Des Cannes site (fig. 1). Continuous streamflow data are available from four sites in the Mermentau River Basin—Bayou Nezpique near Basile, Des Cannes, Lacassine, and Mermentau (fig. 1). Annual streamflow data are available only for Bayou Nezpique near Basile, and Des Cannes (table 2). Streamflow is bidirectional at Lacassine and Mermentau and these sites lack sufficient data to determine annual streamflow statistics.

Table 2. Annual mean flow for selected sites in the Mermentau River Basin, 1999-2001, and period of record

	Annual mean flow (cubic feet per second)			
Site name	**1999**	**2000**	**2001**	**Period of record, 1939-2001**
Des Cannes	201	79.4	322	275
Bayou Nezpique near Basile	651	169	801	833

A combination of ground water and surface water is used for agriculture and aquaculture. Because of the hardpan clay layer underlying the ricefields, a substantial amount of tailwater enters surface water as runoff. It then may be pumped from a waterway to irrigate another field or used for aquaculture farther downstream. Thus, aquatic life is exposed to both ground water and surface water. Also, tidal effects and bidirectional flows preclude the use of stage-discharge relations to calculate streamflow at all but the most upstream sites. The bidirectional-discharge hydrographs from the Mermentau and Lacassine sites define specific hydrologic conditions only at those two locations. They are useful in describing the overall hydrologic conditions in the basin, but cannot provide information such as loads that can be used for management decisions. For these reasons the integrated assessment for this study of surface-water quality, ground-water quality, bed-sediment quality, and ecological indicators is restricted to approximately 2,000 mi^2 of the Mermentau River Basin north of the Lake Arthur and Lacassine sites.

Aquatic Invertebrate Communities

The most important factors influencing the occurrence and distribution of aquatic invertebrates are stream velocity, water temperature, dissolved substances, and substrate (Hynes, 2001). Because of low water velocities, elevated water temperatures, and soil types of the Mermentau River Basin, an aquatic environment that is not conducive to a diverse aquatic invertebrate community is expected. Snags provide a firm substrate and opportunities for colonization often lacking in the clays and mucks of the streambed and banks. Snags also allow aquatic invertebrates to move closer to the water surface during periods of low dissolved-oxygen concentrations and high turbidities. These populations typically include the larvae of chironomid midges, snails, amphipod crustaceans, and worms. DeWalt (1997), in a study designed to locate and characterize wadeable reference streams in this basin, noted that low dissolved-oxygen concentrations significantly distinguish this area from other Louisiana lowlands.

The Mermentau River Basin, especially in the mid-to-lower reaches, typically supports dense growth of exotic macrophyte (aquatic plant) species. Among these are water hyacinth (*Eichhornia crassipes*), alligator weed (*Alternanthera philoxeroides*), and water spangle (*Salvinia minima*). During mild winters these macrophytes may not experience a complete dieback and may cover the water surface, reducing light penetration and lowering dissolved-oxygen concentrations. These plants, however, provide extensive habitat for aquatic invertebrates. Amphipod crustaceans in particular can be found in abundance among the root systems of water hyacinth.

Naturally occurring habitat conditions in the basin favor an aquatic invertebrate community tolerant of turbidity, organic enrichment, and low dissolved-oxygen conditions. The net effect of these natural environmental stressors is to produce a biological community that is, at first examination, indicative of streams that have been adversely affected by human activities. However, what may appear to be a degraded or depauperate biological assemblage may in fact be a healthy community where multiple environmental stressors limit diversity and sensitive taxa.

DATA COLLECTION AND METHODS OF STUDY

Ground-water sample collection was consistent with national goals for the ground-water component of the NAWQA program (Leahy and others, 1990). Samples were collected from wells drilled specifically for the NAWQA program and from existing domestic wells that met specific criteria. Surface-water samples were collected from 24 long- and short-term sites with varied agricultural intensity in the Mermentau River Basin. These sites are referred to in this report by the site names listed in table 1. Long-term sites were sampled to characterize temporal and spatial water-quality conditions, and short-term sites were sampled to characterize water quality during the spring months.

Water samples from wells and surface-water sites were collected for the analysis of nutrients, major inorganic ions, trace elements, and pesticides; samples from surface-water sites also were analyzed for suspended sediment. Water samples were collected from 29 wells (fig. 1). The wells were sampled once during the period January 2000-January 2001, and the well depths ranged from 19 to 230 ft. Surface-water samples were collected at 25 sites (24 sites in the Mermentau River Basin and one additional site in the Calcasieu River Basin) during the period of sample collection for the study described in this report. Bed-sediment samples were collected at 17 sites (table 1) during low-flow conditions August-September 2000. Aquatic invertebrate samples and stream habitat data were collected at 18 sites in the Mermentau River Basin and at one additional site in the Calcasieu River Basin during March-April 2001.

Procedures used to collect and process water samples followed standard USGS guidelines and are described by U.S. Geological Survey (1997 to present), Shelton (1994), Gilliom and others (1995), Mueller and others (1997), and Koterba and others (1995). Water samples were analyzed at the USGS National Water Quality Laboratory (NWQL) in Denver, Colo., using methods described by Fishman and Friedman (1989), Sandstrom and others (1992), Sandstrom (1995), Zaugg and others (1995), and Madsen and others (2003). Water-quality samples were analyzed for a special group of pesticides using a new method that was approved by the USGS Office of Water Quality in April 2001 (app. 2 and 3) (Furlong and others, 2001). Although this analytical method did not change following approval, data analyzed before method approval are considered provisional. Samples analyzed with this method and data used for analysis in this report were collected after January 2000 but before April 2001; therefore, the data are provisional. Ground-water quality data are available in reports by Tollett and Fendick (2004) and Tollett and others (2003). Surface-water quality data are available in Goree and others (2000, 2001, and 2002) and in appendixes 2 and 3.

Turbidity was measured at the USGS Laboratory in Baton Rouge, La., using a turbidimeter according to methods described by the manufacturer (Hach Company, 1999). Water clarity was estimated as a function of light extinction with depth in the water column. The euphotic zone depth (Moulton and others, 2002) and Secchi depth (Wetzel and Likens, 1991) measurements were used to estimate water clarity at ecological data-collection sites.

Subsamples of bed sediment (table 1) were collected with fluoropolymer tubes and spatulas at wadeable sites and with a fluoropolymer-coated Petite-Ponar dredge suspended from a bridge or boat at non-wadeable sites. At each site, the top layer (0.5 to 0.75 in. deep) of each subsample was retained and composited in a container with other subsamples. Methods used to process bed-sediment samples are described by Shelton and Capel (1994). Analytical methods used by the NWQL for the determination of pesticides in bed sediment are described by Foreman and others (1995). Bed-sediment data are available in Goree and others (2001).

Stream habitat characteristics were documented at the time of aquatic invertebrate sampling. Habitat assessment included a combination of qualitative rankings and quantitative measurements. The qualitative rankings were determined by characterizing instream habitat measures such as substrate, sediment deposition, channel flow, and channel alterations, and riparian-zone features at the site, consistent with U.S. Environmental Protection Agency (USEPA) Rapid Bioassessment Protocols (RBP) for low-gradient streams (Barbour and others, 1999). Ten stream habitat parameters were scored on a scale of 0 to 20 (highest) for each sampling reach. Scores increase as habitat quality increases. A total score for each site was used to obtain a final stream habitat rating. Quantitative assessment of physical habitat conditions at the site included measurements of instream characteristics (such as stream width, depth, flow, turbidity, and bed-sediment particle-size distributions) and riparian characteristics (such as bank structure, riparian vegetation, and canopy cover) at three equally spaced transects in the sampling reach. The quantitative measurements of habitat conditions are described by Fitzpatrick and others (1998).

Aquatic invertebrate community surveys are one of the few means of directly assessing the biological integrity of a site and defining a group of aquatic organisms sensitive to changes in water chemistry and physical habitat (Meador and Gurtz, 1994). The aquatic health of stream reaches can be characterized by evaluating the results of qualitative and quantitative measurements of the aquatic invertebrate community. Results of aquatic invertebrate surveys were used to characterize the distribution and community structure of aquatic invertebrate species and their relation to the quality of both water and bed sediment. The species composition and community structure of aquatic invertebrates respond to and indicate physical and chemical conditions present in a stream for time scales ranging from months to years (Cuffney and others, 1993).

Aquatic invertebrate samples were collected at 19 sites (March-April 2001) and analyzed as indicators of water quality to assess the influence of drainage area and agricultural land-use intensity on aquatic health. Samples from instream submerged woody debris (snags) in the stream reach were collected to represent the taxonomically richest-targeted habitat areas in accordance with USGS NAWQA Protocols (Cuffney and others, 1993). The Biology Unit of the USGS NWQL used methods described by Moulton and others (2000) for the identification and enumeration of invertebrate samples.

Site Selection

Water-quality data were collected from 29 wells (fig. 1) and 25 surface-water sites; aquatic invertebrate samples were collected and habitat characteristics were documented for 19 surface-water sites. Tollett and Fendick (2004) and Tollett and others (2003) described well site selection and installation.

The study included 24 surface-water sites in the Mermentau River Basin (fig. 2, table 1) and, because no suitable reference site was available in the Mermentau River Basin, an additional site in the adjacent Calcasieu River Basin (fig. 3, table 1). The additional site is considered to be influenced minimally by agricultural practices, and to represent natural physical, chemical, and ecological characteristics for areas evaluated in this report. Surface-water data collection occurred in three overlapping phases during the study (table 1). Three sites were selected to characterize the effects of land use on water quality over time (long-term sites). These sites were sampled monthly November 1998-September 2001 and semimonthly February-June 1999 and 2000. Fourteen short-term sites were selected to characterize the occurrence and distribution of land-use effects on water quality in the basin. These sites were sampled monthly February-June 2000. Nineteen sites were selected to compare water-quality characteristics with drainage area and agricultural land-use intensity March-May 2001. These included the 3 long-term sites in the Mermentau River Basin, 1 long-term reference site in the Calcasieu River Basin, 8 of the short-term sites sampled in 2000, and 7 additional short-term sites. Bed-sediment samples were collected once at 17 surface-water sites during low-flow conditions August-September 2000.

Two methods were used to group sites. Nineteen ecological data-collection sites were grouped before data collection according to the study design based on drainage area and agricultural intensity and grouped statistically after data collection using ordination (CCA) and classification (cluster analysis) techniques on surface-water quality, habitat, and aquatic invertebrate data (table 1, fig. 7). Drainage areas greater than or equal to 70 mi^2 were considered large basins and those smaller than 70 mi^2 were considered small basins. Sites were selected to represent water-quality conditions influenced by differences in agricultural intensity as indicated by the percentage of the basin used for rice cultivation. In this report, the term "high-intensity" describes an area where at least 45 percent of the drainage area is used for rice cultivation; "low-intensity" is used to describe an area where less than 45 percent of the drainage area is used for rice cultivation. A Geographic Information Systems (GIS) coverage was used to determine basin areas (Joseph Holmes, Louisiana Department of Environmental Quality, written commun., 2001). Rice areas also were determined from this GIS coverage and verified by county agricultural agents within parishes in the basin.

Data Analysis

Concentrations of nutrients, major inorganic ions, trace elements, and pesticides were evaluated in relation to land use and to national drinking-water regulations or criteria. Concentrations in ground water were compared with those in surface water. Nutrients, major inorganic ions, and trace elements were detected frequently in both ground water and surface water and are discussed concurrently. Maximum pesticide concentrations are compared to available aquatic-life criteria, and concentrations for one insecticide, fipronil, are compared to numeric targets for total maximum daily loads (TMDL's) established by USEPA (2002b). Pesticides were detected infrequently in ground water and, other than in general terms, are discussed separately from those in surface water.

Primary and Secondary Drinking Water Regulations (U.S. Environmental Protection Agency, 2000a) were used to evaluate concentrations of nitrate and selected major inorganic ions, as shown below.

Constituent	Concentration	Drinking Water Regulation
Nitrate	10 mg/L	MCL[1]
Chloride	250 mg/L	SMCL[2]
Sulfate	250 mg/L	SMCL[2]
Iron	300 µg/L	SMCL[2]
Manganese	50 µg/L	SMCL[2]

[1]Maximum Contaminant Level.

[2]Secondary Maximum Contaminant Level.

Primary Drinking Water Regulations and health advisories were used to evaluate concentrations of pesticides (table 3). Primary and Secondary Drinking Water Regulations and health advisory levels were established by USEPA (2000a) and include the following:

1. Enforceable Maximum Contaminant Levels (MCL's), established to protect public health by limiting the levels of contaminants in drinking water;
2. Nonenforceable Secondary Maximum Contaminant Levels (SMCL's), available for some nutrients and major inorganic ions, established to limit cosmetic (such as skin or tooth discoloration) or aesthetic (such as taste, odor, or color) effects in drinking water; and
3. Nonenforceable health advisory (HA) levels, established to avoid adverse noncarcinogenic effects for a lifetime of exposure.

Aquatic-life criteria for pesticides in freshwater include USEPA water-quality criteria (2002a), USEPA TMDL's (2002b), and Canadian water-quality guidelines for the protection of aquatic life (Canadian Council of Ministers of the Environment, 2001) (table 3). These criteria are based on single-chemical toxicity tests and do not consider synergistic or antagonistic effects of pesticide mixtures. Criteria from USEPA (2002a) are estimates of the highest concentration to which an aquatic community can be exposed indefinitely without

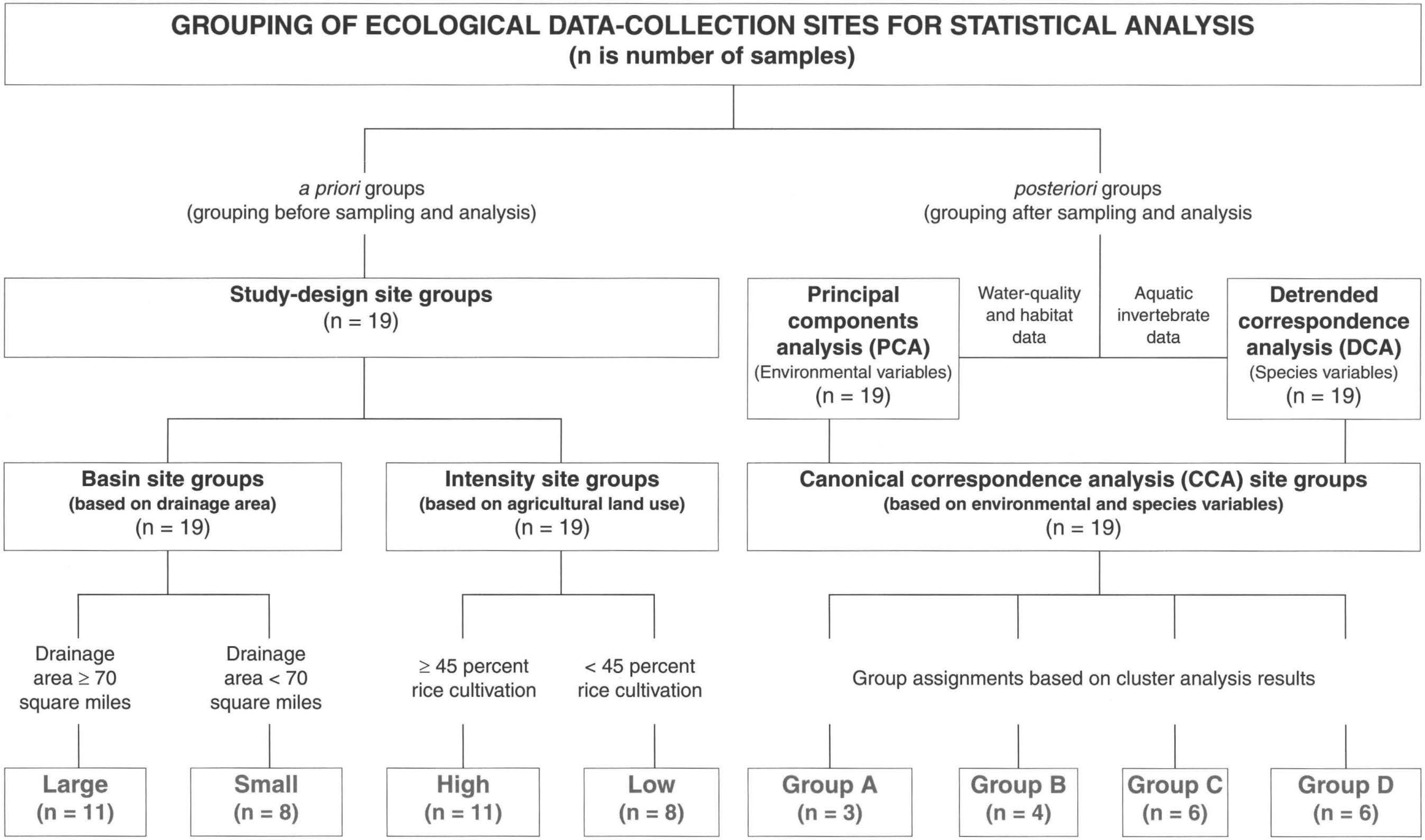


Figure 7. Flowchart of statistical analysis of ecological data used in the study. Median values of the basin and intensity site groups (blue text) were tested for significant differences ($p \leq 0.05$) using a two-factor analysis of variance (Wilkinson and Coward, 1998) on ranked data (Helsel and Hirsch, 1992), and canonical correspondence analysis site groups (green text) were tested for significant differences ($p \leq 0.05$) using a one-factor analysis of variance (Kruskal-Wallis test) on ranked data (Wilkinson, 1998).

Table 3. Drinking-water regulations, health advisory levels, and aquatic-life criteria for selected pesticides
[Concentrations are in micrograms per liter. USEPA, U.S. Environmental Protection Agency; MCL, Maximum Contaminant Level; HA, health advisory; *, based on an annual mean of quarterly samples; --, none; CCME, Canadian Council of Ministers of the Environment]

Compound	USEPA drinking-water MCL or HA [1]		Aquatic-life criteria	
	Criterion	Type of standard	Criterion	Source
Alachlor	2	MCL	--	--
Atrazine	*3	MCL	1.8	CCME[2]
Bentazon	200	HA	--	--
Bromacil	90	HA	5	CCME[2]
Carbaryl	700	HA	.2	CCME[2]
Carbofuran	40	MCL	1.8	CCME[2]
Chlorpyrifos	20	HA	.041	USEPA[3, 4]
Cyanazine	1	HA	2	CCME[2]
2,4-D	70	MCL	--	--
Dacthal (DCPA)	70	HA	--	--
Diazinon	0.6	HA	--	--
Dinoseb	7	MCL	.05	CCME[2]
Diphenamid	200	HA	--	--
Diuron	10	HA	--	--
Fipronil (chronic)	--	--	2.3	USEPA[5]
Fipronil (acute)	--	--	4.6	USEPA[5]
Fluometuron	90	HA	--	--
Malathion	100	HA	.1	USEPA[3, 4]
MCPA	4	HA	--	--
Methomyl	200	HA	--	--
Methyl Parathion	2	HA	--	--
Metolachlor	100	HA	7.8	CCME[2]
Metribuzin	200	HA	1	CCME[2]
Picloram	500	MCL	29	CCME[2]
Prometon	100	HA	--	--
Propachlor	90	HA	--	--
Simazine	4	MCL	10	CCME[2]
Tebuthiuron	500	HA	1.6	CCME[2]
Trifluralin	5	HA	.2	CCME[2]

[1] U.S. Environmental Protection Agency (2000a).

[2] Canadian Council of Ministers of the Environment (2001).

[3] U.S. Environmental Protection Agency (2002a).

[4] The USEPA aquatic-life criteria for malathion and chlorpyrifos are maximum concentrations to which an aquatic organism can be exposed without harmful effects, and should not be exceeded more than once every 3 years.

[5] U.S. Environmental Protection Agency (2002b).

resulting in an unacceptable effect. Numeric targets for chronic and acute TMDL's for fipronil were established primarily for fish and wildlife propagation (U.S. Environmental Protection Agency, 2002b). Acute numeric targets apply to stream mixing zones, areas defined by the Louisiana Department of Environmental Quality (2003) as "portions of water bodies where effluent waters are dispersed into receiving waters." Chronic numeric targets apply to portions of the water body outside mixing zones. Canadian water-quality guidelines for 12 pesticides were established to protect species of aquatic life.

Ecological data were summarized and compared with surface-water quality data. Water quality (app. 4), quantitative habitat (app. 5) and qualitative habitat data (app. 6 and 7) used for the statistical analyses are included in this report. When appropriate, log and square-root transformations of water-quality and habitat data and natural log transformations of aquatic invertebrate data (app. 8) were performed to approximate normal distributions.

The mean values of quantitative habitat variables for the site (reach) were used for analysis of habitat data, except euphotic and Secchi-disk depths, which were measured once for the reach. Ranked and scored values were used for bank-erosion score and bank-stability index variables so these variables could be statistically analyzed. Each reach was ranked in the same way with a score from 1 to 6 that represented the number of observed stream banks with erosion at six transect points within the reach. The bank-stability index was determined as described in Fitzpatrick and others (1998).

Aquatic invertebrate community data were processed using the Invertebrate Data Analysis System (IDAS, version 2.0.6) a program developed by Thomas Cuffney (USGS, written commun., 2001) for the compilation and analysis of NAWQA invertebrate samples. Ambiguous taxa were resolved using IDAS by combining the abundance of children (species or genus) of ambiguous parents and adding abundance to the parent (genus or family). Invertebrate taxa in the dataset that were difficult or impossible to identify, terrestrial adults, and rare taxa (occurring at only one site) were eliminated from the final analysis. Aquatic invertebrate community metrics were calculated in IDAS and statistically analyzed based on this processed dataset.

Exploratory analysis of environmental variables—water-quality and habitat data—(fig. 7) was performed using principal component analysis (PCA) to reduce the number of environmental variables (ter Braak and Smilauer, 1998). Redundant variables were removed from subsequent analyses and surrogate variables were identified to represent a group of correlated variables. Results of a correspondence analysis (CA) of the aquatic invertebrate data (ter Braak and Smilauer, 1998) showed an arch effect with sites and species grouped along the x- and y-axes, which warranted use of detrended correspondence analysis (DCA) to examine distributions of aquatic invertebrate communities (Jongman and others, 1995). Distributions of aquatic invertebrate communities at five or more sites (38 species) were investigated by DCA.

Direct gradient analysis was performed using canonical correspondence analysis (CCA) (fig. 7) to evaluate patterns among sites based on the relative abundance of aquatic invertebrates and on environmental variables (ter Braak and Smilauer, 1998). The CCA was used to establish similarity between sites based on study results and to identify important environmental variables that influenced aquatic invertebrate communities. The CCA included 36 environmental variables determined by PCA to be important from 19 sites. This determination was based on (1) results of final PCA analyses of water-quality and habitat variables (app. 9); (2) correlations between environmental variables, based on a Spearman rank correlation test with an alpha value of 0.05 (Wilkinson, Engelman, and Marcantonio, 1998); and (3) variables considered important for describing water quality and aquatic invertebrate communities in an agricultural land-use setting in southwestern Louisiana. The forward selection process of the CCA was used to test environmental variables for statistical significance ($p \leq 0.05$) using a Monte Carlo simulation before adding it to the final model (ter Braak and Smilauer, 1998).

Cluster analysis (fig. 7) was used to determine which sites had similar water quality, habitat, and aquatic invertebrate characteristics. Ward's method of hierarchical cluster analysis (Wilkinson and others, 1998) was used with a correlation matrix derived from site scores of the first two axes of the CCA. A correlation distance of 2 (cut-level) was used to determine the number of clusters, and discriminate analysis (Engelman, 1998) of cluster analysis groups was used to verify group assignment.

Environmental variables and aquatic invertebrate metrics within the study-design (*a priori*, before sampling) and CCA (*posteriori*, after sampling) site groups were compared (fig. 7). Differences in median values among site groups were determined using nonparametric statistical methods with an alpha level of 0.05. Differences were determined for large-basin (n = 11 sites) and small-basin (n = 8 sites) site groups, and for high-intensity (n = 11 sites) and low-intensity (n = 8 sites) site groups, using a two-factor analysis of variance (ANOVA) (Wilkinson and Coward, 1998) on ranked data (Helsel and Hirsch, 1992). CCA site groups (A, n = 3 sites; B, n = 4 sites; C, n = 6 sites; and D, n = 6 sites) were tested using a one-factor ANOVA on ranked data (Kruskal-Wallis test). When results from the Kruskal-Wallis test indicated significant differences, the Tukeys (Wilkinson, 1998) multiple comparison test was used on ranked data (Helsel and Hirsch, 1992) to determine which site groups were significantly different (fig. 7). Relations between significant variables and relative abundances of aquatic invertebrates at sites were examined to evaluate invertebrate relations to these variables.

WATER-QUALITY CHARACTERISTICS

Median concentrations of nutrients and concentrations of pesticides generally were lower in ground water than in surface water, but median concentrations of major inorganic ions and trace elements often were higher in ground water than in surface water. The MCL for nitrate and the SMCL's for sulfate, iron, and manganese were exceeded in ground water; the SMCL's for sodium, iron, and manganese were exceeded in surface water. Concentrations of nutrients and major inorganic ions in ground water and surface water generally were largest in the southeastern part of the study area. In ground water, concentrations of 16 pesticides and degradation products were detected but did not exceed MCL's, HA's, or aquatic-life criteria. In surface water, 59 pesticides and degradation products were detected. Concentrations of three pesticides exceeded criteria for the protection of drinking water or aquatic life, and peak concentrations of one pesticide exceeded numeric targets for TMDL's.

Nutrients

Nitrogen and phosphorus are nutrients of particular importance because they are necessary for the proper growth and development of plants, but can cause the eutrophication of lakes, streams, and rivers, and at high levels may adversely affect human health. Eutrophication is the enrichment of a water body with nutrients that can occur naturally, but most often results from discharge of wastewater effluent, or runoff from agricultural areas. Streams enriched with nutrients might be subject to excessive plant growth resulting in algal blooms and propagation of invasive aquatic plants, such as water-hyacinth and hydrilla, that contribute to recreational impairment and adverse effects on aquatic life. The USEPA (2002b) has identified Bayou Nezpique, Bayou Mallet, and Bayou des Cannes as impaired by nutrients, and Bayou Plaquemine Brule, Bayou Queue de Tortue, Bayou Lacassine, and the Mermentau River as impaired specifically by nitrogen. The USEPA (2002b) established an MCL of 10 mg/L for nitrate as nitrogen in drinking water because concentrations greater than this increase the risks of methemoglobinemia (blue-baby syndrome) (Hem, 1992). Nitrogen concentrations determined for this study include ammonia; dissolved and total ammonia plus organic nitrogen; nitrite; and nitrite plus nitrate as nitrogen. Minimum, median, and maximum concentrations of nitrogen are shown in table 4. Maximum concentrations of nutrients in surface water occurred at sites with high agricultural intensity between February and July.

Ammonium is the recommended form of nitrogen used to fertilize rice because nitrate is reduced to nitrous oxide and nitrogen gas in flooded rice fields. The highest concentrations of dissolved ammonia and dissolved ammonia plus organic nitrogen in ground and surface water occurred in the southeastern part of the study area. Although the median concentration of dissolved ammonia in surface water (0.11 mg/L) was more than three times the median concentration in ground water (0.032 mg/L) (table 4), the maximum concentration occurred in ground water (2.56 mg/L at well 41) (table 5). The maximum concentration in surface water (1.65 mg/L) occurred at Theriot (table 5), a site with high agricultural intensity. The median concentration of dissolved ammonia plus organic nitrogen in surface water (0.86 mg/L) was more than eight times the median concentration in ground water (less than 0.10 mg/L). Concentrations of dissolved ammonia greater than 0.50 mg/L and concentrations of ammonia plus organic nitrogen greater than 2.0 mg/L occurred at surface-water sites that drained areas with high agricultural intensity. The maximum concentration of dissolved ammonia plus organic nitrogen occurred in surface water (4.0 mg/L at Theriot); the maximum concentration in ground water (2.7 mg/L) occurred at well 41. Concentrations of total ammonia plus organic nitrogen were determined for surface-water samples only (table 4); the median concentration was 1.3 mg/L and the highest concentration (5.1 mg/L) occurred at Mermentau, a site with high agricultural intensity.

The median concentration of nitrite plus nitrate (nitrate) was higher in surface water (0.230 mg/L) than in ground water (less than 0.050 mg/L), but the highest concentration (12.6 mg/L) occurred in ground water (fig. 8) at well 22. Concentrations greater than 1.00 mg/L occurred at three sites (Des Cannes, Iota, and Plaquemine) with high agricultural intensity; however, the maximum concentration in surface water (3.03 mg/L) occurred at the Church Point site, a site with low agricultural intensity. The peak nitrate concentrations at Church Point may have been caused by livestock (fig. 9) and at the other three sites by fertilizer applications in fall and spring (fig. 10). The nitrate concentration at well 22 (12.6 mg/L) was the only exceedance of the USEPA (2000a) MCL for nitrate (10 mg/L) in ground- or surface-water samples. This well is shallow (30 ft), and land around the well was used previously for poultry and swine production. Leaching of animal waste may account for the nitrate concentration in the well.

Nutrients from ground water used for agricultural irrigation do not contribute significantly to eutrophication in surface water. Concentrations of nitrogen and phosphorus in samples from ground water generally were below the thresholds for total nitrogen (1.50 mg/L) and total phosphorus (0.075 mg/L) indicating eutrophic potential (Dodds and others, 1998), whereas concentrations in samples from surface water generally exceeded the thresholds. In ground water, the median concentration of total dissolved nitrogen (the sum of dissolved ammonia plus organic nitrogen and nitrite plus nitrate) was less than the sum of detection limits (0.15 mg/L) (table 4), and the median concentration of dissolved phosphorus was 0.07 mg/L (table 6). In surface water,

Table 4. Minimum, median, and maximum concentrations of selected nitrogen species for ground- and surface-water samples from the Mermentau River Basin, southwestern Louisiana, 1998-2001

[Total nitrogen includes the sum of total ammonia plus organic nitrogen and dissolved nitrite plus nitrate. Concentrations are in milligrams per liter. <, less than indicated value; NA, not available]

Month	Number of samples	Ammonia, dissolved			Ammonia plus organic nitrogen: Dissolved			Ammonia plus organic nitrogen: Total			Nitrite plus nitrate, dissolved			Total nitrogen		
		Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum
Surface water[1]																
January	9	<0.02	0.052	0.129	<0.10	0.62	0.85	0.74	1.1	1.5	0.050	0.240	0.463	0.80	1.4	1.8
February	26	<.02	.026	.257	.21	.62	1.3	.60	.98	1.7	.050	.076	3.03	.65	1.1	4.7
March	43	<.02	.126	.976	.39	.86	3.3	.66	2.0	4.8	.050	.272	.724	.71	2.4	4.9
April	44	.02	.166	.812	.11	1.2	2.7	.57	2.2	5.1	<.047	.448	.993	.91	2.9	5.5
May	37	.02	.198	1.65	.68	1.2	4.0	1.0	1.7	4.8	.042	.371	1.47	1.0	2.1	5.2
June	35	<.02	.113	.873	.58	.91	2.1	.88	1.3	2.4	.050	.199	.767	.99	1.6	2.8
July	12	.03	.093	.154	.17	.65	1.6	.79	.98	1.6	.050	.179	.557	.97	1.1	2.2
August	8	<.02	.090	.161	.43	.62	.79	.72	.87	1.0	.027	.050	.410	.77	.95	1.2
September	8	<.02	.059	.223	.50	.59	.98	.69	.82	1.3	.050	.050	.379	.74	.87	1.7
October	6	<.02	.039	.065	.46	.62	.65	.69	.84	1.1	<.047	.066	.221	.74	.98	1.2
November	9	<.02	.101	.262	.41	.70	.96	.43	.92	1.3	.050	.210	.667	.64	1.1	2.0
December	9	<.02	.041	.231	.44	.67	.91	.65	.90	1.5	.026	.124	.423	.70	1.2	1.9
All samples	246	<.02	.110	1.65	<.10	.86	4.0	.43	1.3	5.1	[2].026	.230	3.03	.64	1.6	5.5
Ground water[3]																
All samples	29	<.02	.032	2.56	<.10	<.10	2.7	NA	NA	NA	<.047	<.050	12.6	NA	NA	NA

[1] Samples were collected more than once November 1998-September 2001.

[2] Minimum detected concentration.

[3] Samples were collected once between January 2000 and January 2001.

the median concentration of total nitrogen (the sum of total ammonia plus organic nitrogen and dissolved nitrite plus nitrate) was greater than the eutrophic threshold March-June and December, and the median concentration of total phosphorus was greater than the eutrophic threshold throughout the year. Thus, the greatest potential for eutrophic conditions in surface water, based on nutrient concentrations, existed March-June, about the same time ricefields were drained, and December, shortly after fertilizers were applied.

Table 5. Maximum concentrations and occurrence of selected nutrients in ground water and surface water in the Mermentau River Basin, southwestern Louisiana, 1998-2001
[Concentrations are in milligrams per liter. NA, not applicable]

	Ground water		Surface water	
Nutrient	Concentration	Well number	Concentration	Site name
Dissolved ammonia	2.56	41	1.65	Theriot
Dissolved ammonia plus organic nitrogen	2.7	41	4.0	Theriot
Nitrite plus nitrate, dissolved	12.6	22	3.03	Church Point
Dissolved phosphorus	.445	41	1.33	Church Point
Orthophosphorus, dissolved	.249	24	1.20	Church Point
Total phosphorus	NA	NA	1.83	Church Point

Table 6. Minimum, median, and maximum concentrations of selected phosphorus species for ground- and surface-water samples from the Mermentau River Basin, southwestern Louisiana, 1998-2001
[Concentrations are in milligrams per liter. <, less than indicated value; E, estimated; NA, not analyzed]

	Dissolved phosphorus			Orthophosphorus			Total phosphorus		
Month	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum
					Surface water[1]				
January	0.020	0.095	0.155	0.010	0.072	0.116	0.078	0.198	0.344
February	.018	.062	.715	.010	.042	.642	.057	.204	.697
March	.012	.066	1.33	<.010	.055	1.20	.034	.469	1.83
April	.014	.091	.650	E.016	.055	.550	.004	.419	1.18
May	.015	.114	.631	.013	.077	.623	.057	.286	.745
June	.055	.130	.477	.016	.099	.416	.164	.288	.795
July	.055	.108	.143	.035	.088	.122	.179	.236	.329
August	.079	.091	.147	.061	.072	.121	.189	.210	.238
September	.023	.117	.183	.010	.090	.161	.096	.222	.332
October	.032	.082	.098	.020	.064	.078	.110	.175	.223
November	.030	.077	.188	.016	.057	.170	.081	.173	.381
December	.019	.081	.120	.014	.051	.108	.068	.191	.382
All samples	.012	.094	1.33	<.010	.066	1.20	.004	.266	1.83
					Ground water[2]				
All samples	E.003	.070	.445	<.010	.056	.249	NA	NA	NA

[1] Samples were collected more than once November 1998-September 2001.

[2] Samples were collected once between January 2000 and January 2001.

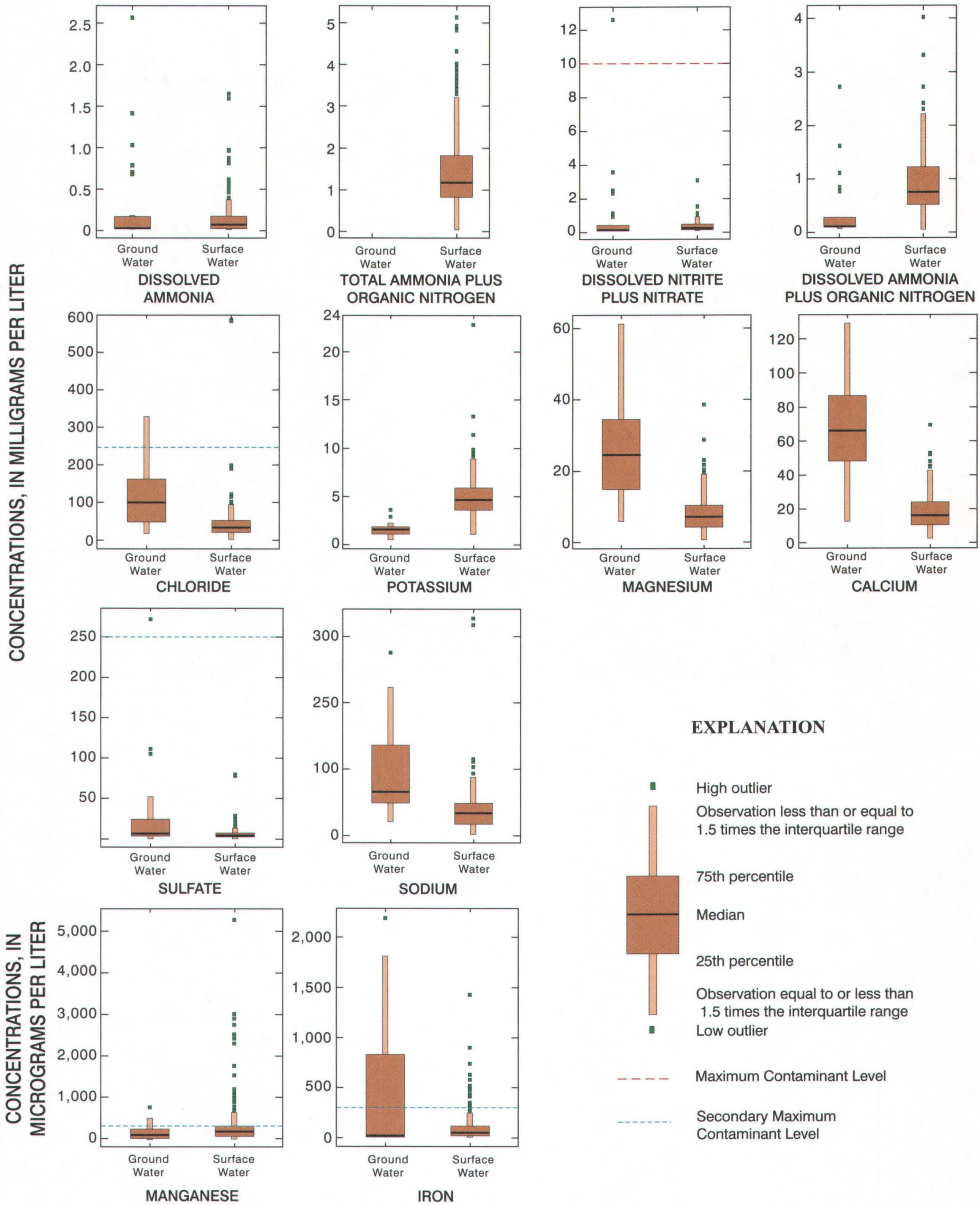


Figure 8. Concentrations of selected nutrients and major inorganic ions in ground water and surface water from the Mermentau River Basin, southwestern Louisiana 1998-2001. Maximum Contaminant Levels and Secondary Maximum Contaminant Levels established by the U.S. Environmental Protection Agency (2000a).

Photograph by Dennis K. Demcheck, U.S. Geological Survey, 2001

Figure 9. Grazing livestock near a surface-water data-collection site in the Mermentau River Basin, southwestern Louisiana.

Comparisons between thresholds and the concentrations determined during the sampling period should be made carefully for the following reasons:

1. Nutrient concentrations greater than the thresholds might not cause excessive or nuisance plant growth immediately, because other factors such as turbidity and stream shading affect light penetration, and influence photosynthesis and aquatic-plant productivity. Downstream, these factors might become more favorable for eutrophic conditions to occur.
2. Drought and streamflow conditions that occurred during the sampling period may not represent long-term conditions (fig. 6).
3. Nutrient thresholds are probably lower for subtropical streams, including those found in the study area, than for the more northern temperate streams for which they were developed (Walter Dodds, Kansas State University, written commun., June 6, 2002).

Phosphorus exists in natural water in several forms but transformation pathways for phosphorus are not as numerous as those for nitrogen. Most phosphorus in aquatic systems is not available for biological uptake because the solubility of phosphorus is relatively low and phosphorus adsorbs strongly to particles. Concentrations of dissolved phosphorus and orthophosphorus in ground water and surface water, and total phosphorus in surface water were determined for this study and are listed in table 6.

The median concentration of dissolved phosphorus was 0.070 mg/L in ground water and 0.094 mg/L in surface water (table 6). The highest concentrations of phosphorus in surface water occurred February-June. Concentrations greater than 0.25 mg/L were detected at

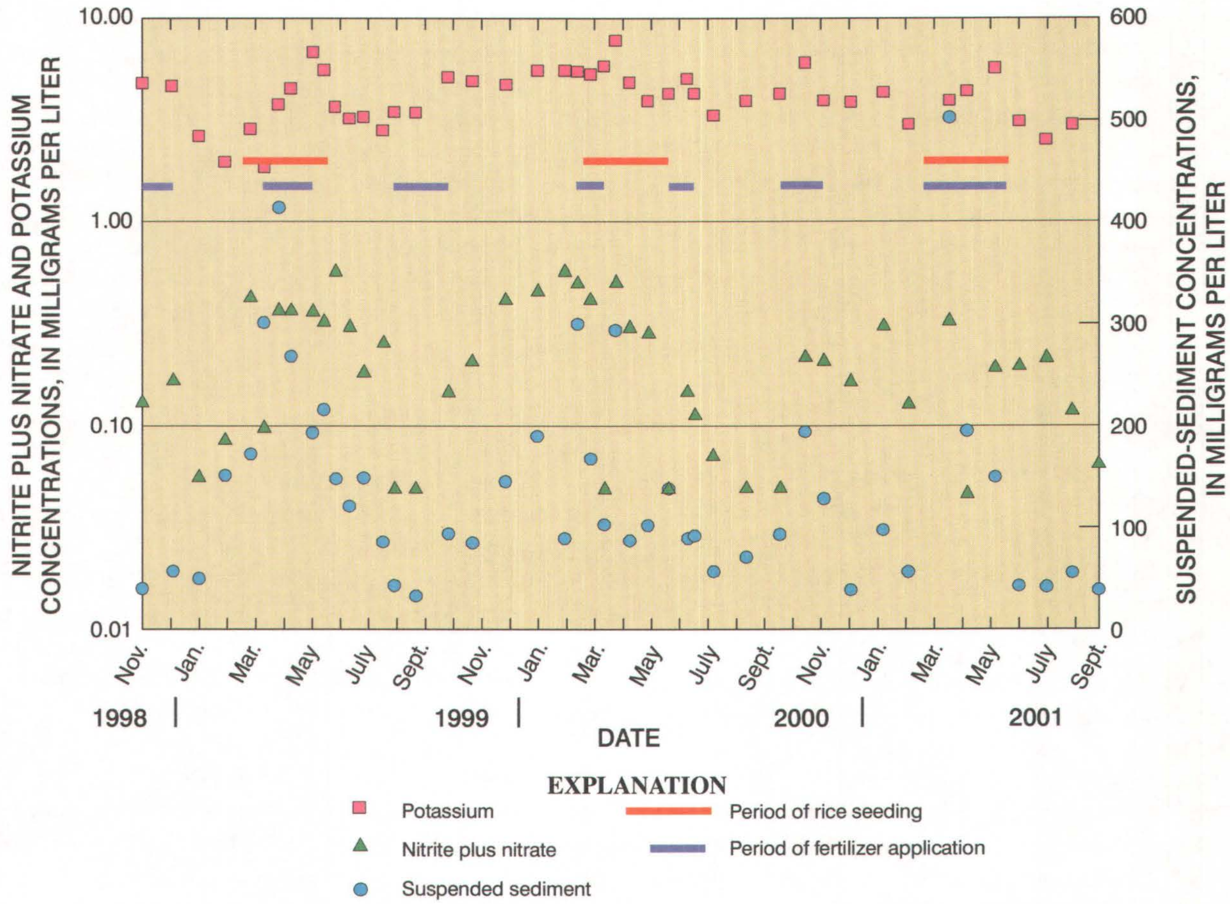


Figure 10. Concentrations of nitrite plus nitrate, potassium, and suspended sediment at the Mermentau data-collection site in the Mermentau River Basin, southwestern Louisiana, 1998-2001.

six sites in the eastern half of the study area: Plaquemine, Wikoff, Grand Marais, Mallet, Church Point, and Theriot. The highest concentration of dissolved phosphorus (1.33 mg/L) was detected in surface water at the Church Point site and was more than four times the maximum concentration in ground water (0.445 mg/L at well 41). The median concentration of orthophosphorus was 0.056 mg/L in ground water and 0.066 mg/L in surface water. Concentrations greater than 0.25 mg/L were detected at six sites: Chene, Plaquemine, Wikoff, Grand Marais, Church Point, and Theriot. The highest concentration of orthophosphorus (1.20 mg/L) was detected in surface water at the Church Point site (table 5), and was more than four times the maximum concentration in ground water (0.249 mg/L at well 24). Orthophosphorus was not detected at three of the northernmost sites with low agricultural intensity, Boggy, Caney, and Castor. Total phosphorus concentrations were determined for surface-water samples only and correlate positively with suspended-sediment concentrations (Pearson r = 0.72). The maximum concentration (1.83 mg/L) occurred at the Church Point site. The median concentration of total phosphorus was 0.266 mg/L. Concentrations greater than 1.00 mg/L were detected at three sites: East Lacassine, Blue, and Church Point. Elevated concentrations of phosphorus in ground water may result from marine deposits (Hem, 1992) or agriculture, and in surface water may result from agriculture. The Church Point site drains a large area with low agricultural intensity, and grazing livestock may have caused the relatively high phosphorus concentration. In a previous study, Demcheck (1994) found similar results for Church Point and suggested the elevated phosphorus concentrations might result from runoff of agricultural fertilizer. The highest phosphorus concentrations coincide with fertilizer applications in mid-spring and late fall.

Major Inorganic Ions and Trace Elements

Dissolved concentrations of 7 major inorganic ions were determined for ground- and surface-water samples, and dissolved concentrations of 16 trace elements were determined for samples from all wells and one surface-water site, Mermentau. Concentrations of major inorganic ions and trace elements were compared with MCL's and SMCL's (U.S. Environmental Protection Agency, 2000a). MCL's were established to protect public health by limiting the levels of contaminants in drinking water; SMCL's were established to limit cosmetic (for example, skin or tooth discoloration) or aesthetic affects (for example, taste, odor, or color) in drinking water. No MCL's were exceeded in either ground- or surface-water samples; however, one or more SMCL's were exceeded in samples from 20 wells and all the surface-water sites (fig. 8). Concentrations of antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, selenium, and thallium generally were below detection limits, but when detected did not exceed MCL's.

Median concentrations of calcium and magnesium in ground water were more than three times the median concentrations in surface water (fig. 8). The median concentrations for calcium and magnesium in ground water were 66.0 mg/L and 25.2 mg/L; maximum concentrations occurred at well 35 (129 mg/L) and well 8 (61.1 mg/L). The median concentrations for calcium and magnesium in surface water were 15.9 mg/L and 7.02 mg/L; maximum concentrations occurred at Theriot (69.3 mg/L) and Lacassine (38.5 mg/L), sites with high agricultural intensity (table 7).

Median potassium concentrations were about three times higher in surface water than in ground water (fig. 8). The maximum and median potassium concentrations in ground water were 3.61 mg/L and 1.52 mg/L and in surface water were 22.8 mg/L and 4.31 mg/L. The maximum concentration detected in ground water was at well 10 and in surface water was at Theriot (table 7). Potassium concentrations in surface water peaked twice annually (fig. 10), in mid-spring and late fall; peaks probably were caused by runoff from fertilizer applications and by re-solution of detrital plant material (Hem, 1992).

Median concentrations of sodium and chloride (fig. 8) were higher in ground water than in surface water, but the highest concentrations of both constituents occurred in surface water (fig. 8). The median sodium concentration in ground water was 64.3 mg/L and the median chloride concentration was 101 mg/L; the highest concentrations were 275 mg/L at well 7, and 328 mg/L at well 22 (table 7). Chloride concentrations in ground water exceeded the SMCL (250 mg/L) (U.S. Environmental Protection Agency, 2000a) in four wells: well 35 (264 mg/L), well 25 (281 mg/L), well 7 (293 mg/L), and well 22 (328 mg/L). The median chloride and sodium concentrations in surface water were 33.4 mg/L and 33.0 mg/L. The maximum concentrations of sodium (327 mg/L) and chloride (586 mg/L) in surface water occurred at Lacassine (table 7) in March 2000 and probably resulted from saltwater intrusion induced by flow reversal (bidirectional) during the drought. The chloride concentration exceeded the SMCL (U.S. Environmental Protection Agency, 2000a).

Table 7. Maximum concentrations and occurrence of selected major inorganic ions in ground water and surface water in the Mermentau River Basin, southwestern Louisiana, 1998-2001

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Major inorganic ion	Ground water		Surface water	
	Concentration	Well number	Concentration	Site name
Calcium, in mg/L	129	35	69.3	Theriot
Magnesium, in mg/L	61.1	8	38.5	Lacassine
Potassium, in mg/L	3.61	10	22.8	Theriot
Sodium, in mg/L	275	7	327	Lacassine
Chloride, in mg/L	328	22	586	Lacassine
Alkalinity as calcium carbonate, in mg/L	546	10	380	Theriot
Sulfate, in mg/L	272	10	79.2	Lacassine
Iron, in µg/L	2,190	49	1,430	Chene
Manganese, in µg/L	739	9	5,270	Boggy

The median value for alkalinity in ground water was more than three times that in surface water. The maximum and median values were 546 mg/L and 302 mg/L in ground water, and 380 mg/L and 82 mg/L in surface water. The highest value in ground water was at well 10 and in surface water at Theriot (table 7).

Median and maximum sulfate concentrations were higher in ground water than in surface water (fig. 8). In ground water, the median concentration was 6.1 mg/L; the maximum concentration (272 mg/L) occurred at well 10 and was the only concentration to exceed the SMCL (250 mg/L) (U.S. Environmental Protection Agency, 2000a). In surface water, the median concentration was 4.55 mg/L, and the maximum concentration occurred at Lacassine (79.2 mg/L) during March 2000.

Iron concentrations exceeded the SMCL (300 µg/L) (U.S. Environmental Protection Agency, 2000a) in ground water and surface water (fig. 8). Although the median iron concentration in ground water (20 µg/L) was one-third the median in surface water (60 µg/L), the highest concentration occurred in ground water. In seven wells, iron concentrations exceeded the SMCL; the maximum (2,190 µg/L) occurred at well 49. Iron concentrations in surface water exceeded the SMCL at eight sites: Blue, Lacassine, Mermentau, Boggy, East Lacassine, Caney, Castor, and Chene; the maximum, 1,430 µg/L, occurred at Chene in May 2000 (table 7).

Manganese concentrations exceeded the SMCL (50 µg/L) (U.S. Environmental Protection Agency, 2000a) in ground water and surface water. The median manganese concentration in ground water (121 µg/L) was less than the median in surface water (150 µg/L). The maximum concentration in surface water was more than seven times the maximum in ground water (table 7). Manganese concentrations exceeded the SMCL in 17 wells. Manganese concentrations in ground water exceeding the SMCL ranged between 52.8 µg/L and 739 µg/L; the maximum occurred at well 9. Manganese concentrations exceeded the SMCL at all surface-water sites and were highest at Blue, Caney, Boggy, and Castor, in the northwestern part of the study area; the maximum (5,270 µg/L) occurred at Boggy. Manganese leached from geologic deposits may cause the higher concentrations.

Pesticides

Fewer pesticides were detected in ground water than in surface water. Thirty-eight percent of the samples collected from wells contained at least one pesticide, and all surface-water samples contained at least three pesticides. Pesticide concentrations in ground water did not exceed criteria for drinking water or the protection of aquatic life (fig. 11). In surface water, however, concentrations of atrazine, malathion, and tebuthiuron exceeded

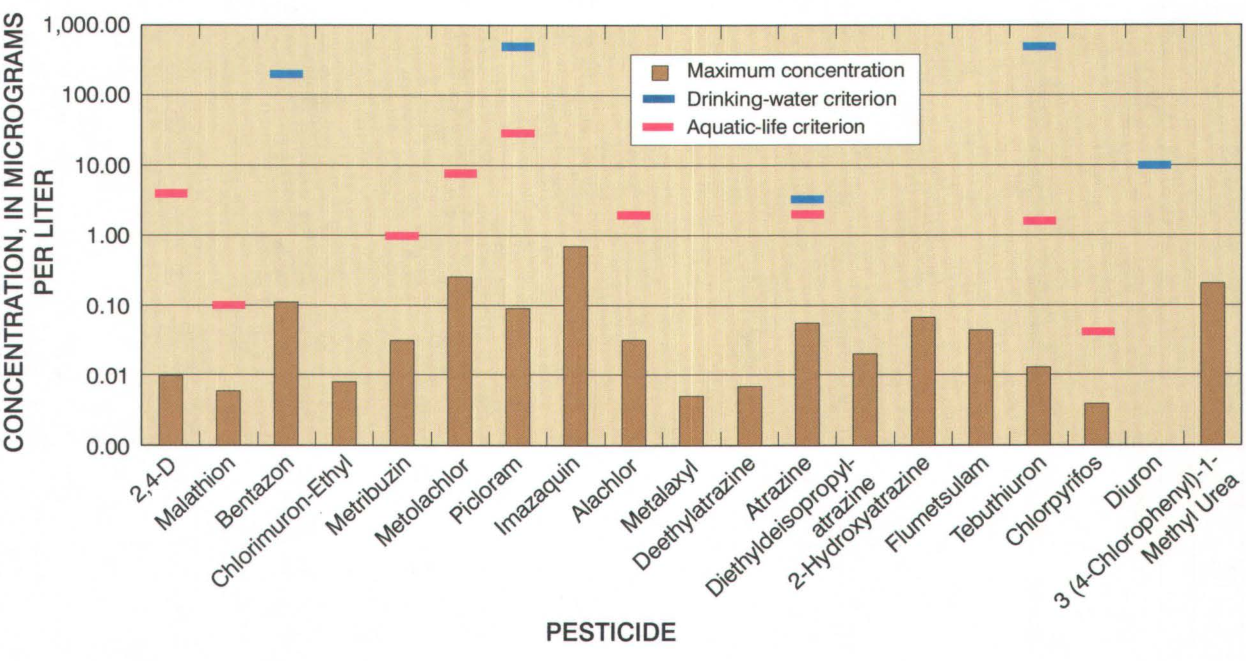


Figure 11. Drinking-water and aquatic-life criteria, and maximum detected concentrations of selected pesticides in ground water in the Mermentau River Basin, southwestern Louisiana, 2000-2001 (Diuron was detected, but concentration was not quantified).

criteria for the protection of drinking water or aquatic life (fig. 12). Concentrations of fipronil exceeded USEPA (2002b) numeric targets for TMDL's (table 3). Although atrazine concentrations in three samples collected in the spring exceeded 3 µg/L, the MCL (U.S. Environmental Protection Agency, 2000a) was not exceeded because it is based on an annual average of quarterly samples. Concentrations larger than 3 µg/L were not detected in samples collected during other times of the year, and the average annual concentrations did not exceed 3 µg/L for sites sampled throughout the year.

Concentrations were determined for 109 pesticides and degradation products in samples from 29 wells. Concentrations were detected in less than 1 percent (25) of the analyses for ground-water samples; 19 pesticides and degradations products were detected (fig. 11). Pesticides and degradation products were detected in samples from 11 wells; samples from wells 6 and 35 each accounted for 24 percent of the detections. Pesticides and degradation products detected most frequently were the herbicides bentazon (3 detections) and atrazine (5 detections).

Concentrations were determined for 109 pesticides and degradation products in surface-water samples; concentrations were detected in 20 percent of these analyses. Concentrations of 47 pesticides and degradation products were detected in surface water; at least 3 pesticides were detected in all samples. Annual maximum concentrations of different pesticides and pesticide degradation products usually occurred during the spring, about the time ricefields were drained, as shown in figure 13 for the Mermentau site. More than 190 samples collected from 24 surface-water sites were analyzed for 51 hydrophilic pesticides and degradation products (app. 2); 28 pesticides were detected. A total of 36 samples collected from Des Cannes, Lacassine, and Mermentau sites were analyzed for 58 hydrophobic pesticides and degradation products. Nineteen pesticides were detected, and at least 3 were detected in more than 70 percent of the samples.

The herbicides atrazine, molinate, and tebuthiuron, and the insecticide fipronil were detected in samples collected from all surface-water sites. Herbicides were detected more frequently and in larger concentrations than insecticides. Atrazine occurred in over 92 percent of the samples; concentrations in 3 samples exceeded the criterion (3 µg/L) for drinking water, and concentrations in 10 samples exceeded the criterion for the protection of aquatic life (1.8 µg/L). Molinate occurred in more than 86 percent of the samples and at the largest concentration (154 µg/L) for any of the pesticides detected in the study area. Tebuthiuron and malathion each were detected once in concentrations exceeding criteria for the protection of aquatic life. Fipronil concentrations at 17 sites exceeded the freshwater chronic numeric target concentration for TMDL of 2.3 µg/L (table 3), and at 3 sites exceeded the acute numeric target concentration for TMDL of 4.6 µg/L (U.S. Environmental Protection Agency, 2002b).

Atrazine is the most commonly used herbicide in the United States (Hayes and others, 2002). Two atrazine degradation products, 2-hydroxyatrazine and deethylatrazine, were detected in 83 and 90 percent of the samples. Although concentrations at Riceville (5.23 µg/L) and Lacassine (5.83 and 8.91 µg/L) exceeded 3 µg/L, the USEPA (2000a) MCL (3 µg/L) was not exceeded because it is based on an annual average of quarterly samples. Concentrations at Riceville, Mermentau, and Lacassine exceeded the criterion for the protection of aquatic life (1.8 µg/L). There is some evidence that atrazine disrupts the endocrine system in some amphibians at concentrations less than 1 µg/L (Hayes and others, 2002). Concentrations greater than 1 µg/L were detected at Des Cannes, Mermentau, Riceville, Lake Arthur, Lacassine, Tortue, Church Point, and Mallet sites. Concentrations greater than 0.1 µg/L were detected at all sites except Boggy, Castor, Blue, Upper Des Cannes, and Caney.

Tebuthiuron, a urea-based broad-spectrum herbicide, is used to control weeds in rights-of-way, industrial sites, and rangeland (Oregon State University, 1996). Tebuthiuron was detected at all the surface-water sites and in 95 percent of all surface-water samples. The largest concentration (6.33 µg/L) was detected at the Des Cannes site and was the only detection exceeding the criterion (1.6 µg/L) for the protection of aquatic life (table 3).

Malathion, an organophosphate insecticide, is used for public health mosquito control (U.S. Environmental Protection Agency, 2000b), recommended for control of household insects by homeowners (Louisiana State University Agricultural Center, 2002), and recommended for control of stinkbugs associated with rice agriculture (Louisiana State University Agricultural Center, 2001). Malathion was detected at 16 surface-water sites; the largest concentration (0.113 µg/L) occurred at the Lacassine site and was the only detection that exceeded the criterion (0.1 µg/L) for the protection of aquatic life (table 3).

In 1999, carbofuran was replaced with fipronil, a relatively new phenypyrazole insecticide, to control the rice water weevil. Carbofuran was sprayed in areas where the rice water weevil was observed, whereas fipronil is used prophylactically as a seed coating prior to planting (fig. 13). Fipronil was detected in more than

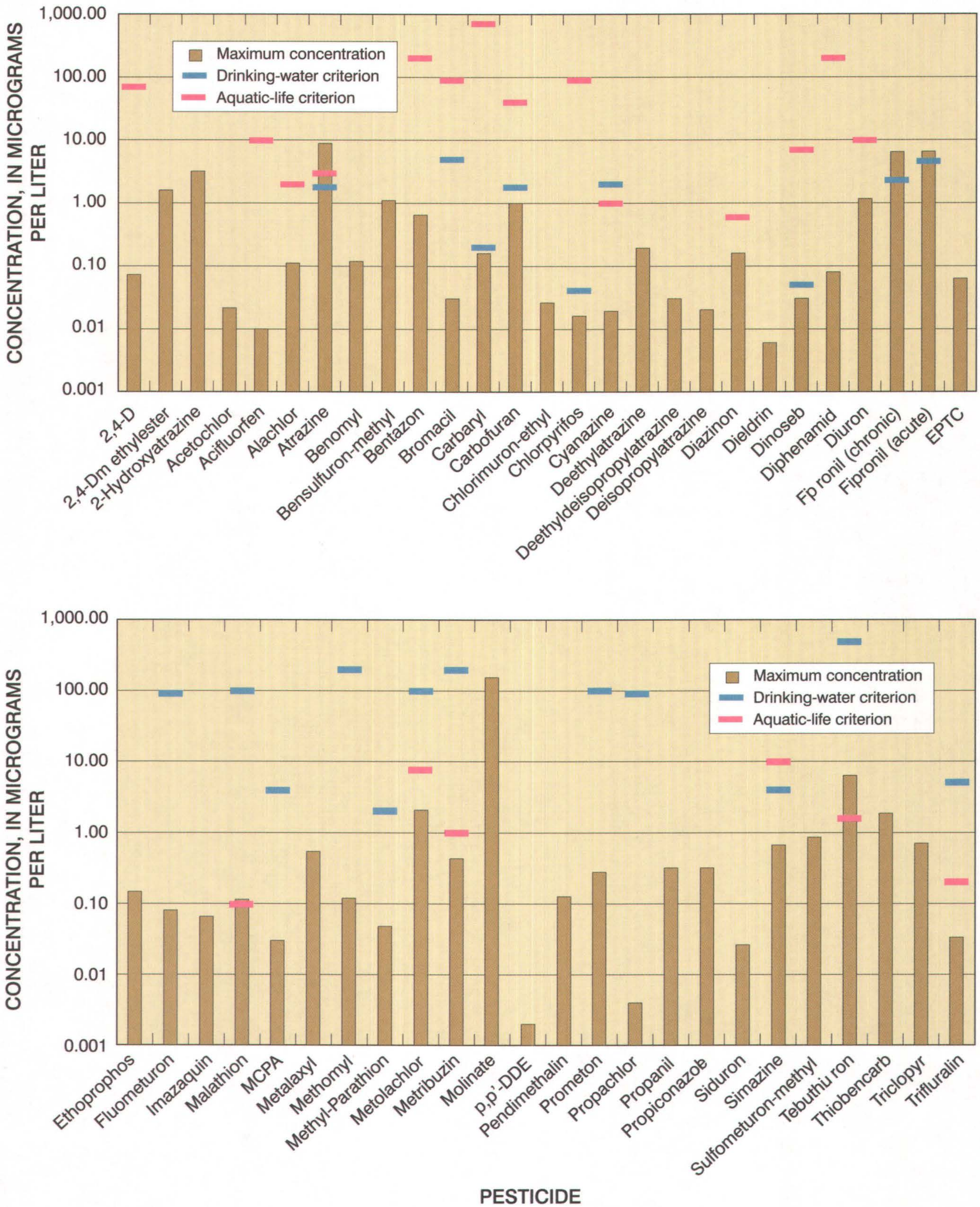


Figure 12. Drinking-water and aquatic-life criteria, and maximum detected concentrations of selected pesticides in surface water in the Mermentau River Basin, southwestern Louisiana, 1998-2001.

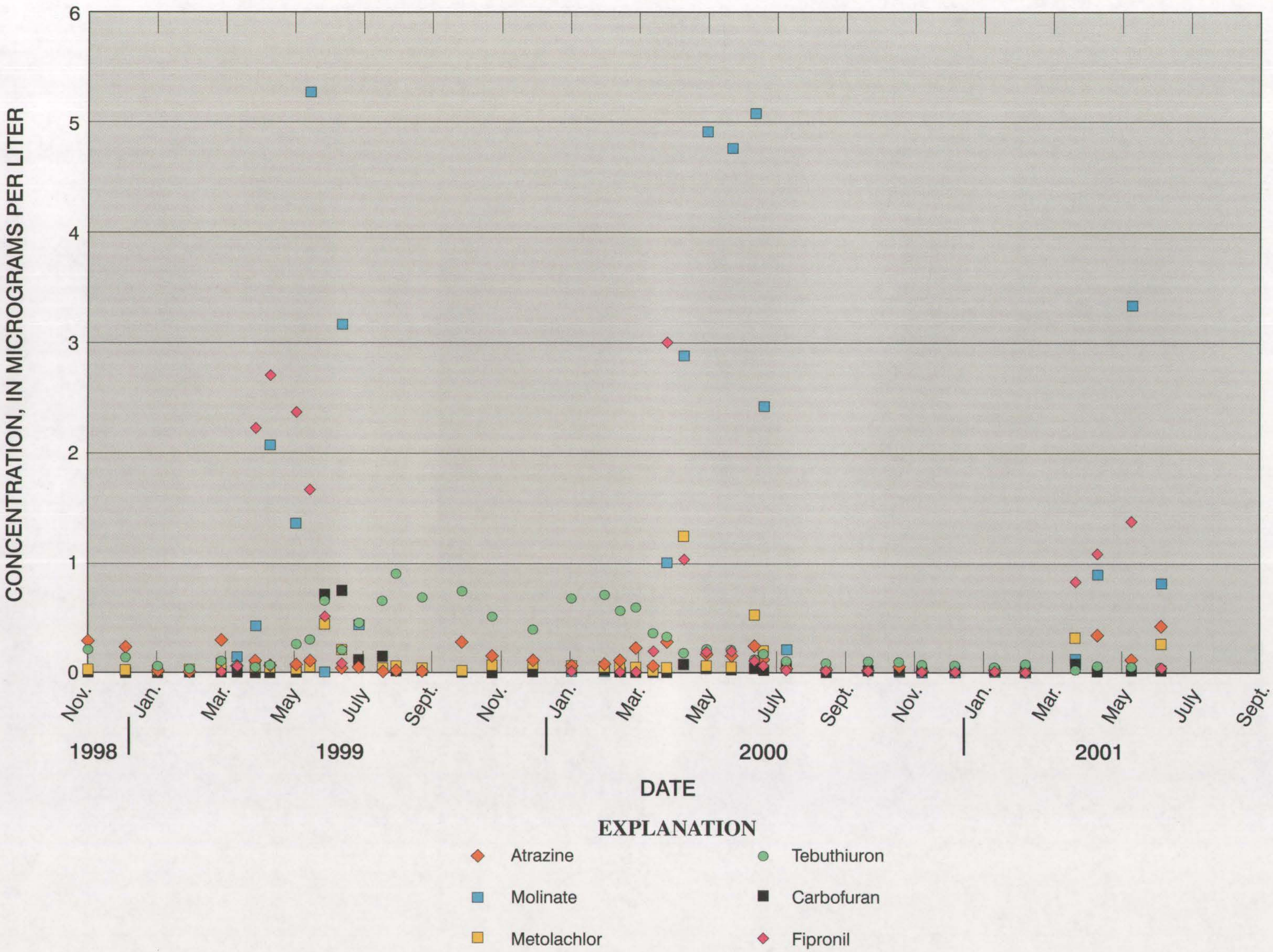


Figure 13. Concentrations of selected pesticides at the Mermentau data-collection site in the Mermentau River Basin, southwestern Louisiana, 1998-2001.

72 percent of the surface-water samples. Maximum concentrations of fipronil and degradation products occurred in the headwaters of small bayous surrounded by rice agriculture during March and April, which coincided with the release of ricefield tailwaters (Demcheck and Skrobialowski, 2003). Concentrations of fipronil at surface-water sites (app. 3) ranged from less than 0.004 μg/L to 6.41 μg/L and exceeded the freshwater acute numeric target for TMDL (4.6 μg/L) at Grand Marais (5.19 μg/L), East Lacassine (5.29 μg/L), and Blue (6.41 μg/L), and the chronic numeric target for TMDL (2.3 μg/l) (U.S. Environmental Protection Agency, 2002b) at 14 other surface-water sites. Fipronil can be degraded by several pathways into at least six degradation products, four of which were analyzed for and detected in this study: RPA 105048, fipronil sulfone, fipronil sulfide, and desulfinylfipronil. Each of the reported degradation products occurred in more samples than the parent compound. Fipronil sulfone, fipronil sulfide, and desulfinylfipronil are more persistent and toxic to some aquatic life than the parent compound (Connelly, 2001). Fipronil is toxic to hatchling crawfish at concentrations as low as 4.95 μg/L and toxic to large crawfish at 43.5 μg/L (Ottea and Romaire, 2001). Fipronil concentrations as low as 0.005 μg/L can affect survival, reproduction and growth of estuarine shrimp (U.S. Environ-mental Protection Agency, 1996). The USEPA (1996) also states

1. Fipronil sulfone is 3.3 times more toxic to native bluegill sunfish than the parent compound;
2. Fipronil sulfone is 6.6 times more toxic and fipronil sulfide is 1.9 times more toxic to freshwater invertebrates than the parent compound; and
3. Desulfinylfipronil is extremely stable and is more toxic than the parent compound.

Demcheck and Skrobialowski (2003) also found that fipronil rapidly degrades within the water column, usually within 3 months. Desulfinylfipronil is the primary degradation product in the water column, whereas fipronil sulfone and fipronil sulfide are predominant in bed sediment.

Bed-sediment samples collected at 17 surface-water sites in 2000 were analyzed for hydrophobic pesticides. Of the 39 pesticides analyzed, only degradation products from DDT and fipronil were detected. Degradation products from DDT, mostly DDE, were detected in bottom material from 10 sites (Goree and others, 2002). Concentrations of DDE at Des Cannes and the Church Point site exceeded interim freshwater sediment quality guidelines (1.42 μg/kg) for the protection of aquatic life (Canadian Council of Ministers of the Environment, 1999). Of the fipronil degradation products, concentrations of fipronil sulfide were highest and were detected at all 17 sites, fipronil sulfone was detected at 16 sites, and desulfinylfipronil was detected at 17 sites. Demcheck and Skrobialowski (2003) concluded fipronil degradation products in bed sediment accumulate and concentrations generally increase from headwater streams to the mainstem of the Mermentau River. Guidelines are not available (2002) to evaluate the environmental effects of fipronil and fipronil degradation products in bed sediment.

ECOLOGICAL INDICATORS OF SURFACE-WATER QUALITY

Results of ANOVA testing of study-design and CCA site groups indicated that habitat characteristics including channel size and morphology, water clarity, open canopy, and substrate differed between streams in the northern and southern parts of the study area. In the northern part of the study area, characterized by low agricultural intensity, streams drain a transitional zone where mixed pine hardwood forests change to wet prairie. These small streams with incised channels were typically clear, with little open canopy, and contained fine sand to clay substrates with abundant woody debris. In the southern part of the study area, characterized by high agricultural intensity, streams drain treeless wet prairie where an impermeable clay layer (hardpan) prevents vertical drainage of surface water and growth of tree roots. Where the hardpan is discontinuous, water cypress-tupelo hardwoods grow along flood plains and wetlands, which may contain submerged and emergent macrophytes (aquatic plants). These large, wide streams typically were turbid, had open canopy, and contained organic-rich silt and clay substrates with some woody debris.

Stream habitat ratings were based on the total of 10 habitat parameter scores using the RBP habitat characterization (Barbour and others, 1999). Scores increase as habitat quality increases. Ratings at 16 of 19 sites ranged from suboptimal (102-154) to optimal (155-200) for biological communities (app. 6 and 7). Theriot, Tortue, and Grand Marais sites were rated as marginal (49-101) for biological communities because of disturbances in the habitat. Heavy deposits of sediment in the stream at these sites may affect availability of aquatic invertebrate habitat by decreasing potential colonization locations because of silt- and clay-coated woody debris. At Tortue and Grand Marais, the streams have been channelized and lack the microhabitat diversity normally present at other similar-size stream reaches studied. Decreased bank stability at Tortue and the reduced riparian vegetative zone at Grand Marais also contributed to lower RBP habitat scores for these sites.

Typically, organisms considered tolerant of turbidity, organic enrichment, and low dissolved-oxygen concentrations were common in the entire study area and dominated the overall aquatic invertebrate community. Sensitive taxa such as Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) were rare at all sites in the Mermentau River Basin and were only abundant at the Whisky site in the Calcasieu River Basin. Tolerant taxa abundant throughout the Mermentau River Basin included Diptera (true flies), especially the family Chironomidae (midges); Tubificida (aquatic worms); the tolerant Ephemeroptera family Caenidae (caenids); and the Gastropoda (snails, limpets) family Physidae (pouch snails).

A total of 22,678 aquatic invertebrates were collected at ecological data-collection sites, including 95 species, 80 genera, and 43 families. Taxon groups of Diptera were the most common (40 species), followed by Coleoptera (beetles; 14 species), Trichoptera (7 species), Ephemeroptera (6 species), and Gastropoda (5 species). Greater than 80 percent of all sampled aquatic invertebrates were accounted for by the orders Diptera (46 percent), Amphipoda (scuds, sideswimmers; 18 percent), Tubificida (7 percent), Ephemeroptera (6 percent), and Gastropoda (5 percent) (app. 8).

Comparison of Site Groups

The study design, based on drainage area and agricultural land-use intensity, was used to determine natural and human-related influences on surface-water quality at 19 ecological data-collection sites. Aquatic invertebrate communities were used as ecological indicators of water quality and habitat conditions at these sites. Through CCA, four significant ($p \leq 0.05$) environmental variables (instream cover score, percentage of open canopy, and concentrations of dissolved oxygen and maximum dissolved fipronil) were identified that described the distribution of aquatic invertebrate communities among ecological data-collection sites. Cluster analysis of CCA site scores from the first two axes identified four site groups which separated ecological data-collection sites geographically within the study. Environmental variables and aquatic invertebrate metrics within the study-design (*a priori*, before sampling) and CCA (*posteriori*, after sampling) site groups were compared (fig. 7).

Study-Design Site Groups

The study was designed to determine significant differences in chemical, biological, and physical habitat indicators of surface-water quality among (1) basin site groups (large and small), and (2) intensity site groups (high and low agricultural intensity). Low-intensity sites were used to characterize natural chemical, biological, and physical habitat conditions. Site groups were compared to evaluate aquatic invertebrate relations to environmental variables.

Stream Habitat Characteristics

Significant statistical differences ($p \leq 0.05$) in stream habitat characteristics occurred between basin and intensity site groups (table 8). Bank erosion scores and bankfull and wetted channel widths differed between basin site groups, whereas the bank stability index and pool substrate differed between intensity site groups. Differences in bank characteristics, channel width, and pool substrate may account for some differences in aquatic invertebrate communities among site groups.

Generally, median bank erosion scores and median measurements of bankfull and wetted channel widths were greatest at sites with large drainage areas. Median bank erosion scores at large-basin sites were 2.5 times the scores at small-basin sites. Median bankfull and wetted channel widths at large-basin sites were at least two times the median at small-basin sites.

Generally, the median bank stability index and pool substrate characterization score were lowest at all site groups with high agricultural intensity. The bank stability index (Fitzpatrick and others, 1998) was used to assess stream bank structure among site groups and included bank measurements of angle, vegetative cover, height, and substrate. A higher bank stability index indicated a less stable bank. Eighty percent of the sites were classified as having unstable banks. High-intensity sites had greater bank stability (smaller median bank stability index) than low-intensity sites. Differences in the bank stability index between intensity site groups were attributed to differences in bank height. As bank height increased the bank stability index increased. The median pool substrate characterization score at low-intensity sites was more than 1.5 times the score at high-intensity sites. The high-intensity sites had mud- or clay-dominated pool substrate containing few or no root mats and little or no submerged vegetation. Pool substrate at low-intensity sites was fine sand mixed with mud or clay with some root mats and submerged vegetation.

Table 8. Median stream habitat variables for study-design site groups in southwestern Louisiana, 2001

[Boldface values indicate significant differences ($p \leq 0.05$) among site groups. Pool substrate characterization protocols from Barbour and others (1999). n, number of sites; RBP, Rapid Bioassessment Protocols (Barbour and others, 1999)]

Stream habitat variables	Basin site groups		Intensity site groups	
	Large (n=11)	Small (n=8)	High (n=11)	Low (n=8)
	Quantitative measurements			
Bank angle (degrees)	49	48	**53**	**43**
Bank erosion score	**5**	**2**	4	3
Bank height (meter)	3.1	2.0	**1.3**	**3.2**
Bank stability index	13	12	**11**	**13**
Bankfull channel width (meter)	**28.6**	**14.3**	21.6	20.3
Wetted channel width (meter)	**20.4**	**6.8**	16.2	9.2
	Qualitative measurements (score)			
Pool substrate characterization (0-20)	13	9	**9**	**15**
RBP total site score (0-200)	142	149	142	163

Aquatic Invertebrate Communities

Significant statistical differences ($p \leq 0.05$) in aquatic invertebrate community metrics occurred between basin and intensity site groups (table 9). Generally, aquatic invertebrate community structures were significantly different based on the percentage of noninsects, abundance of midge taxa, abundance and percentage of feeding groups, and number of tolerant organisms between intensity site groups. A significant interaction between drainage area and agricultural intensity is evident in the percentage of noninsects and the percentage of collector-gatherer taxa. The percentage of noninsects, notably Amphipods and Gastropods, was largest in large-basin sites with high intensity. Highest abundances of total aquatic invertebrates occurred at low-intensity sites regardless of drainage area. The abundance of midges, particularly the percentage of Tanytarsini midges, largely accounts for the differences in abundance of total aquatic invertebrates (total abundance) between intensity site groups. Diversity metrics were similar within basin and intensity site groups. Percentages of collector-gatherers, notably Orthocladiinae midges, generally were higher at small-basin sites, particularly those with high agricultural intensity. The abundance of omnivores was higher and percentage of shredder taxa was lower at low-intensity sites. The abundance-weighted tolerance (biotic index) was consistent with composition metrics and indicated the most tolerant organisms typically were present at high-intensity sites.

The largest differences in percentages of predominant groups occurred between intensity site groups (fig. 14). All predominant groups except Diptera, Malacostraca, and Oligochaeta varied by less than 7 percent between large- and small-basin and between high- and low-intensity site groups. Diptera dominated low-intensity sites regardless of drainage area. Low-intensity sites had 22 percent more Diptera and 18 percent fewer Malacostraca than high-intensity sites. Malacostraca, particularly more tolerant Amphipods such as *Hyalella azteca* and the Gastropoda families Physidae and Planorbidae (orb snails), dominated large-basin sites with high intensity. Oligochaeta, especially tubificids, were more abundant at small-basin sites than at large-basin sites.

Median abundance of aquatic invertebrates, midges, and Tanytarsini midges varied between intensity site groups (fig. 15, table 9). Generally, abundances doubled from high- to low-intensity sites regardless of drainage area. The abundance of Tanytarsini midges was expected to decrease with increased perturbation at a site (Barbour and others, 1999). The percentage of Tanytarsini midges remained the same between large- and small-basin sites but increased from 4 percent at the high-intensity sites to 16 percent at the low-intensity sites (table 9). The smaller abundance of total aquatic invertebrates, midges, and Tanytarsini midges at high-intensity sites indicated that these organisms may be sensitive to water-quality and habitat conditions associated with agricultural intensity.

Table 9. Median aquatic invertebrate metrics for basin and intensity site groups in southwestern Louisiana, 2001
[Median densities and taxa of aquatic invertebrates are rounded to the nearest whole number. Densities are reported as organisms per square meter. Boldface values indicate significant differences ($p \leq 0.05$) among site groups, based on results of two-factor analysis of variance (ANOVA). n, number of sites; <, less than value indicated]

Aquatic invertebrate metrics	Basin site groups		Intensity site groups	
	Large (n=11)	Small (n=8)	High (n=11)	Low (n=8)
Composition metrics				
Abundance (number of organisms)				
Abundance (total)	707	991	707	1,602
Amphipoda (percent)	2	1	8	<1.0
Chironomidae (total)	228	359	**202**	**929**
Mollusca and Crustacea (percent)	20	5	35	5
Noninsects (percent)	36	25	**42**	**14**
Orthocladiinae midges (percent)	2	12	3	12
Tanytarsini midges (percent)	9	9	4	16
Richness (number of non-ambiguous taxa)				
Gastropoda taxa	1	1	**2**	**1**
Orthocladiinae midge taxa	2	4	2	4
Diversity metrics				
Five most abundant taxon (percent)	72	74	75	71
Shannon's diversity[1]	.95	.93	.92	.97
Feeding metrics[2]				
Abundance (number of organisms)				
Collector-gatherers (percent)	**57**	**74**	62	61
Omnivores (total)	0	3	**0**	**7**
Richness (number of non-ambiguous taxa)				
Collector-gatherer taxa (percent)	**44**	**48**	44	46
Shredder taxa (percent)	5	4	**5**	**4**
Tolerance metrics[2]				
Abundance-weighted tolerances (biotic index)	7.04	6.31	**7.11**	**6.18**

[1] Brower, J.E., and Zar, J.H., 1984, Field and laboratory methods for general ecology (2d ed.): Dubuque, Iowa, Wm. C. Brown Publishers, p. 226.

[2] Feeding and tolerance metrics based on Barbour and others (1999, app. B).

Median abundance and richness as measures of feeding differed between basin and intensity site groups (table 9). Median percentage of collector-gatherers for small-basin site group (74 percent) was greater than for the large-basin site group (57 percent). Unlike the percentages of collector-gatherers, which were similar among intensity sites, the median percentages of Orthocladiinae midges were four times higher at the low-intensity site group (12 percent) than at the high-intensity site group (3 percent). The presence of omnivores was restricted to low-intensity sites. The percentage of shredders was expected to decrease with increased perturbation at a site (Barbour and others, 1999); however, the median percentage of shredder taxa for the high-intensity site group (5 percent) was greater than the median for the low-intensity site group (4 percent). The variable patterns in feeding metrics among site groups may be complicated by the presence of aquatic macrophytes (plants) at the large-basin sites. Collector-gatherer feeding groups are influenced more by water-quality and

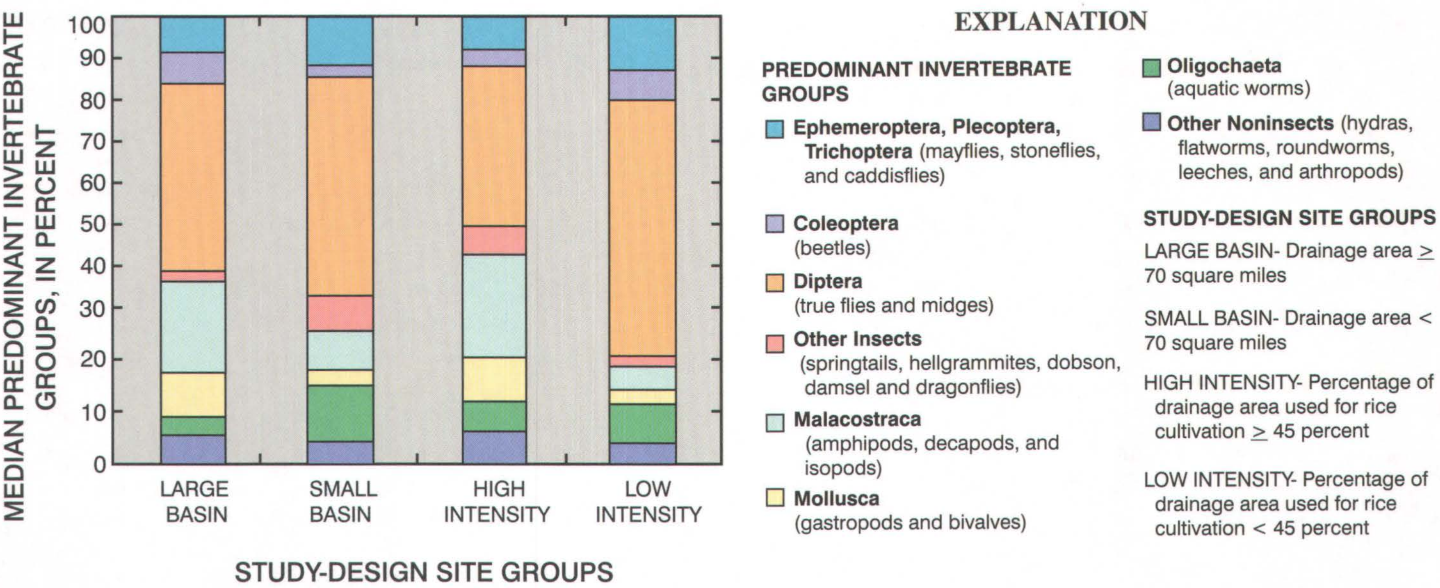


Figure 14. Composition of predominant groups of aquatic invertebrates at basin and intensity site groups in southwestern Louisiana, 2001 (data listed in appendix 8).

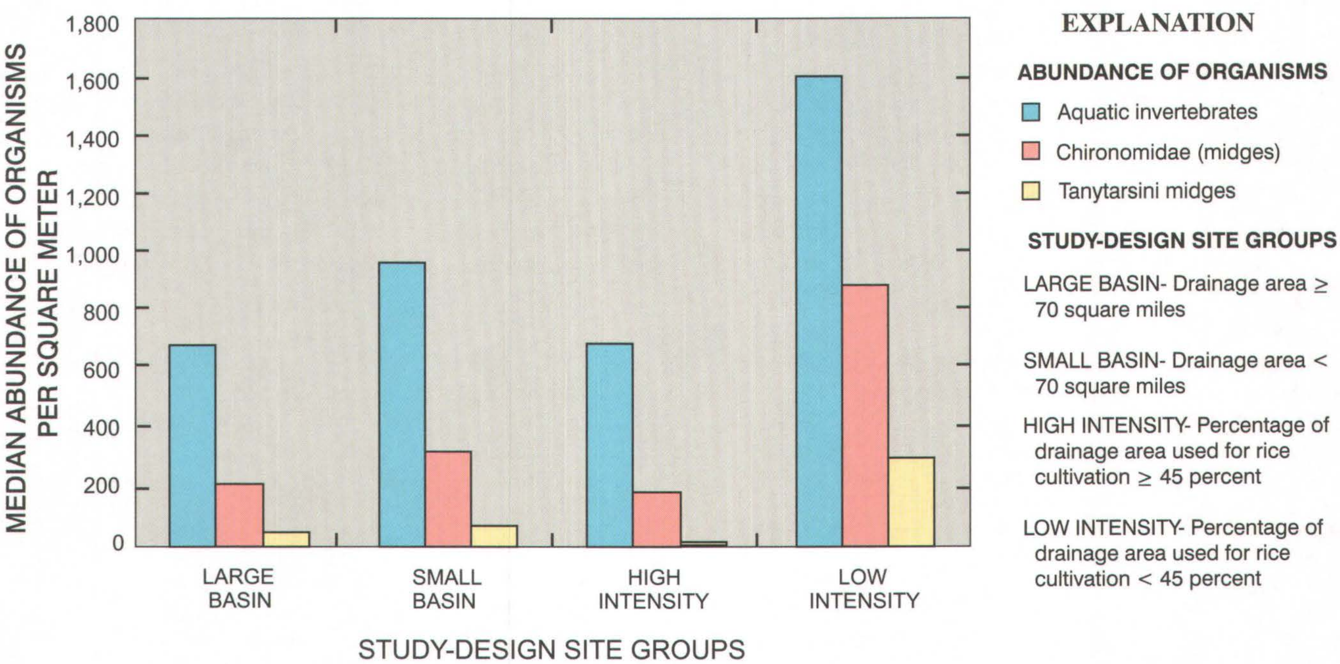


Figure 15. Median abundances of aquatic invertebrates, Chironomidae (midges), and Tanytarsini midges at basin and intensity site groups in southwestern Louisiana, 2001 (data listed in appendix 8).

habitat conditions associated with drainage area than by conditions associated with agricultural intensity.

The abundance-weighted tolerance (biotic index) results were consistent with composition metrics results and indicated most tolerant organisms occurred at high-intensity sites, mainly the large high-intensity sites (table 9). The abundance-weighted values were calculated by weighting the tolerance value by the abundance of the organism in the sample. Tolerance values were based on a scale from 0 to 10, where 0 represented the tolerance value of an extremely sensitive organism and 10 represented the value for a tolerant organism. Thus, a higher abundance-weighted tolerance value indicated that the communities at these sites were composed of more organisms considered tolerant to many types of stress associated with stream disturbance. Median abundance-weighted tolerance was greater at the high-intensity sites (7.11) than at the low-intensity sites (6.18).

Canonical Correspondence Analysis Site Groups

For this report, CCA (ter Braak and Smilauer, 1998) was used to evaluate patterns among sites based on the relative abundance of aquatic invertebrates and environmental variables. The CCA and the forward selection process reduced 36 environmental variables to 4 that best described the relations among water quality, habitat, and invertebrate communities among sites. The CCA identified four significant ($p \leq 0.05$) environmental variables (instream cover score, percentage of open canopy, concentrations of dissolved oxygen, and maximum concentration of dissolved fipronil) that described the distribution of aquatic invertebrate communities among ecological data-collection sites (fig. 16). The first CCA axis represents the dissolved oxygen and open canopy gradient, and the second CCA axis represents the instream cover and fipronil concentration gradient. The labeled arrows (vectors) in the CCA biplot indicate spatial associations of site and species scores with environmental variables. The value of the environmental variable increases in the direction the vector points. The length of the vector reflects the importance of the environmental variable in the CCA model. Vectors parallel to an axis are highly correlated with that axis and vectors perpendicular to an axis are poorly correlated with that axis (table 10).

Cluster analysis using site scores from the first two CCA axes (Wilkinson and others, 1998) identified four site groups (A, B, C, and D) that had similar water quality, habitat, and aquatic invertebrate characteristics. These site groups were geographically separated within the study (fig. 17). Group A included 2 sites in the northern part of the Mermentau River Basin and 1 site in the adjacent Calcasieu River Basin. Other sites, all in the Mermentau River Basin, were grouped as follows: 4 sites in the southeastern part of the basin (group B), 6 sites in the north-central and southeastern parts (group C), and 6 in the south-central and southwestern parts (group D). Discriminate analysis (Engelman, 1998) showed statistical significance (Wilk's lambda = 0.014, $p \leq 0.001$) of cluster analysis site group assignments with 89 percent of sites correctly classified to CCA site groups.

Figure 16 shows the distribution of ecological data-collection sites and site groups in relation to CCA environmental variables. The highest instream cover and smallest fipronil concentrations were present at sites in group A. Sites in group B were characterized by moderate instream cover, open canopy, and dissolved oxygen concentrations, and small fipronil concentrations. Group C sites were characterized by large dissolved-oxygen and fipronil concentrations. The largest amount of open canopy and the smallest dissolved-oxygen concentrations were present at sites in group D. Figure 16 also shows the CCA distribution of relative abundances of aquatic

Table 10. Canonical correlation coefficients of environmental variables with the first four canonical correspondence analysis axes for aquatic invertebrates at ecological data-collection sites in southwestern Louisiana, 2001
[Numbers in parentheses are eigenvalues]

Canonical correspondence analysis model environmental variables	Axis 1 (0.31)	Axis 2 (0.18)	Axis 3 (0.16)	Axis 4 (0.09)
Open canopy	0.67	0.16	0.14	0.80
Instream cover	-.21	.32	-.80	.56
Dissolved oxygen	-.64	-.51	.14	.69
Dissolved fipronil (maximum)	<.01	-.96	-.53	-.07
Cumulative percent of species variance explained	16.0	25.4	33.6	38.4
Cumulative percent of species-environment variance explained	41.8	66.2	87.4	100

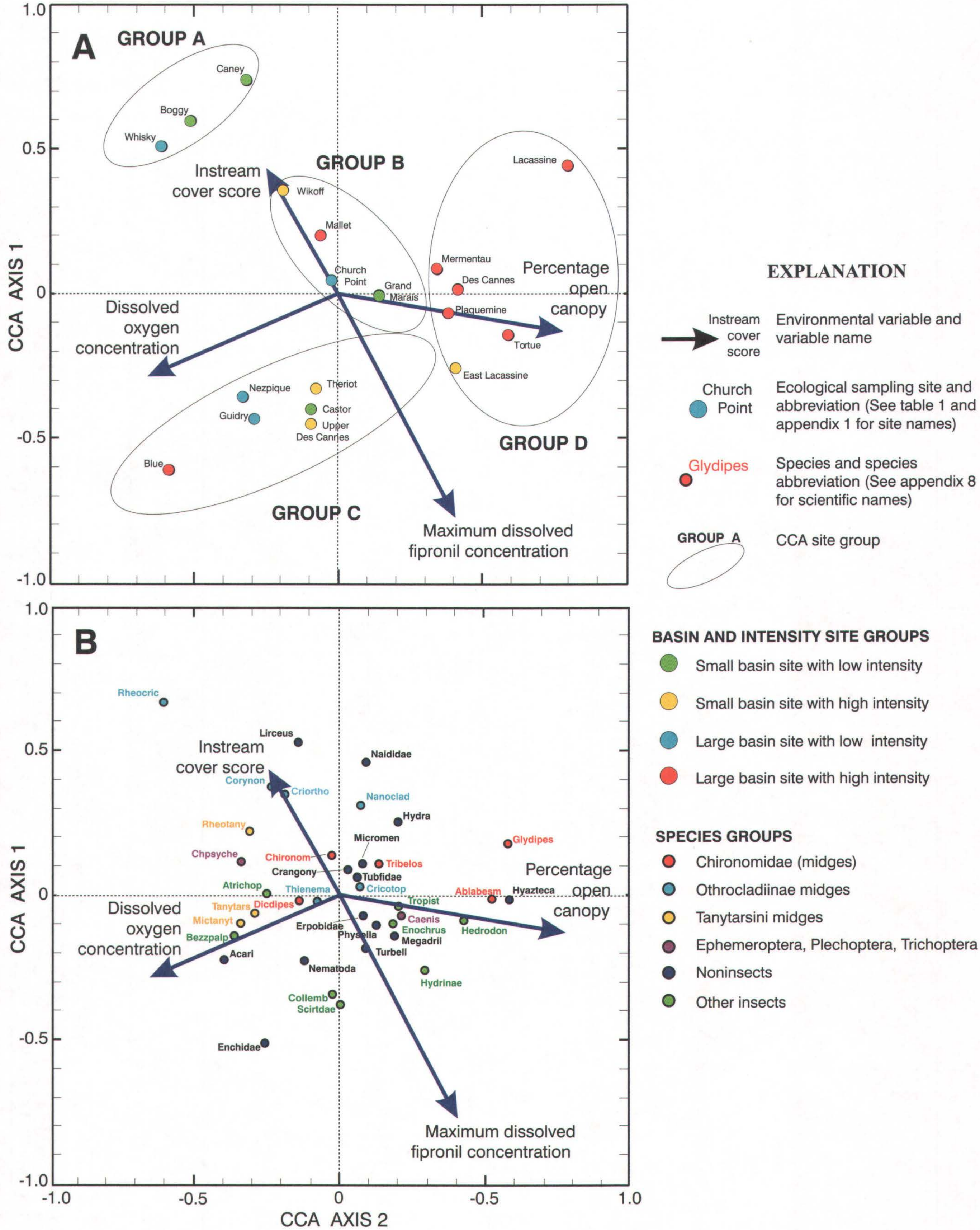
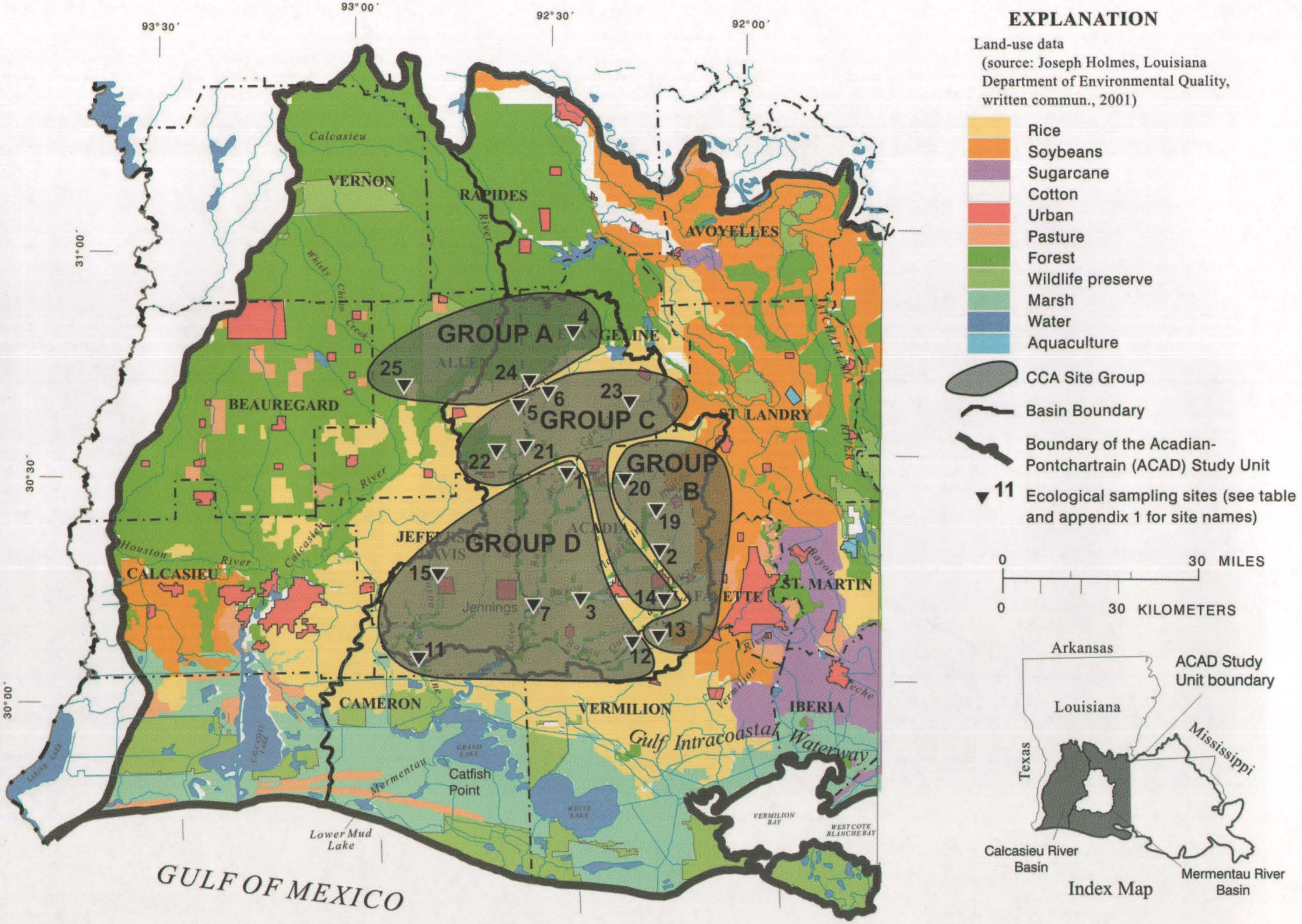


Figure 16. Canonical correspondence analysis (CCA) ordination biplot showing site (A) and species (B) locations in relation to environmental variables of ecological data-collection sites in southwestern Louisiana, 2001. The environmental variables shown are related significantly (p≤0.05) to one or more of the CCA axes. The value of the environmental variable increases in the direction the arrow (vector) points. The length of the vector reflects the importance of an environmental variable and direction of influence in the CCA model.



Map credit: Modified from Official Map of Louisiana, Department of Transportation and Development, 1986

Figure 17. Land use and location of ecological data-collection sites and canonical correspondence analysis (CCA) site groups in southwestern Louisiana, 2001.

invertebrate species in relation to environmental variables. Communities at large-basin sites tended to vary along the dissolved-oxygen and open-canopy gradient, whereas communities at small-basin sites tended to vary along the instream-cover and fipronil-concentration gradient.

Water-Quality Characteristics

Significant statistical differences ($p \leq 0.05$) in water-quality characteristics occurred among CCA site groups (table 11). Median values were smallest for 17 water-quality variables at group A sites and largest for 11 water-quality variables at group B sites. Median values of turbidity, and concentrations of total ammonia plus organic nitrogen, nitrate, total phosphorus, and dissolved fipronil, were largest at group C sites. Group D sites were characterized by midrange concentrations for all water-quality variables except concentrations of dissolved oxygen, which were lowest.

Possible explanations for the differences in water quality among site groups include the differences in (1) general soil composition and drainage characteristics (Touchet and others, 1974), and (2) the percentage of land used for agriculture in these basins. Drainage areas for sites in group A are low in agricultural intensity and contain pine uplands and alluvial terraces. Soils are acidic and loamy with moderate sand content and are moderately well-drained. Drainage areas for group B

Table 11. Median water-quality variables for canonical correspondence analysis (CCA) site groups in southwestern Louisiana, 2001

[Boldface values indicate significant differences ($p \leq 0.05$) among site groups, based on Kruskal-Wallis test; for each variable, values preceded by the same superscript letter are not significantly different from each other. n, number of sites; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; NTU, nephelometric turbidity units; <, less than indicated value; µg/L, micrograms per liter]

Water-quality variable	CCA site groups A (n=3)	B (n=4)	C (n=6)	D (n=6)
Physiochemical properties				
Specific conductance (µS/cm)	[a] **44**	[b] **360**	140	[b] **162**
Dissolved oxygen (mg/L)	7.3	6.3	**7.4**	**5.5**
Turbidity (NTU's)	**15**	201	**455**	240
Major inorganic ions (mg/L)				
Calcium, dissolved	[a] **3.0**	[b] **28**	[a, c] **7.9**	[b, c] **11**
Magnesium, dissolved	[a] **1.0**	[b] **9.9**	[a, c] **3.0**	[b, c] **4.1**
Potassium, dissolved	[a] **1.3**	[b] **4.5**	[b] **4.1**	3.5
Sodium, dissolved	**3.4**	**28**	11	13
Alkalinity, as $CaCO_3$	[a] **8**	[b] **141**	30	[b] **51**
Chloride, dissolved	**3.3**	**22**	13	13
Nutrients (mg/L)				
Nitrogen (as N):				
Ammonia + organic, total	**.7**	1.8	**3.1**	2.1
Ammonia + organic, dissolved	**.5**	**1.0**	.8	.9
Nitrate, dissolved	.10	.27	.33	.21
Nitrite, dissolved	[a] **<.01**	[b] **.04**	[b] **.03**	.02
Phosphorus (as P):				
Total	**.05**	.68	**.82**	.49
Dissolved	[a] **.02**	[b] **.23**	.04	[b] **.12**
Ortho, dissolved	[a] **.01**	[b] **.18**	.03	[b] **.09**
Organic carbon (mg/L)				
Carbon, organic (suspended)	[a] **1.4**	[b] **4.0**	[b] **4.0**	[b] **4.0**
Insecticide (µg/L)				
Fipronil, dissolved (maximum)	[a] **.0044**	[a, c] **.184**	[b] **2.4556**	[b, c] **1.615**

sites are mixed in agricultural intensity and contain loess uplands and low terrace areas that are influenced by post prairie-age loess. Soils are loamy with clayey subsoil, and are poorly drained. Drainage areas for group C sites are mixed in agricultural intensity. Soils contain alluvial and outwash deposits, are loamy with clayey subsoils, and are poorly drained. Increased turbidity and increased concentrations of nutrients and insecticides, which are normally associated with agricultural activities, occurred at group C sites. Drainage areas for sites in group D are high in agricultural activities. Group D sites contain mixtures of upstream water, which may explain the midrange concentrations of water-quality constituents at these sites.

Stream Habitat Characteristics

Water clarity and the amount of open canopy among CCA site groups were significantly different ($p \leq 0.05$) (table 12). Streams in group A were clear with little open canopy. Streams in group B were slightly turbid with some open canopy. In group C, streams were turbid with some open canopy; water clarity was lowest and turbidity highest in these streams. Streams in group D were slightly turbid, with open canopy. Median euphotic and Secchi disk depths were greater for group A (1.35 m and 0.66 m) than for group C (0.13 m and 0.03 m). Median values for open canopy differed between group A (8 percent) and group D (65 percent), and between group C (26 percent) and group D. Differences in water clarity probably were related to agricultural intensity, whereas differences in the canopy were probably related to drainage-area characteristics. Differences in water clarity and open canopy may account for some differences in aquatic invertebrate communities.

Aquatic Invertebrate Communities

Aquatic invertebrate community metrics were significantly different ($p \leq 0.05$) in the percentage of noninsects, abundance of midge taxa, abundance of feeding groups, and number of tolerant organisms among intensity (table 9) and CCA (table 13) site groups. Comparable to the large basin sites with high intensity, noninsects, notably Amphipods, dominated sites in group D. Similar to intensity site groups, CCA site groups differed in abundance of total aquatic invertebrates, midges, and Tanytarsini midges. The relative highest total abundances were at groups A and D. The relative abundance of midges, particularly the percentage of Tanytarsini midges, largely accounts for the differences in total abundance between groups A and D. Diversity metrics were similar between basin and intensity site groups but dominance and diversity differed significantly among CCA site groups. Diversity metrics differed between groups B and C and between groups B and D. Although the abundance and richness of collector-gatherers were similar among CCA site groups, the percentage of collector-gatherer Orthocladiinae midges generally was larger in small headwater streams, particularly in groups A and B. The abundance-weighted tolerance (biotic index) indicated the most tolerant organisms typically were present at sites in group D, similar to large basin sites with high intensity.

Figure 18 shows the composition of predominant invertebrate groups for the CCA site groups. Among all CCA site groups, the composition of predominant invertebrate groups was most balanced in group B. The greatest shifts in predominant invertebrate groups was between groups A and D. Diptera dominated group A (similar to small basins with low intensity) and Malacostraca, especially Amphipoda, dominated site group D (similar to large basins with high intensity). The median percentage of Amphipoda (table 13) for group D (38 percent) differed from all other CCA site groups (all less than 1 percent). The median percentages of Mollusca plus Crustacea (table 13), as well as noninsects (table 13), differed between group D (45, 58 percent) and group A (4, 6 percent) and between group C (5, 15 percent) and group D. Although not sampled for aquatic invertebrates, macrophytes such as water hyacinth and alligator weed provide good habitat for Molluscs and Crustaceans, especially Amphipods, at group D sites.

Table 12. Median stream habitat variables for canonical correspondence analysis (CCA) site groups in southwestern Louisiana, 2001

[Boldface values indicate significant differences ($p \leq 0.05$) among site groups, based on Kruskal-Wallis test; for each variable, values preceded by the same superscript letter are not significantly different from each other. n, number of sites]

Stream-habitat variable	CCA site groups A (n=3)	B (n=4)	C (n=6)	D (n=6)
Quantitative measurements				
Euphotic depth (meter)	**1.35**	0.31	**0.13**	0.21
Open canopy (percent)	[a] **8**	25	[a] **26**	[b] **65**
Secchi disk depth (meter)	**.66**	.09	**.03**	.08

Table 13. Median aquatic invertebrate metrics for canonical correspondence analysis (CCA) site groups in southwestern Louisiana, 2001

[Median densities of aquatic invertebrates are rounded to the nearest whole number and reported as organisms per square meter. Boldface values indicate significant differences ($p \leq 0.05$) among site groups, based on results of Kruskal-Wallis test; for each variable, values preceded by the same superscript letter are not significantly different from each other. n, number of sites; <, less than indicated value.]

Aquatic invertebrate metrics	CCA site groups			
	A (n=3)	B (n=4)	C (n=6)	D (n=6)
Composition metrics				
Abundance (number of organisms)				
Abundance (total)	**2,323**	872	**448**	1,260
Amphipoda (percent)	[a] **<1.0**	[a] **<1.0**	[a] **<1.0**	[b] **38**
Chironomidae (total)	1,235	367	151	171
Mollusca and Crustacea (percent)	[a] **4**	19	[a] **5**	[b] **45**
Noninsects (percent)	[a] **6**	35	[a] **15**	[b] **58**
Orthocladiinae midges (percent)	[a] **13**	[a] **15**	[b] **2**	[b] **2**
Tanytarsini midges (percent)	**33**	11	11	**<1.0**
Richness (number of non-ambiguous taxa)				
Gastropoda taxa	[a] **1**	2	[a] **1**	[b] **3**
Orthocladiinae midge taxa	[a] **5**	[a] **4**	[b] **2**	[b] **2**
Diversity metrics				
Five most abundant taxon (percent)	71	[a] **67**	[b] **75**	[b] **79**
Shannon's diversity[1]	.98	[a] **1.1**	[b] **.92**	[b] **.89**
Feeding metrics[2]				
Abundance (number of organisms)				
Collector-gatherer (percent)	62	62	55	64
Omnivores (total)	[a] **17**	6	[b] **0**	[b] **0**
Richness (number of non-ambiguous taxa)				
Collector-gatherer taxa (percent)	47	46	38	49
Shredder taxa (percent)	<1.0	4	7	5
Tolerance metrics[2]				
Abundance-weighted tolerances (biotic index)	**5.92**	6.67	6.83	**7.51**

[1] Brower, J.E., and Zar, J.H., 1984, Field and laboratory methods for general ecology (2d ed.): Dubuque, Iowa, Wm. C. Brown Publishers, p. 226.

[2] Feeding and tolerance metrics based on Barbour and others (1999).

Similar to intensity site groups, median abundance of total aquatic invertebrates, midges, and Tanytarsini midges varied among CCA site groups (fig 19, table 13). Except for the total abundance in group D (which was composed of over 50 percent noninsects), abundances generally decreased gradually in order of group A > group B > groups C and D. Relative total abundance was more than five times higher in group A (2,323 organisms/m^2) than in group C (448 organisms/m^2). The abundance of midges, particularly the percentage of Tanytarsini, largely accounts for the differences in total abundance between groups A and D. Tanytarsini midge abundances were the highest in group A (33 percent), composing one-third of the midge population, and lowest at group D (<1.0 percent). A gradual decrease in the abundances of midges and Tanytarsini midges indicated that these organisms may be sensitive to a gradient of water-quality and habitat conditions associated with CCA site groups.

Significant differences in median diversity metrics at CCA site groups included the percentage of the five most abundant taxon and the Shannon's diversity (Thomas Cuffney, U.S. Geological Survey, written commun., 2002) (table 13). In group B, the percentage of dominant taxon was smaller (67 percent) and the Shannon's diversity was higher (1.1) than in group C (75 percent, 0.92) and group D (79 percent, 0.89). Lower dominance and higher Shannon's diversity values indicated aquatic invertebrate communities in group B were more diverse with respect to predominant invertebrate groups (fig. 18).

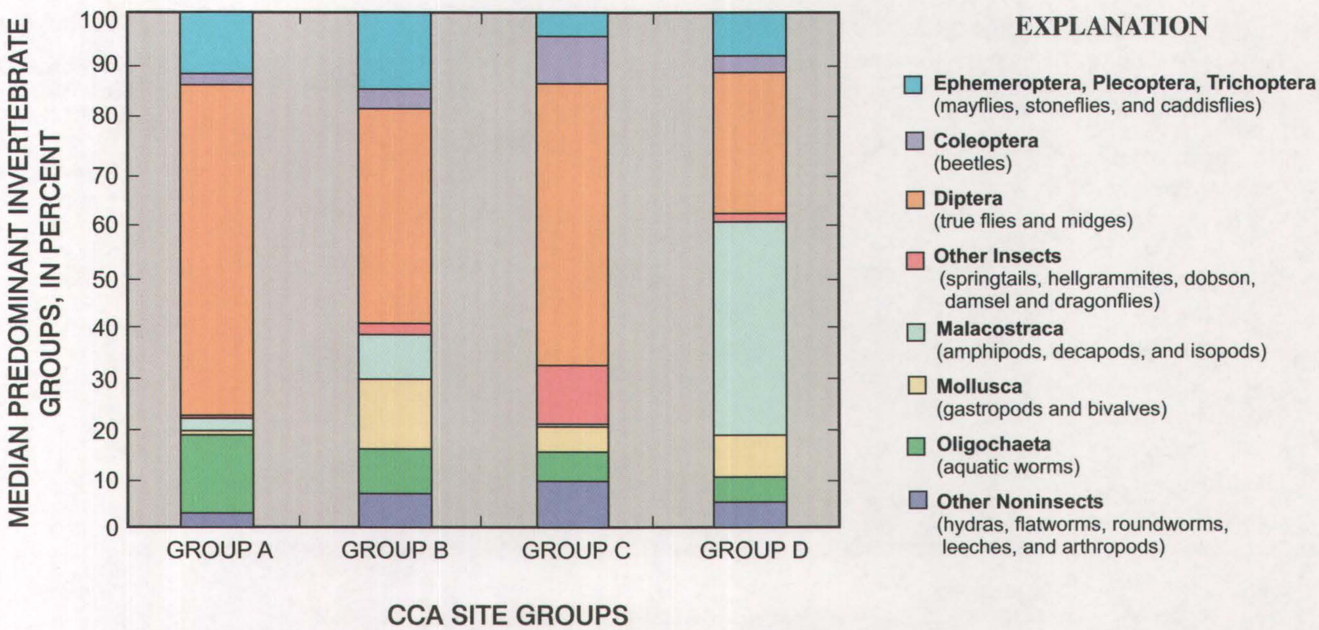


Figure 18. Composition of predominant groups of aquatic invertebrates at canonical correspondence analysis (CCA) site groups in southwestern Louisiana, 2001 (data listed in appendix 8).

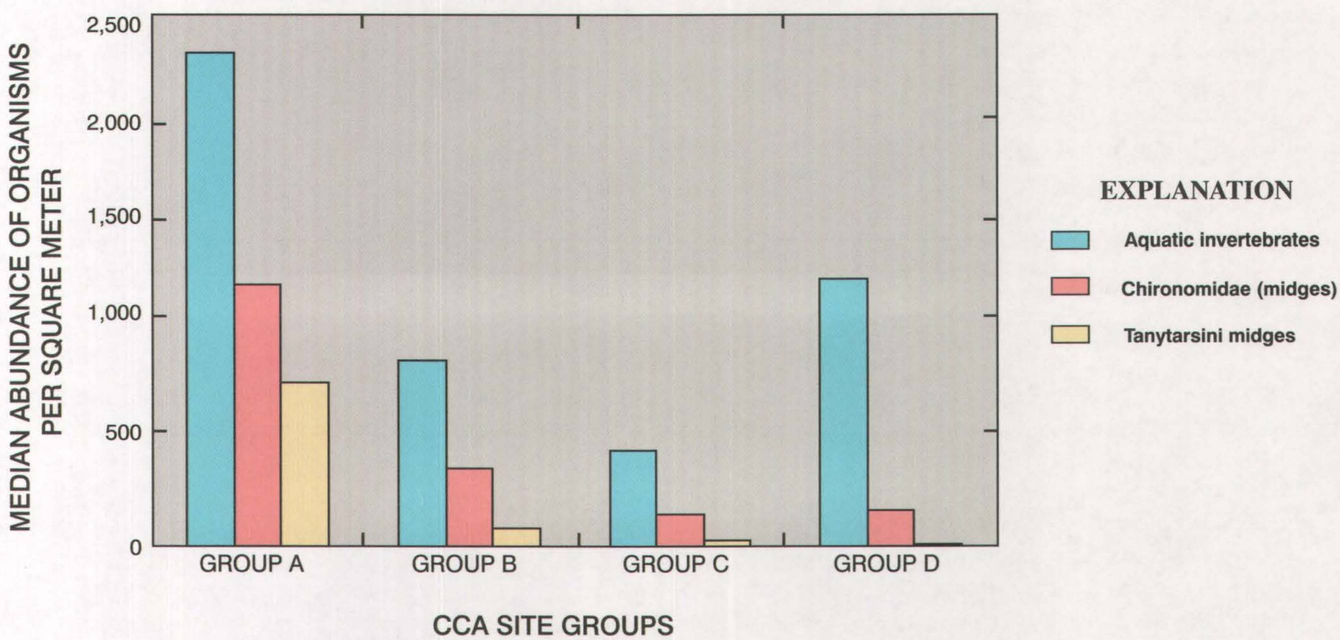


Figure 19. Median abundances of aquatic invertebrates, Chironomidae (midges), and Tanytarsini midges at canonical correspondence analysis (CCA) site groups in southwestern Louisiana, 2001 (data listed in appendix 8).

Median abundance and richness as measures of feeding differed among CCA groups (table 13). Unlike results for basin and intensity site groups, abundance and richness of collector-gatherers except Orthocladiinae midges were similar among CCA groups. Orthocladiinae midge abundances were more than five times higher in groups A (13 percent) and B (15 percent) than in groups C (2 percent) and D (2 percent). Orthocladiinae midge richness was higher in groups A (5) and B (4) than in groups C (2) and D (2). Omnivores were present only at low-intensity sites and in groups A and B. Median abundance of omnivores was highest in group A (17).

The abundance-weighted tolerance values (biotic index) were highest for group D sites (table 13) and large basin sites with high intensity (table 9). The median abundance-weighted tolerance values differed between groups A (5.92) and D (7.51). Patterns in abundance-weighted tolerance were similar for basin and intensity site groups and CCA site groups, and indicated greater abundance of sensitive organisms at low-intensity sites.

Relations Between Species and Environmental Variables

Scatter plots were used to evaluate relations between aquatic invertebrates and significant environmental variables from the CCA model. One genus of tolerant mayfly, *Caenis*, and one genus of midge, *Rheotanytarsus*, were selected to illustrate these relations. These species were selected because of their wide distribution among ecological data-collection sites and because the observed patterns were common for many other species. The environmental variables used for the evaluation were instream cover score, percentage of open canopy, concentrations of dissolved oxygen, and maximum concentrations of dissolved fipronil.

The relative abundance of *Caenis* sp. (fig. 20) decreased with increasing instream cover and fipronil concentrations but showed little to no relation to dissolved-oxygen concentrations or open canopy. *Caenis* sp. abundance may be an indicator of water quality in streams influenced by fipronil because this species exhibits little sensitivity to most environmental variables except increasing instream cover and concentrations of fipronil. Tanytarsini midges, particularly *Rheotanytarsus* sp. (fig. 20), were similarly sensitive to fipronil as *Caenis* sp., but also to other environmental variables. Relative abundance of *Rheotanytarsus* sp. increased as dissolved oxygen and instream cover increased, and decreased as open canopy increased. Relative abundance of Orthocladiinae midges and the amphipod, *Hyalella azteca*, were similar to that of *Rheotanytarsus* sp. in similar habitats. Orthocladiinae midges may be an indicator of water quality for small-basin sites. *Hyalella azteca* favored large-basin sites, notably those with high agricultural intensity. The *Hyalella azteca* amphipod decreased in relative abundance as dissolved oxygen increased, and increased as open canopy increased.

Ali and others (1998) showed two species of chironomid (midge) larvae were highly susceptible to fipronil. In the study described in this report, scatter plots (fig. 20) indicate that an increase in the maximum concentration of dissolved fipronil was the only significant environmental variable in the CCA model that was related to consistent decreases in relative abundance for many species, notably midges. The degradation products of fipronil also are toxic. The USEPA (1996) states that fipronil sulfone is 6.6 times more toxic, and fipronil sulfide is 1.9 times more toxic to freshwater invertebrates than the parent compound. Findings in this study were similar to those of the USEPA: Relative abundances for many species decreased at lower concentrations of fipronil degradation products (fipronil sulfone, fipronil sulfide, and desulfinylfipronil) than of the fipronil parent compound. Demcheck and Skrobialowski (2003) concluded these fipronil degradation products accumulate in bed sediment, and concentrations generally increase from headwater streams to the mainstem of the Mermentau River. This possibly would explain the negative response between aquatic invertebrate abundance and fipronil.

SUMMARY AND CONCLUSIONS

A study was completed in the Mermentau River Basin in 2001 to better understand the relations among ground-water and surface-water and bed-sediment quality; aquatic invertebrate communities; and habitat conditions with respect to land use and agricultural intensity. The study area is located entirely within the Acadian Pontchartrain Study Unit, a part of the National Water-Quality Assessment Program. Water from wells and streams used to irrigate ricefields is returned to streams and bayous and may return to the ground through infiltration, be used downstream for agriculture, or drain to the Gulf of Mexico. Low-gradient streams with bidirectional flow, modifications for navigation, and water control structures are characteristic of the hydrology in the study area. The northwestern part of the study area is mostly forested and land in the remainder of the study area is used for rice agriculture. Throughout the study area, a drought occurred in 1999 and intensified to extreme conditions in 2000. Soils contain more sand and are moderately well drained in the northwestern part of the study area, are loamy and clayey in the center and south, and contain thick loess deposits in the southeastern part.

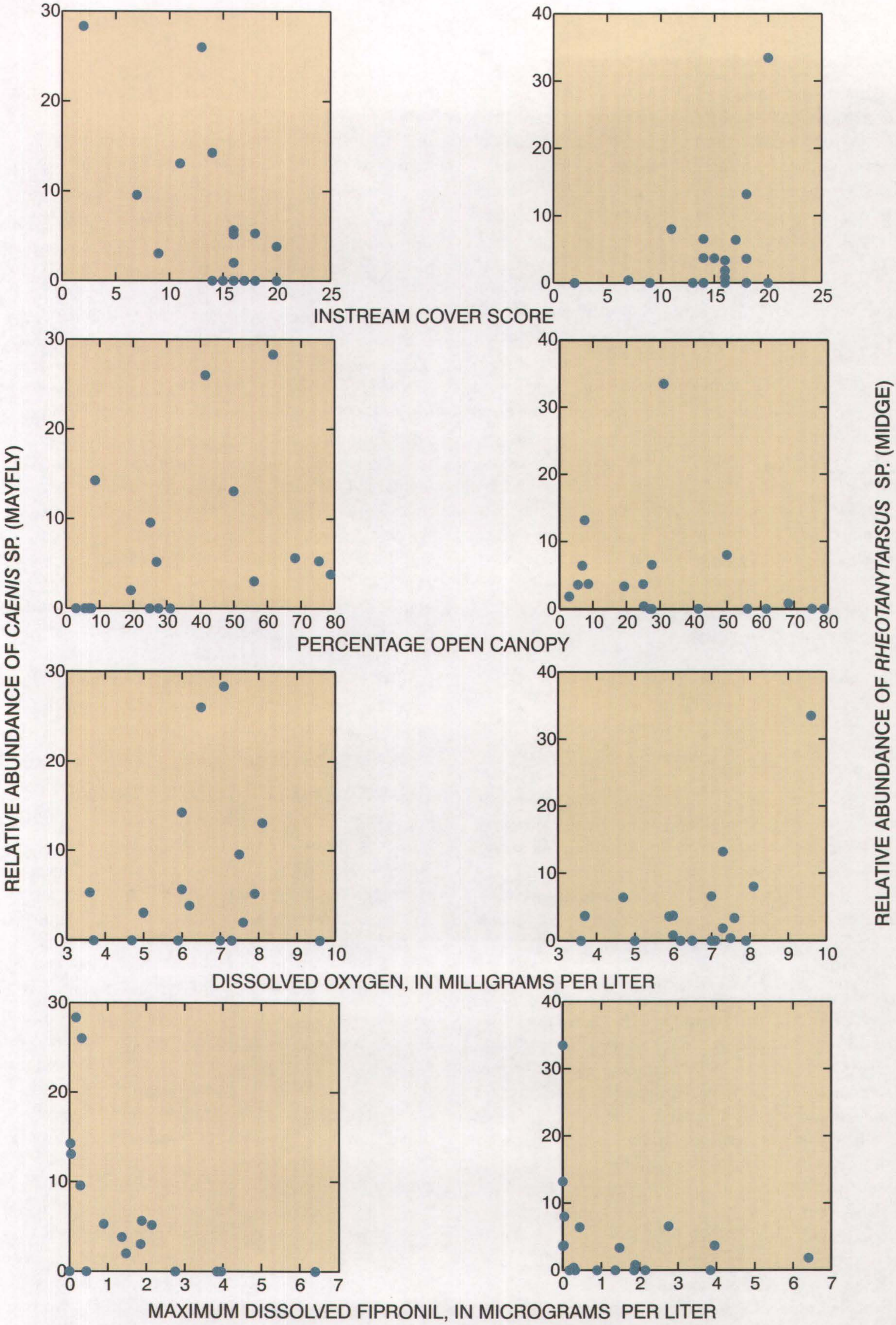


Figure 20. Relative abundances of *Caenis* sp. (mayfly) and *Rheotanytarsus* sp. (midge), and significant habitat and water-quality variables identified by canonical correspondence analysis (CCA) for ecological data-collection sites in southwestern Louisiana, 2001. Increases in concentration of maximum dissolved fipronil was the only significant variable in the CCA model that was related to consistent decreases in relative abundance for many species.

Water-quality data were compared to drinking-water and aquatic-life criteria and bed-sediment data were compared to aquatic-life criteria. Water-quality data were analyzed statistically and related to agricultural land-use intensity. Samples from 29 wells and 24 stream sites analyzed for selected nutrients, major inorganic ions, and pesticides indicate the following:

Nutrients

- Concentrations of nutrients and major inorganic ions in ground and surface water generally were largest in the southeastern part of the study area, an area of intense agriculture.
- The only drinking water regulation exceeded in a ground-water sample was that for nitrate in a well located in an area previously used for raising poultry and swine.
- Concentrations of nutrients from ground water used for agricultural irrigation were not high enough to contribute to eutrophication in surface water.
- The greatest potential for eutrophic conditions in surface water, based on nutrient thresholds, occurred March-May, at about the same time or shortly after ricefields were drained.

Major Inorganic Ions and Trace Elements

- Secondary Maximum Contaminant Levels established by the U.S. Environmental Protection Agency were exceeded in samples from 20 wells—sulfate in 1 well, chloride in 4 wells, iron in 7 wells, and manganese in 17 wells.
- Secondary Maximum Contaminant Levels were exceeded in samples from all surface-water sites—iron at 8 sites, and manganese at all sites.
- The maximum concentrations of sodium and chloride in surface water occurred at Bayou Lacassine near Lake Arthur and probably resulted from saltwater intrusion induced by reverse flow during the drought.

Pesticides

- Fewer pesticides and degradation products were detected in ground water than in surface water. Concentrations were lower in ground water than in surface water, and did not exceed drinking water or aquatic life criteria. Concentrations were detected in less than 1 percent of all analyses; 19 pesticides and degradation products were detected in samples from 11 wells.
- Pesticides and degradation products most frequently detected in ground water were the herbicides bentazon and atrazine.
- Concentrations of 47 pesticides and degradation products were detected in surface water. At least 3 pesticides were detected in all surface-water samples. In 72 percent of the samples at least 5 hydrophylic pesticides were detected, and in more than 70 percent of the samples at least 3 hydrophobic pesticides were detected.
- Although atrazine concentrations in three surface-water samples exceeded 3 µg/L (micrograms per liter), the Maximum Contaminant Level established by the U.S. Environmental Protection Agency was not exceeded because it is based on an annual average of quarterly samples. Concentrations larger than 3.0 µg/L were not detected in samples collected during other times of the year, and the average annual concentrations did not exceed 3 µg/L for sites sampled throughout the year.
- Pesticides concentrations in surface water exceeded aquatic-life criteria for atrazine (1.8 µg/L), tebuthiuron (1.6 µg/L), and malathion (0.1 µg/L).
- Fipronil was detected in concentrations exceeding the numeric targets for acute total maximum daily loads (2.30 µg/L) at 3 surface-water sites and the numeric targets for chronic total maximum daily loads (4.6 µg/L) at 14 sites.
- Maximum pesticide concentrations in surface water usually occurred in the spring at about the same time or shortly after ricefields were drained.
- Concentrations of DDE in bed sediment at Des Cannes and Church Point sites exceeded interim freshwater sediment-quality guidelines for the protection of aquatic life.
- Fipronil sulfide was detected at all bed-sediment sites, but there are no current (2002) guidelines with which to evaluate the environmental effects of fipronil and degradation products.

The study design, based on drainage basin area and agricultural land-use intensity, was used to determine differences in natural and human-related influences on surface-water quality at 19 ecological data-collection sites. Aquatic invertebrate communities were used as indicators of surface-water quality and habitat conditions at these sites. Canonical correspondence analysis (CCA) identified four significant environmental variables (instream cover score, percentage of open canopy, and concentrations of dissolved oxygen and maximum dissolved fipronil) that described the distribution of aquatic invertebrate communities among ecological data-collection sites. Cluster analysis revealed four site groups which separated ecological data-collection sites geographically within the study. Environmental data and aquatic invertebrate metrics within the study design and CCA-assigned site groups were compared and indicate the following:

- Stream habitat ratings using RBP habitat characterizations were rated optimal to marginal for all ecological data-collection sites; ratings for 16 sites were rated optimal to suboptimal.
- Generally, median bank erosion scores and median measurements of bankfull and wetted channel widths were greatest at all site groups with large drainage areas.
- Generally, the median bank stability index and pool substrate characterization score were lowest at all site groups with high agricultural intensity.
- Median values were lowest for 17 water-quality variables at group A sites and highest for 11 water-quality variables at group B sites.
- Possible explanations for the differences in water quality among site groups include the differences in general soil types and agricultural land use in these basins.
- Increased turbidity and concentrations of nutrients and insecticides, which normally are associated with agricultural activities, occurred at group C sites.
- Water clarity and the amount of open canopy differed among CCA site groups.
- Organisms tolerant of turbidity, organic enrichment, and low dissolved-oxygen concentrations are common in the study and dominated the aquatic invertebrate community.
- Aquatic invertebrate communities at large-basin sites tended to vary along the dissolved-oxygen and open-canopy gradient, whereas communities at small-basin sites tended to vary along the instream-cover and fipronil-concentration gradient.
- Aquatic invertebrate communities were significantly different in percentage of noninsects, abundance of midge taxa, abundance of feeding groups, and number of tolerant organisms among intensity and CCA site groups.
- Diversity metrics were similar among study-design site groups but significant differences in dominance and diversity occurred among CCA site groups.
- In this study, the maximum concentration of dissolved fipronil was the only significant environmental variable related to consistent decreases in relative abundance for many species, notably midges.
- Relative abundances for many species decreased at lower concentrations of the fipronil degradation products (fipronil sulfone, fipronil sulfide, and desulfinylfipronil) than of the fipronil parent compound.

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APPENDIXES

1. Complete names for surface-water and ecological data-collection sites in the Mermentau River Basin and adjacent Calcasieu River Basin in southwestern Louisiana, 1998-2001

2. Pesticides and degradation products analyzed, use, and occurrence in ground- and surface-water samples from the Mermentau River Basin, southwestern Louisiana, 1998-2001

3. Concentrations of fipronil and degradation products in surface water, Mermentau River Basin, southwestern Louisiana, 1999-2001

4. Selected physiochemical properties and fipronil concentrations for ecological data-collection sites in southwestern Louisiana, 2001

5. Mean quantitative habitat variables from ecological data-collection sites in southwestern Louisiana, 2001

6. Classification ranking of U.S. Environmental Protection Agency's Rapid Bioassessment Protocols habitat variables for ecological data-collection sites in southwestern Louisiana, 2001

7. Habitat assessment results using U.S. Environmental Protection Agency's Rapid Bioassessment Protocols for ecological data-collection sites in southwestern Louisiana, 2001

8. Taxa and densities of richest-targeted habitat aquatic invertebrates for ecological data-collection sites in southwestern Louisiana, March-April 2001

9. Loadings of environmental variables on the first two principal components (PC) derived from principal components analysis (PCA) of ecological data-collection sites in southwestern Louisiana, 2001

Appendix 1. Complete names for surface-water and ecological data-collection sites in the Mermentau River Basin and adjacent Calcasieu River Basin in southwestern Louisiana, 1998-2001

Site number (fig. 2)	Abbreviated site name	Complete site name	U.S. Geological Survey station number
		Mermentau River Basin	
1	Des Cannes	Bayou des Cannes near Eunice	08010000
2	Wikoff	Bayou Wikoff near Rayne	08010500
3	Plaquemine	Bayou Plaquemine Brule at Estherwood	08011020
4	Boggy	Boggy Bayou at State Hwy. 106 near Pine Prairie	08011500
5	Castor	Castor Creek at Cottongin Castor Road near Oberlin	08011800
6	Nezpique	Bayou Nezpique at State Hwy. 376 north of Basile	08011860
7	Mermentau	Mermentau River at Mermentau	08012150
8	Riceville	Bayou Queue de Tortue at Riceville	08012300
9	Lake Arthur	Mermentau River at Lake Arthur	08012400
10	Chene	Bayou Chene at State Hwy. 382 near Welsh	08012447
11	Lacassine	Bayou Lacassine near Lake Arthur	08012470
12	Tortue	Bayou Queue de Tortue at State Hwy. 13 near Lelieux	300446092214200
13	Grand Marais	Bayou Grand Marais at State Hwy. 699 near Kaplan	300514092173500
14	Theriot	Bayou Queue de Tortue at Theriot Road near Rayne	301154092145900
15	East Lacassine	East Bayou Lacassine at State Hwy. 99 north of Welsh	301520092491800
16	Roanoke	West Bayou Grand Marais at Aaron Road near Roanoke	301538092421900
17	Iota	Bayou des Cannes at State Hwy. 98 west of Iota	301959092323400
18	Panchoville	Bayou Nezpique near Panchoville	302128092373800
19	Church Point	Bayou Plaquemine Brule at State Hwy. 370 near Church Point	302403092152300
20	Mallet	Bayou Mallet at State Hwy. 367 near Eunice	302749092203500
21	Guidry	Bayou Nezpique at Guidry Road north of Basile	303206092360000
22	Blue	Bayou Blue at State Hwy. 26 near Elton	303209092401800
23	Upper Des Cannes	Bayou des Cannes at State Hwy. 104 near Ville Platte	303755092190400
24	Caney	Caney Creek at Bond Road near Oakdale	304130092344100
		Calcasieu River Basin (additional site)	
[1]25	Whisky	Whisky Chitto Creek near Oberlin	08014500

[1] Shown in figure 3.

Appendix 2. Pesticides and degradation products analyzed, use, and occurrence in ground- and surface-water samples from the Mermentau River Basin, southwestern Louisiana, 1998-2001

[H, herbicide; DP, degradation product; I, insecticide; F, fungicide; Pesticides in bold italics were analyzed before analytical method approval, and data in this report are provisional.]

		Ground water		Surface water	
Pesticide or degradation product	Use	Number of samples collected	Samples with detected concentrations (percent)	Number of samples collected	Samples with detected concentrations (percent)
2,4-D	H	29	3	36	77.8
2,4-D methyl ester	H	29	0	36	27.8
2,4-DB	H	29	0	36	.0
2,6-Diethylaniline	H, DP	29	0	242	.0
2-Hydroxyatrazine	H, DP	29	3	36	83.3
3(4-Chlorophenyl)-1-methyl urea	H, DP	29	3	36	.0
3-Hydroxycarbofuran	I, DP	29	0	36	.0
3-Ketocarbofuran	I, DP	29	0	36	.0
Acetochlor	H	29	0	242	.4
Acifluorfen	H	29	0	36	.0
Alachlor	H	29	3	242	10.7
Aldicarb	I	29	0	36	.0
Aldicarb sulfone	I, DP	29	0	36	.0
Aldicarb sulfoxide	I, DP	29	0	36	.0
alpha-HCH	I	29	0	242	.0
Atrazine	H	29	3	242	99.6
Bendiocarb	I	29	0	36	.0
Benfluralin	H	29	0	242	.0
Benomyl	F	29	0	36	36.1
Bensulfuron-methyl	H	29	0	36	47.2
Bentazon	H	29	10	36	75.0
Bromacil	H	29	0	36	22.2
Bromoxynil	H	29	0	36	.0
Butylate	H	29	0	242	.0
Carbaryl	I	29	0	241	26.1
Carbofuran	I	29	0	242	25.2
Chloramben, methyl ester	H	29	0	36	.0
Chlorimuron-ethyl	H	29	3	36	2.8
Chlorothalonil	H	29	0	36	.0
Chlorpyrifos	I	29	3	242	5.8
Clopyralid	H	29	0	36	.0
Cyanazine	H	29	0	242	.8
Cycloate	H	29	0	36	.0
Dacthal (DCPA)	H	29	0	242	.4
Dacthal monoacid	H, DP	29	0	36	.0
Deethylatrazine	H, DP	29	3	242	90.1
Deethyldeisopropylatrazine	H, DP	29	7	36	13.9
Deisopropylatrazine	H, DP	29	0	36	22.2
Desulfinylfipronil	I, DP	29	0	186	89.2
Diazinon	I	29	0	242	39.3
Dicamba	H	29	0	36	.0

Appendix 2. Pesticides and degradation products analyzed, use, and occurrence in ground- and surface-water samples from the Mermentau River Basin, southwestern Louisiana, 1998-2001—Continued

		Ground water		Surface water	
Pesticide or degradation product	Use	Number of samples collected	Samples with detected concentrations (percent)	Number of samples collected	Samples with detected concentrations (percent)
Dichlorprop	H	29	0	36	0.0
Dieldrin	I	29	0	242	.8
Dinoseb	H	29	0	36	2.8
Diphenamid	H	29	0	36	33.3
Disulfoton	I	29	0	242	.0
Diuron	H	29	3	36	91.7
EPTC	H	29	0	242	11.6
Ethalfluralin	H	29	0	242	.0
Ethoprophos	I	29	0	242	5.4
Fenuron	H	29	0	36	.0
Fipronil	I	29	0	192	72.4
Fipronil degradate RPA105048	I, DP	29	0	207	84.1
Fipronil Sulfone	I, DP	29	0	207	87.4
Fipronil Sulfide	I, DP	29	0	207	88.8
Flumetsulam	H	29	3	36	.0
Fluometuron	H	29	0	36	5.6
Fonofos	I	29	0	242	.0
Imazaquin	H	29	7	36	8.3
Imazethapyr	H	29	0	36	.0
Imidacloprid	I	29	0	36	.0
Lindane	I	29	0	242	.0
Linuron	H	29	0	242	.0
Malathion	I	29	3	242	19.4
MCPA	H	29	0	36	2.8
MCPB	H	29	0	36	.0
Metalaxyl	F	29	3	36	38.9
Methiocarb	I	29	0	36	.0
Methomyl	I	29	0	36	.0
Methomyl oxime	I, DP	29	0	36	.0
Methyl-Azinphos	I	29	0	242	.0
Methyl-Parathion	I	29	0	242	1.2
Metolachlor	H	29	7	242	92.6
Metribuzin	H	29	3	242	33.1
Metsulfuron methyl	H	29	0	36	.0
Molinate	H	29	0	242	86.4
Napropamide	H	29	0	242	2.1
Neburon	H	29	0	36	.0
Nicosulfuron	H	29	0	36	.0
Norflurazon	H	29	0	36	.0
Oryzalin	H	29	0	36	.0
Oxamyl	I, DP	29	0	36	.0

Appendix 2. Pesticides and degradation products analyzed, use, and occurrence in ground- and surface-water samples from the Mermentau River Basin, southwestern Louisiana, 1998-2001—Continued

		Ground water		Surface water	
Pesticide or degradation product	Use	Number of samples collected	Samples with detected concentrations (percent)	Number of samples collected	Samples with detected concentrations (percent)
Oxamyl oxime	I, DP	29	0	36	0.0
p,p'-DDE	I, DP	29	0	242	.4
Parathion	I	29	0	242	.0
Pebulate	H	29	0	242	.0
Pendimethalin	H	29	0	242	4.1
Permethrin-cis	I	29	0	242	.0
Phorate	I	29	0	242	.0
Picloram	H	29	3	36	.0
Prometon	H	29	0	242	44.2
Propachlor	H	29	0	242	1.2
Propanil	H	29	0	242	10.3
Propargite	I	29	0	241	.0
Propham	H	29	0	36	.0
Propiconazole	F	29	0	36	25.0
Propoxur	I	29	0	36	2.8
Propyzamide	H	29	0	242	.0
Siduron	H	29	0	36	2.8
Simazine	H	29	0	239	32.6
Sulfometuron-methyl	H	29	0	36	30.6
Tebuthiuron	H	29	7	242	95.0
Terbacil	H	29	0	36	.0
Terbufos	I	29	0	242	.0
Thiobencarb	H	29	0	242	18.2
Tri-allate	H	29	0	242	.0
Tribenuron-methyl	H	29	0	36	.0
Triclopyr	H	29	0	36	52.8
Trifluralin	H	29	0	242	4.1

Appendix 3. Concentrations of fipronil and degradation products in surface water, Mermentau River Basin, southwestern Louisiana, 1999-2001

[Concentrations in micrograms per liter; <, less than; NA, not analyzed; E, estimated]

USGS station number	Abbreviated site name[1]	Date	Degradation product: Desulfinyl-fipronil	Degradation product: Fipronil degradate RPA 105048	Degradation product: Fipronil sulfide	Degradation product: Fipronil sulfone	Fipronil
08010000	Des Cannes	03/10/1999	<0.010	<0.005	<0.010	<0.001	<0.004
08010000	Des Cannes	03/24/1999	.519	E.005	.043	.11	3.01
08010000	Des Cannes	04/07/1999	.889	.017	.124	.203	2.81
08010000	Des Cannes	04/20/1999	1.26	.046	.278	.302	3.22
08010000	Des Cannes	05/13/1999	.331	.039	.14	.087	.37
08010000	Des Cannes	05/26/1999	.341	.033	.226	.101	.198
08010000	Des Cannes	06/09/1999	.189	.025	.152	.067	.11
08010000	Des Cannes	06/24/1999	.186	.022	.119	.058	.233
08010000	Des Cannes	02/22/2000	NA	.013	NA	.014	<.005
08010000	Des Cannes	03/09/2000	NA	.014	NA	.012	<.044
08010000	Des Cannes	04/05/2000	.166	.015	.045	.05	.799
08010000	Des Cannes	04/18/2000	.593	.031	.124	.163	2.69
08010000	Des Cannes	05/10/2000	.102	.015	.076	.039	.088
08010000	Des Cannes	06/21/2000	.046	.015	.058	.03	.014
08010000	Des Cannes	06/27/2000	.061	.016	.081	.04	.016
08010000	Des Cannes	07/19/2000	<.010	<.005	<.010	<.001	<.004
08010000	Des Cannes	08/23/2000	.054	.013	.064	.037	.013
08010000	Des Cannes	11/14/2000	.011	.011	.012	.007	E.004
08010000	Des Cannes	12/14/2000	E.008	.009	.011	.007	<.004
08010000	Des Cannes	01/18/2001	E.005	.008	E.008	.006	<.004
08010000	Des Cannes	02/15/2001	E.009	.008	.013	.007	<.004
08010000	Des Cannes	03/28/2001	.336	.007	.029	.067	1.46
08010000	Des Cannes	04/16/2001	.607	.024	.163	.223	3.96
08010000	Des Cannes	05/16/2001	0.419	0.062	0.169	0.103	0.455
08010000	Des Cannes	06/11/2001	.027	.009	.024	.013	.031
08010500	Wikoff	02/23/2000	NA	E.024	NA	.004	<.004
08010500	Wikoff	03/21/2000	.091	E.004	.026	.018	.106
08010500	Wikoff	04/19/2000	.482	.017	.044	.09	1.07
08010500	Wikoff	06/01/2000	.038	.011	.027	.015	.008
08010500	Wikoff	06/27/2000	E.009	<.005	.012	.006	<.004
08010500	Wikoff	03/14/2001	<.010	<.005	<.010	<.001	<.004
08010500	Wikoff	04/24/2001	.041	.011	.02	.017	.03
08010500	Wikoff	05/24/2001	E.006	<.005	E.006	0.003	E.003
08011020	Plaquemine	02/23/2000	NA	.013	NA	.013	<.004
08011020	Plaquemine	04/20/2000	.541	.028	.105	.144	2.47

Appendix 3. Concentrations of fipronil and degradation products in surface water, Mermentau River Basin, southwestern Louisiana, 1999-2001—Continued

USGS station number	Abbreviated site name[1]	Date	Degradation product: Desulfinyl-fipronil	Degradation product: Fipronil degradate RPA 105048	Degradation product: Fipronil sulfide	Degradation product: Fipronil sulfone	Fipronil
08011020	Plaquemine	06/01/2000	0.157	0.017	0.129	0.062	0.243
08011020	Plaquemine	06/28/2000	.049	.013	.066	.034	.019
08011020	Plaquemine	03/13/2001	E.003	E.002	E.005	.003	<.004
08011020	Plaquemine	04/24/2001	.382	.013	.081	.11	1.89
08011020	Plaquemine	05/21/2001	.131	.014	.077	.042	.293
08011500	Boggy	03/20/2001	<.010	<.005	E.001	<.001	<.004
08011500	Boggy	04/26/2001	E.002	<.005	E.002	<.001	E.004
08011500	Boggy	05/23/2001	E.002	<.005	E.002	<.001	<.004
08011800	Castor	03/20/2001	E.002	E.002	E.006	.002	<.004
08011800	Castor	04/26/2001	.297	.011	.364	.151	2.76
08011800	Castor	05/22/2001	.175	.024	.433	.101	.704
08011860	Nezpique	02/22/2000	NA	.01	NA	.006	<.004
08011860	Nezpique	03/21/2000	.151	.011	.053	.065	1.29
08011860	Nezpique	04/18/2000	.158	.017	.109	.052	.593
08011860	Nezpique	05/30/2000	.063	<.005	.148	.03	.028
08011860	Nezpique	06/2//2000	.036	.011	.087	.022	.009
08011860	Nezpique	03/27/2001	0.146	E0.004	0.021	0.034	1.48
08011860	Nezpique	04/25/2001	.109	.006	.086	.047	.351
08011860	Nezpique	05/23/2001	.085	.014	.13	.034	.203
08012150	Mermentau	03/09/1999	<.010	<.005	<.010	<.001	<.004
08012150	Mermentau	03/23/1999	E.004	<.005	<.010	<.001	.059
08012150	Mermentau	04/08/1999	.285	E.005	.046	.104	2.22
08012150	Mermentau	04/21/1999	.504	.013	.14	.189	2.7
08012150	Mermentau	05/14/1999	.968	.036	.308	.267	2.36
08012150	Mermentau	05/26/1999	.522	.027	.226	.196	1.66
08012150	Mermentau	06/08/1999	.228	.03	.226	.117	.51
08012150	Mermentau	06/23/1999	.096	.019	.143	.048	.085
08012150	Mermentau	01/11/2000	NA	.017	NA	.012	.006
08012150	Mermentau	02/23/2000	NA	.011	NA	.015	.006
08012150	Mermentau	03/08/2000	NA	.013	NA	.013	<.004
08012150	Mermentau	03/23/2000	.037	.011	.03	.018	.193
08012150	Mermentau	04/04/2000	.51	.018	.103	.163	3
08012150	Mermentau	04/19/2000	.207	.017	.071	.064	1.02
08012150	Mermentau	05/09/2000	.068	.014	.059	.038	.188
08012150	Mermentau	05/31/2000	.101	.017	.083	.044	.188
08012150	Mermentau	06/20/2000	.109	.017	.122	.052	.109
08012150	Mermentau	06/28/2000	.086	.022	.115	.052	.059

Appendix 3. Concentrations of fipronil and degradation products in surface water, Mermentau River Basin, southwestern Louisiana, 1999-2001—Continued

USGS station number	Abbreviated site name[1]	Date	Degradation product				Fipronil
			Desulfinyl-fipronil	Fipronil degradate RPA 105048	Fipronil sulfide	Fipronil sulfone	
08012150	Mermentau	07/18/2000	0.04	0.015	0.074	0.035	0.016
08012150	Mermentau	08/22/2000	.039	.009	.062	.031	.017
08012150	Mermentau	09/28/2000	.036	.007	.055	.03	.014
08012150	Mermentau	11/14/2000	E.009	.011	.013	.01	.004
08012150	Mermentau	12/13/2000	E.008	.011	.015	.009	<.004
08012150	Mermentau	01/17/2001	E.006	.01	.011	.009	.006
08012150	Mermentau	02/13/2001	E.005	.007	.011	.006	<.004
08012150	Mermentau	03/29/2001	0.092	E0.004	0.016	0.03	0.82
08012150	Mermentau	04/17/2001	.119	.006	.041	.054	1.08
08012150	Mermentau	05/17/2001	.32	.029	.165	.127	1.37
08012150	Mermentau	06/12/2001	.018	.007	.027	.014	.044
08012300	Riceville	02/24/2000	NA	.018	NA	.01	<.004
08012300	Riceville	03/23/2000	.305	.016	.037	.064	1.64
08012300	Riceville	04/20/2000	.534	.031	.167	.194	3.23
08012300	Riceville	06/01/2000	.158	.027	.14	.063	.282
08012300	Riceville	06/29/2000	.052	.017	.084	.039	.016
08012400	Lake Arthur	02/24/2000	NA	.009	NA	.015	<.004
08012400	Lake Arthur	03/23/2000	.034	.01	.028	.016	.09
08012400	Lake Arthur	04/20/2000	.195	.016	.064	.06	.915
08012400	Lake Arthur	06/01/2000	.112	.018	.08	.046	.161
08012400	Lake Arthur	06/29/2000	.1	.018	.113	.053	.077
08012447	Chene	02/24/2000	NA	.02	NA	.012	<.004
08012447	Chene	03/23/2000	.09	.013	.045	.067	1.44
08012447	Chene	04/20/2000	.284	.022	.122	.012	2.6
08012447	Chene	05/31/2000	.092	.027	.107	.043	.086
08012447	Chene	06/28/2000	.115	.032	.169	.058	.047
08012470	Lacassine	03/09/1999	<.010	<.005	<.010	<.001	<.004
08012470	Lacassine	03/24/1999	E.008	<.005	<.010	.003	.149
08012470	Lacassine	04/08/1999	.229	E.004	.038	.076	2.35
08012470	Lacassine	04/21/1999	.206	E.003	.054	.07	1.66
08012470	Lacassine	05/13/1999	.138	.007	.063	.043	.465
08012470	Lacassine	05/26/1999	.141	.006	.056	.047	.457
08012470	Lacassine	06/08/1999	.12	.005	.047	.036	.253
08012470	Lacassine	06/24/1999	.139	.012	.108	.051	.256
08012470	Lacassine	02/24/2000	NA	.01	NA	.01	<.004
08012470	Lacassine	03/08/2000	NA	0.006	NA	0.009	<0.004
08012470	Lacassine	03/23/2000	0.025	E.005	0.011	.008	<.004

Appendix 3. Concentrations of fipronil and degradation products in surface water, Mermentau River Basin, southwestern Louisiana, 1999-2001—Continued

USGS station number	Abbreviated site name[1]	Date	Degradation product: Desulfinyl-fipronil	Fipronil degradate RPA 105048	Fipronil sulfide	Fipronil sulfone	Fipronil
08012470	Lacassine	04/04/2000	0.226	0.01	0.077	0.081	1.94
08012470	Lacassine	04/20/2000	.219	.022	.08	.068	1.04
08012470	Lacassine	05/09/2000	.059	.015	.048	.029	.176
08012470	Lacassine	06/01/2000	.08	.019	.072	.033	.097
08012470	Lacassine	06/20/2000	.094	.014	.075	.033	.056
08012470	Lacassine	06/28/2000	.121	.015	.085	.042	.052
08012470	Lacassine	07/18/2000	.057	.022	.09	.039	.02
08012470	Lacassine	08/23/2000	.051	.012	.054	.03	.013
08012470	Lacassine	11/14/2000	.015	.012	.021	.012	.007
08012470	Lacassine	12/13/2000	E.009	.021	.013	.008	<.004
08012470	Lacassine	01/17/2001	E.006	.014	.01	.006	<.004
08012470	Lacassine	02/13/2001	E.006	.012	.011	.006	<.004
08012470	Lacassine	03/15/2001	E.008	.006	E.008	.005	.05
08012470	Lacassine	03/22/2001	.013	.007	E.007	.004	.048
08012470	Lacassine	03/29/2001	<.010	<.005	<.010	<.001	<.004
08012470	Lacassine	04/05/2001	.028	.006	.016	.013	.35
08012470	Lacassine	04/13/2001	.044	.007	.024	.018	.464
08012470	Lacassine	04/17/2001	.074	.008	.041	.034	.897
08012470	Lacassine	042/7/2001	.068	.009	.06	.029	.545
08012470	Lacassine	05/17/2001	.085	.017	.078	.037	.46
08012470	Lacassine	06/12/2001	.018	.009	.03	.013	.04
08014500	Whisky	04/05/2000	<.010	<.005	<.010	<.001	<.004
08014500	Whisky	06/21/2000	<.010	<.005	<.010	<.001	<.004
08014500	Whisky	08/23/2000	<.010	<.005	<.010	<.001	<.004
08014500	Whisky	09/29/2000	<.010	<.005	<.010	<.001	<.004
08014500	Whisky	11/14/2000	<.010	<.005	<.010	<.001	<.004
08014500	Whisky	12/14/2000	<.010	<.005	<.010	<.001	<.004
08014500	Whisky	01/17/2001	<.010	<.005	<.010	<.001	<.004
08014500	Whisky	02/13/2001	<.010	<.005	<.010	<.001	<.004
08014500	Whisky	03/28/2001	<.010	<.005	<.010	<.001	<.004
08014500	Whisky	04/17/2001	<.010	<.005	<.010	<.001	<.004
08014500	Whisky	06/12/2001	<.010	<.005	<.010	<.001	<.004
300446092214200	Tortue	02/25/2000	NA	.019	NA	.009	<.004
300446092214200	Tortue	03/24/2000	.47	.007	.069	.16	4.07
300446092214200	Tortue	06/01/2000	.236	.026	.184	.11	.807
300446092214200	Tortue	06/28/2000	.03	.007	.062	.024	.007
300446092214200	Tortue	03/13/2001	E.003	E.002	E.005	.003	<.004

Appendix 3. Concentrations of fipronil and degradation products in surface water, Mermentau River Basin, southwestern Louisiana, 1999-2001—Continued

USGS station number	Abbreviated site name[1]	Date	Degradation product: Desulfinyl-fipronil	Degradation product: Fipronil degradate RPA 105048	Degradation product: Fipronil sulfide	Degradation product: Fipronil sulfone	Fipronil
300446092214200	Tortue	04/23/2001	0.32	0.013	0.123	0.119	1.86
300446092214200	Tortue	05/21/2001	.122	.007	.07	.039	.432
300514092173500	Grand Marais	03/23/2001	.059	E.003	E.006	.011	.324
300514092173500	Grand Marais	04/23/2001	.085	.014	.017	.018	.156
300514092173500	Grand Marais	05/21/2001	.037	.006	.016	.006	.006
301154092145900	Theriot	03/16/2001	E.002	<.005	E.003	<.001	<.004
301154092145900	Theriot	04/23/2001	.145	.014	.087	.052	.287
301154092145900	Theriot	05/21/2001	.048	.007	.044	.018	.035
301520092491800	East Lacassine	02/24/2000	NA	.048	NA	.019	<.004
301520092491800	East Lacassine	03/23/2000	.2	E.003	.046	.132	E5.29
301520092491800	East Lacassine	04/19/2000	.4	.014	.171	.205	4.54
301520092491800	East Lacassine	05/31/2000	.082	.019	.163	.079	.09
301520092491800	East Lacassine	06/28/2000	.041	.012	.1	.046	.024
301520092491800	East Lacassine	03/14/2001	E.004	.006	E.008	.005	<.004
301520092491800	East Lacassine	04/24/2001	E.009	.01	.012	.01	.027
301520092491800	East Lacassine	05/22/2001	.139	.024	.131	.115	.176
301538092421900	Roanoke	02/23/2000	NA	.021	NA	.017	.007
301538092421900	Roanoke	03/22/2000	.12	.007	.043	.066	1.28
301538092421900	Roanoke	04/19/2000	.425	.021	.128	.202	E5.19
301538092421900	Roanoke	05/31/2000	.066	.016	.145	.057	.047
301538092421900	Roanoke	06/28/2000	.033	.01	.097	.037	.017
301959092323400	Iota	02/23/2000	NA	.008	NA	.013	.005
301959092323400	Iota	03/22/2000	.416	.017	.071	.116	2.69
301959092323400	Iota	04/19/2000	.413	.02	.137	.126	2.26
301959092323400	Iota	05/31/2000	.171	.026	.214	.07	.104
302128092373800	Panchoville	02/23/2000	.052	.012	.042	.012	<.004
302128092373800	Panchoville	04/19/2000	.36	.021	.149	.143	3.24
302128092373800	Panchoville	05/31/2000	.079	.017	.172	.051	.083
302128092373800	Panchoville	06/28/2000	.071	.017	.186	.05	.03
302403092152300	ChurchPoint	02/22/2000	NA	<.005	NA	<.005	<.004
302403092152300	ChurchPoint	03/21/2000	1.13	.015	.034	.126	1.59
302403092152300	ChurchPoint	04/18/2000	.036	E.002	.018	.011	.128
302403092152300	ChurchPoint	05/30/2000	E.005	<.005	E.008	.004	<.004
302403092152300	ChurchPoint	06/27/2000	E.004	<.005	E.007	.004	<.004
302403092152300	ChurchPoint	03/22/2001	E.004	E.003	E.003	.003	.043
302403092152300	ChurchPoint	04/24/2001	E.004	E.009	E.006	.004	.005
302403092152300	ChurchPoint	05/24/2001	E.002	<.005	E.002	E.002	E.004

Appendix 3. Concentrations of fipronil and degradation products in surface water, Mermentau River Basin, southwestern Louisiana, 1999-2001—Continued

USGS station number	Abbreviated site name[1]	Date	Degradation product: Desulfinyl-fipronil	Degradation product: Fipronil degradate RPA 105048	Degradation product: Fipronil sulfide	Degradation product: Fipronil sulfone	Fipronil
302749092203500	Mallet	02/22/2000	NA	E0.005	NA	0.005	<0.004
302749092203500	Mallet	04/18/2000	0.13	.014	0.043	.044	.829
302749092203500	Mallet	05/30/2000	.282	.022	.043	.027	.298
302749092203500	Mallet	06/27/2000	.018	E.003	.022	.008	<.004
302749092203500	Mallet	04/18/2001	.143	.005	.064	.044	.442
302749092203500	Mallet	05/23/2001	.018	.005	.026	.007	.015
303206092360000	Guidry	02/22/2000	NA	.008	NA	.012	<.004
303206092360000	Guidry	03/21/2000	.651	.017	.067	.146	3.94
303206092360000	Guidry	04/18/2000	.242	.016	.109	.089	1.7
303206092360000	Guidry	05/30/2000	.082	.014	.127	.049	.297
303206092360000	Guidry	06/27/2000	.059	.016	.12	.037	.019
303206092360000	Guidry	03/27/2001	.106	.006	.021	.041	1.33
303206092360000	Guidry	04/25/2001	.225	.012	.129	.125	2.15
303206092360000	Guidry	05/22/2001	.132	.021	.153	.066	.258
303209092401800	Blue	03/21/2001	.141	.009	.024	.034	1.34
303209092401800	Blue	04/25/2001	.475	.025	.372	.282	E6.41
303209092401800	Blue	05/22/2001	.205	.026	.507	.123	1.09
303755092190400	Upper Des Cannes	03/21/2001	1.54	.021	.078	.196	3.85
303755092190400	Upper Des Cannes	04/26/2001	.536	.022	.133	.132	.879
303755092190400	Upper Des Cannes	05/23/2001	.243	.029	.188	.079	.185
304130092344100	Caney	03/19/2001	<.010	<.005	<.010	<.001	<.004
304130092344100	Caney	04/25/2001	E.001	<.005	E.001	<.001	.005
304130092344100	Caney	05/23/2001	<.010	<.005	<.010	<.001	<.004

[1] Complete site name is listed in appendix 1.

Appendix 4. Selected physiochemical properties and fipronil concentrations for ecological data-collection sites in southwestern Louisiana, 2001
[mg/L, milligram per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius, NTU, nephelometric turbidity units; µg/L, micrograms per liter]

Site number (fig. 17)	Abbreviated site name[1]	USGS station number	Date	Time	Dissolved oxygen, field (mg/L)	pH, field (standard units)	Specific conductance, field (µS/cm)	Temperature, field (°C)	Turbidity, laboratory (NTU)	Maximum dissolved fipronil[2] (µg/L)
1	Des Cannes	08010000	4/16/2001	1300	3.7	7.8	424	27.7	49	3.960
2	Wikoff	08010500	3/14/2001	1515	6.0	7.6	155	18.9	64	.030
3	Plaquemine	08011020	3/13/2001	1030	6.0	7.5	161	19.1	254	1.890
4	Boggy	08011500	3/20/2001	1000	7.3	6.4	36	13.1	8	<.004
5	Castor	08011800	3/20/2001	1530	7.0	6.4	49	13.6	26	2.760
6	Nezpique	08011860	3/27/2001	0930	7.6	7.3	117	13.2	434	1.480
7	Mermentau	08012150	3/29/2001	0700	6.2	7.3	162	12.8	514	1.370
11	Lacassine	08012470	3/15/2001	1045	3.6	6.8	126	17.3	198	.897
12	Tortue	300446092214200	3/13/2001	1730	5.0	7.5	175	19.9	349	1.860
13	Grand Marais	300514092173500	3/23/2001	0830	6.5	8.1	367	18.9	1,043	.324
14	Theriot	301154092145900	3/16/2001	1200	7.5	7.9	168	16.4	345	.287
15	East Lacassine	301520092491800	3/14/2001	1000	7.1	7.4	107	19.0	226	.176
19	Church Point	302403092152300	3/22/2001	1115	8.1	8.1	352	14.5	276	.043
20	Mallet	302749092203500	4/18/2001	0700	4.7	7.9	434	18.0	125	.442
21	Guidry	303206092360000	3/27/2001	1515	7.9	7.7	162	13.9	758	2.150
22	Blue	303209092401800	3/21/2001	1500	7.3	6.7	95	14.0	476	6.410*
23	Upper Des Cannes	303755092190400	3/21/2001	0930	7.0	7.5	250	13.5	650	3.850
24	Caney	304130092344100	3/19/2001	1230	5.9	6.5	44	12.8	16	.005
25	Whisky	08014500	4/17/2001	1530	9.6	7.2	55	21.4	15	<.004

[1] Complete site name is listed in appendix 1.
[2] Maximum dissolved fipronil concentration of three water-quality samples collected between March and May 2001.
* Estimated value.

Appendix 5. Mean quantitative habitat variables from ecological data-collection sites in southwestern Louisiana, 2001
[--, not available]

Site number (fig. 17)	Abbreviated site name[1]	USGS station number	Date	Time	Drainage area, square miles	Bank angle,[2] degrees	Bank erosion score[3]	Bank height,[2] meter	Bank stability index[2]	Bank vegetative cover,[2] percent	Euphotic zone depth,[4] meter
1	Des Cannes	08010000	4/16/2001	1300	142	49.2	5	3.3	13	73.3	0.22
2	Wikoff	08010500	3/14/2001	1515	63	47	2	1.3	11.35	45	.47
3	Plaquemine	08011020	3/13/2001	1030	320	60	6	0.8	9.7	86.7	.20
4	Boggy	08011500	3/20/2001	1000	65	65.2	2	2.3	13	35	1.35
5	Castor	08011800	3/20/2001	1530	33	31.8	1	3.2	12.35	41.7	.61
6	Nezpique	08011860	3/27/2001	0930	166	42.2	3	3.1	12.65	55	.14
7	Mermentau	08012150	3/29/2001	0700	1,381	--	--	--	--	--	.13
11	Lacassine	08012470	3/15/2001	1045	296	--	--	--	--	--	.26
12	Tortue	300446092214200	3/13/2001	1730	97	73.3	6	1.2	10.7	66.7	.15
13	Grand Marais	300514092173500	3/23/2001	0830	26	38.2	2	2.3	11.35	66.7	.06
14	Theriot	301154092145900	3/16/2001	1200	37	49	5	1.3	12.2	25	.14
15	East Lacassine	301520092491800	3/14/2001	1000	15	52.7	2	0.6	9.7	85	.24
19	Church Point	302403092152300	3/22/2001	1115	74	48.8	5	4.4	14.15	75	.14
20	Mallet	302749092203500	4/18/2001	0700	91	54.5	4	1.6	12.15	35	.49
21	Guidry	303206092360000	3/27/2001	1515	381	41.8	6	3.9	14	38.3	.09
22	Blue	303209092401800	3/21/2001	1500	80	47.3	3	1.2	11.7	31.7	.13
23	Upper Des Cannes	303755092190400	3/21/2001	0930	46	60.3	2	1.7	11.35	76.7	.11
24	Caney	304130092344100	3/19/2001	1230	18	44.7	1	2.7	13.85	23.3	1.30
25	Whisky	08014500	4/17/2001	1530	504	51.8	5	3.7	16.85	41.7	2.28

Appendix 5. Mean quantitative habitat variables from ecological data-collection sites in southwestern Louisiana, 2001—Continued

Site number (fig. 17)	Abbreviated site name[1]	Habitat cover,[3] percent	Open canopy,[2] percent	Riparian canopy closure,[2] percent	Secchi disk depth,[5] meter	Stream bankfull channel width,[2] meter	Stream depth,[2] meter	Stream open angle,[2] degrees	Stream velocity,[2] square foot per second	Stream wetted channel width,[2] meter	Width-to-depth ratio[6]
1	Des Cannes	27.8	25	69.6	0.03	22.6	0.95	45	0	16.2	17.1
2	Wikoff	33.3	8.7	90.2	.18	11.4	.75	15.7	.94	8.53	11.4
3	Plaquemine	44.4	68.3	74.5	.1	58.8	--	123	--	57	--
4	Boggy	38.9	7.6	84.3	.655	17.5	.88	13.7	.03	11.1	12.6
5	Castor	30.6	27.6	57.8	.325	21.6	.54	49.7	.29	7	13
6	Nezpique	30.6	19.4	85.3	.06	26.5	.97	35	.81	15.8	16.3
7	Mermentau	47.2	78.9	89.2	.04	113	9.72	142	--	113	11.6
11	Lacassine	47.2	75.4	82.4	.09	112	4.74	136	--	112	23.6
12	Tortue	38.9	56.1	81.4	.07	28.6	--	101	--	26.5	--
13	Grand Marais	38.9	41.5	33.3	.025	14.3	.54	74.7	.16	6.6	12.2
14	Theriot	30.6	25.2	58.8	.025	14.1	.8	45.3	1.17	5.59	6.99
15	East Lacassine	22.2	61.7	5.9	.1	6.9	.63	111	1.19	5.88	9.3
19	Church Point	30.6	50	5.9	.04	18.9	.45	90	.51	7.23	16.1
20	Mallet	33.3	6.9	92.2	.14	15.8	.52	12.3	.1	10.8	20.8
21	Guidry	30.6	27	81.4	.025	31.1	1.86	48.7	.21	20.4	11
22	Blue	41.7	3	84.3	.03	17.1	1.16	5.3	.63	12	10.3
23	Upper Des Cannes	41.7	27.6	79.4	.025	21.6	1.36	49.7		17.1	12.6
24	Caney	36.1	5.6	88.2	.575	14.3	.46	10	.18	5.47	11.9
25	Whisky	36.1	31.1	90.2	1.23	39.3	.88	56	.94	28.6	32.5

[1] Complete site name is listed in appendix 1.
[2] Habitat variables measured according to Fitzpatrick and others (1998).
[3] Percent availability was ranked and scored for habitat variables measured according to Fitzpatrick and others (1998).
[4] Euphotic zone depth measured according to Moulton and others (2002).
[5] Secchi disk depth measured according to Wetzel and Likens (1991).
[6] Width-to-depth ratio determined by dividing stream wetted width by the stream depth.

Appendix 6. Classification ranking of U.S. Environmental Protection Agency's Rapid Bioassessment Protocols habitat variables for ecological data-collection sites in southwestern Louisiana, 2001

[>, greater than; <, less than; SAV, submerged aquatic vegetation]

RBP* Habitat Category[1]	Habitat variables: Instream cover[2] (percent submerged habitat)	Pool substrate characterization[3] (substrate quality)	Pool variability[4] (pool quality)	Sediment deposition[5] (percent recent deposition)	Channel flow status[6] (percent available channel exposed)	Channel alteration[7] (percent channelized stream reach)
Optimal (16-20)	>50	Mixed bottom, roots, SAV	Mixed shallow and deep	<5	Minimal	Minimal
Suboptimal (11-15)	30-50	Mixed bottom, roots	Large and deep	20-50	<25	<40
Marginal (6-10)	10-30	Mud bottom, little roots	Small and deep	50-80	25-75	40-80
Poor (0-5)	<10	Clay bottom, no roots	Small and shallow	>80	>75	>80

RBP* Habitat Category[1]	Habitat variables: Channel sinuosity[8] (stream bends increase length)	Bank stability[9] (erosion of streambanks)	Bank vegetation protection[10] (percent vegetative cover)	Riparian vegetative zone width[11] (meter)	RBP* site score range[12]	RBP* site habitat rating[13]
Optimal (16-20)	3-4 times	Stable	>90	>18	200-155	Optimal
Suboptimal (11-15)	2-3 times	Moderately stable	70-90	12-18	154-102	Suboptimal
Marginal (6-10)	1-2 times	Moderately unstable	50-70	6-12	101-49	Marginal
Poor (0-5)	Straight	Unstable	<50	<6	48-0	Poor

* RBP = Rapid Bioassessment Protocols include a visual-based habitat assessment for low gradient streams, modified for use in this study (Barbour and others, 1999).

[1] RBP habitat rank was based on a score ranging from 0-20 for each habitat parameter with the exception of bank vegetation protection, bank stability, and riparian vegetative zone width, which were based on scores from 0-10 for the right streambank and scores from 0-10 for the left streambank. Numbers in parenthesis represent the range of scores within each category.

[2] Instream cover was based on the percentage of mix of submerged logs, undercut banks, or other stable habitat at the site.

[3] Pool substrate characterization was based on the mixture of substrate materials, availability of root mats and submerged aquatic vegetation (SAV's) at the site.

[4] Pool variability was based on the quality of pools (pool width compared to stream width and pool depth compared to stream depth) at the site.

[5] Sediment deposition was based on the percentage of stream bottom affected by recent sediment deposition (enlargement of islands or point bars) at the site.

[6] Channel flow status was based on the percentage of available channel exposed at the site.

[7] Channel alteration was based on the percentage of disrupted stream bottom and streambanks due to dredging, channelization, or other disruptive stream activities at the site.

[8] Channel sinuosity was based on the amount of stream length increase due to bends in the stream compared to a straight line at the site.

[9] Bank stability was based on the evidence of streambank erosion or bank failure and potential for future problems at the site.

[10] Bank vegetation protection was based on the percentage of vegetative cover on the streambank at the site.

[11] Riparian vegetative zone width was the width of the riparian zone not affected by human activities at the site.

[12] RBP site score range represents the sum of each habitat parameter score for a site; these ranges correspond to the RBP site habitat rating for the site.

[13] RBP site habitat rating is the overall stream habitat rating for the site, based on the total score for the site; the score is based on the RBP site score range.

Appendix 7. Habitat assessment results using U.S. Environmental Protection Agency's Rapid Bioassessment Protocols for ecological data-collection sites in southwestern Louisiana, 2001

		Habitat variables[1]											
Site number (fig. 17)	Abbreviated site name[2]	Instream cover (percent submerged habitat)	Pool substrate characterization (substrate quality)	Pool variability (pool quality)	Sediment deposition (percent recent deposition)	Channel flow status (percent available channel exposed)	Channel alteration (percent channelized stream reach)	Channel sinuosity (stream bends increase length)	Bank stability (erosion of streambank)	Bank vegetation protection (percent vegetative cover)	Riparian vegetative zone width (meter)	RBP* site score range	RBP* site habitat rating
1	Des Cannes	15	14	18	3	18	8	6	10	20	20	132	Suboptimal
2	Wikoff	14	9	16	12	18	17	8	14	16	20	144	Suboptimal
3	Plaquemine	16	9	13	7	15	15	9	6	18	20	128	Suboptimal
4	Boggy	18	15	17	20	18	20	18	12	20	20	178	Optimal
5	Castor	14	18	19	18	16	15	14	14	16	18	162	Optimal
6	Nezpique	16	15	18	11	17	20	18	14	14	20	163	Optimal
7	Mermentau	20	15	18	13	20	8	15	20	20	20	169	Optimal
11	Lacassine	18	15	15	8	18	20	20	20	20	20	174	Optimal
12	Tortue	9	8	12	3	14	6	3	2	14	18	89	Marginal
13	Grand Marais	13	8	8	3	18	10	3	6	16	4	89	Marginal
14	Theriot	7	7	8	1	14	10	6	10	10	15	88	Marginal
15	East Lacassine	2	3	15	17	18	13	8	14	9	8	107	Suboptimal
19	Church Point	11	13	8	14	14	18	13	16	12	8	127	Suboptimal
20	Mallet	17	13	8	4	17	19	18	16	10	20	142	Suboptimal
21	Guidry	16	10	13	8	17	15	19	8	10	20	136	Suboptimal
22	Blue	16	10	18	15	20	20	20	18	18	20	175	Optimal
23	Upper Des Cannes	14	8	13	6	18	18	17	20	20	20	154	Suboptimal
24	Caney	18	15	16	15	18	20	10	18	20	20	170	Optimal
25	Whisky	20	20	20	15	20	20	18	18	20	20	191	Optimal

[1] Habitat variables descriptions are included in appendix 6.

[2] Complete site name is listed in appendix 1.

* RBP = Rapid Bioassessment Protocols include a visual-based habitat assessment for low gradient streams, modified for use in this study (Barbour and others, 1999).

Appendix 8. Taxa and densities of richest-targeted habitat aquatic invertebrates for ecological data-collection sites in southwestern Louisiana, March-April 2001

[Densities and total number of aquatic invertebrates are rounded to the nearest whole number and reported as organisms per square meter; –, species not used as part of canonical correspondence analysis; --, species not collected; *, Subfamily; **, Tribe]

Taxonomic heirarchy PHYLUM CLASS ORDER Family *Genus species*	Species abbrevi-ation (see fig. 16)	Densities Abbreviated site names (see table 1, appendix 1) Des Cannes	Wikoff	Plaque-mine	Boggy	Castor	Nez-pique	Mer-men-tau	Lacas-sine	Tortue
CNIDARIA (coelenterates)	–	--	--	--	--	--	--	--	--	--
HYDROZOA (hydras)	–	--	--	--	--	--	--	--	--	--
HYDROIDA	–	--	--	--	--	--	--	--	--	--
Hydridae	–	--	--	--	--	--	--	--	--	--
Hydra sp.	Hydra	--	--	10	41	10	--	--	140	--
PLATYHELMINTHES (flatworms)	–	--	--	--	--	--	--	--	--	--
TURBELLARIA (free-living flatworms)	Turbell	18	--	5	8	35	12	40	107	5
NEMATODA (roundworms)	Nematoda	--	--	5	25	10	33	10	--	--
MOLLUSCA (clams, snails, and limpets)	–	--	--	--	--	--	--	--	--	--
BIVALVIA (bivalue molluscs)	–	--	--	--	--	--	--	--	--	--
VENEROIDA	–	--	--	--	--	--	--	--	--	--
Sphaeriidae (fingernail clams)	–	--	--	--	--	--	--	--	--	--
Eupera cubensis sp.	–	25	--	--	--	--	5	6	--	--
Musculium sp.	–	--	--	--	--	--	--	10	2	--
GASTROPODA (snails, limpets)	–	--	--	--	--	--	--	--	--	--
BASOMMATOPHORA	–	--	--	--	--	--	--	--	--	--
Ancylidae (limpets)	–	--	--	--	--	--	--	--	--	--
Laevapex sp.	–	--	--	--	--	--	--	--	--	--
Lymnaeidae (pond snails)	–	--	--	--	--	--	--	--	--	--
Pseudosuccinea columella	–	--	--	--	--	--	--	40	54	5
Physidae (pouch snails)	–	--	--	--	--	--	--	--	--	--
Physella sp.	Physella	4	9	25	8	37	61	110	177	22
Planorbidae (orb snails)	–	--	--	--	--	--	--	--	--	--
Micromenetus sp.	Micromen	--	22	--	--	--	--	60	32	17
Planorbella sp.	–	--	--	--	--	--	--	--	--	--
ANNELIDA (segmented worms)	–	--	--	--	--	--	--	--	--	--
HIRUDINEA (leeches)	–	--	--	--	--	--	--	--	--	--
ARHYNCHOBDELLAE	–	--	--	--	--	--	--	--	--	--
Erpobdellidae	Erpobidae	--	4	5	--	--	23	10	--	--
RHYNCHOBDELLAE	–	--	--	--	--	--	--	--	--	--
Glossiphoniidae	–	2	--	--	--	--	--	--	--	--
OLIGOCHAETA (aquatic worms)	–	--	--	--	--	--	--	--	--	--
ENCHYTRAEIDA	–	--	--	--	--	--	--	--	--	--
Enchytraeidae	Enchidae	--	--	--	--	40	5		--	--
LUMBRICULIDA	–	--	--	--	--	--	--	--	--	--
Lumbriculidae	–	--	--	--	8	--	--	17	--	--
Megadrile sp.	Megadrill	--	--	2	--	--	--	6	--	--
TUBIFICIDA	–	--	--	--	--	--	--	--	--	--
Naididae	Naididae	--	--	--	--	--	--	--	32	71
Tubificidae	Tubfidae	18	99	--	--	10	5	23	--	--
ARTHROPODA (arthropods)	–	--	--	--	--	--	--	--	--	--
ARACHNIDA (eight-legged arthropods)	–	--	--	--	--	--	--	--	--	--
ACARI (water mites)	Acari	--	13	--	--	--	5	--	--	--

Appendix 8. Taxa and densities of richest-targeted habitat aquatic invertebrates for ecological data-collection sites in southwestern Louisiana, March-April 2001—Continued

Taxonomic heirarchy PHYLUM CLASS ORDER Family *Genus species*	Species abbreviation (see fig. 16)	Densities Abbreviated site names (see table 1, appendix 1) Des Cannes	Wikoff	Plaquemine	Boggy	Castor	Nezpique	Mermentau	Lacassine	Tortue
MALACOSTRACA (crustaceans)	--	--	--	--	--	--	--	--	--	--
AMPHIPODA (scuds, sideswimmers)	–	--	--	--	--	--	--	--	--	--
Crangonyctidae	–	--	--	--	--	--	--	--	--	--
Crangonyx sp.	Crangony	--	--	--	58	10	--	6	11	--
Hyalellidae	–	--	--	--	--	--	--	--	--	--
Hyalella azteca	Hyazteca	20	1	205	--	--	--	722	1,171	1,363
DECAPODA (crayfishes, shrimps)	–	--	--	--	--	--	--	--	--	--
Palaemonidae (prawns and river shrimps)	–	--	--	--	--	--	--	--	--	--
Palaemonetes kadiakensis	–	--	--	--	--	--	--	--	--	--
ISOPODA (aquatic sow bugs)	–	--	--	--	--	--	--	--	--	--
Asellidae	–	--	--	--	--	--	--	--	--	--
Caecidotea sp.	–	--	--	--	--	10	--	--	--	--
Lirceus sp.	Lirceus	--	--	--	19	--	--	--	11	--
INSECTA (insects)	–	--	--	--	--	--	--	--	--	--
COLEOPTERA (beetles)	–	--	--	--	--	--	--	--	--	--
Carabidae (predaceous ground beetles)	–	2	--	--	--	--	--	--	--	--
Curculionidae (weevils)	–	4	--	--	--	--	--	--	--	--
Dytiscidae (predaceous diving beetles)	–	--	--	--	--	--	--	--	--	--
Thermonectus sp.	–	--	--	--	--	--	--	--	--	--
Hydroporinae*	Hydrinae	11	--	--	--	--	--	6	--	17
Laccophilinae*	–	--	--	--	--	--	--	--	--	--
Laccophilus sp.	–	--	--	--	--	--	--	--	--	--
Elmidae (riffle beetles)	–	--	--	--	--	--	--	--	--	--
Macronychus glabratus	–	--	--	--	--	--	--	--	--	--
Stenelmis sp.	–	--	4	--	--	--	--	--	--	--
Hydrophilidae (water scavenger beetles)	–	--	--	--	--	--	--	--	--	--
Berosus sp.	–	2	--	2	--	--	--	--	--	--
Enochrus sp.	Enochrus	--	--	--	--	--	--	6	--	--
Helochares sp.	–	--	--	--	--	--	--	--	--	--
Tropisternus sp.	Tropist	--	4	--	--	--	--	--	--	11
Noteridae (burrowing water beetles)	–	--	--	--	--	--	--	--	--	--
Hydrocanthus sp.	–	--	--	--	--	--	--	--	--	--
Suphisellus bicolor	–	--	--	--	--	--	--	--	--	5
Scirtidae (marsh beetles)	Scirtdae	--	--	43	--	--	5	--	--	5
COLLEMBOLA (springtails)	Collemb	7	--	5	--	30	12	--	11	5
DIPTERA (true flies)	–	--	--	--	--	--	--	--	--	--
Ceratopogonidae (biting midges, no-see-ums)	–	--	--	--	--	--	--	--	--	--
Ceratopogoninae*	–	--	--	--	--	--	--	--	--	--
Bezzia/Palpomyia sp.	Bezzpalp	--	--	--	--	30	--	6	--	--
Forcipomyiinae*	–	--	--	--	--	--	--	--	--	--
Atrichopogon sp.	Atrichop	--	--	--	8	30	--	--	--	--
Chironomidae (midges)	–	--	--	--	--	--	--	--	--	--
Chironominae*	–	--	--	--	--	--	--	--	--	--

Appendix 8. Taxa and densities of richest-targeted habitat aquatic invertebrates for ecological data-collection sites in southwestern Louisiana, March-April 2001—Continued

Taxonomic heirarchy PHYLUM CLASS ORDER Family *Genus species*	Species abbreviation (see fig. 16)	Densities Abbreviated site names (see table 1, appendix 1) Des Cannes	Wikoff	Plaquemine	Boggy	Castor	Nezpique	Mermentau	Lacassine	Tortue
Chironomini**	–	--	--	--	--	--	--	--	--	--
Chironomus sp.	Chironom	--	4	10	--	20	--	--	--	--
Dicrotendipes sp.	Dicdipes	63	77	14	803	377	390	23	11	5
Endochironomus sp.	–	--	--	--	--	--	--	40	--	--
Glyptotendipes sp.	Glydipes	--	--	109	--	--	--	216	623	11
Goeldichironomus sp.	–	--	--	--	--	--	--	--	--	--
Kiefferulus sp.	–	--	--	--	--	--	--	--	--	--
Parachironomus sp.	–	--	--	--	--	--	--	--	--	--
Phaenopsectra/Tribelos sp.	–	--	4	--	--	--	--	--	43	--
Polypedilum sp.	–	--	--	--	--	--	--	6	11	--
Stenochironomus sp.	–	--	--	--	--	--	5	--	--	--
Tribelos sp.	Tribelos	--	26	--	--	--	5	6	32	5
Zavreliella marmorata	–	--	--	--	--	--	--	--	--	--
Pseudochironomini**	–	--	--	--	--	--	--	--	--	--
Pseudochironomus sp.	–	4	--	--	--	--	--	17	--	--
Tanytarsini**	–	--	--	--	--	--	--	--	--	--
Cladotanytarsus sp.	–	--	--	5	--	--	--	--	--	--
Micropsectra/Tanytarsus sp.	Mictanyt	--	4	10	124	50	12	--	--	--
Rheotanytarsus sp.	Rheotany	9	30	5	306	79	23	--	--	--
Tanytarsus sp.	Tanytars	--	77	33	340	367	80	6	--	--
Diamesinae*	–	--	--	--	--	--	--	--	--	--
Potthastia sp.	–	--	--	--	17	--	--	--	--	--
Orthocladiinae*	–	--	--	--	--	--	--	--	--	--
Corynoneura sp.	Corynon	--	125	10	207	10	--	--	11	--
Cricotopus sp.	Cricotop	2	112	5	--	--	--	--	--	--
Cricotopus/Orthocladius sp.	Criortho	--	30	--	--	--	--	--	--	--
Gymnometriocnemus sp.	–	--	--	--	--	--	--	--	--	--
Nanocladius sp.	Nanoclad	2	17	14	108	--	5	--	75	5
Parakiefferiella sp.	–	--	--	--	157	10	--	--	--	--
Parametriocnemus sp.	–	--	--	--	--	10	--	--	--	--
Rheocricotopus sp.	Rheocric	--	--	--	17	--	--	--	--	--
Thienemanniella sp.	Thienema	--	9	5	58	--	5	--	--	5
Tvetenia sp.	–	--	--	--	--	--	--	--	--	--
Tanypodinae*	–	--	--	--	--	--	--	--	--	--
Natarsiini**	–	--	--	--	--	--	--	--	--	--
Natarsia sp.	–	--	--	--	--	--	--	--	--	--
Pentaneurini**	–	--	--	--	--	--	--	--	--	--
Ablabesmyia sp.	Ablabesm	2	--	10		30		6	75	11
Larsia sp.	–	--	--	--	--	--	--	--	--	--
Thienemannimyia group sp.	–	--	--	--	--	--	--	--	--	--
Procladiini**	–	--	--	--	--	--	--	--	--	--
Procladius sp.	–	--	--	--	--	--	--	--	--	--
Ephydridae (shore and brine flies)	–	--	--	--	--	--	--	--	--	--
Psychodidae (moth flies)	–	--	--	--	--	--	--	--	--	--
Psychoda sp.	–	--	--	--	--	10	--	--	--	--

Appendix 8. Taxa and densities of richest-targeted habitat aquatic invertebrates for ecological data-collection sites in southwestern Louisiana, March-April 2001—Continued

Taxonomic heirarchy PHYLUM CLASS ORDER Family *Genus species*	Species abbreviation (see fig. 16)	Densities: Abbreviated site names (see table 1, appendix 1) Des Cannes	Wikoff	Plaquemine	Boggy	Castor	Nezpique	Mermentau	Lacassine	Tortue
Simuliidae (black flies)	–	--	--	--	--	--	--	--	--	--
Simulium sp.	–	--	--	--	10	--	--	--	--	--
Stratiomyidae (soldier flies)	–	--	--	--	--	--	--	--	--	--
Stratiomyinae*	–	--	--	--	--	--	--	--	--	--
Hedriodiscus/Odontomyia sp.	Hedrodon	47	--	24	--	--	--	6	--	--
Tabanidae	–	--	--	--	--	--	--	--	--	--
Tabanus sp.	–	--	--	--	--	--	--	--	--	--
EPHEMEROPTERA (mayflies)	–	--	--	--	--	--	--	--	--	--
Baetidae	–	--	--	--	--	--	--	--	--	--
Baetis intercalaris	–	--	--	--	--	--	--	--	--	--
Callibaetis sp.	–	--	--	--	--	--	--	--	--	--
Caenidae	–	--	--	--	--	--	--	--	--	--
Caenis sp.	Caenis	--	116	33	--	--	14	56	150	49
Heptageniidae	–	--	--	--	--	--	--	--	--	--
Stenacron sp.	–	--	--	--	--	--	--	--	--	--
Stenonema sp.	–	--	--	--	--	--	--	--	--	--
Isonychiidae	–	--	--	--	--	--	--	--	--	--
Isonychia sp.	–	--	--	--	--	--	--	--	--	--
MEGALOPTERA (dobsonflies/hellgrammites)	–	--	--	--	--	--	--	--	--	--
Corydalidae	–	--	--	--	--	--	--	--	--	--
Corydalus cornutus	–	--	--	--	--	--	--	--	--	--
ODONATA (damsel/dragonflies)	–	--	--	--	--	--	--	--	--	--
Coenagrionidae	–	--	--	--	--	--	--	--	--	--
Argia, sp.	–	--	4	--	--	--	--	--	--	--
Corduliidae	–	--	--	--	--	--	--	--	--	--
Epitheca princeps	–	--	--	--	--	--	--	--	30	--
PLECOPTERA (stoneflies)	–	--	--	--	--	--	--	--	--	--
Perlidae	–	--	--	--	--	--	--	--	--	--
Perlesta sp.	–	--	--	--	--	--	--	--	--	--
TRICHOPTERA (caddisflies)	–	--	--	--	--	--	--	--	--	--
Glossosomatidae	–	--	--	--	--	--	--	--	--	--
Protoptila sp.	–	--	--	--	--	--	--	--	--	--
Hydroptilidae (microcaddis)	–	--	--	--	--	--	--	--	--	--
Hydroptila sp.	–	--	--	--	--	--	--	--	--	--
Hydropsychidae	–	--	--	--	--	--	--	--	--	--
Cheumatopsyche sp.	Chpsyche	--	22	--	--	--	--	--	--	--
Hydropsyche sp.	–	--	--	--	--	--	--	--	--	--
Macrostemum carolina	–	--	--	--	--	--	--	--	--	--
Leptoceridae	–	--	--	--	--	--	--	--	--	--
Oecetis sp.	–	--	--	--	--	--	--	6	32	--
Polycentropodidae	–	--	--	--	--	--	--	--	--	--
Paranyctiophylax sp.	–	--	--	--	--	--	--	--	--	--
TOTAL ABUNDANCE		**245**	**814**	**590**	**2,323**	**1,213**	**702**	**1,468**	**2,842**	**1,619**

Appendix 8. Taxa and densities of richest-targeted habitat aquatic invertebrates for ecological data-collection sites in southwestern Louisiana, March-April 2001—Continued

Taxonomic heirarchy PHYLUM CLASS ORDER Family *Genus species*	Species abbrevi-ation (see fig. 16)	Densities									
		Abbreviated site names (see table 1, appendix 1)									
		Grand Marais	Theriot	East Lacas-sine	Church Point	Mallet	Guidry	Blue	Upper Des Cannes	Caney	Whisky
CNIDARIA (coelenterates)	–	--	--	--	--	--	--	--	--	--	--
HYDROZOA (hydras)	–	--	--	--	--	--	--	--	--	--	--
HYDROIDA	–	--	--	--	--	--	--	--	--	--	--
Hydridae	–	--	--	--	--	--	--	--	--	--	--
Hydra sp.	Hydra	58	--	--	11	18	--	--	--	12	--
PLATYHELMINTHES (flatworms)	–	--	--	--	--	--	--	--	--	--	--
TURBELLARIA (free-living flatworms)	Turbell	20	3	14	26	9	6	3	48	12	--
NEMATODA (roundworms)	Nematoda	6	7	6	11	--	--	--	19	--	11
MOLLUSCA (clams, snails, and limpets)	–	--	--	--	--	--	--	--	--	--	--
BIVALVIA (bivalue molluscs)	–	--	--	--	--	--	--	--	--	--	--
VENEROIDA	–	--	--	--	--	--	--	--	--	--	--
Sphaeriidae (fingernail clams)	–	--	--	--	--	--	--	--	--	--	--
Eupera cubensis sp.	–	6	--	--	--	--	--	--	--	--	--
Musculium sp.	–	--	--	--	--	--	--	--	--	--	--
GASTROPODA (snails, limpets)	–	--	--	--	--	--	--	--	--	--	--
BASOMMATOPHORA	–	--	--	--	--	--	--	--	--	--	--
Ancylidae (limpets)	–	--	--	--	--	--	--	--	--	--	--
Laevapex sp.	–	12	--	--	--	--	--	--	--	--	--
Lymnaeidae (pond snails)	–	--	--	--	--	--	--	--	--	--	--
Pseudosuccinea columella	–	--	--	8	--	--	--	--	--	--	--
Physidae (pouch snails)	–	--	--	--	--	--	--	--	--	--	--
Physella sp.	Physella	6	19	39	52	9	--	2	24	36	--
Planorbidae (orb snails)	–	--	--	--	--	--	--	--	--	--	--
Micromenetus sp.	Micromen	--	--	--	--	317	6	--	--	--	--
Planorbella sp.	–	--	--	6	--	--	--	--	--	--	--
ANNELIDA (segmented worms)	–	--	--	--	--	--	--	--	--	--	--
HIRUDINEA (leeches)	–	--	--	--	--	--	--	--	--	--	--
ARHYNCHOBDELLAE	–	--	--	--	--	--	--	--	--	--	--
Erpobdellidae	Erpobidae	6	--	39	56	27	--	--	--	--	--
RHYNCHOBDELLAE	–	--	--	--	--	--	--	--	--	--	--
Glossiphoniidae	–	--	--	--	--	--	--	--	--	--	--
OLIGOCHAETA (aquatic worms)	–	--	--	--	--	--	--	--	--	--	--
ENCHYTRAEIDA	–	--	--	--	--	--	--	--	--	--	--
Enchytraeidae	Enchidae	6	9	--	52	--	--	11	76	--	--
LUMBRICULIDA	–	--	--	--	--	--	--	--	--	--	--
Lumbriculidae	–	--	--	--	--	--	--	--	--	--	--
Megadrile sp.	Megadrill	--	6	146	26	9	--	--	--	--	14
TUBIFICIDA	–	--	--	--	--	--	--	--	--	--	--
Naididae	Naididae	38	--	--	--	9	--	--	--	893	--
Tubificidae	Tubfidae	12	--	--	258	9	--	--	5	--	--
ARTHROPODA (arthropods)	–	--	--	--	--	--	--	--	--	--	--
ARACHNIDA (eight-legged arthropods)	–	--	--	--	--	--	--	--	--	--	--
ACARI (water mites)	Acari	17	12	--	--	9	--	24	19	--	119

Appendix 8. Taxa and densities of richest-targeted habitat aquatic invertebrates for ecological data-collection sites in southwestern Louisiana, March-April 2001—Continued

Taxonomic heirarchy PHYLUM CLASS ORDER Family *Genus species*	Species abbreviation (see fig. 16)	Densities									
		Abbreviated site names (see table 1, appendix 1)									
		Grand Marais	Theriot	East Lacassine	Church Point	Mallet	Guidry	Blue	Upper Des Cannes	Caney	Whisky
MALACOSTRACA (crustaceans)	–	--	--	--	--	--	--	--	--	--	--
AMPHIPODA (scuds, sideswimmers)	–	--	--	--	--	--	--	--	--	--	--
Crangonyctidae	–	--	--	--	--	--	--	--	--	--	--
Crangonyx sp.	Crangony	248	3	--	--	--	--	--	--	--	--
Hyalellidae	–	--	--	--	--	--	--	--	--	--	--
Hyalella azteca	Hyazteca	44	--	279	--	--	2	--	--	--	--
DECAPODA (crayfishes, shrimps)	–	--	--	--	--	--	--	--	--	--	--
Palaemonidae (prawns and river shrimps)	–	--	--	--	--	--	--	--	--	--	--
Palaemonetes kadiakensis	–	--	--	--	--	--	--	--	--	3	--
ISOPODA (aquatic sow bugs)	–	--	--	--	--	--	--	--	--	--	--
Asellidae	–	--	--	--	--	--	--	--	--	--	--
Caecidotea sp.	–	--	--	41	--	--	--	--	--	48	--
Lirceus sp.	Lirceus	--	--	--	11	18	--	--	--	24	--
INSECTA (insects)	–	--	--	--	--	--	--	--	--	--	--
COLEOPTERA (beetles)	–	--	--	--	--	--	--	--	--	--	--
Carabidae (predaceous ground beetles)	–	--	--	--	--	--	--	--	--	--	--
Curculionidae (weevils)	–	--	6	--	--	--	25	3	--	--	--
Dytiscidae (predaceous diving beetles)	–	--	--	--	--	--	--	--	--	--	--
Thermonectus sp.	–	--	1	--	--	--	--	--	--	--	--
Hydroporinae*	Hydrinae	--	10	6	--	--	--	--	10	--	--
Laccophilinae*	–	--	--	--	--	--	--	--	--	--	--
Laccophilus sp.	–	--	--	--	--	27	--	--	10	--	--
Elmidae (riffle beetles)	–	--	--	--	--	--	--	--	--	--	--
Macronychus glabratus	–	--	--	--	--	--	--	--	--	--	60
Stenelmis sp.	–	--	1	--	191	--	--	--	--	--	95
Hydrophilidae (water scavenger beetles)	–	--	--	--	--	--	--	--	--	--	--
Berosus sp.	–	6	--	--	--	--	6	--	--	--	--
Enochrus sp.	Enochrus	6	1	--	--	--	--	--	--	--	--
Helochares sp.	–	--	1	--	--	--	--	--	--	--	--
Tropisternus sp.	Tropist	--	1	--	--	--	--	--	--	--	--
Noteridae (burrowing water beetles)	–	--	--	--	--	--	--	--	--	--	--
Hydrocanthus sp.	–	--	3	--	--	--	--	--	--	--	--
Suphisellus bicolor	–	17	9	--	--	--	--	--	--	--	--
Scirtidae (marsh beetles)	Scirtdae	--	10	--	--	--	12	--	--	--	--
COLLEMBOLA (springtails)	Collemb	20	24	19	78	9	--	8	210	--	--
DIPTERA (true flies)	–	--	--	--	--	--	--	--	--	--	--
Ceratopogonidae (biting midges, no-see-ums)	–	--	--	--	--	--	--	--	--	--	--
Ceratopogoninae*	–	--	--	--	--	--	--	--	--	--	--
Bezzia/Palpomyia sp.	Bezzpalp	--	--	--	--	--	31	--	--	24	60
Forcipomyiinae*	–	--	--	--	--	--	--	--	--	--	--
Atrichopogon sp.	Atrichop	--	--	--	--	9	--	--	--	--	11
Chironomidae (midges)	–	--	--	--	--	--	--	--	--	--	--
Chironominae*	–	--	--	--	--	--	--	--	--	--	--

Appendix 8. Taxa and densities of richest-targeted habitat aquatic invertebrates for ecological data-collection sites in southwestern Louisiana, March-April 2001—Continued

Taxonomic heirarchy PHYLUM CLASS ORDER Family *Genus species*	Species abbrevi-ation (see fig. 16)	Densities: Abbreviated site names (see table 1, appendix 1)									
		Grand Marais	Theriot	East Lacas-sine	Church Point	Mallet	Guidry	Blue	Upper Des Cannes	Caney	Whisky
Chironomini**	–	--	--	--	--	--	--	--	--	--	--
Chironomus sp.	Chironom	--	--	--	--	9	--	--	--	24	--
Dicrotendipes sp.	Dicdipes	12	1	--	601	82	--	11	67	119	--
Endochironomus sp.	–	--	--	--	--	--	--	--	--	--	--
Glyptotendipes sp.	Glydipes	--	3	--	11	--	--	--	--	12	--
Goeldichironomus sp.	–	--	4	--	--	--	--	--	--	--	--
Kiefferulus sp.	–	--	--	--	--	--	--	--	--	131	--
Parachironomus sp.	–	12	--	--	--	--	--	--	--	--	--
Phaenopsectra/Tribelos sp.	–	--	--	--	--	--	--	--	--	--	--
Polypedilum sp.	–	--	--	--	--	--	--	--	--	--	--
Stenochironomus sp.	–	--	--	--	--	--	--	--	--	--	--
Tribelos sp.	Tribelos	--	--	--	--	--	--	--	5	--	--
Zavreliella marmorata	–	--	--	--	--	--	--	--	--	12	--
Pseudochironomini**	–	--	--	--	--	--	--	--	--	--	--
Pseudochironomus sp.	–	--	--	--	--	--	--	--	--	--	25
Tanytarsini**	–	--	--	--	--	--	--	--	--	--	--
Cladotanytarsus sp.	–	--	--	--	11	9	--	--	--	--	--
Micropsectra/Tanytarsus sp.	Mictanyt	--	1	--	64	--	--	19	10	83	--
Rheotanytarsus sp.	Rheotany	--	1	--	205	45	--	2	--	71	828
Tanytarsus sp.	Tanytars	--	--	6	64	9	6	25	10	143	35
Diamesinae*	–	--	--	--	--	--	--	--	--	--	--
Potthastia sp.	–	--	--	--	11	--	--	--	--	--	11
Orthocladiinae*	–	--	--	--	--	--	--	--	--	--	--
Corynoneura sp.	Corynon	--	--	--	26	--	--	--	5	36	11
Cricotopus sp.	Cricotop	50	4	66	258	9	--	--	5	12	--
Cricotopus/Orthocladius sp.	Criortho	6	--	8	64	--	--	--	--	24	35
Gymnometriocnemus sp.	–	--	1	--	--	--	--	--	--	--	--
Nanocladius sp.	Nanoclad	38	--	--	--	18	--	--	--	24	--
Parakiefferiella sp.	–	--	--	--	26	--	--	--	--	119	--
Parametriocnemus sp.	–	--	--	--		--	--	--	--	--	--
Rheocricotopus sp.	Rheocric	--	--	--	11	--	--	--	--	12	74
Thienemanniella sp.	Thienema	20	184	33	64	--	--	--	--	12	35
Tvetenia sp.	–	--	--	--	--	9	--	--	--	--	158
Tanypodinae*	–	--	--	--	--	--	--	--	--	--	--
Natarsiini**	–	--	--	--	--	--	--	--	--	--	--
Natarsia sp.	–	--	--	--	11	27	--	13	--	--	--
Pentaneurini**	–	--	--	--	--	--	--		--	--	--
Ablabesmyia sp.	Ablabesm	--	--	--	--	--	--		--	--	--
Larsia sp.	–	--	--	--	--	--	--		--	60	--
Thienemannimyia group sp.	–	--	--	--	11	--	6	--	--	--	25
Procladiini**	–	--	--	--	--	--	--	--	--	--	--
Procladius sp.	–	--	--	--	--	--	--	--	--	12	--
Ephydridae (shore and brine flies)	–	--	--	--	--	--	--	--	--	12	--
Psychodidae (moth flies)	–	--	--	--	--	--	--	--	--	--	--
Psychoda sp.	–	--	--	--	--	--	--	--	--	12	--

Appendix 8. Taxa and densities of richest-targeted habitat aquatic invertebrates for ecological data-collection sites in southwestern Louisiana, March-April 2001—Continued

Taxonomic heirarchy PHYLUM CLASS ORDER Family *Genus species*	Species abbrevi-ation (see fig. 16)	Densities: Abbreviated site names (see table 1, appendix 1) Grand Marais	Theriot	East Lacas-sine	Church Point	Mallet	Guidry	Blue	Upper Des Cannes	Caney	Whisky
Simuliidae (black flies)	–	--	--	--	--	--	--	--	--	--	--
Simulium sp.	–	--	--	--	--	--	--	--	--	--	--
Stratiomyidae (soldier flies)	–	--	--	--	--	--	--	--	--	--	--
Stratiomyinae*	–	--	--	--	--	--	--	--	--	--	--
Hedriodiscus/Odontomyia sp.	Hedrodon	6	6	6	--	--	--	--	--	--	--
Tabanidae	–	--	--	--	--	--	--	--	--	--	--
Tabanus sp.	–	--	--	--	--	--	--	--	5	--	--
EPHEMEROPTERA (mayflies)	–	--	--	--	--	--	--	--	--	--	--
Baetidae	–	--	--	--	--	--	--	--	--	--	--
Baetis intercalaris	–	--	--	--	--	--	--	--	--	--	25
Callibaetis sp.	–	--	--	6	--	--	--	--	--	--	--
Caenidae	–	--	--	--	--	--	--	--	--	--	--
Caenis sp.	Caenis	242	36	298	336	--	6	--	--	--	--
Heptageniidae	–	--	--	--	--	--	--	--	--	--	--
Stenacron sp.	–	--	--	--	--	--	2	--	--	--	--
Stenonema sp.	–	--	--	--	--	--	--	--	--	--	11
Isonychiidae	–	--	--	--	--	--	--	--	--	--	--
Isonychia sp.	–	--	--	--	--	--	--	--	--	--	11
MEGALOPTERA (dobsonflies/hellgrammites)	–	--	--	--	--	--	--	--	--	--	--
Corydalidae	–	--	--	--	--	--	--	--	--	--	--
Corydalus cornutus	–	--	--	--	--	--	--	--	--	--	4
ODONATA (damsel/dragonflies)	–	--	--	--	--	--	--	--	--	--	--
Coenagrionidae	–	--	--	--	--	--	--	--	--	--	--
Argia, sp.	–	--	--	--	11	--	--	--	--	--	--
Corduliidae	–	--	--	--	--	--	--	--	--	--	--
Epitheca princeps	–	--	--	--	--	--	--	--	--	--	--
PLECOPTERA (stoneflies)	–	--	--	--	--	--	--	--	--	--	--
Perlidae	–	--	--	--	--	--	--	--	--	--	--
Perlesta sp.	–	--	--	--	--	--	--	--	--	--	144
TRICHOPTERA (caddisflies)	–	--	--	--	--	--	--	--	--	--	--
Glossosomatidae	–	--	--	--	--	--	--	--	--	--	--
Protoptila sp.	–	--	--	--	--	--	--	--	--	12	--
Hydroptilidae (microcaddis)	–	--	--	--	--	--	--	--	--	--	--
Hydroptila sp.	–	--	--	28	--	--	--	--	--	--	--
Hydropsychidae	–	--	--	--	--	--	--	--	--	--	--
Cheumatopsyche sp.	Chpsyche	17	--	--	11	9	10	--	--	--	158
Hydropsyche sp.	–	--	--	--	--	--	--	--	--	--	361
Macrostemum carolina	–	--	--	--	--	--	--	--	--	--	74
Leptoceridae	–	--	--	--	--	--	--	--	--	--	--
Oecetis sp.	–	--	--	--	--	--	--	--	--	--	25
Polycentropodidae	–	--	--	--	--	--	--	--	--	--	--
Paranyctiophylax sp.	–	--	--	--	--	--	--	--	--	--	60
TOTAL ABUNDANCE		**930**	**372**	**1,052**	**2,570**	**707**	**119**	**122**	**525**	**1,990**	**2,473**

Appendix 9. Loadings of environmental variables on the first two principal components (PC) derived from principal components analysis (PCA) of ecological data-collection sites in southwestern Louisiana, 2001

[Environmental variables with boldface values were selected for use in canonical correspondence analysis based on multiple iterations of PCA and/or considered important for describing water quality and aquatic invertebrate communities in an agricultural land-use setting in southwestern Louisiana. mi^2, square mile; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; NTU, nephelometric turbidity units; °C, degrees Celsius; µg/L, micrograms per liter; m, meter; ft/s, feet per second; RBP, Rapid Bioassessment Protocols (Barbour and others, 1999)]

	Number and description of environmental variable	PC1	PC2	Correlations*
	SITE CHARACTERISTICS			
	General			
1	Drainage basin area (mi^2)	0.55	0.42	49, 53
2	Rice agriculture by basin (percent)	-0.45	**0.81**	
	WATER QUALITY			
	Physiochemical Data			
	Dissolved oxygen (mg/L)			
3	Time of biological sampling	**0.19**	0.09	
4	1-month low	-0.32	**0.37**	
	pH			
5	Time of biological sampling	**-0.53**	0.20	6, 9, 10, 15, 27
	Specific conductance (µS/cm)			
6	Time of biological sampling	**-0.71**	-0.03	9, 10, 13, 15, 27, 66
	Turbidity (NTU's)			
7	Time of biological sampling	-0.79	0.25	18, 24, 28, 44, 48
	Water temperature (°C):			
8	Time of biological sampling	0.03	**0.12**	
	Water-Quality Data (mg/L)			
9	Alkalinity (as calcium carbonate)	**-0.62**	0.06	10, 15, 27
10	Calcium, dissolved	-0.60	-0.04	15, 27
	Carbon, organic:			
11	Dissolved	-0.01	**-0.06**	
12	Suspended	**-0.69**	0.19	
13	Chloride, dissolved	-0.85	-0.17	19, 20, 21, 25, 27, 35, 38
14	Chlorophyll-*a* (µg/L)	**-0.63**	0.39	
15	Magnesium, dissolved	-0.60	-0.02	27
	Nitrogen (as N)			
16	Ammonia, dissolved	-0.38	0.18	24
17	Ammonia + organic, dissolved	-0.55	-0.16	
18	Ammonia + organic, total	**-0.85**	0.09	24, 28, 44, 48
19	Nitrite, dissolved	0.28	-0.40	20, 21, 25
20	Nitrate, dissolved	-0.73	-0.28	21
21	Nitrite + nitrate, dissolved	**-0.74**	-0.26	25
	Phosphorus (as P)			
22	Dissolved	-0.13	0.15	23
23	Ortho, dissolved	-0.19	**0.21**	
24	Total	**-0.80**	0.27	44, 48
25	Potassium, dissolved	-0.79	-0.06	
26	Silicon, dissolved	0.08	-0.05	
27	Sodium, dissolved	-0.74	0.03	
28	Suspended sediments, total	**-0.85**	0.13	44, 48
	Herbicides and degradation products			
29	Atrazine	-0.31	**0.42**	33
30	Metolachlor	-0.30	-0.09	
	WATER QUALITY (Cont.)			
	Herbicides and degradation products (Cont.)			
31	Molinate	-0.24	**0.70**	33
32	Tebuthiuron	-0.36	**0.49**	
33	Herbicides, cumulative	-0.63	**0.68**	
	Insecticides and degradation products			
34	Desulfinyl	**-0.81**	-0.47	35
35	Fipronil	**-0.90**	-0.31	37, 38
36	Fipronil, maximum	**-0.76**	0.06	
37	Sulfide	-0.74	-0.43	38
38	Sulfone	-0.90	-0.37	
	STREAM HABITAT**			
	Quantitative measurements (mean values)			
39	Bank angle (degrees)	-0.57	-0.56	
40	Bank erosion score	-0.55	-0.42	
41	Bank height (m)	-0.29	**-0.83**	42
42	Bank stability index	-0.29	**-0.85**	
43	Bank vegetative cover (percent availability)	-0.66	-0.43	
44	Euphotic zone depth (m)	**0.44**	-0.41	48
45	Habitat cover (percent availability)	0.49	0.35	
46	Open canopy (percent)	-0.06	**0.66**	
47	Riparian canopy closure (percent)	**0.46**	0.04	
48	Secchi disk depth (m)	**0.45**	-0.44	
49	Stream bankfull channel width (m)	-0.60	0.73	53
50	Stream depth (m)	0.16	**0.64**	53
51	Stream open angle (degrees)	-0.06	0.66	
52	Stream velocity (ft/s)	-0.09	**-0.63**	
53	Stream wetted channel width (m)	0.51	**0.68**	
54	Visual algae growth (percent availability)	-0.19	0.13	
55	Width-to-depth ratio	**0.53**	-0.05	
56	Woody debris (snag, percent availability)	0.23	0.12	
	Qualitative measurements			
	RBP parameters (each score, 0-20)			
57	Bank stability	0.63	0.13	
58	Bank vegetation protection	0.61	0.08	
59	Channel alteration	**0.53**	-0.40	
60	Channel flow status	0.55	0.07	
61	Channel sinuosity	0.72	-0.02	
62	Instream cover	**0.83**	-0.04	
63	Pool substrate characterization	0.80	-0.19	
64	Pool variability	0.63	-0.06	
65	Riparian vegetative zone width	0.52	0.08	
66	Sediment deposition	**0.55**	-0.40	
67	RBP total site score (0-200)	**0.91**	-0.13	

* Environmental variables with variable number(s) are correlated with these variables based on a Spearmann-rank correlation test with an alpha value of 0.05.

** Separate principal components analysis was performed on stream habitat measurements.

Acadian - Pontchartrain Study Unit

National Water-Quality Assessment