Water Quality in the Acadian-Pontchartrain Drainages

Louisiana and Mississippi, 1999–2001

U.S. Department of the Interior
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Circular 1232

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Acadian-Pontchartrain Drainages contact and web site:

USGS State Representative
U.S. Geological Survey
Water Resources Discipline
3535 South Sherwood Forest Blvd., Suite 120
Baton Rouge, Louisiana 70816
e-mail: dc_la@usgs.gov
http://la.water.usgs.gov/nawqa/

National NAWQA Program:

Chief, NAWQA Program
U.S. Geological Survey
Water Resources Division
12201 Sunrise Valley Drive, M.S. 413
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Front Cover: Bayou Lacassine near Lake Arthur, Louisiana *(photograph by Dennis Demcheck)*
Back Cover: Left: Lake Fausse Pointe at Bird Island Chute, Louisiana; middle, Whiskey Chitto near Oberlin, Louisiana; right, mature rice near Fordoche, Louisiana *(photographs by Dennis Demcheck)*

Water Quality in the Acadian-Pontchartrain Drainages, Louisiana and Mississippi, 1999–2001

By Dennis K. Demcheck, Roland W. Tollett, Scott V. Mize,
Stanley C. Skrobialowski, Robert B. Fendick, Jr., Christopher M. Swarzenski,
and Stephen Porter

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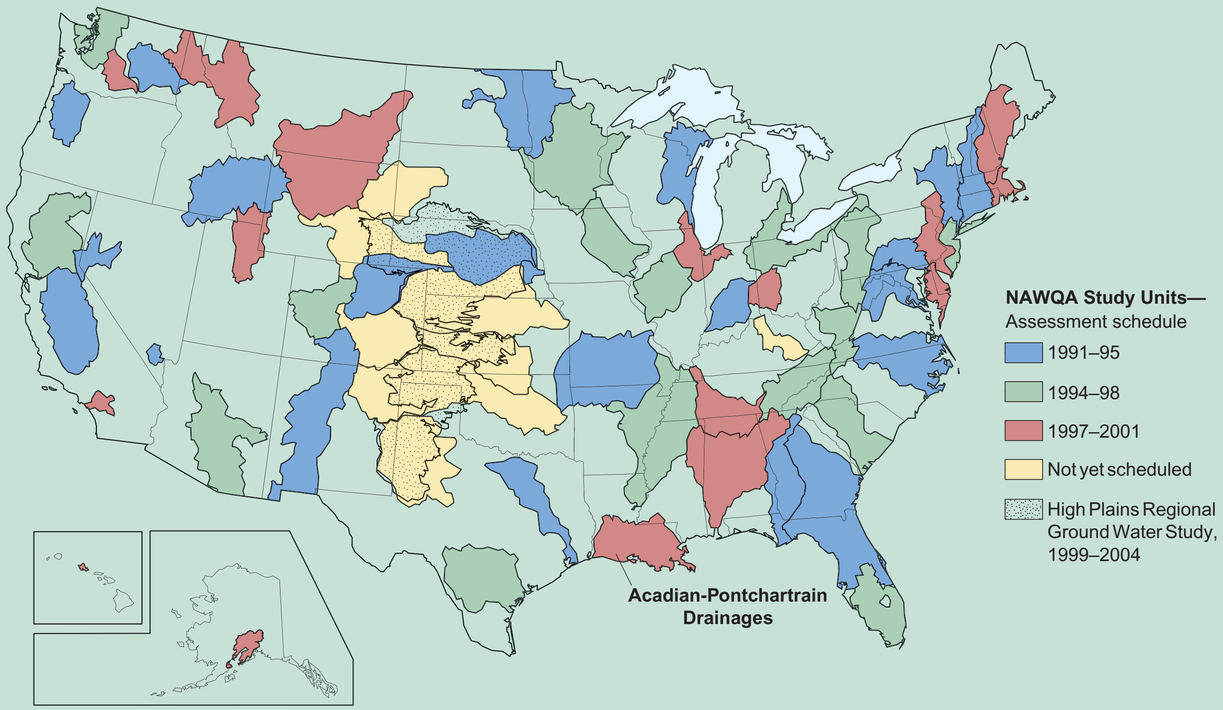
National Water-Quality Assessment Program

The quality of the Nation's water resources is integrally linked to the long-term availability of water that is clean and safe for drinking and recreation and also suitable for industry, irrigation, and **habitat** for fish and wildlife. Recognizing the need for long-term, nationwide assessments of water resources, the U.S. Congress has appropriated funds since 1991 for the USGS to conduct the **National Water-Quality Assessment (NAWQA) Program**. Scientists in the NAWQA Program work with partners in government, research, and public interest groups to assess the spatial extent of water-quality conditions, how water quality changes with time, and how human activities and natural factors affect water quality. This information is useful for guiding water-management and protection strategies, research, and monitoring in different hydrologic and land-use settings across the Nation.



The Acadian-Pontchartrain Drainages is one of 51 water-quality assessments initiated since 1991. Together, the 51 major river basins and **aquifer** systems, referred to as "Study Units," include water resources used by more than 60 percent of the population in watersheds that cover about half of the land areas of the conterminous United States. Timing of the assessments varies because of the program's rotational design in which one-third of all Study Units are intensively investigated for 3 to 4 years, with trends assessed every 10 years. As indicated on the map, the Acadian-Pontchartrain Drainages is part of the third set of intensive investigations that began in 1997.

What kind of water-quality information does the NAWQA Program provide?

Water-quality assessments by a single program cannot possibly address all of the Nation's water-resources needs and issues. Therefore, it is necessary to define the context within which NAWQA information is most useful.

- Total resource assessment—NAWQA assessments are long-term and interdisciplinary, and include information on water chemistry, hydrology, land use, stream habitat, and aquatic life. Assessments are not limited to a specific geographic area or water-resource problem at a specific time. Therefore, the findings describe the general health of the total water resource, as well as emerging water issues, thereby helping managers and decision makers to set priorities.

- Source-water characterization—Assessments focus on the quality of the available, untreated resource and thereby complement (rather than duplicate) Federal, State, and local programs that monitor drinking water. Findings are compared to **drinking-water standards** and health advisories as a way to characterize the resource.

- Compounds studied—Assessments focus on chemical compounds that have well-established methods of investigation. It is not financially or technically feasible to assess all the contaminants in our Nation's waters. In general, the NAWQA Program investigates those **pesticides**, **nutrients**, **volatile organic compounds**, and metals that have been or are currently used commonly in agricultural and urban areas across the Nation. A complete list of compounds studied is on the NAWQA Web site at *http://water.usgs.gov/nawqa*.

- Detection relative to risk—Compounds are measured at very low **concentrations**, often 10 to 100 times lower than Federal or State standards and health advisories. Detection of compounds, therefore, does not necessarily translate to risks to human health or aquatic life. However, these analyses are useful for identifying and evaluating emerging issues, as well as for tracking contaminant levels over time.

- Multiple scales—Assessments are guided by a nationally consistent study design and uniform methods of sampling and analysis. Findings thereby pertain not only to water quality of a particular stream or aquifer, but also contribute to the larger picture of how and why water quality varies regionally and nationally. This consistent, multiscale approach helps to determine if a water-quality issue is isolated or pervasive. It also allows direct comparisons of how human activities and natural processes affect water quality in the Nation's diverse environmental settings.

Introduction to this Report

"The Acadian-Pontchartrain Drainages NAWQA program has contributed valuable information to the U.S. EPA Office of Pesticide Program (OPP) understanding of the occurrence of pesticides in ground and surface water in one of the nation's major rice and sugarcane production areas. As a reliable source of comprehensive information, results from the USGS' study unit have been used in pesticide exposure and risk assessments. The OPP has found the data useful in understanding the relationship between land use (e.g., agriculture) and the frequency and levels of pesticide detections in water."

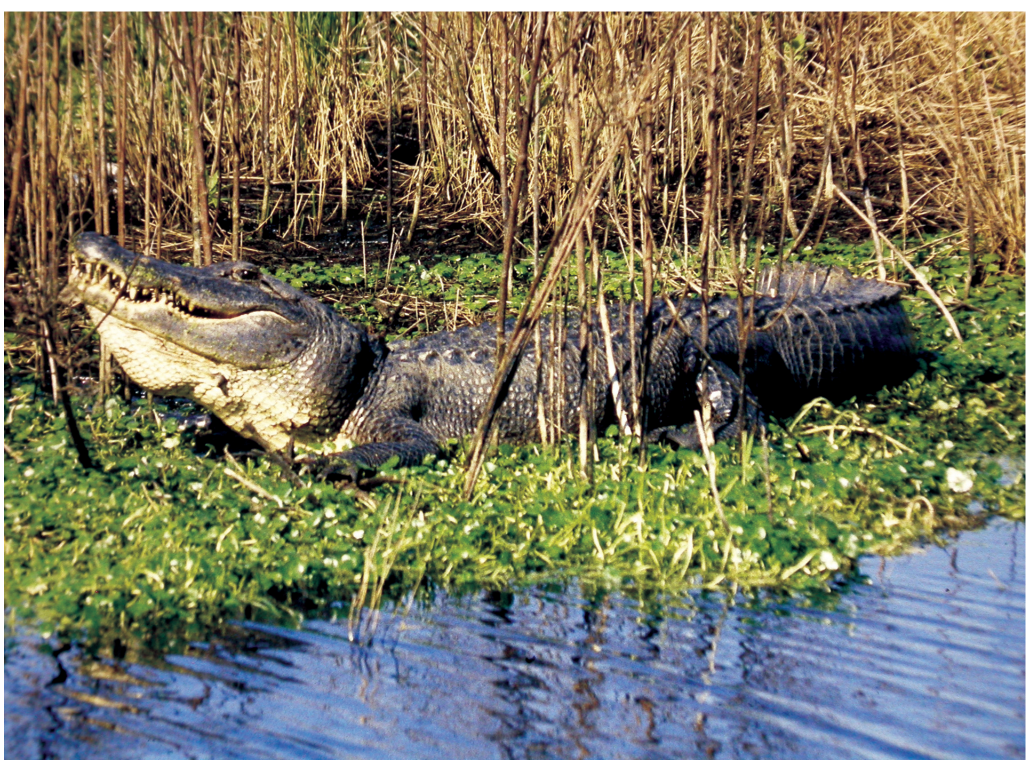
Sid Abel,
Environmental Fate and Effects Division, Office of Pesticide Programs, U.S. Environmental Protection Agency

This report contains the major findings of a 1999–2001 assessment of water quality in the Acadian-Pontchartrain Drainages Study Unit. It is one of a series of reports by the National Water-Quality Assessment (NAWQA) Program that present major findings in 51 major river basins and aquifer systems across the Nation.

In these reports, water quality is discussed in terms of local, State, and regional issues. Conditions in a particular basin or aquifer system are compared to conditions found elsewhere and to selected national benchmarks, such as those for drinking-water quality and the protection of aquatic organisms.

This report is intended for individuals working with water-resource issues in Federal, State, or local agencies, universities, public interest groups, or in the private sector. The information will be useful in addressing a number of current issues, such as the effects of agricultural and urban land use on water quality, human health, drinking water, source-water protection, hypoxia and excessive growth of **algae** and plants, pesticide registration, and monitoring and sampling strategies. This report also is for individuals who wish to know more about the quality of streams and **ground water** in areas near where they live, and how that water quality compares to other areas across the Nation.

The water-quality conditions in the Acadian-Pontchartrain Drainages Study Unit summarized in this report are discussed in detail in other reports that can be accessed from (*http://la.water.usgs.gov/nawqa/default.htm*). Detailed technical information, data and analyses, collection and analytical methodology, models, graphs, and maps that support the findings presented in this report in addition to other reports in this series from other basins can be accessed from the national NAWQA Web site (*http://water.usgs.gov/nawqa*).



Summary of Major Findings

Stream and River Highlights

Surface water sampled in the Acadian-Pontchartrain Drainages of southern Louisiana and southwestern Mississippi generally meets State and Federal guidelines for drinking-water quality and the protection of aquatic life. Agriculture, urbanization, and oil and gas production, however, have degraded water quality and aquatic communities in rivers, streams, and bayous by increasing concentrations of pesticides, nutrients, and **suspended sediment** and disturbing the stream habitat. The combination of low-lying topography, slow and sluggish streams, and organic-rich **bed sediment**s has resulted in some undesirable chemicals and contaminants, particularly pesticides, remaining in the surface-water system for prolonged periods.

- Pesticides are widespread in streams. At least one pesticide parent compound or **degradation product** was detected in 272 of 299 water samples (about 91 percent) collected from 8 sites. Concentrations were low, however, only rarely exceeding standards and guidelines established to protect human health and aquatic life (p. 8).

- Herbicides most heavily used for weed control on rice, soybeans, or sugarcane—including atrazine, molinate, and tebuthiuron—were the most frequently detected compounds in agricultural streams. The **insecticide** most heavily used on rice—fipronil—was detected in 72 percent of all samples from agricultural streams. Other insecticides—carbaryl, chlorpyrifos, diazinon, and malathion—were detected more frequently and usually at higher concentrations in urban Dawson Creek within the City of Baton Rouge than in the agricultural or mixed land-use streams. Diazinon was detected in 47 of 50 samples (about 94 percent) in Dawson Creek, and concentrations exceeded guidelines for the protection of aquatic life in 21 of 50 samples (about 42 percent) (p. 8).

- Concentrations of nitrogen generally were low in streams. For example, the **median** concentration of total nitrogen in agricultural streams in the Acadian-Pontchartrain Drainages (1.2 mg/L) was less than one-half the median value for 137 agricultural streams sampled across the Nation by the NAWQA Program (median of 3.5 mg/L) (p. 15).

- Median concentration of total **phosphorus** was 0.2 mg/L, and concentrations exceeded the U.S. Environmental Protection Agency (USEPA) desired goal to prevent nuisance plant growth (0.1 mg/L) in 90 percent of samples collected from streams draining agricultural or urban land (p. 15).

- Organochlorine pesticides and PCBs persist in streambed sediment and fish in the Acadian-Pontchartrain Drainages, although few concentrations exceeded State alert levels or consumption guidelines. The most frequently detected **organochlorine compounds** were PCBs, mirex, dieldrin, and degradation products of **DDT** and chlordane (p. 18).

- Mercury is widespread in sediment and fish, detected in all 21 bed-sediment samples and in all 19 fish-tissue samples. Concentrations of mercury in fish tissue exceeded one component used in the Louisiana State alert level assessment process in 8 of 19 streams. The highest concentrations were measured in tissue of fish collected (largemouth bass and selected **species** of sunfish) in sandy streams north of Lake Pontchartrain and in streams in the western part of the Study Unit (p. 19).

- Aquatic **invertebrate** and fish communities in southern Louisiana streams, rivers, and bayous differ among **ecoregions** and land uses. Diverse, abundant, and pollution-intolerant communities are associated with undeveloped and forest basins in the northern part of the Acadian-Pontchartrain Drainages study unit. More **tolerant species**, such as **midges**, worms, snails, catfish, gar, and certain sunfish are in the southern part (p. 20, 22).

Major Influences on Water Quality in Streams and Rivers

- **Runoff** from agriculture, aquaculture, and urban areas.

- **Contamination** of fish tissue and sediment by persistent organic chemicals and trace elements, such as mercury.

Ground-Water Highlights

The Chicot aquifer system, located west of the Mississippi River, and the Chicot equivalent aquifer system, located east of the river, are primary sources for domestic and public-water supplies within the Acadian-Pontchartrain Drainages Study Unit and are designated as **sole-source aquifers** by the USEPA. The quality of water throughout these aquifer systems generally is of high quality and acceptable for drinking and other purposes. The water generally meets Federal guidelines established by the USEPA to protect drinking water.

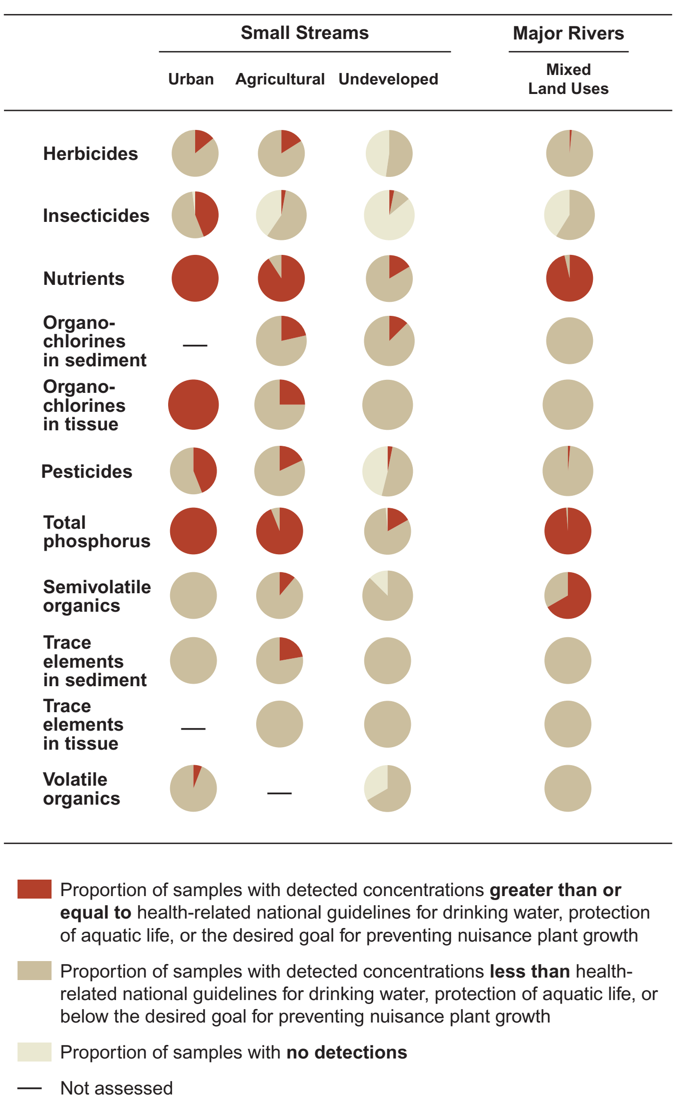
- **Nitrate**, pesticide parent compounds and degradation products, and volatile organic compounds (VOCs) were detected at low concentrations in the Chicot and Chicot equivalent aquifer systems, in large part because downward movement of waters is impeded by a thick, relatively impermeable layer of clay below the soil (p. 24).

- Concentrations of **trace elements** in ground-water samples generally were low, rarely exceeding any USEPA drinking-water standards, although such standards have been established for only 12 of 24 trace elements included in this study. Arsenic exceeded the USEPA drinking-water standard of 10 µg/L in one well, which is not used for drinking supplies (p. 24).
- Natural chemistry of ground water in the Chicot and Chicot equivalent aquifer systems is similar. Concentrations of **dissolved solids**, calcium, sodium, bicarbonate, chloride, and iron, and values of **pH** typically were lowest in wells in the outcrop areas of the two systems (p. 25).
- Concentrations of **radon** in samples collected from 94 wells were elevated, and values exceeded the USEPA proposed drinking-water standard of 300 **picocuries** per liter (pCi/L) in 53 wells (about 55 percent). The source of uranium (from which radon is derived) in rocks underlying the Acadian-Pontchartrain Drainages is uncertain (p. 25).

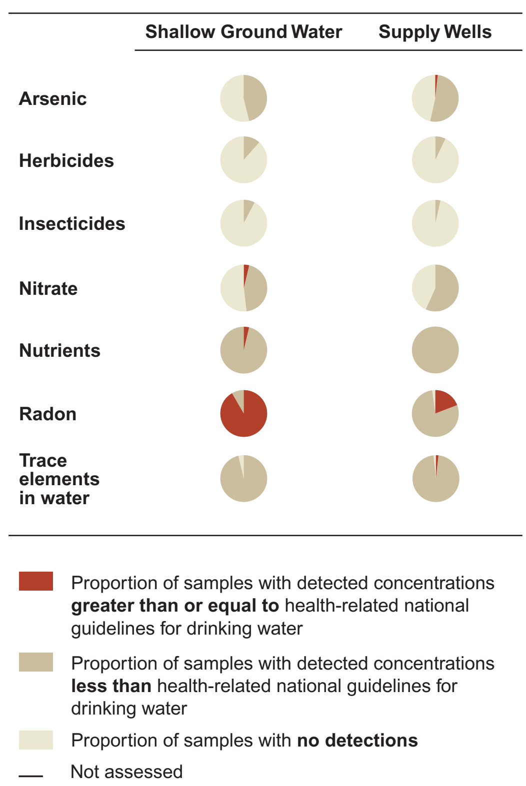
Major Influences on Ground-Water Quality

- Geologic features, including a thick, relatively impermeable layer of clay below the soil that protects ground water from agricultural chemicals and other surface contaminants.
- Hydrologic features, including depth to water, recharge areas, and depth of flowpath.
- Agricultural and urban activities, including pumping for irrigation and domestic supply.

Selected Indicators of Streamwater Quality



Selected Indicators of Ground-Water Quality



Introduction to the Acadian-Pontchartrain Drainages

The Acadian-Pontchartrain Drainages Study Unit (fig. 1) encompasses 26,000 square miles (mi^2) of rolling hills, deltaic plains, and hardwood-dominated bottomland in southern Louisiana and southwestern Mississippi. Elevations range from sea level in the southern coastal marshes to more than 600 feet in the rolling hills of southwestern Mississippi. The area is classified as subtropical, with average annual precipitation ranging from 55 to 62 inches.

Crawfish harvesting boat.

Crawfish farming is an important industry in the Mermentau River Basin in the central and western parts of the Study Unit where rice also is grown.

About 3 million people live in the Acadian-Pontchartrain Drainages. More than two-thirds live in the three largest urban areas, which include New Orleans, Baton Rouge, and Lafayette.

Rice is the most important crop produced in the Study Unit. Total rice acreage in the seven Parishes (Counties) of the Mermentau River Basin (Acadia, Allen, Evangeline, Jefferson Davis, Lafayette, St. Landry, and Vermilion) exceeds 300,000 acres.

Rice fields in southwestern Louisiana are primary wintering grounds for tens of thousands of geese and are important stopover feeding areas for migratory shorebirds.

Oil and gas production, distribution, and processing are common in the southern part of the Study Unit.

Figure 1. The Acadian-Pontchartrain Drainages support a variety of water needs for humans, aquatic life, and wildlife, including substantial rice, sugarcane, and crawfish industries; wintering and feeding grounds for geese and shorebirds; and oil and gas production.

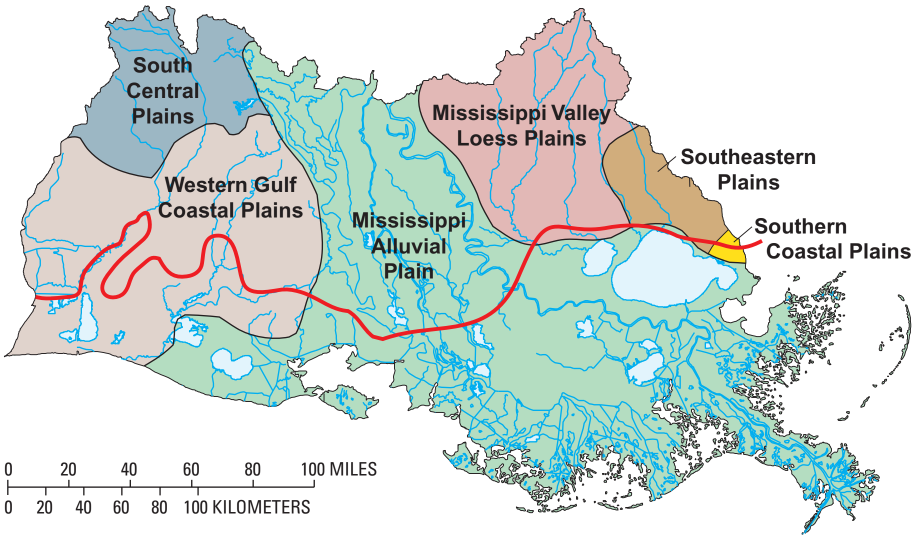


Figure 2. The Acadian-Pontchartrain Drainages lie within parts of six ecoregions. The red line is the approximate northern boundary of the flat Louisiana coastal plains.

The Acadian-Pontchartrain Drainages lie within parts of six U.S. Environmental Protection Agency ecoregions (fig. 2), including the South Central Plains, Western Gulf Coastal Plains, Southeastern Plains, Southern Coastal Plains, Mississippi Valley Loess Plains, and the Mississippi Alluvial Plain (Omernik, 1985). The South Central Plains in the northwestern part of the Study Unit is characterized by low hills and forests with longleaf and shortleaf pine. The Western Gulf Coastal Plains in the southwest comprise five major bayous that divide the basin into a series of broad, flat-lying areas separated by bottomland hardwood **riparian** corridors, which vary in width from only a few hundred feet to several miles. The upper part of this ecoregion is characterized by rolling, pine-covered hills with sandy streams. The Southeastern Plains and Southern Coastal Plains in the eastern part of the Study Unit consists of small streams and mixed longleaf pine forest. The Mississippi Valley Loess Plains, east of the Mississippi River, consist of rolling hills, loessial (windblown) soils, small branching streams, and mixed hardwoods. The Mississippi Alluvial Plain is characterized by low relief and slope, cypress swamps, and fresh-to-saline marshes.

Land use affects water quality

Approximately 50 percent of the Acadian-Ponchartrain Drainages is covered by agricultural cropland interspersed with pasture, woodlands, or forests (fig. 1). The remaining land is marshes (about 25 percent), swamp land (about 20 percent), and open water (about 5 percent). Agricultural land is most common in the Western Gulf Coastal Plains, where thick **loess** and a loamy and clayey **alluvium** are ideally suited for rice cultivation. Rice is the most important agricultural crop produced in the basin. Total rice acreage in the seven Parishes (Counties) of the Mermentau River Basin (Acadia, Allen, Evangeline, Jefferson Davis, Lafayette, St. Landry, and Vermilion) was nearly 400,000 acres in 1998 and about 340,000 acres in 2000 (Louisiana Cooperative Extension Service, 1998, 2000). Rice is routinely treated with the insecticide fipronil, which can be toxic to aquatic life. Releases of water from the rice fields during March through May result in elevated concentrations of insecticides and suspended sediment in receiving streams and bayous.

Sugarcane is the predominant crop in the southern and southeastern parts of the Study Unit and is grown in scattered areas in the southwestern part. More than 460,000 acres of sugarcane were planted in 1999. This crop routinely is treated with the **herbicide** atrazine for broadleaf weed control. Atrazine is applied several times each year at both pre-emergent and post-emergent stages of the plants.

Aquaculture, primarily crawfish farming, is important in the central and western parts of the Study Unit in the Mermentau River Basin, where rice also is grown. There were about 80,000 acres of crawfish ponds in the Acadian-Pontchartrain Drainages in 1999. Two species are grown commercially, including the red swamp crawfish (*Procambarus clarkii)* and the white river crawfish (*Procambarus zonangulus)*. Crawfish ponds may be managed solely for the purpose of cultivating crawfish, or rice and crawfish may be double-cropped annually. In double-cropping, rice is planted in flooded fields during March and April, drained, re-flooded in June, and stocked with crawfish. The fields are drained again in August for harvesting, re-flooded in October, and crawfish are harvested from November through the next April (Avery and Lorio, 1999).

Nearly 3 million people live in the Acadian-Pontchartrain Drainages. More than two-thirds live in the large population centers (greater than 250,000), including New Orleans, Baton Rouge, and Lafayette (2000 Census). Although urban areas account for only 1 percent of the land in the Study Unit, their effect on water quality and aquatic life can be substantial. Contaminant sources associated with urban areas include septic systems and wastewater effluent; **fertilizers** and pesticides used on lawns, gardens, parks, rights-of-way, and golf courses; and runoff containing oil, solvents, metals, and other contaminants from streets and parking lots.

Oil and gas production, distribution, and processing are major and conspicuous features of the landscape in the southeastern parts of the Study Unit. Thousands of miles of pipeline canals and oilfield-support canals have facilitated saltwater intrusion from coastal areas into historically fresh marshes and allowed interbasin flow of water from the Atchafalaya and Mississippi-Atchafalaya River system. The production of oil and gas also is common, though declining, in the southwestern part of the Study Unit, where individual oil wells often are drilled in rice fields and separated from the fields by a low earthen berm. Rice fields in southwestern Louisiana are wintering grounds for tens of thousands of geese and are important stopover feeding areas for migratory shorebirds. Southwestern Louisiana fulfills a variety of important functions for both humans and wildlife.

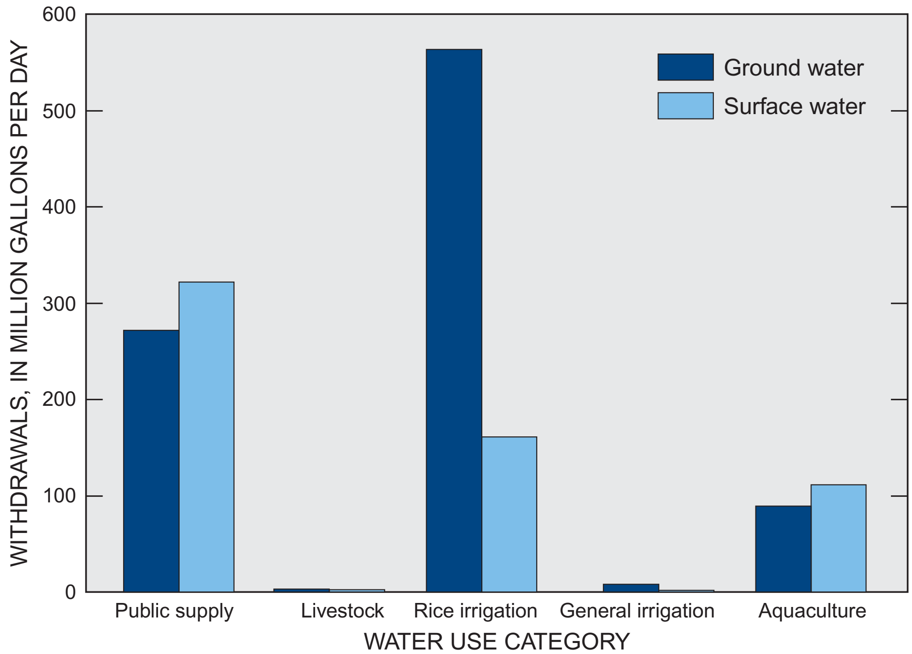


Figure 3. Rice irrigation is a major use of water in southwestern Louisiana.

Water Use in Louisiana

Extensive surface-water and ground-water resources within the Acadian-Pontchartrain Drainages are used for rice agriculture, crawfish aquaculture, and drinking-water supplies. Ground water used for domestic and public-water supply accounted for about 300 million gallons per day in 2000 (Sargent, 2002, fig. 3). Surface-water sources (also about 300 million gallons per day in 2000) supply drinking water to residents. Some surface water is transported from outside the Study Unit to supplement water needs within the drainages. Specifically, water from the Mississippi River is used to supply drinking water to residents in the City of New Orleans and water for industries and power-generation facilities along the Mississippi River from Baton Rouge to New Orleans (not included in numbers in fig. 3).

Large amounts of water are used to support rice agriculture, primarily in the Mermentau River Basin. In 2000, 563 million gallons of ground water per day was withdrawn from the Chicot aquifer system for rice irrigation (fig. 3). Surface-water sources also are used for rice agriculture, contributing about 150 million gallons per day. Both surface water and ground water also are used for crawfish farming in the Mermentau River Basin. Because of the double-cropping practice involving rice production and crawfish, water is recycled between the ground-water and surface-water systems. Specifically, ground water is pumped onto rice fields, released to drainage ditches and streams after a brief period, and later possibly reused for other surface-water purposes farther downstream.

The types of water used within the Mermentau River Basin vary geographically. Ground water supplies most needs, including those for drinking and irrigation, in the northeastern part of the basin. The southern part of the basin relies heavily on surface water for irrigation.

A drought in southern Louisiana, which began in the spring of 1999 and lasted into the summer of 2001, caused a decrease in the availability of fresh surface water, particularly in the southwestern part of the Study Unit. As a result, rice farmers had to depend more heavily on ground-water supplies, and in many cases planted fewer acres of rice.

Hydrologic Conditions and Their Effects on Water Quality

Hydrologic conditions are complex in the Acadian-Pontchartrain Drainages Study Unit because of its location at the terminus of the Mississippi River, low-lying topography, and an extensive levee network. Specifically, water resources in the central part of the Study Unit are affected by inputs from the Mississippi River, which drains more than 40 percent of the continental United States. Studies conducted in the last decade show that considerable amounts of compounds from both natural and human sources, such as total nitrogen, originate from upstream watersheds in the Mississippi River Basin quite distant from Louisiana and the river's receiving water, the Gulf of Mexico (Alexander and others, 2000).

The generally low-lying topography of southern Louisiana results in low stream gradients and flow velocities, the latter typically less than 1 foot per second. The low gradients can result in reverse, upstream flow in some streams. For example, upstream flows typically occur in the summer and fall in the Mermentau River, which is tidally affected. Upstream flow can be enhanced by natural events, such as storms and sustained winds from the south in conjunction with unusually high tides. These reverse flows can increase in magnitude and duration during periods of low stream **discharge**, such as those during the drought of 1999–2001.

Natural hydrology of the Acadian-Pontchartrain Drainages has been modified by an extensive levee network built for flood control that began in the early 1800's. The scale and magnitude of the modifications were accelerated after the great Mississippi River flood in 1927, with the unintended consequence that coastal **wetlands** were isolated from the Mississippi River. River sediment and nutrients needed to maintain freshwater and saltwater wetlands no longer nourish and sustain the valuable wetlands but rather are deposited in the Gulf of Mexico. Such modifications also have facilitated unnatural basin interflow, such as in the Gulf Intracoastal Waterway, which allows water from the Atchafalaya River to flow east and west to points 30 to 50 miles away (Swarzenski, 2003).

Extreme events can substantially affect stream hydrology in the Acadian-Ponchartrain Drainages. For example, **streamflow** during the extreme drought over the 2-year period 1999–2000 was below historical average conditions (fig. 4). Streamflow increased to more normal levels in 2001, when precipitation was greater.

Water quality in streams, rivers, and shallow aquifers (ground water) varies in response to changing hydrologic conditions. Thus, information on streamflow is critical for assessing water-quality conditions and ecosystem health. When precipitation and runoff are below average, streamflow is lower than normal, and concentrations of suspended sediment and constituents that attach to sediment particles, such as phosphorus and some trace elements, often are lower than average. In contrast, concentrations of **dissolved constituents**, particularly those contributed by ground water and sewage treatment effluent, often are higher than average during low precipitation and streamflow conditions.

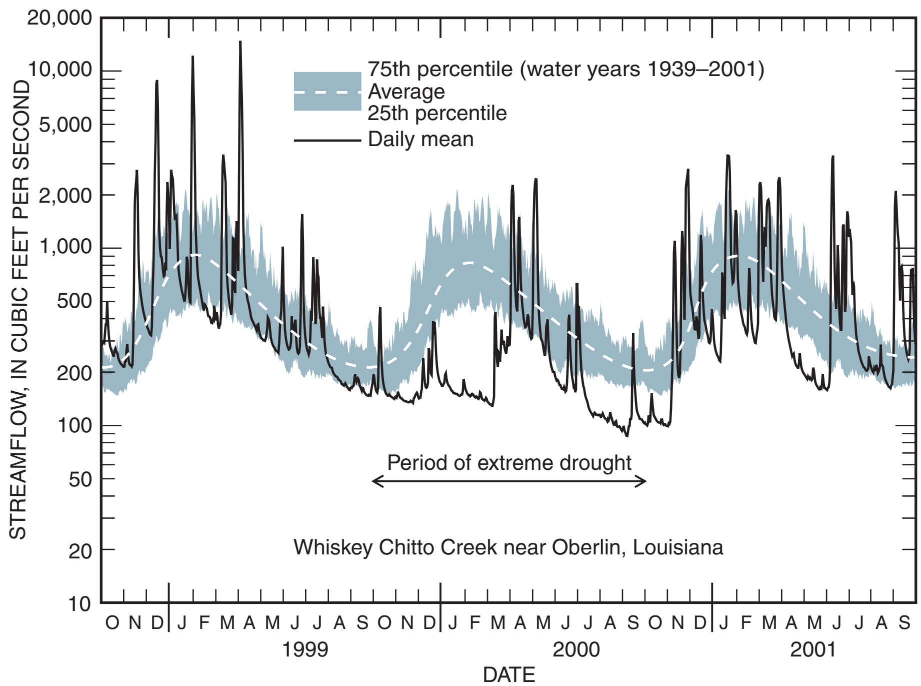


Figure 4. Streamflow at Whiskey Chitto Creek, 1999–2001, was lower than the 62-year historical average because of a drought (classified as "Extreme") from the fall of 1999 to the fall of 2000 (John M. Grymes, Louisiana State Climatologist, written commun., 2002).

Ground Water

Southern Louisiana and southwestern Mississippi are underlain by a thick sequence of southerly and southeasterly dipping interbedded clays, silts, and gravels. To the west of the Mississippi River, the Chicot aquifer system includes two major units—an upper and a lower sand (Nyman, 1984) (fig. 5). These sands are several hundred feet thick and are separated in places by thick, discontinuous clays. At the top of the Chicot aquifer system is a layer of clay that acts as a surficial confining unit. The thickness of this clay layer averages about 100 feet in the Acadian-Pontchartrain Drainages Study Unit. The clay layer once was thought to be impermeable, but results of simulations made with ground-water models indicate that as much as 6 inches of water per year, primarily from the land surface, recharge the Chicot aquifer system near major pumping centers (Nyman and others, 1990, p. 33). Ground water in the outcrop area in the northern part of the Study Unit is considered unconfined or semiconfined. This water flows generally south from the outcrop areas to deeper parts of the system, where it is confined. Ground water in the outcrop areas is more vulnerable to contamination from overlying land-use activities than deeper ground water that travels along regional flow paths in the southern part of the Study Unit. This description of the Chicot aquifer system also applies to the Chicot equivalent aquifer system (which is the upper part of the Southern Hills regional aquifer system) to the east of the Mississippi River.

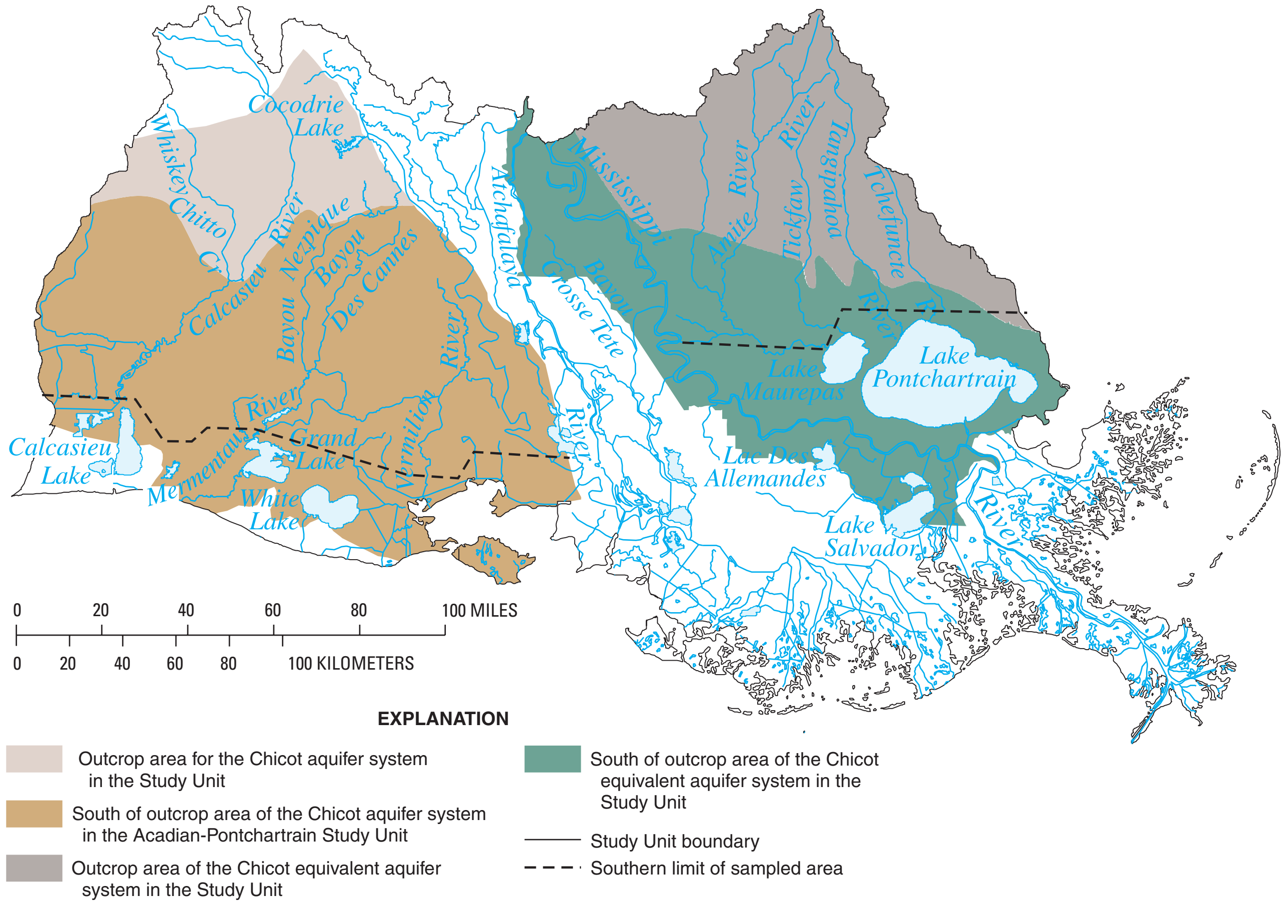


Figure 5. The Chicot and Chicot equivalent aquifer systems are both characterized by water-rich sands interlayered in places by discontinuous clay layers.

Major Findings

These findings are supported by the NAWQA study design described on pages 27–30.

Surface Water

Water quality of streams and rivers in the Acadian-Pontchartrain Drainages of southern Louisiana is generally good. Land-use activities related to agriculture, urbanization, and oil and gas production, however, have increased the frequency of occurrence and concentrations of pesticides and other organic compounds, nutrients, and suspended sediment in surface waters and have disturbed aquatic habitats.

Pesticides

Pesticides, which are used to control weeds, insects, and fungi, can have unintended effects on the health of humans and aquatic communities. Although the concentrations of pesticides in streams and rivers in the Acadian-Pontchartrain Drainages infrequently exceeded standards and guidelines to protect human health and aquatic life, the occurrence of these compounds was widespread. Specifically, at least one pesticide parent compound or degradation product was detected in 272 of 299 water samples (about 91 percent) collected at eight stream sites. In all, 58 different pesticides or their degradation products, including 38 herbicides and 20 insecticides, were detected. In addition, these compounds seldom occurred alone. Mixtures of pesticides were frequently detected, and the effects of long-term exposure to mixtures of pesticides, even at low concentrations, are poorly understood.

Pesticide compounds vary with land use

The types of pesticide compounds and the degree of contamination in streams are closely linked to land use and to the chemicals used in each setting. For example, in the Mermentau River Basin, a total of 47 different pesticides and degradation products were detected in streams draining agricultural areas. Herbicides most heavily used for weed control on major agricultural crops or highway margins—including atrazine, molinate, and tebuthiuron—were the most frequently detected in the agricultural streams. The most heavily used and most frequently detected insecticide in the agricultural streams of the Mermentau Basin was fipronil. Atrazine was detected in nearly 100 percent of the samples; tebuthiuron was detected in more than 95 percent, molinate in about 75 percent, and fipronil in about 72 percent of samples (Skrobialowski and others, 2003).

Although pesticides commonly were detected, concentrations were low (generally below 0.1 μg/L), and only a few exceeded guidelines established for the protection of aquatic life. Specifically, concentrations of atrazine in the Mermentau River Basin exceeded the guideline for the protection of aquatic life (1.8 μg/L) in 27 samples from 14 sites in the Mermentau Basin. The largest concentration of tebuthiuron (6.33 μg/L) was detected at one site on Bayou des Cannes and was the only detection exceeding the Canadian Council of the Ministers of the Environment guideline for the protection of aquatic life (1.6 μg/L). No standards or guidelines have been established for molinate and fipronil.

Pesticides are not just an agricultural problem. In fact, pesticides also are prevalent in urban streams because of chemicals used on lawns, parks, golf courses, and rights-of-way, and commonly were detected at greater frequencies and concentrations in these areas than in other land-use settings. Specifically, the insecticides carbaryl, chlorpyrifos, diazinon, and malathion were detected more frequently and usually at higher concentrations in the urban Dawson Creek within the city of Baton Rouge, than in the agricultural or mixed land-use sites. Diazinon was detected in 47 of 50 samples (94 percent) in Dawson Creek, but in only 95 of 242 samples (39 percent) collected from agricultural streams. Concentrations of diazinon in Dawson Creek exceeded guidelines for the protection of aquatic life (0.08 μg/L established by the International Joint Commission) in 21 of 50 samples (42 percent). Samples from Dawson Creek also contained 10 herbicides (such as atrazine, simazine, and prometon used in lawn care and in maintenance of rights-of-way) and four atrazine degradation products.

Major rivers and streams draining areas of mixed land use commonly contain pesticides from both agricultural and urban sources, resulting in a wider mix of compounds, including pesticides commonly associated with agriculture (atrazine, tebuthiuron, molinate, and fipronil) and those associated with urban areas (prometon, diazinon, and carbaryl). The broader suite is illustrated by samples collected from Bayou Grosse Tete at Rosedale, where 20 pesticides were detected. The 7 pesticides detected in the highest concentrations are shown in figure 6.

NAWQA findings show that the occurrence of pesticides in streams is strongly related to land use, chemical application, and **nonpoint source** runoff. Understanding the relations among pesticide occurrence, land use, and nonpoint source runoff is a major step toward reducing contaminant levels in urban and agricultural settings. While commercial, urban, and agricultural chemical application activities fall within the scope of State and Federal regulation, it is the applicator's responsibility to use pesticides properly. Information about current chemical use by landowners is generally insufficient, however, and in urban areas is virtually

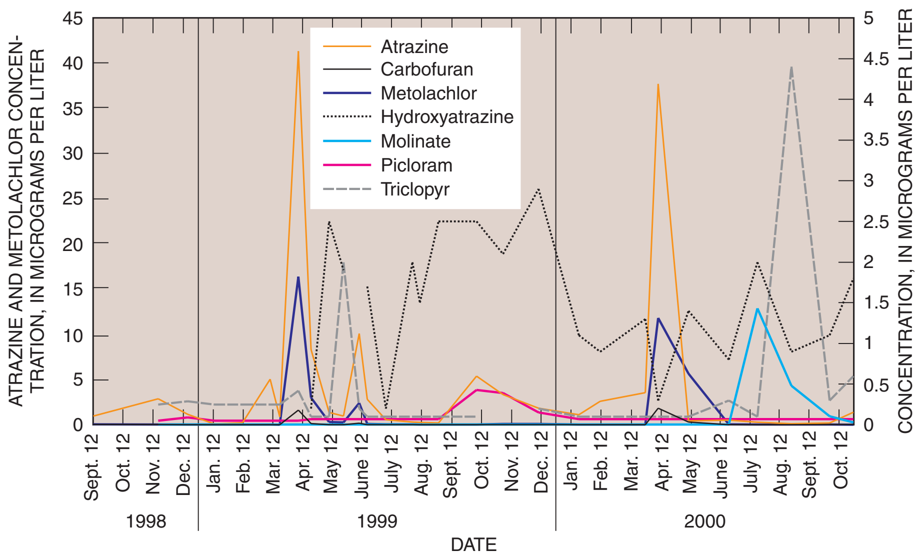


Figure 6. Pesticides in Bayou Grosse Tete showed a broad mix of herbicides and insecticides, which reflects the urban and agricultural nature of the area.

What concentrations of pesticides are considered safe for aquatic life?

Several agencies, including U.S. Environmental Protection Agency (USEPA), Environment Canada, and the IJC (International Joint Commission), have established guidelines to protect aquatic life. These guidelines are designed to prevent adverse short-term (acute) and long-term (chronic) effects on aquatic life. The aquatic-life guidelines or benchmarks developed by USEPA are based on 4-day average concentrations, are intended to protect 95 percent of the aquatic species, and should not be exceeded more than once in 3 years. The Canadian and IJC aquatic-life guidelines, which are more stringent than those of the USEPA, indicate a single maximum concentration that should never be exceeded. Aquatic-life guidelines have been developed for 14 pesticides analyzed for this study.

unavailable for local and regional water-resource management and decisionmaking. Improved tracking of chemical use and continued monitoring for pesticides in streams would help identify suspected sources (for example nonpoint runoff) of specific contaminants and support appropriate management actions.

Pesticides occur in mixtures and as degradation products

Pesticides seldom occurred alone in streams. More than 75 percent of the samples collected from agricultural streams draining the Mermentau River Basin contained at least three compounds. The Mermentau River Basin is primarily a rice and soybean agricultural area, and these uses are reflected in the detection of the herbicides atrazine, molinate, tebuthiuron, and the insecticide fipronil. The urban site Dawson Creek at Baton Rouge also was characterized by mixtures of insecticides such as diazinon and malathion with the herbicide 2,4-D.

Chemical degradation products are often as common in streams as parent compounds (U.S. Geological Survey, 1999). For example, two atrazine degradation products, 2-hydroxyatrazine and deethylatrazine, were detected in 84 and 90 percent, respectively, of the samples collected from the agricultural Mermentau River Basin (where atrazine was detected in 100 percent of the samples). The highest concentrations of desulfinylfipronil, a rapidly formed, light-induced degradation product of fipronil, were typically found with the highest concentrations of the parent compound at 14 of 17 sites. Degradation products can have similar, lesser, or even greater toxicities than parent compounds. Possible risks to human health and aquatic life from degradation products are not well understood, and drinking-water standards or **aquatic-life guidelines** have not been established for many of these products (see inset, p. 14).

Pesticides vary seasonally in streams

Concentrations of pesticides varied seasonally in streams in response to seasonal patterns of chemical use and the frequency and magnitude of runoff from precipitation and irrigation. For example, elevated concentrations of atrazine, molinate, tebuthiuron, and fipronil generally were elevated in the Mermentau River in April and May (fig. 7). The seasonal peaks are coincident with applications of pesticides on corn, sugarcane, and rice, as well as the draining of ricefields (particularly associated with elevated concentrations of molinate and fipronil). Concentrations of molinate were the highest among all agricultural pesticides, reaching a maximum of more than 150 μg/L in a small tributary of the Mermentau River in 2000. Tebuthiuron, which is used more broadly and throughout the year for general weed control on crops (except for rice) as well as for nonagricultural uses such as along roads and other rights-of-way, does not demonstrate seasonal peaks as pronounced as those for other pesticides in agricultural streams.

Seasonal patterns in concentrations of herbicides and insecticides were highly variable and less predictable in the urban Dawson Creek than in the agricultural streams (fig. 8). For example, concentrations of the broad-spectrum herbicide 2,4-D peaked in April,

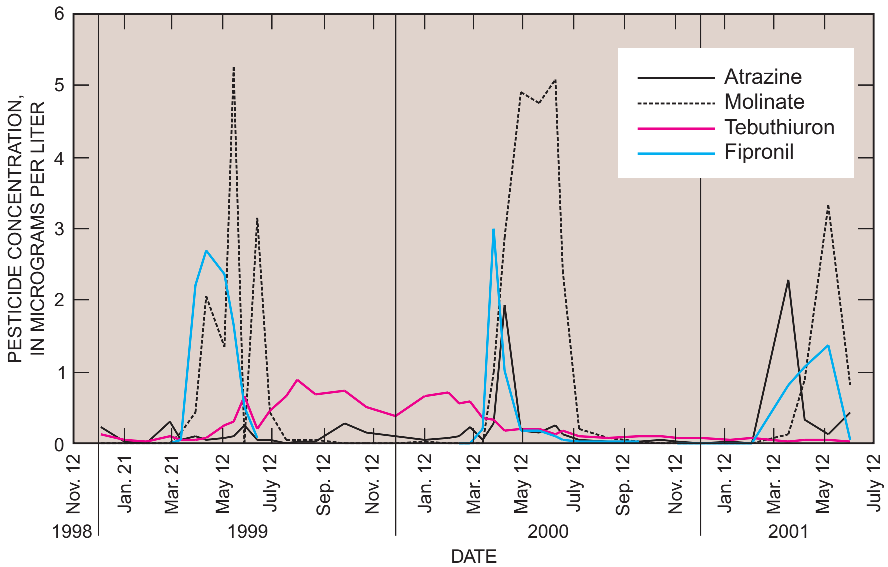


Figure 7. Pesticides in the Mermentau River at Mermentau, Louisiana varied seasonally in response to seasonal use of the chemicals and the frequency and magnitude of runoff from precipitation and irrigation.

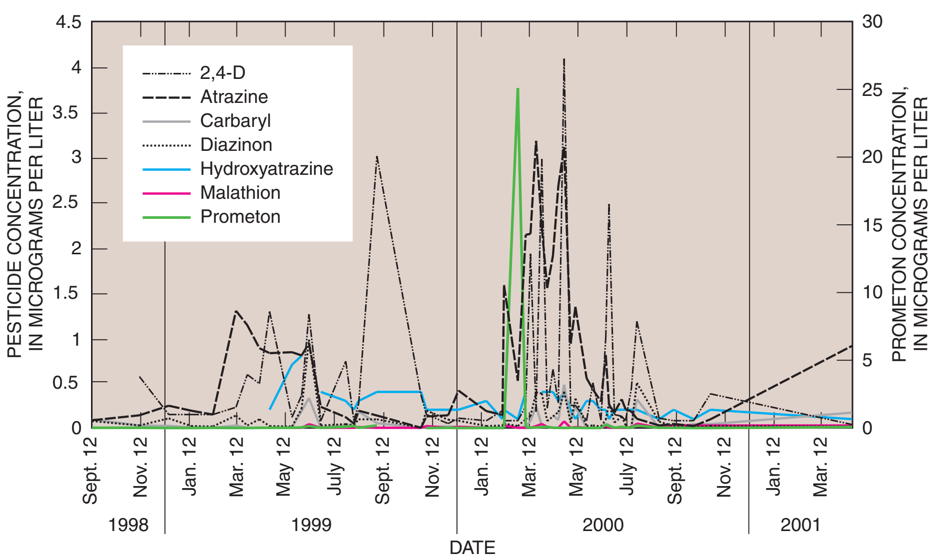


Figure 8. Relatively low concentrations of pesticides were punctuated with highly variable and unpredictable peaks in the urban Dawson Creek.

June, and September 1999, and in April, June, and July of 2000 (reaching a maximum of 4.1 µg/L); but otherwise concentrations were low, generally below 0.5 µg/L. Prometon was detected at 24.8 µg/L in April 2000 but never above 0.25 µg/L throughout the remaining 2-year sampling period. Temporal patterns in the concentrations of pesticides in the urban creek most likely reflect targeted and sporadic applications as needed, as opposed to patterns in streams draining agricultural areas, where pesticides are applied at specific times during the growing season. For example, 2,4-D is used in Baton Rouge for control of exotic and invasive plant species, such as water hyacinth, that interfere with urban stormwater drainage and navigation. It is likely that the mild winters of 1999 and 2000, combined with drought conditions, necessitated several applications of 2,4-D during those years.

NAWQA findings clearly show seasonal variations. Improved information and monitoring of temporal patterns will aid in water management and watershed protection because seasonal peaks significantly affect the timing of the highest concentrations in drinking-water supplies and aquatic habitats (possibly affecting, for example, critical life stages of aquatic organisms).

Mississippi River hydrology affects occurrence of atrazine in streams and rivers

Concentrations of atrazine can vary seasonally, in large part because of the fluctuating regional inputs from the Mississippi River, which drains more than 40 percent of the continental United States, and local inputs from streams draining agricultural and urban areas within the Acadian-Pontchartrain Drainages (Demcheck and Swarzenski, 2003). For example, water samples collected from the Mississippi River at Baton Rouge showed peak concentrations during May and June over a 2-year period, 1999–2000. This period of increased chemical concentrations in the water is commonly referred to as the “spring flush” and is the result of chemical applications and subsequent runoff in the upstream agricultural areas of the Midwest (Goolsby and Battaglin, 2000) (fig. 9).

In contrast, water samples collected from Bayou Grosse Tete at Rosedale, which is hydrologically isolated from the Mississippi River and is affected mostly by local urban and agricultural land use in the Terrebonne basin, showed pronounced atrazine peaks in April, well before atrazine is transported to southern Louisiana from upstream sources by the Mississippi River (fig. 10). Concentrations reflect applications of atrazine on corn and sugarcane, as well as applications in residential areas and light commercial businesses on both sides of the bayou. Seasonal peak concentrations in Bayou Grosse

Tete greatly exceeded those in the Mississippi River at Baton Rouge, reaching a maximum of 42 µg/L (fig. 6). Water in the bayou is not used as a major drinking water source, but some downstream communitities mix water from this bayou with water from other sources for drinking-water supply. Control measures are being implemented by local and State water managers to reduce applications of atrazine and to promote the use of activated carbon filters at downstream public-water-supply intakes.

Samples collected from Bayou Boeuf at Amelia demonstrate dual effects of local and regional inputs of atrazine (fig. 11). Specifically, this bayou receives water directly from the Atchafalaya River, which carries atrazine transported from agricultural land throughout the Midwest and runoff from nearby sugarcane fields where atrazine is applied. The overall temporal pattern in concentrations of atrazine from Bayou Boeuf shows broader and smaller peaks of longer duration than those demonstrated by the Mississippi River at Baton Rouge and Bayou Grosse Tete at Rosedale. Water from these diverse sources combined with tidally caused backwater effects that often impede efficient drainage in this low-relief area interact to produce this pattern. The water does not move quickly or efficiently enough to produce a sharp peak in atrazine concentration. The basin also drains so slowly that any atrazine in the water takes a prolonged amount of time to be removed from the basin.

For additional information on pesticides in surface-water resources of the Acadian-Pontchartrain Drainages, refer to Skrobialowski and others (2003), Demcheck and Swarzenski (2003), and Demcheck and Skrobialowski (2003). These reports also are available at *http://la.water.usgs.gov/publications.html*

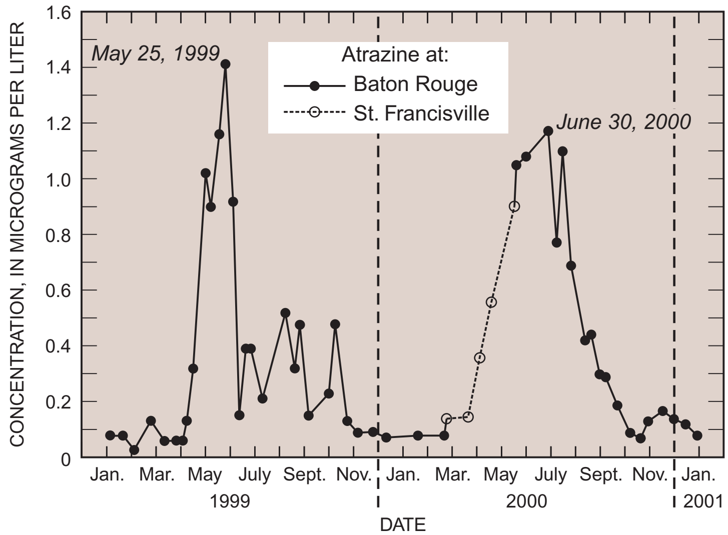


Figure 9. Atrazine in the Mississippi River at Baton Rouge generally peaks in the months of May and June.

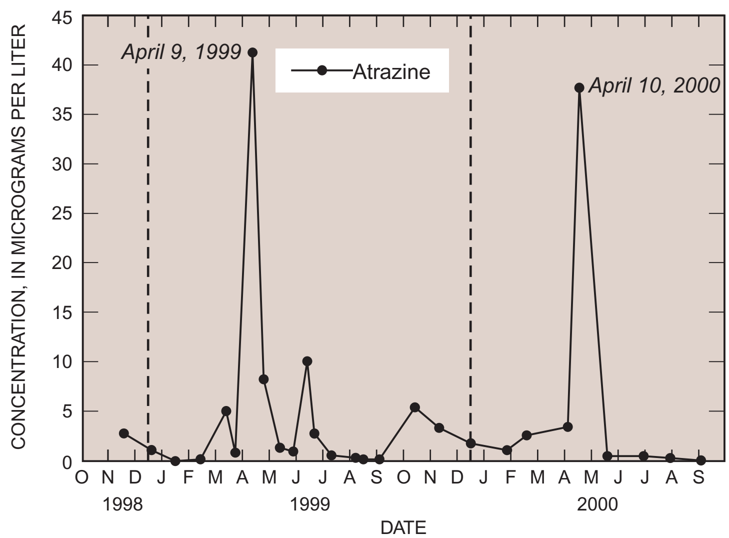


Figure 10. Atrazine in Bayou Grosse Tete at Rosedale comes from local urban and agricultural sources in the Terrebonne basin and generally peaks in April.

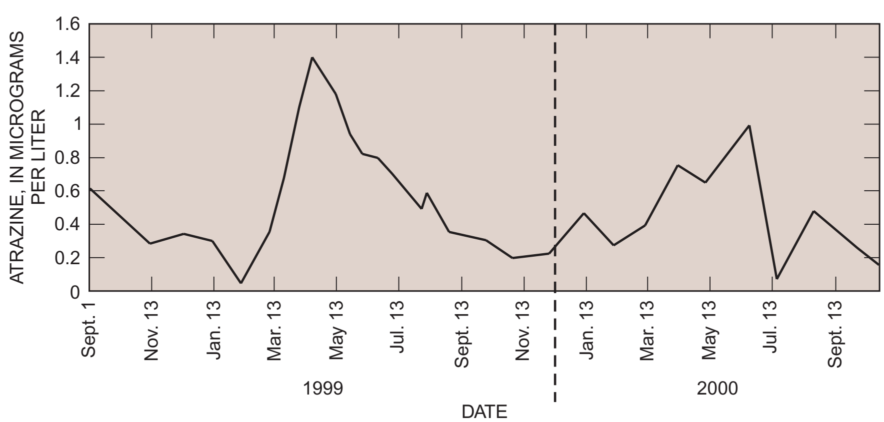


Figure 11. Atrazine in Bayou Boeuf at Amelia was detected at low-level concentrations throughout the year.

Fipronil—A relatively new insecticide applied in southern Louisiana

Fipronil, a relatively new insecticide licensed for use in 1996, came into widespread use in Louisiana in 1999, replacing carbofuran. Fipronil is licensed for use on a large and growing list of targeted organisms, including fleas, termites, water weevils, and fire ants. In the summer of 1999, public concerns arose in Louisiana over the use of fipronil-coated rice seed and its possible negative effects on crawfish populations.

In response to these concerns, the NAWQA Program initiated a study of fipronil and three degradation products in water and sediment. Fipronil was detected in about 72 percent of water samples from 19 sites on agricultural streams in the Mermentau River Basin. Concentrations of fipronil ranged from less than 0.004 µg/L to 6.41 µg/L in a small headwater tributary surrounded by ricefields. Concentrations exceeded the freshwater acute numeric target for Total Maximum Daily Loads (TMDL) (4.6 µg/L) at 3 sites and the chronic numeric target for TMDL (2.3 µg/L) at 14 additional sites (U.S. Environmental Protection Agency, 2002b). For additional information concerning the TMDL program in Louisiana, see *http://www.deq.state.la.us/technology/tmdl/*.

Concentrations of fipronil vary seasonally in water, mostly in response to agricultural practices. Specifically, the maximum concentrations occurred in the headwaters of small bayous surrounded by rice agriculture during March and April (fig. 12), which coincided with the release of ricefield tailwaters. The maximum concentration detected in the main stem of the Mermentau River was 3 µg/L. The peak concentration of fipronil occurred concurrently with or slightly before the peak concentrations of other ricefield pesticides, including molinate (Goree and others, 2000, 2001).

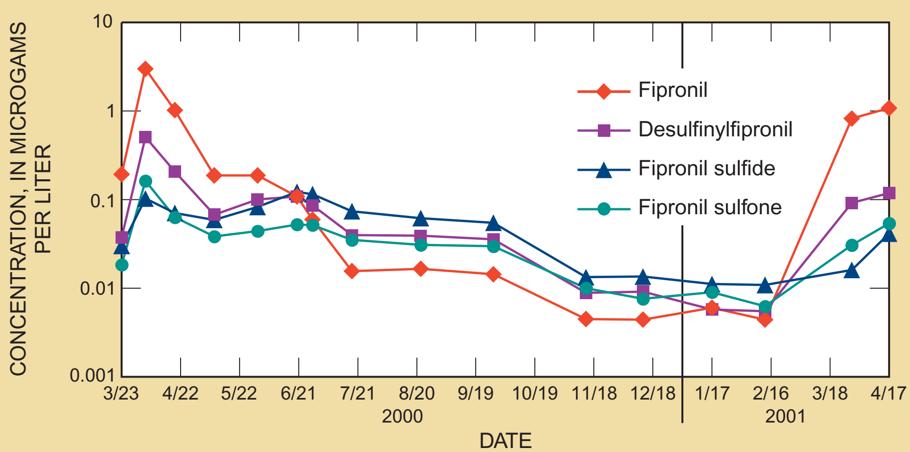


Figure 12. Concentrations of fipronil and its degradation products in the Mermentau River at Mermentau typically peak in late March through mid April after applications.

Typical of many recently introduced pesticides, fipronil degrades quickly into other forms or “degradation products.” In fact, the highest concentrations of the photodegradate desulfinylfipronil were found with the highest fipronil concentrations at 14 out of 17 sampling sites, indicating that aerobic, light-induced degradation occurs rapidly while relatively large amounts of the parent compound are still present in water (fig. 12). Other degradation products, fipronil sulfide and fipronil sulfone, generally were initially detected in lower concentrations, most likely because they are produced in soils, either aerobically or anaerobically, rather than by light (Connelly, 2001). As degradation processes proceed, however, the degradation products begin to be detected in higher concentrations than the parent compound. This is shown in figure 12, but the logarithmic scale used tends to de-emphasize the differences in concentrations between the parent compound and the various degradation products.

Bed-sediment samples contained no detectable levels of the fipronil parent compound (fig. 13). Fipronil degradation products, however, were detected in sediment at all 17 sites. Fipronil sulfide, produced by sulfide-reduction processes occurring in anaerobic sediment, was detected at all 17 sites at the highest concentrations, ranging from 0.6 µg/kg to as much as nearly 25 µg/kg. Desulfinylfipronil also was detected at all sites, ranging from 0.55 µg/kg up to about 7 µg/kg. Fipronil sulfone, a soil-oxidation product, was detected at 16 of 17 sites, with a maximum concentration of 10.5 µg/kg. Concentrations of the three degradation products in bed sediments increased downstream, with maximum concentrations at the most downstream sites on the main stem of the Mermentau River (fig. 13).

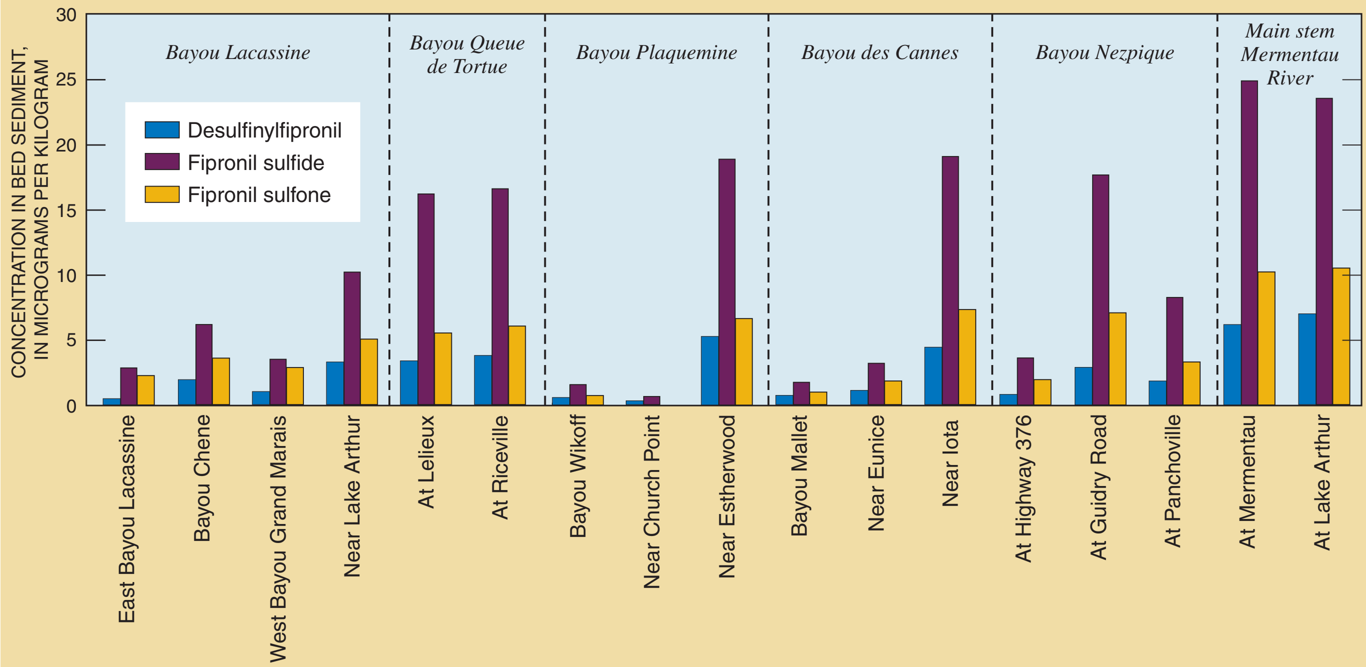


Figure 13. Fipronil degradation products were detected in bed sediments of the Mermentau River Basin, generally increasing in a downstream direction.

The presence of fipronil and, particularly, its degradation products in the Mermentau River Basin are of concern to water-resource managers because of their possible effects on aquatic life. Fipronil degradation products are more persistent and can be more toxic to aquatic life than the parent compound (Connelly, 2001). Specifically, the USEPA reports that fipronil sulfone is about 6.5 times more toxic, and fipronil sulfide is nearly 2 times more toxic to freshwater invertebrates than the parent compound (U.S. Environmental Protection Agency, 1996).

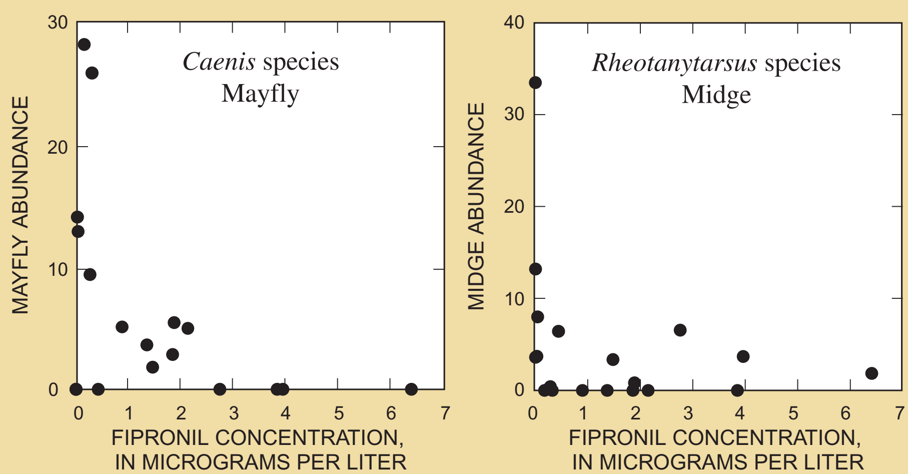


Figure 14. Decreases in mayfly and midge abundance correspond to increases in fipronil concentrations in the Mermentau River basin.

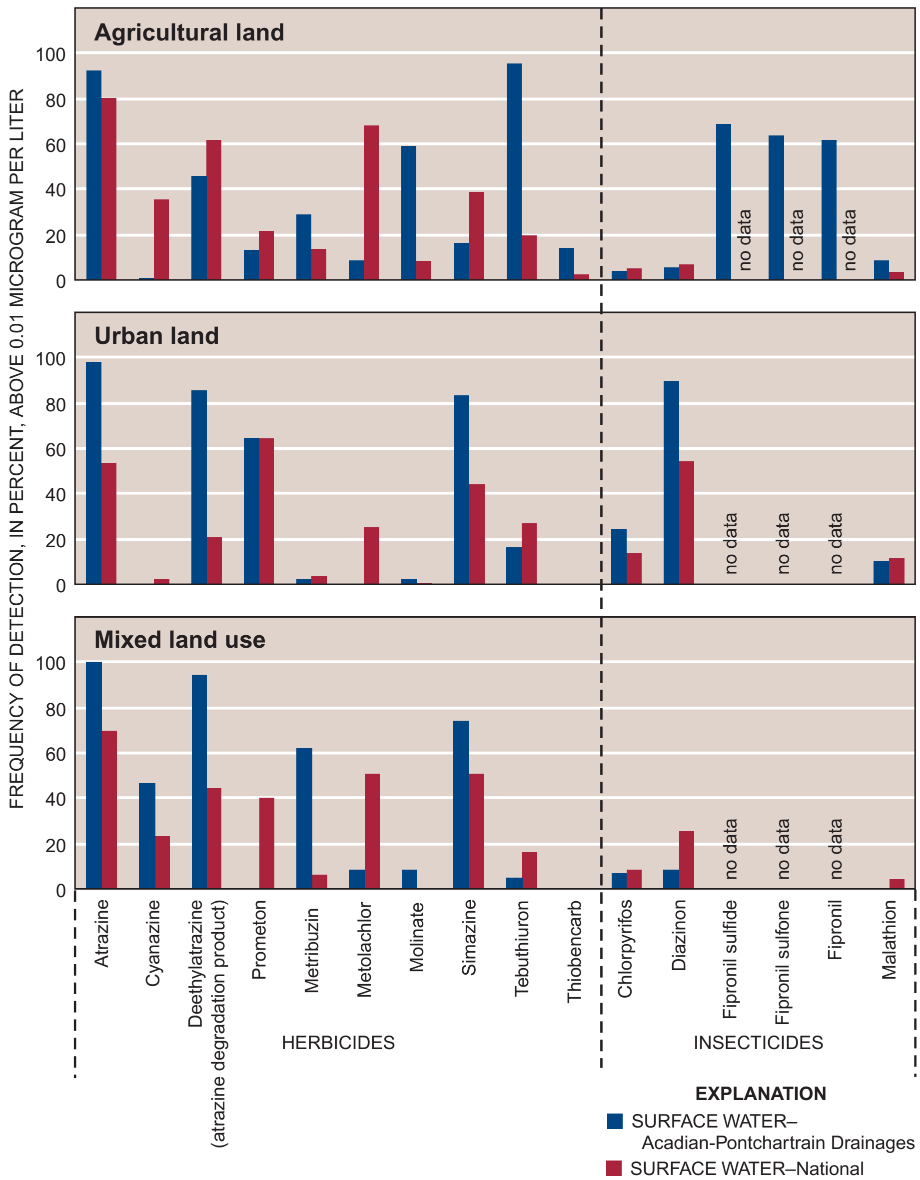
Changes in invertebrate communities in the Mermentau River Basin are associated with elevated concentrations of fipronil. For example, abundances of tolerant mayflies in the genus *Caenis* and midges in the genus *Rheotanytarsus* decreased with increasing fipronil concentrations (fig. 14). Concentrations of fipronil in selected stream samples in the Mermentau River Basin were more than 10 times the known acute lethal concentration to selected midge larvae of 0.5 µg/L. Similar patterns occur in other midges as well. The overall abundance of aquatic invertebrates also was lower in streams with elevated concentrations of the degradation products fipronil sulfone, fipronil sulfide, and desulfinylfipronil.

Occurrence of Pesticides in the Acadian-Pontchartrain Drainages

The types of pesticides detected in the Acadian-Pontchartrain Drainages generally are among the top pesticides most often detected nationally, in addition to others—including molinate and fipronil—used heavily in the Study Unit for weed control or pest control on rice. For example, the herbicide molinate was detected in 59 percent of the agricultural samples, compared to 8 percent nationally. Because minimum detection levels change as analytical methods are refined, for the purposes of this comparison only pesticide detection greater than 0.01 µg/L were used. Using a consistent minimum detection level facilitates comparisons between different studies. Fipronil and its degradation products were detected in about 60 percent of water samples in the Acadian-Pontchartrain Drainages. No data for fipronil are available for samples collected in other river basins nationwide. The compound is now included in analyses by the NAWQA Program as this insecticide is licensed for use on a growing number of insect pests such as ants, fleas, and termites, and the use of fipronil is expected to increase substantially throughout the Nation in the coming years. Atrazine, the most heavily applied and commonly detected herbicide in the Nation's waters also is the most commonly detected herbicide in southern Louisiana.

Diazinon, a commonly used insecticide in urban areas across the Nation, was detected more frequently in the urban Dawson Creek within Baton Rouge (about 90 percent of samples) than in 33 urban streams sampled across the Nation (about 54 percent). Similarly, atrazine and simazine, herbicides commonly used in lawn care, were detected more frequently in the urban Dawson Creek than others nationally. Higher frequencies of these compounds in the Study Unit most likely reflect a longer growing season and increased survival of insect pests in the subtropical climate of the Acadian-Pontchartrain Drainages (which, in other parts of the Nation, are naturally controlled by winters), requiring applications of pesticides throughout much of the year.

Major rivers and streams in the Acadian-Pontchartrain Drainages Study Unit draining areas of mixed land use commonly contain pesticides from both agricultural and urban sources, resulting in a wide mix of compounds, including pesticides commonly associated with agriculture (atrazine, tebuthiuron, molinate, and fipronil) and those associated with urban areas such as diazinon. Frequency of detections, particularly for herbicides, was greater in streams in the Acadian-Pontchartrain Drainages than nationally.



Pesticide risks to humans and aquatic life remain unclear

Although pesticides and their degradation products were detected frequently, concentrations generally were lower than current standards and guidelines for drinking water and human health. The risks to humans and aquatic life from present-day levels of pesticide exposure, however, remain unclear. Pesticide information gathered in the Acadian-Pontchartrain Drainages indicated that pesticide exposure is complicated by lengthy periods of low concentrations that are punctuated by seasonal spikes of much higher concentrations, in addition to complex mixtures of compounds and degradation products. Possible risks implied by these patterns of exposure have not been fully evaluated for several reasons. First, drinking-water standards or guidelines have not been established for many pesticides and their degradation products. Specifically, only 27 of the pesticides for which samples were analyzed in this study have current U.S. Environmental Protection Agency (USEPA) human health standards. Additionally, current standards do not yet address exposure to pesticide mixtures and the possibility that the presence of multiple compounds, even at low concentrations, may have adverse cumulative health effects. Further, standards and guidelines usually are based on expected long-term exposure to constant concentrations rather than lengthy periods of low concentrations punctuated by brief pulses of high concentrations. Finally, various potential effects, such as endocrine disruption and unique responses of sensitive individuals, have not yet been completely assessed.

Nutrients

Nitrogen and phosphorus occur naturally in streams, but human activities—including the use of fertilizers in agricultural and urban areas and the discharge of municipal wastewater—can contribute to increases in the natural concentrations of these nutrients. Nitrogen and phosphorus are essential to the growth and health of plants and animals, but elevated concentrations of these nutrients are a potential concern for human health and aquatic life. Excessive concentrations can contribute to the overgrowth of algae and other nuisance plants, whose death and subsequent decay can cause oxygen levels in streams to decrease substantially during warm weather and at night (see inset on Hypoxia, p. 17).

Concentrations of nitrogen generally were low in the Acadian-Pontchartrain Drainages. Specifically, median concentration of nitrogen was 1.2 mg/L for the eight streams sampled. The nitrogen levels generally were less than those found in other streams sampled across the Nation by the NAWQA Program. For example, the median value for nitrogen in 137 agricultural streams sampled across the Nation was about 3.5 mg/L, more than twice the value measured in agricultural streams in the Acadian-Pontchartrain Drainages. The median concentration of phosphorus in the eight streams sampled in the Acadian-Pontchartrain Drainages was 0.2 mg/L, a value similar to that in streams sampled across the Nation.

Transport of nutrients in the environment depends on chemical mobility. Some compounds, such as nitrate, readily dissolve and move with water in streams and ground water. Many forms of phosphorus, however, attach to soil particles rather than dissolve; a large proportion of phosphorus is transported to streams with eroded soil, particularly during times of high runoff from precipitation or irrigation.

Nutrient concentrations differ with land use

Concentrations of nutrients differed with land use, with the largest concentrations detected in streams draining basins with large areas of agricultural or urban land. Specifically, the median concentration of nitrogen was slightly greater than 1 mg/L—a concentration considered to represent naturally occurring or “background” conditions for the Nation as a whole—in agricultural and urban basins, but only about 0.4 mg/L in the undeveloped basins (fig. 15A). The maximum concentration for total nitrogen (5.8 mg/L) was measured in Bayou Grosse Tete, which drains a mix of agricultural and urban land. Concentrations of total phosphorus were greatest in the urban stream, Dawson Creek, with a median concentration of 0.46 mg/L and maximum concentration of 1.1 mg/L (fig. 15B). Elevated phosphorus concentrations, however, also were detected in streams draining agricultural land. In fact, concentrations of total phosphorus exceeded the USEPA desired goal to prevent nuisance plant growth (0.1 mg/L) in 90 percent of samples collected from streams draining agricultural or urban land, but in only 17 percent of samples from streams draining undeveloped land.

Forms of nitrogen vary among streams in the Acadian-Pontchartrain Drainages and in the Mississippi River at St. Francisville

Overall, organic nitrogen was the most frequently detected form of nitrogen in the 368 samples collected from the eight streams in the Acadian-Pontchartrain Drainages, accounting for about two-thirds of the total nitrogen (fig. 16). Large percentages of organic nitrogen generally indicate suspended algae (phytoplankton) or other organic matter in the water. **Ammonia** generally was minimal except in the urban Dawson Creek, where it accounted for about 25 percent of the total nitrogen con-

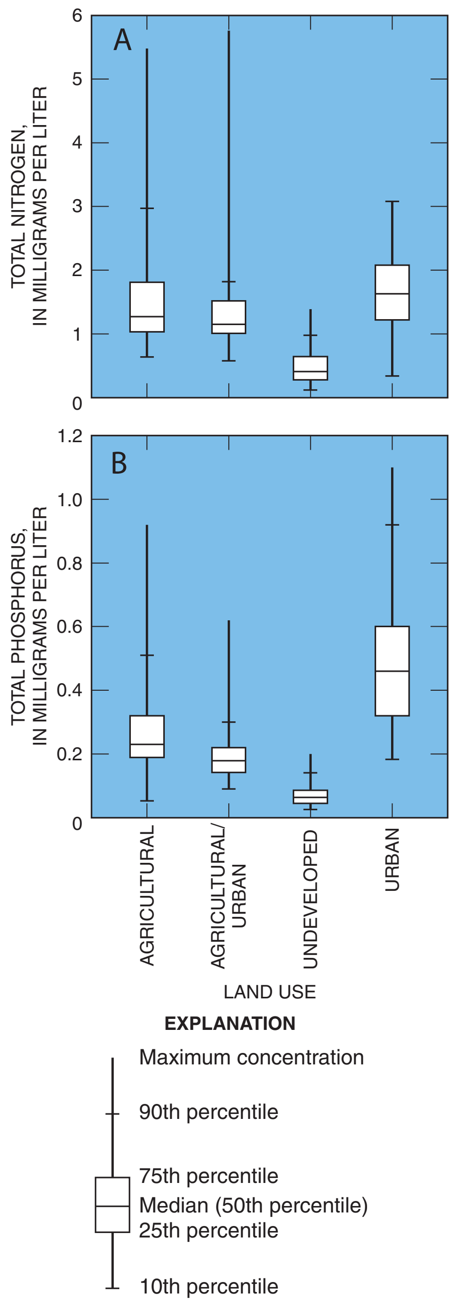


Figure 15. Concentrations of total nitrogen (A) and phosphorus (B) differ with land use, with the largest concentrations in streams draining agricultural or urban land.

centration. Nitrate generally was not a dominant form of nitrogen in any of the streams draining the Acadian-Pontchartrain Drainages (fig. 16). This is due, in large part, to nitrate being readily taken up by plants in the subtropical environmental setting, or being converted to other forms through denitrification or mineralization.

The low occurrence of nitrate relative to other forms of nitrogen in the Acadian-Pontchartrain streams is in contrast to the presence of nitrate in the Mississippi River, which integrates upstream regional conditions. Nitrate is the dominant form of nitrogen in the Mississippi River near St. Francisville, Louisiana, where it accounts for nearly 70 percent of the total nitrogen (fig. 16). The relatively large proportion of nitrate in the Mississippi River is attributable to large amounts of fertilizers used on farmland in the Midwest, high water **turbidity** that limits plant growth and nitrogen uptake in the river, and its relatively large channel size. Apparently, nitrate is not as readily assimilated or removed by natural processes in the larger Mississippi River as in the smaller streams and tributaries of the Acadian-Pontchartrain Drainages. The controlling effects of stream channel size and other hydrologic and basin characteristics are documented throughout the Mississippi River Basin, clearly showing that the proximity of nitrogen sources to large streams and rivers increases transport of the nitrate and nutrients down the Mississippi River (Alexander and others, 2000) and ultimately to its receiving water, the Gulf of Mexico (see inset on p. 17 for nutrient effects on the Gulf of Mexico).

Nutrient concentrations vary seasonally in streams

Concentrations of total nitrogen and phosphorus varied seasonally in all streams, with maximum concentrations occurring during April through June (fig. 17), reflecting agricultural applications of fertilizers in the region. Minimum concentrations generally occurred during the fall and winter months. Similar to seasonality patterns with atrazine, peaks in concentrations in total nitrogen in streams in the Acadian-Pontchartrain Drainages occurred earlier than in the Mississippi River near St. Francisville, where peaks generally occurred in June and July (representing the "spring flush" from agricultural applications and subsequent runoff in the upstream agricultural areas of the Midwest). Peaks in concentrations of total phosphorus in the Bayou Lacassine, which reflects releases of highly turbid water from the ricefields, were more pronounced than those in the Mississippi River (fig. 17).

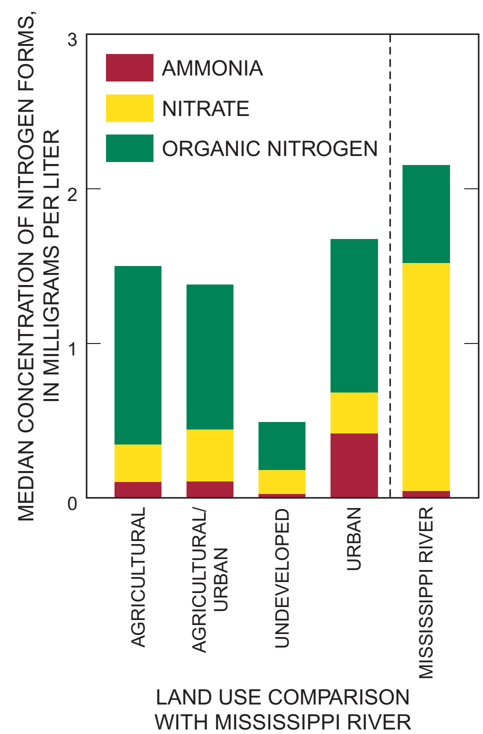


Figure 16. Organic nitrogen is the most common form of nitrogen in streams in the Acadian-Pontchartrain Drainages, whereas nitrate is the most common form in the main stem of the Mississippi River near St. Francisville.

For additional information on nutrients in surface-water resources of the Acadian-Pontchartrain Drainages, refer to Skrobialowski and others (2003). This report also is available at *http://la.water.usgs.gov/publications.html*

Nutrients in the Mississippi River Basin contribute to hypoxia in the Gulf of Mexico

Nutrients from the Mississippi River Basin may pose an environmental threat to the Gulf of Mexico, which is experiencing hypoxic areas and degradation of aquatic resources (Rabalais and others, 1996). The hypoxic zone (an area with concentrations of dissolved oxygen less than 2 mg/L) develops each spring and summer on the Louisiana-Texas shelf of the Gulf of Mexico. Hypoxia can cause stress or death in bottom-dwelling organisms that cannot leave the zone. The midsummer extent of the hypoxic zone varies greatly from year to year but in general has more than doubled in size since it was first systematically mapped in 1985. One of the principal causes for the increasing size of the hypoxic zone is believed to be the increasing supply of phosphorus and nitrogen, particularly nitrate from agricultural sources (Burkart and James, 1999) delivered to the gulf each year from the Mississippi River Basin. Concentrations of nitrate have increased several-fold during the past 100 years in streams draining parts of the Mississippi Basin, and the annual delivery of nitrate from the Mississippi River to the gulf has nearly tripled since the late 1950s. The amount of nitrate delivered peaked in the late 1970's and has remained constant or decreased slightly since then. (For more detailed information, refer to Goolsby and Battaglin, 2000, and website *http://webserver.cr.usgs.gov/midconherb/index.html*).

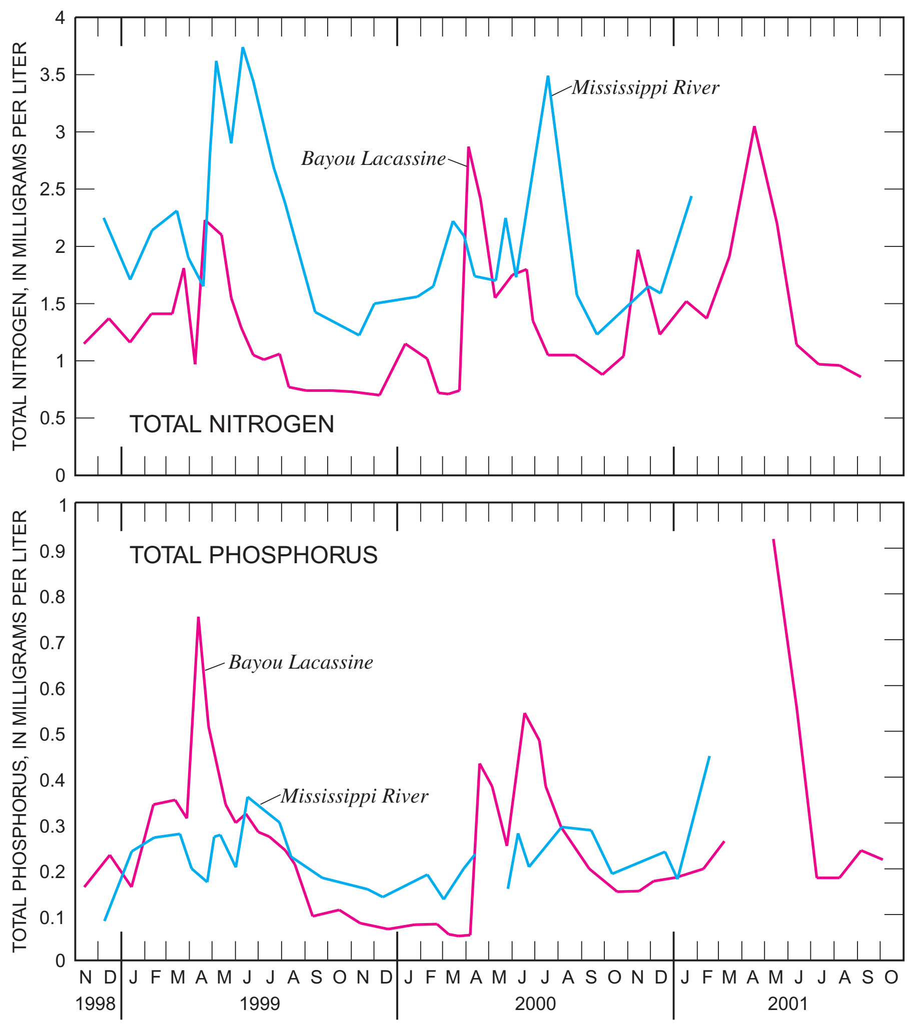


Figure 17. Concentrations of total nitrogen and phosphorus varied seasonally in all streams in the Acadian-Pontchartrain Drainages, with maximum concentrations occurring during April through June. Peaks generally are earlier than peaks in the Mississippi River near St. Francisville, which occurred in June and July.

Elevated nutrients threaten floating freshwater marshes in Jean Lafitte National Historical Park

The Barataria Preserve of Jean Lafitte National Historical Park and Preserve is a 20,000-acre wetland complex comprising swamp forests and marshes located about 15 miles southwest of New Orleans. The park contains a flourishing example of floating marshes, a globally rare type that dominates freshwater reaches of coastal Louisiana. Floating marshes move vertically to some degree in response to changes in water levels because of their buoyant, organic-rich peat substrate.

Beginning in the 1930s, with the construction of flood control levees and canals along the Mississippi River, water has been less available to the wetlands. In fact, loss of wetlands has amounted to about 25 to 35 square miles per year, which can have significant economic and ecological implications. Strategies are in place for diverting water from the Mississippi River and restoring the natural wetland hydrology that was typical before the building of the levees.

Water introduced from the Mississippi River for wetland restoration purposes, however, may have negative consequences for the health of floating marshes. Floating marshes are widespread in areas where nutrient concentrations are naturally low (about 0.04 mg/L) and the inflow of river water, mineral sediments, and contaminants such as herbicides are scarce. Nutrient concentrations such as nitrate in the Mississippi River have increased (to about a median of 1.3 mg/L) and herbicides are newly present in the Mississippi River since the last time many freshwater marshes were regularly inundated by overbank flooding in coastal Louisiana, prior to the 1930s. The long-term effects of the elevated concentrations of nutrients and low-level concentrations of herbicides (0.2–2.0 µg/L of atrazine, for example) on the floating marshes are not known.

Organochlorine compounds persist in sediment and fish tissue

Most organochlorine pesticides and PCBs have not been manufactured or used in the United States for 25 to 30 years; but because of their widespread use and chemical stability (persistence), they were detected commonly in streambed sediment and in whole-fish tissue samples from 21 streams in the Acadian-Pontchartrain Drainages in 1999–2001 (fig. 18). Many of these compounds are classified as **endocrine** disruptors and are known to cause liver and kidney lesions in fish. The compounds also pose a threat to fish-eating wildlife, and some are a concern for human consumption because of possible carcinogenic toxicity.

Organochlorine compounds are not readily soluble in water but instead bind strongly to soil particles and are carried with eroded soils to streams by runoff.

The most frequently detected organochlorine compounds were PCBs, mirex, dieldrin, and degradation products of DDT (such as *p,p´*-DDE and *p,p´*-DDD) and chlordane (such as trans-Nonachlor, cis-Chlordane, cis-Nonachlor, trans-Chlordane, and oxychlordane) (fig.18). *p,p´*-DDE accounted for the most detections, with detections in sediment samples from 8 of 21 streams (Skrobialowski, 2002) and in fish-tissue samples from 11 of 19 streams. Organochlorine compounds generally were detected more frequently in fish tissue than in sediment. For example, PCBs were detected in fish-tissue samples from 8 of 19 streams but in bed-sediment samples from only one stream.

Organochlorine compounds were detected more frequently in streambed sediment and fish tissue at sites draining agricultural and urban land than at sites draining undeveloped areas. Occurrences of chlordane and dieldrin reflect their past use for termite control in urban areas, whereas mirex was used extensively for control of fire ants. The occurrence of DDT reflects its principal use as an insecticide and the occurrence of PCBs reflect their uses as industrial chemicals in hydraulic lubricants and heat-resistent oils in electrical transformers.

When compared to the national range of detected concentrations, total concentrations of DDT and its degradation compounds, chlordane, and PCBs in bed sediment and fish tissue in southern Louisiana were generally in the medium range (middle 50 percent, nationally) to high range (highest 25 percent, nationally) for sites draining urban and agricultural lands and in the low range (lowest 25 percent, nationally) for sites draining mixed land uses (see Appendix). Concentrations of total chlordane in bed sediment samples at 2 of 21 streams (Dawson Creek and Bayou Lafourche) exceeded the Canadian Council of Ministers of the Environment's Probable Effects Level (PEL) of 8.87 µg/kg (micrograms per kilogram) (Skrobialowski, 2002) and were among the highest in the national range of detected concentrations. Concentrations of *p,p´*-DDE in bed-sediment samples at 2 streams (Bayou Teche, and Vermilion River at Perry) exceeded the PEL of 6.75 µg/kg for total degradates. Compounds exceeding the PEL are likely to result in adverse effects on aquatic organisms. At some sites, concentrations of total PCBs and DDT compounds exceeded the New York State Department of Environmental Conservation (NYSDEC) criteria for the protection of fish-eating wildlife (Nowell and others, 1987). Concentrations above the criteria may have a detrimental effect on fish-eating organisms. Concentrations of total PCBs exceeded the NYSDEC criteria of 110 µg/kg for fish in five of the 8 streams. Concentrations of **total DDT** exceeded the NYSDEC criteria of 200 µg/kg at Bayou Teche, reaching a maximum of about 350 µg/kg.

Semivolatile organic contaminants (SVOCs), such as the combustion byproducts polyaromatic hydrocarbons (PAHs), were detected frequently in sediment (SVOCs were not measured in fish because they do not bioaccumulate in fish). Specifically, sediment samples from 10 of 21 streams contained detectable concentrations of one or more SVOC compounds. Concentrations generally were low, except for those of pyrene, phenanthrene, acenaphthene,

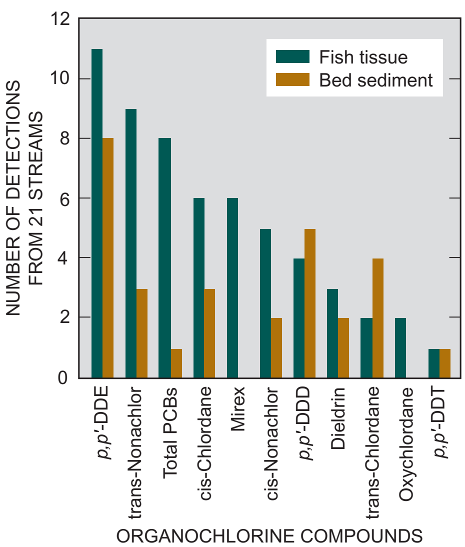


Figure 18. Organochlorine compounds persist in both bed sediment and whole-fish tissue in southern Louisiana streams, particularly those draining agricultural and urban areas.

and anthracene, which exceeded PELs at five sites across the Acadian-Pontchartrain Drainages. Some PAHs are potentially toxic and carcinogenic.

For additional information on organochlorine compounds in bed sediment in streams of the Acadian-Pontchartrain Drainages, refer to Skrobialowski (2002). This report also is available at *http://la.water.usgs.gov/pdfs/BedSediment.pdf*

Guidelines for Protection of Aquatic Life and Wildlife

Contaminant concentrations in streambed sediment are compared with the guidelines for the protection of aquatic life established by the Canadian Council of Ministers of the Environment (1999). The Probable Effect Level (PEL) defines the level above which adverse effects to biota are expected to occur frequently. These guidelines are based on chronic (long-term) effects of individual contaminants on aquatic invertebrates. Contaminants in fish are compared with the New York State Department of Environmental Conservation (NYSDEC) guidelines for the protection of birds and other wildlife that consume fish (Nowell and others, 1987).

Elevated levels of mercury are present in fish north of Lake Pontchartrain

Mercury has more than 2,000 uses in industry, medicine, agriculture, and commerce. Mercury also is released to the atmosphere as a by-product of coal combustion and waste incineration (David Krabbenhoft, U.S Geological Survey, written commun., 2003). For most ecosystems, atmospheric deposition is the primary source of mercury. Over the last 50 years, atmospheric emissions have increased mercury levels about three to five-fold, and have caused corresponding increases in mercury levels in terrestrial and aquatic ecosystems.

Mercury was detected in all 21 bed-sediment samples and in all 19 fish-tissue samples collected from streams in the Acadian-Pontchartrain Drainages. The highest concentrations of total mercury in bed sediment were detected in samples from Tchefuncte River near Covington (0.27 µg/g), Bayou Lafourche at Thibodaux (0.15 µg/g), and Dawson Creek at Baton Rouge (0.10 µg/g). These concentrations were relatively low, however, and none exceeded the PEL for mercury in sediment (0.486 µg/g). NAWQA findings showed that concentrations of mercury in sediment were not geographically clustered but rather were distributed throughout the Study Unit, which may reflect an atmospheric nonpoint source of mercury.

In contrast to the finding for mercury in sediments, concentrations of total mercury in game fish (largemouth bass and selected species of sunfish) exhibited a distinct geographic distribution pattern (fig. 19). Specifically, the highest concentrations (greater than 500 nanograms per gram) were found in tissue of fish collected in sand-bottom streams north of Lake Pontchartrain and in streams in the western part of the Study Unit; the lowest concentrations generally were found in tissue of fish collected in the silt- and clay-bottom streams in the flat southern Louisiana coastal marshes (fig. 19). This geographic distribution appears to be controlled by regional differences in environmental conditions, which correspond with chemical and physical properties of the landscape and the efficiency with which inorganic mercury is converted to methylmercury, the form most readily bioaccumulated in fish (see inset, p. 21). For example, streams north of Lake Pontchartrain are relatively acidic (low pH), which could potentially increase the solubility of mercury and enhance the conversion of mercury to the methylated form. In 8 of 19 streams sampled, concentrations of mercury in edible portions of fish tissue exceeded one component (500 nanograms per gram mercury in fish edible portions) considered by the Louisiana State Departments of Health and Hospitals and Environmental Quality in their alert-level assessment process. These findings confirm previous data for mercury in edible fish fillets collected by the Louisiana Department of Environmental Quality in this area, which led to fish-consumption advisories for humans. Concentrations of mercury in fish, however, are not used alone to determine risk assessment and do not absolutely determine whether an advisory will be issued for fish taken from the water body. For additional information, see *http://www.deq.state.la.us/surveillance/mercury/index.htm*.

NAWQA findings at four streams in the Acadian-Pontchartrain Drainages that had data for methylmercury in water and total mercury in fish showed that as the concentrations of methylmercury increase in water, the total mercury concentrations also increase in fish (fig. 20). Data on methylmercury in water are not commonly collected and available in most monitoring programs, however, as compared to data on total mercury.

For additional information on mercury in bed sediment in streams of the Acadian-Pontchartrain Drainages, refer to Skrobialowski (2002). This report also is available at *http://la.water.usgs.gov/pdfs/BedSediment.pdf*. Additional information on mercury can be found at *http://infotrek.er.usgs.gov/mercury*.

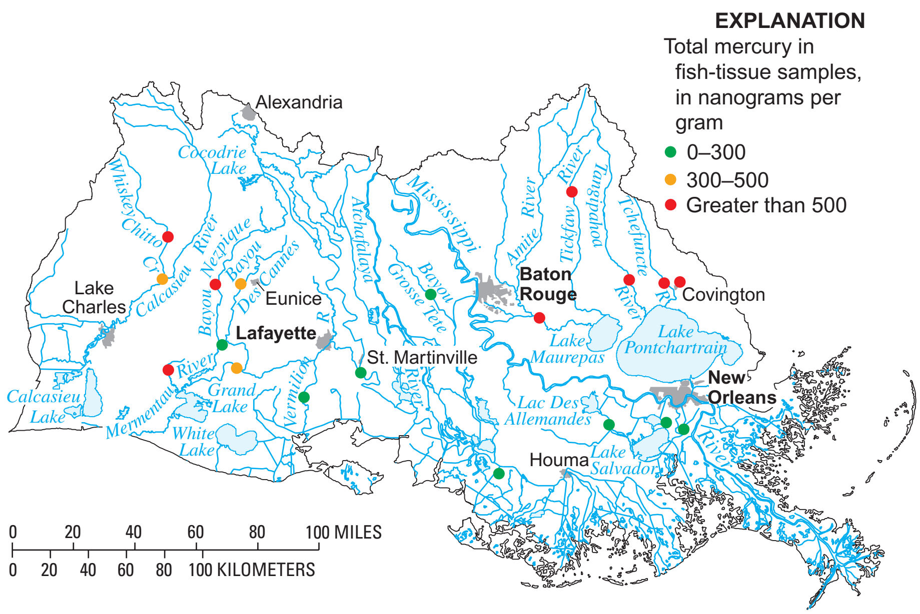


Figure 19. Concentrations of total mercury in fish-tissue samples were highest in sand-bottom streams north of Lake Pontchartrain and lowest in the flat southern Louisiana coastal marshes.

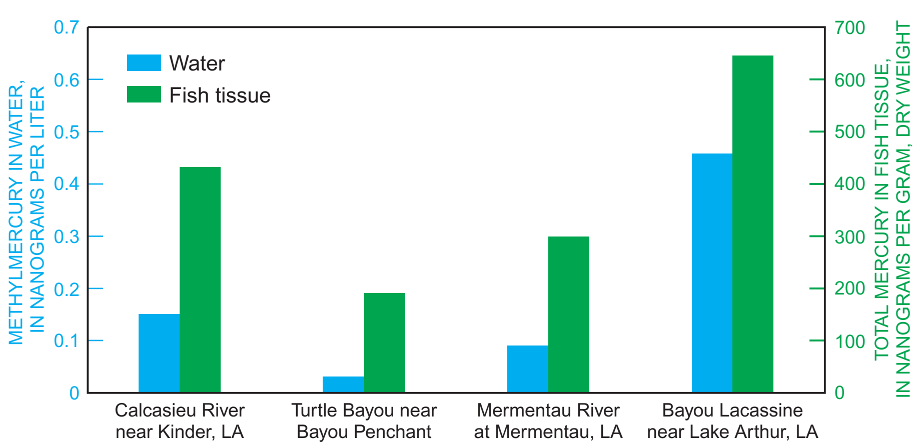
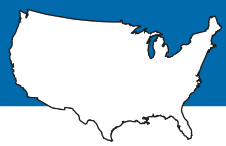


Figure 20. As concentrations of methylmercury increase in water, concentrations also increase in fish.

Aquatic communities are affected by land use and habitat

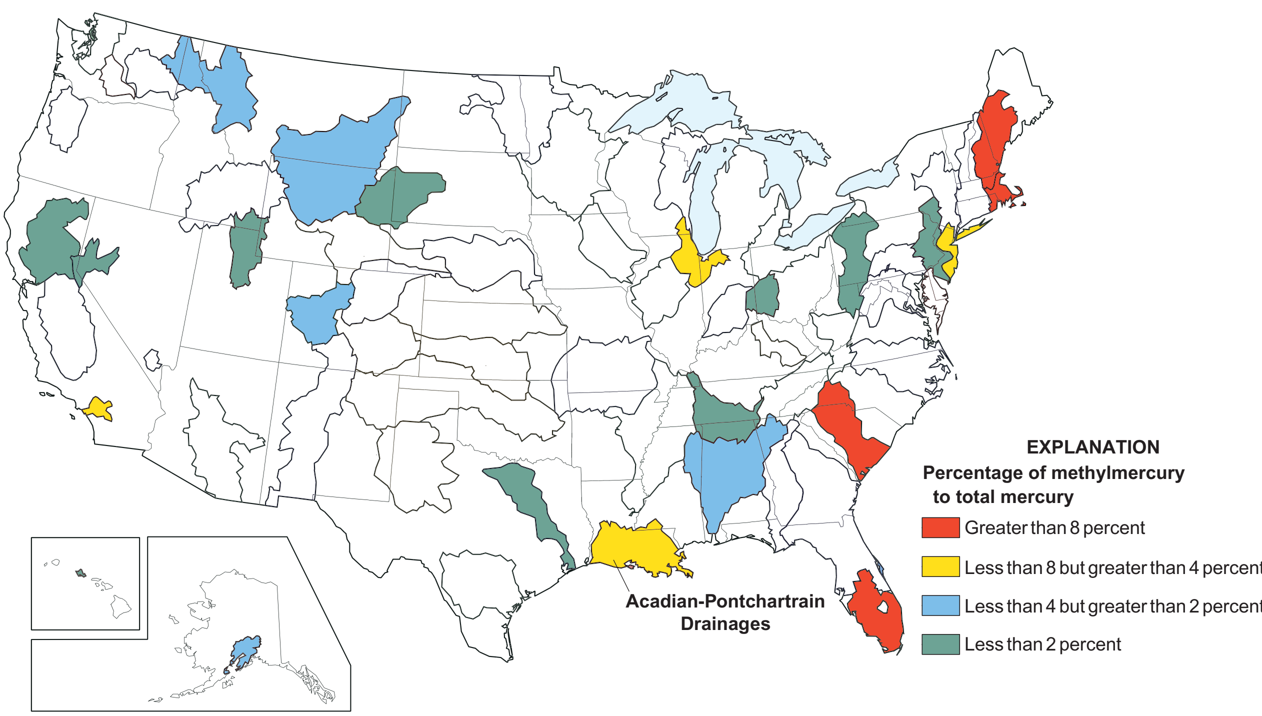
Aquatic communities in southern Louisiana streams, rivers, and bayous differ among land uses. Specifically, the percentages of pollution-intolerant invertebrate and fish taxa were greatest for two undeveloped streams and lowest at an urban stream. The undeveloped streams were dominated by invertebrate species that are intolerant to pollution or degraded water quality, including selected mayfly, caddisfly, and stonefly species (referred to as "EPT taxa") (fig. 21), as well as intolerant fish species (fig. 22), such as darters and selected minnows. Streams in the relatively undeveloped basins in the northern, forested, sandy areas of the Western Gulf Coastal Plains and Southeastern Plains ecoregions (Tchefuncte River and Whiskey Chitto Creek) are characterized by cooler water temperatures, low concentrations of suspended sediment and clear water, substantial ground-water inputs, and moderate flow velocities—all of which are related to greater land-surface relief and stream-channel slope than in the more southern areas of these ecoregions. In addition, stream habitat generally is undisturbed in the undeveloped basins, with relatively coarse and stable stream-bottom substrates (such as sand), riparian tree shading, and submerged woody debris, which provide habitat and food resources for aquatic communities to thrive.

In contrast, the aquatic communities in the southern part of the Western Gulf Coastal Plain ecoregion (Bayou



Mercury in the Acadian-Pontchartrain Drainages is evaluated as part of a national study

In 1998, USGS examined mercury contamination in streams—including that in water, sediment, and fish—at a national scale (Krabbenhoft and others, 1999). Samples for analysis of mercury were collected at 106 stream sites within 21 major river basins across the Nation, including the Acadian-Pontchartrain Drainages. Findings showed that the occurrence of mercury is not limited to local sites, such as those associated with the discharge of mining and industrial wastes, but rather is a National contamination issue. The findings also begin to explain mercury distribution patterns at many geographic scales across the Nation. Specifically, the findings showed that the occurrence and concentration of methylmercury (the most toxic and bioaccumulated form of mercury) generally corresponds with the amount of wetlands in the watershed, and that concentrations are affected by chemical and environmental conditions, such as the presence of sulfur, carbon, organic matter, and dissolved oxygen. These variables are conducive to methylation and an increase in the relative amounts (or ratio) of methylmercury to total mercury. From a national perspective, basins with the greatest percentage of methylmercury to total mercury (greater than 8 percent) in sediment and water were along the East Coast (see map). The ratio of methylmercury to total mercury in the Acadian-Pontchartrain Drainages was in the middle range of the 21 basins—a ratio of less than 8 percent but greater than 4 percent. Explanations for the relatively high methylation efficiency in the Acadian-Pontchartrain Drainages are not consistent with those for other basins across the Nation, particularly the strong relation between methylation and wetlands. Specifically, some of the highest concentrations of mercury were detected in sand-bottom streams north of Lake Pontchartrain, as opposed to silt- and clay-bottom streams in the southern Louisiana wetlands. As a result, further USGS studies are ongoing to improve understanding of processes controlling mercury in water, sediment, and fish in the Lake Pontchartrain Basin.



Des Cannes, Bayou Lacassine, and the Mermenteau River) generally are dominated by species considered to be pollution-tolerant invertebrates (such as midges, worms, and snails) and fish (such as gar, catfish, and certain sunfish). Natural habitat conditions in these basins favor an aquatic **community** that is tolerant of turbidity, organic enrichment, and low levels of dissolved oxygen. The net effect is a biological community in these southern areas that is, at first examination, indicative of streams that have been adversely affected by human activity, when, in fact, it may be a naturally occurring "healthy" community in which natural environmental stressors exclude sensitive species and limit species richness and diversity. Consequently, southern Louisiana streams support aquatic communities that are uniquely adapted to these habitat conditions. Agricultural activity that results in warmer stream temperatures, straighter channels, and increased turbidity, however, can alter these unique natural environments and place additional stress on the aquatic communities.

NAWQA findings show that chemical and physical characteristics play a role in the distribution of biological communities. Specifically, disturbance to the physical habitat of streams and changes in stream temperature and hydrology that are associated with watershed development (including for agricultural and urban uses) can affect aquatic health of streams as much as, or even more than, chemical water-quality degradation. Improvements to stream quality will, therefore, require consideration and management of physical alterations to landscapes and stream habitats in addition to management of chemical use and nonpoint source runoff.

Attached algal communities also differ among land uses, and are controlled primarily by availability of light and turbidity of water, rather than by elevated concentrations of nutrients. Specifically, total algal biovolume (proportional to algal **biomass**) was larger in the undeveloped streams than in the agricultural and urban streams (fig. 23). The larger algal biovolume in the undeveloped streams was associated with rel-

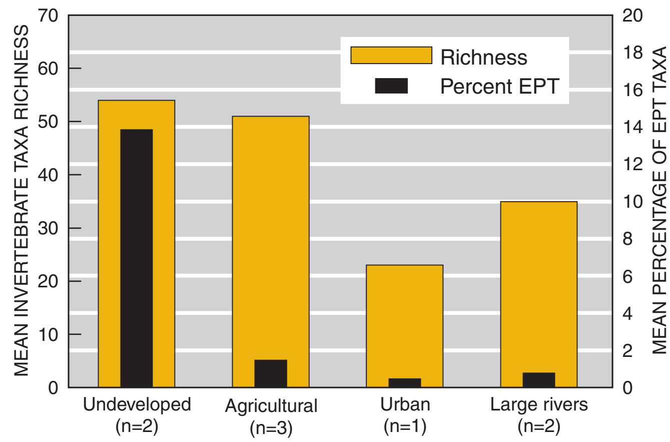


Figure 21. The richness (reflecting total number of taxa) and percentage of pollution-intolerant aquatic invertebrate communities (represented by EPT taxa) decrease in streams draining agriculture and urban areas. (n, number of sites)

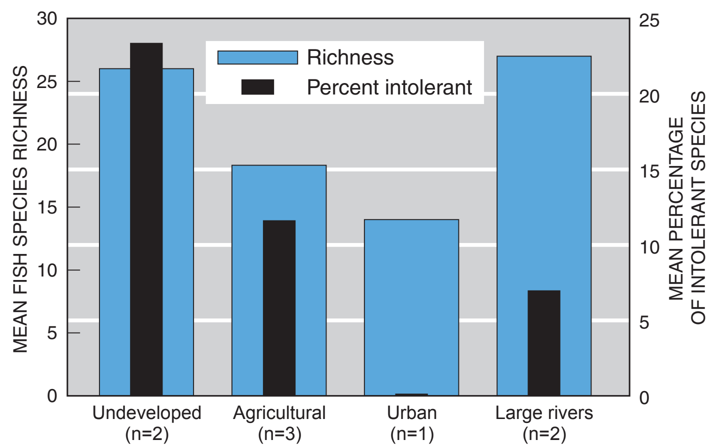


Figure 22. The richness (reflecting total number of fish species) and the percentage of pollution-intolerant species were lowest for Dawson Creek, an urban stream. (n, number of sites)

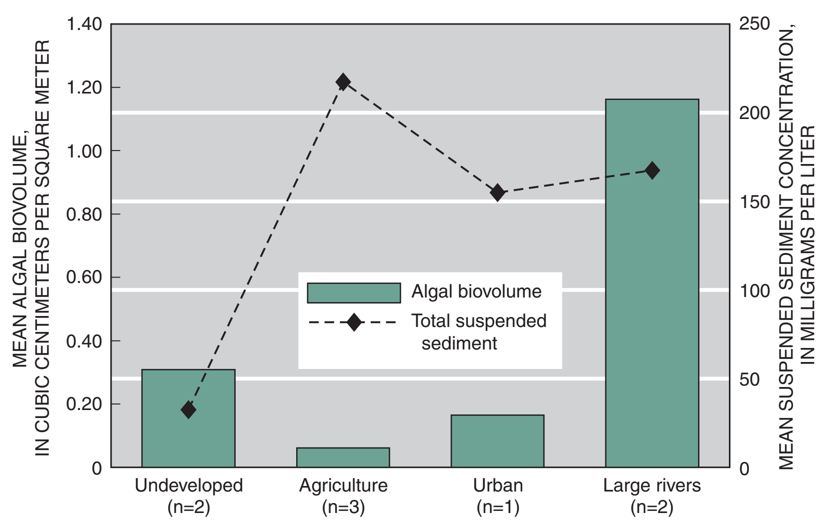


Figure 23. Algal biovolume was lowest in agricultural streams, which are associated with relatively high suspended sediment. Despite elevated suspended sediment in large rivers, algal biovolume is large, mostly composed of green algae that attach to submerged vegetation and wood. (n, number of sites)

atively low concentrations of suspended sediment and low turbidity, which allows increased light for algal growth. Agricultural and urban streams are more turbid, with elevated concentrations of suspended sediment, which reduces the light available for algal growth. Despite elevated concentrations of suspended sediment in large rivers (Mermentau River and Bayou Boeuf), total algal biovolume is large. This is caused, in part, by large quantities of the common green algae *Oedogonium. Oedogonium* grows on emergent aquatic vegetation and submerged wood (Prescott, 1968) in marshy areas connected to main river channels with low stream velocities, where suspended sediment particles settle.

Ground Water

The Chicot aquifer system, located west of the Mississippi River, and the Chicot equivalent aquifer system (which is the upper part of the Southern Hills regional aquifer system), to the east of the river, are designated as sole-source aquifers by the U.S. Environmental Protection Agency (2002d). These aquifer systems are primary drinking-water sources for domestic and public supply and, therefore, require protection because they are susceptible to contamination from overlying land-use activities. Ground water sampled by the NAWQA Program in the Acadian-Pontchartrain Drainages during 1999–2000 included 115 wells, 60 of which are used for domestic supply (median depth of 120 feet). The remaining wells (median depth 26 feet) are **monitoring wells** installed for this study (see Study Unit Design). Water throughout these aquifer systems generally is of high quality. The water generally meets Federal guidelines established to protect drinking water by the USEPA, but guidelines have not been established for many of the compounds measured.

Habitat conditions and aquatic invertebrate communities are most degraded in the downstream parts of the Mermentau River Basin

Invertebrate communities change in a downstream direction in the Mermentau River Basin (fig. 24). Specifically, invertebrates tolerant to pollution are dominant at the large, downstream sites (those draining areas larger than 70 square miles), which are associated with organic enrichment (elevated dissolved organic carbon), low concentrations of dissolved oxygen, low or stagnant water velocity, elevated water temperatures, high water turbidity, and silt-clay-dominated streambottoms. In addition, these sites are associated with elevated concentrations of insecticides and degradation compounds in water and sediment (such as fipronil and its degradation products) associated with rice agriculture. Aquatic invertebrate communities are dominated by more pollution-intolerant species at the smaller upstream sites in the Mermentau River Basin, where streams feature coarse and stable substrates, undisturbed stream habitat, woody debris, cooler water temperatures, relatively quick velocities, and relatively good water quality, all of which provide conditions more favorable for sustaining productive and diverse invertebrate communities.

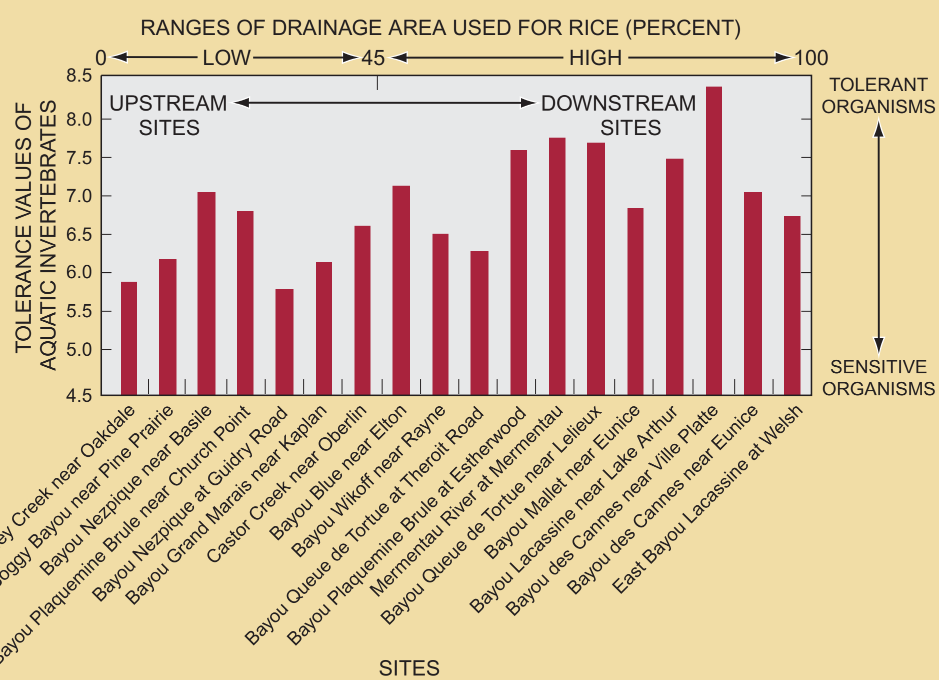


Figure 24. Aquatic invertebrates with low tolerance to pollution are more common in streams with less area used for rice cultivation. Lower **tolerance values** correspond to better water-quality and habitat conditions.

Nitrate, Pesticides, and Volatile Organic Compounds

Agricultural and urban activities have had minimal effects on ground-water quality in the Chicot and the Chicot equivalent aquifer systems. This is, in large part, because the downward movement of water is impeded by a relatively impermeable layer of clay below the soils. This clay layer, however, is not continuous or completely impermeable throughout the entire area overlying the Chicot aquifer. Isolated areas exist where downward flow from the surface or lateral flow to adjacent streams is possible.

Concentrations of nitrate were low, with samples from only eight wells exceeding 2 mg/L, which is considered to be the naturally occurring (or “background”) level above which the effects of human activities are indicated (Mueller and Helsel, 1996; Nolan and Hitt, 2003). Samples from two of the eight wells exceeded the USEPA drinking-water standard of 10 mg/L for nitrate. These two wells are not used for drinking-water supply but rather are used for monitoring the quality of shallow ground water underlying agricultural land in the Mermentau River Basin. These two wells were completed below the clay layer, supporting the concept that the clay layer is semipermeable.

Pesticides and degradation products were detected in water from 26 of 115 wells (about 23 percent). Pesticide compounds were most commonly detected in shallow monitoring wells (median depth of 26 feet) in the rice-growing areas in the Mermentau River Basin (fig. 25). The most commonly detected compounds were atrazine and its degradation product, deethylatrazine. Concentrations were low and always below USEPA drinking-water standards. Two degradation products of fipronil, fipronil RPA and fipronil sulfone, were detected in one well. The degradation products were not detected upon resampling. The absence of fipronil in ground water most likely reflects its chemical tendency to readily break down in the environment as well as its relatively recent introduction to the environment, which may not have allowed enough time for this compound to move vertically through the clay layer and reach the ground-water system.

Volatile organic compounds (VOCs) were detected in 18 of 28 shallow monitoring wells (median depth of 58 feet) in an urban area near Lafayette (fig. 25). VOCs also were detected in 44 of 60 domestic wells (about 73 percent) sampled throughout the Chicot and Chicot equivalent aquifer systems. The concentrations, however, were very low. The minimum concentration detected in the domestic wells was 0.03 µg/L, the maximum was 70 µg/L (methyl ethyl ketone), and the median concentration of VOCs was 0.27 µg/L. All detected concentrations were below USEPA drinking water standards. Detections were most frequent in wells in the outcrop areas of these aquifer systems, which are in the northern part of the Study Unit. Greater detection of VOCs in the outcrop areas most likely represents recently recharged and shallow ground water that is more vulnerable to contamination from overlying land-use activities than deeper ground water that travels along regional flow paths in the southern part of the Study Unit.

The most frequently detected VOCs in the shallow monitoring and domestic wells were chloroform (35 wells) and carbon disulfide (19 wells). Individual VOCs seldom occurred alone; mixtures of two or more compounds were detected in samples from 18 of the wells. The most common mixture was toluene and carbon disulfide, detected in samples from 14 wells.

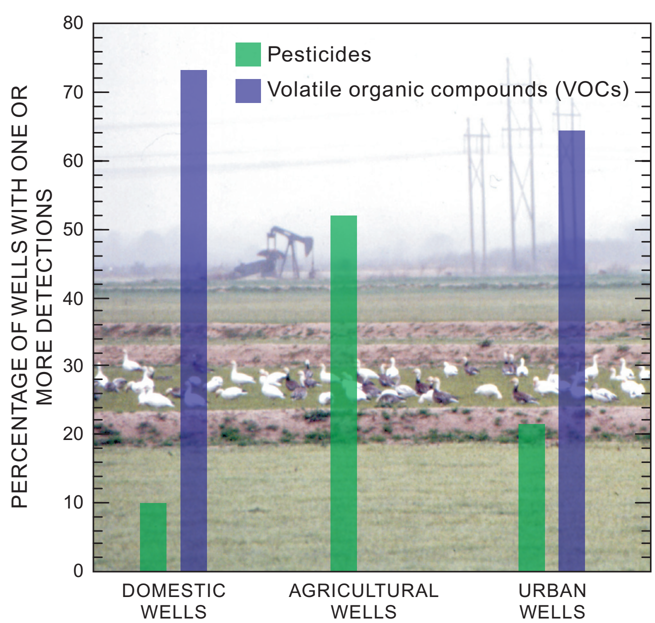


Figure 25. Pesticides were commonly detected in shallow ground water underlying agricultural and urban areas. VOCs were detected in very low concentrations most frequently in shallow outcrop areas.

Naturally Occurring Trace Elements and Water Chemistry

Most trace elements detected in ground water in the Acadian-Pontchartrain drainages occur naturally, reflecting the chemistry of the geologic material underlying the Study Unit. Concentrations of trace elements in ground water underlying the Acadian-Pontchartrain Drainages generally are low, rarely exceeding any USEPA drinking-water standards, although such standards have been established for only 12 of 24 trace elements included in this study. Arsenic exceeded the USEPA drinking-water standard of 10 µg/L in one well sampled in the Chicot aquifer system near the Vermilion River, with a maximum concentration of 55.3 µg/L. This well is not used for drinking-water supply. The source of the arsenic in this 90-foot well is not known. Concentrations of iron in samples collected from 16 wells

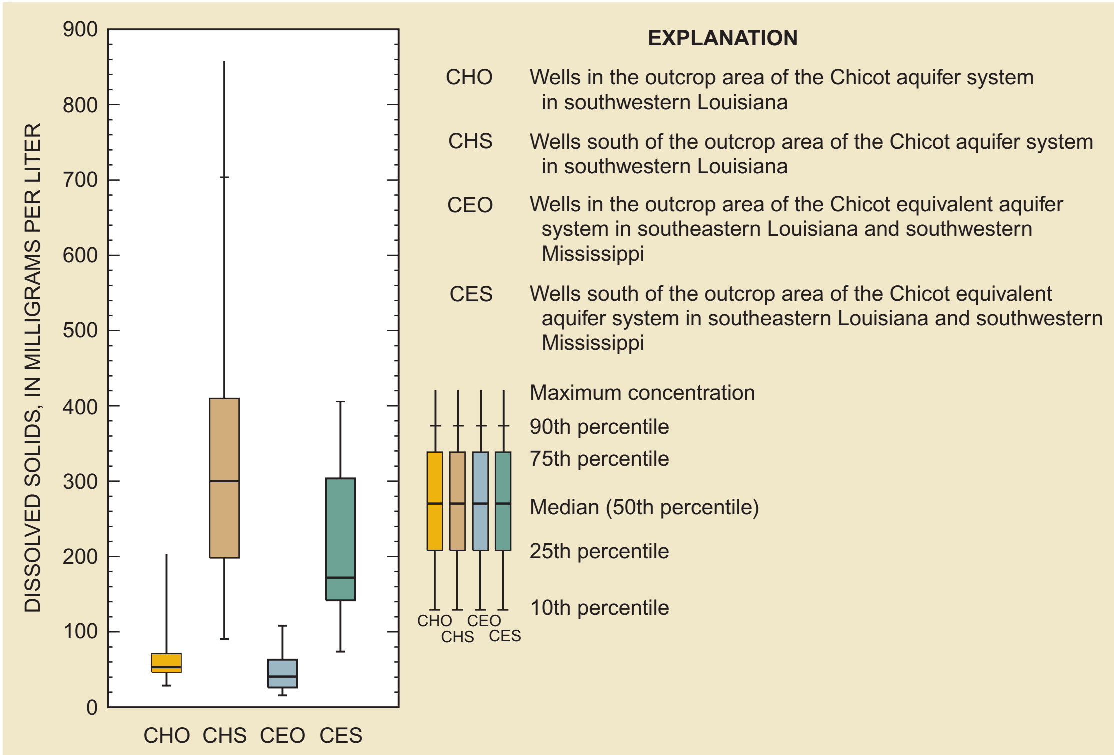


Figure 26. Values for dissolved solids were lowest in wells in the outcrop areas of the Chicot and Chicot equivalent aquifer systems.

in the Chicot aquifer system and 6 wells in the Chicot equivalent aquifer system exceeded the USEPA **Secondary Maximum Contaminant Level** (SMCL) of 300 µg/L, with a maximum concentration of 8,670 µg/L. Similarly, concentrations of manganese in samples collected from 19 wells in the Chicot aquifer system and 7 wells in the Chicot equivalent aquifer system exceeded the USEPA SMCL of 50 µg/L, with a maximum concentration of 481 µg/L. Elevated concentrations of iron and manganese reported in the NAWQA study are consistent with those previously reported by Fendick and Tollett (2003). SMCLs are nonenforceable guidelines intended to prevent undesirable cosmetic and esthetic effects (such as taste and odor) of drinking water.

NAWQA findings clearly demonstrate similarities in the natural chemistry of ground water between the Chicot aquifer system west of the Mississippi River and the Chicot equivalent aquifer system east of the river. Values for dissolved solids (fig. 26), pH, calcium, sodium, bicarbonate, chloride, and iron typically were lowest in wells in the outcrop areas of the two systems. As water moves from the outcrop areas of the two aquifer systems along regional flow paths to the southern part of the Study Unit, it dissolves various minerals and its chemistry changes. The water is then less acidic and has a greater amount of dissolved constituents than water in the outcrop areas.

Radon

Radon is a colorless, odorless, gas that forms naturally in rocks and soils through the radioactive decay of radium, a product of uranium decay. Radon from ground water is released into household air when water is used for showering, washing, and other everyday purposes. According to the U.S. Surgeon General, exposure to airborne radon is second only to cigarette smoking as a cause of lung cancer. The risk of cancer increases with exposure to increasing levels of radon (U.S. Environmental Protection Agency, 1994).

Concentrations of radon are elevated in the Chicot and Chicot equivalent aquifer systems. Concentrations in samples collected from 53 of 94 wells (about 55 percent) exceeded the proposed drinking-water standard of 300 pCi/L (fig. 27). The maximum concentration recorded was 2,220 pCi/L. Although elevated concentrations occurred in both the Chicot and Chicot equivalent aquifer systems, there appear to be two distinct groups of concentrations (fig. 27). The majority of the elevated concentrations were detected in southwestern Louisiana. The median concentration of radon for 60 domestic wells was 225 pCi/L, which is well within the drinking-water standard. Samples collected from four domestic wells in the Chicot aquifer system and five domestic wells in the Chicot equivalent aquifer system had radon concentrations exceeding the 300 pCi/L standard. No sample had concentrations that exceeded the USEPA proposed alternative maximum contaminant level for radon of 4,000 pCi/L. The source of uranium in rocks underlying the Acadian-Pontchartrain Drainages is unclear.

Concentrations of radon in ground water underlying the Acadian-Pontchartrain Drainages are generally below concentrations in ground water collected across the Nation by the NAWQA Program (median of about 400 pCi/L for 4,191 samples) (fig. 27). Elevated concentrations in the Study Unit are still somewhat surprising, however, because previous studies by the USEPA indicate that concentrations of radon generally are less than 150 pCi/L in southern Louisiana (U.S.Environmental Protection Agency, 2002e) (fig. 28).

For additional information on nitrate, pesticides, VOCs in ground water, naturally occurring trace elements and chemistry in ground water, and radon in ground water, refer to Tollett and others (2003) (in press), Tollett and Fendick (2003) (in press), and Fendick and Tollett (2003) (in press).

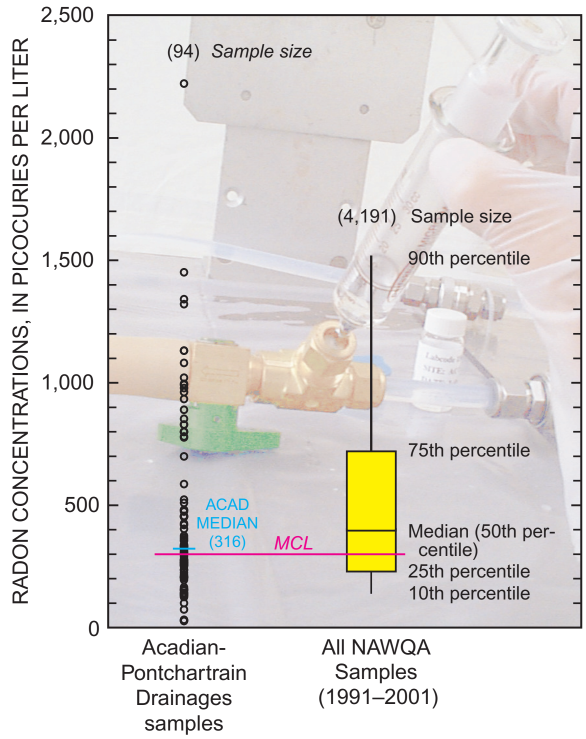


Figure 27. Concentrations of radon in ground water underlying the Acadian-Pontchartrain Drainages exceeded the USEPA drinking-water standard in about 55 percent of 94 wells.

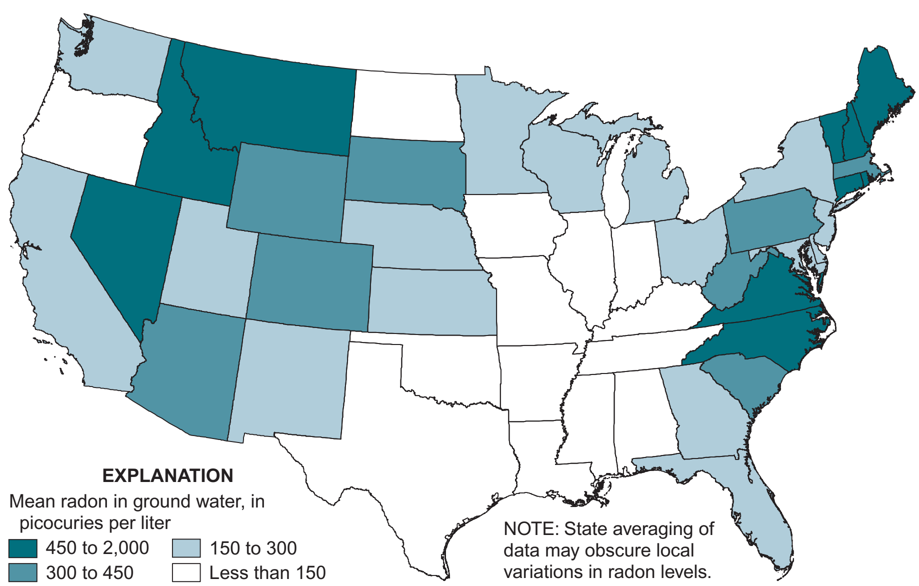


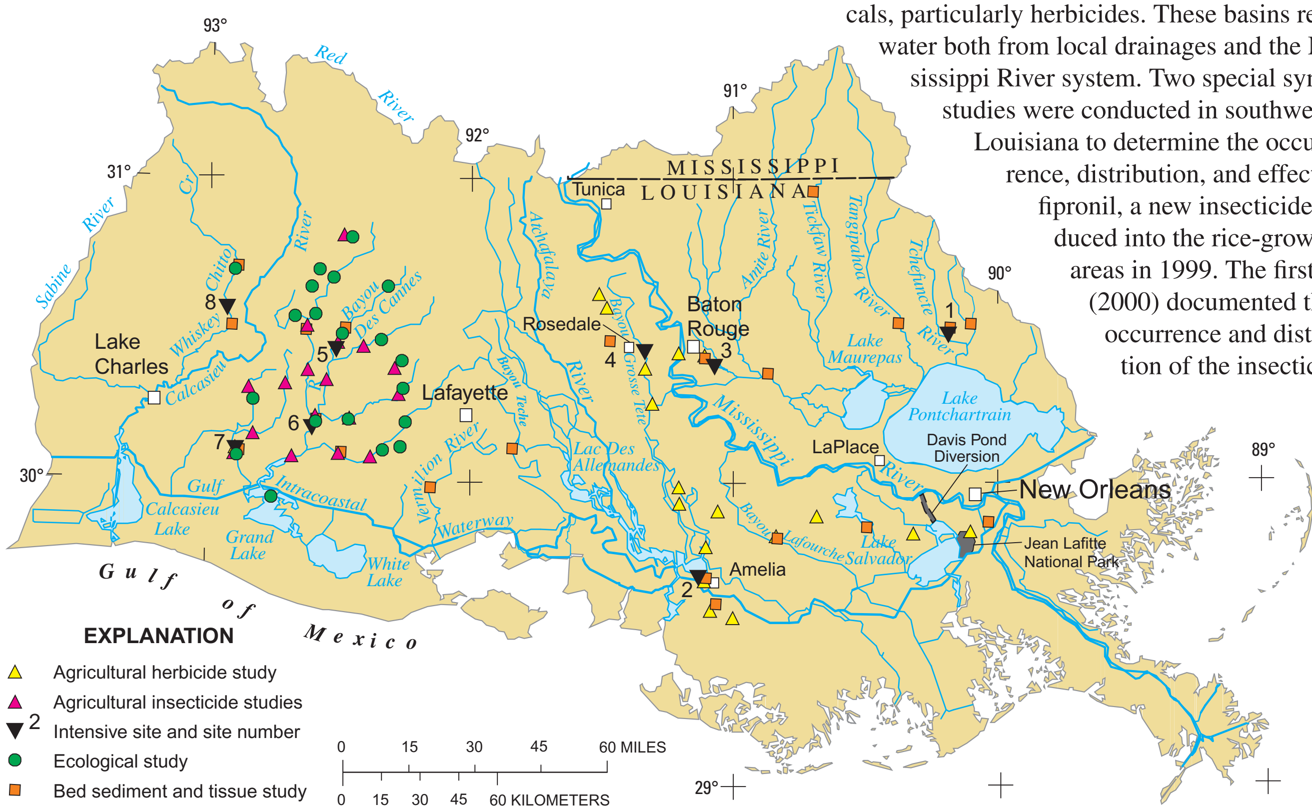
Figure 28. General patterns of radon occurrence in ground water in the United States indicate that concentrations of radon in southern Louisiana should be relatively low (U.S. Environmental Protection Agency, 2002e).

Study Unit Design

The Acadian-Pontchartrain Drainages study design includes assessments of physical, chemical, and biological characteristics of surface and ground water. This design includes national components and work elements specific to these southern Louisiana drainages. Information was collected on stream chemistry and ecology and ground-water chemistry using nationally consistent protocols and methods (Gilliom and others, 1995). Thus, water-quality findings in the basin can be compared to findings in other basins and be placed in a regional and national context.

Stream-Chemistry and Ecology

The sampling network was designed to measure how natural factors and human activities such as different land uses affect water quality in eight representative drainages. Surface-water chemistry, aquatic ecology, bed sediment, and fish-tissue monitoring was conducted at intensive sampling sites. Additional bed sediment and tissue samples were collected throughout the drainages at sites representing a variety of land uses, including undeveloped reference areas. In southeastern Louisiana a synoptic study was conducted to evaluate concentrations and sources of agricultural chemicals, particularly herbicides. These basins receive water both from local drainages and the Mississippi River system. Two special synoptic studies were conducted in southwestern Louisiana to determine the occurrence, distribution, and effects of fipronil, a new insecticide introduced into the rice-growing areas in 1999. The first study (2000) documented the occurrence and distribution of the insecticide,



Stream sampling sites, Acadian-Pontchartrain Drainages, 1998-2001

Site number	Site name	Site type	Basin area (square miles)
1	Bayou Boeuf at Amelia	Agricultural	141
2	Tchefuncte River near Covington	Agricultural/undeveloped	145
3	Dawson Creek at Baton Rouge	Urban	15.1
4	Bayou Grosse Tete at Rosedale	Agricultural/urban	176
5	Bayou des Cannes near Eunice	Agricutural/urban	142
6	Mermentau River at Mermentau	Mixed land use	1,381
7	Bayou Lacassine near Lake Arthur	Agricultural	296
8	Whiskey Chitto Creek near Oberlin	Undeveloped, forested	504

and the second study (2001) assessed possible effects of this pesticide and its degradation products on aquatic invertebrate communities.

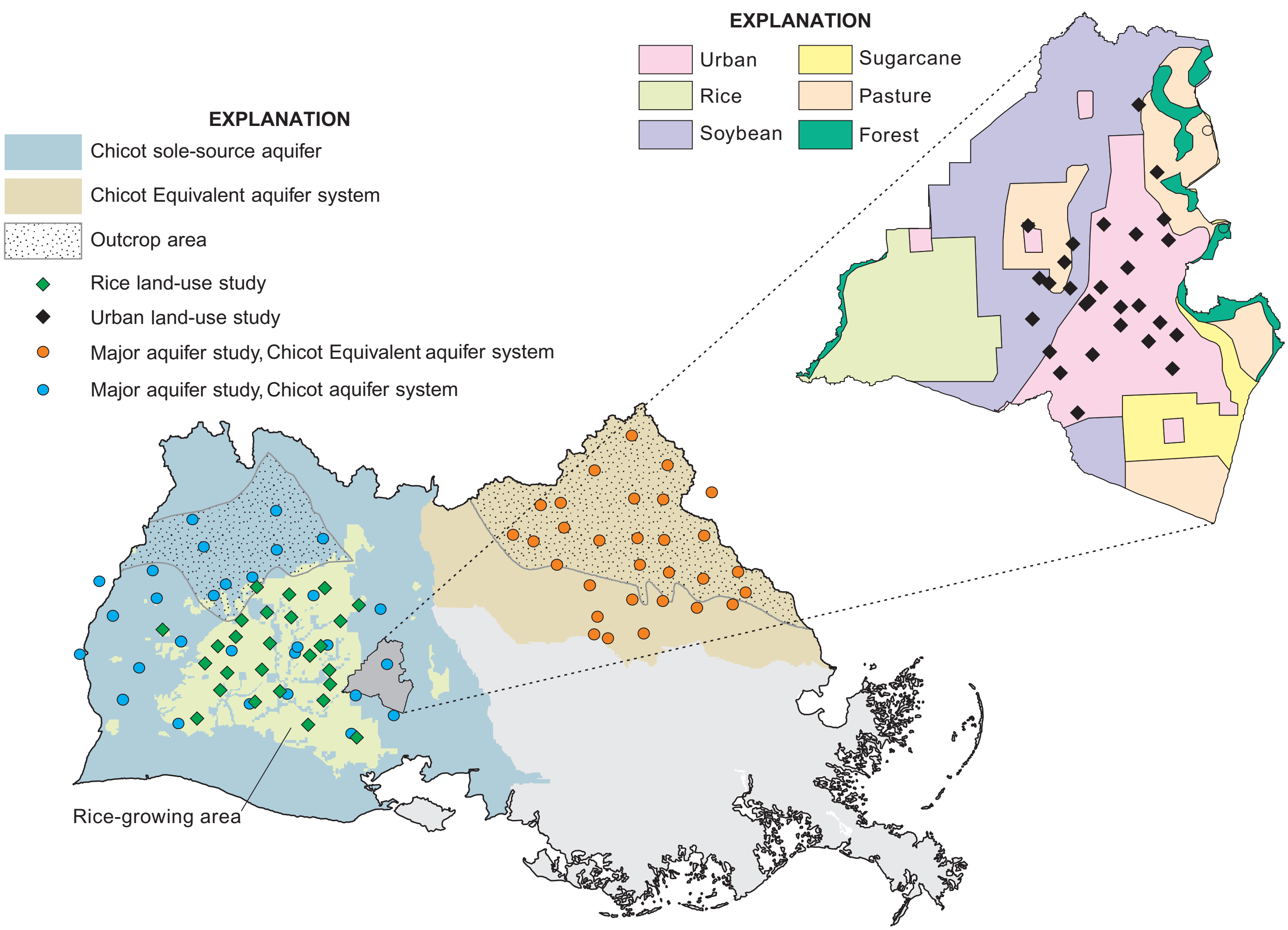
Ground Water

Ground-water studies focused on the Chicot aquifer, designated as a sole-source aquifer by the U.S. Environmental Protection Agency. This aquifer system, divided by the Mississippi River into the Chicot and Chicot Equivalent aquifer systems, is heavily utilized for agricultural, aquacultural, and domestic water-supply purposes. Ground-water studies were designed to measure water quality in:

- Domestic wells screened at various depths in the Chicot and Chicot Equivalent aquifer systems
- Shallow ground water in a rice-agriculture and crawfish aquaculture area in southwestern Louisiana
- Shallow ground water in an area overlain by urban land use (City of Lafayette, Louisiana)

Additional Information

For detailed information regarding sites where water-quality and ecological data were collected in the Acadian-Pontchartrain Drainages, please access *http://la.water.usgs.gov/nawqa/*.



Study component	What data are collected and why	Types of sites sampled	Number of sites sampled	Sampling frequency and period
		Stream Chemistry		
Intensive sites— General water quality	Streamflow, nutrients, major ions, bacteria, organic carbon, pesticides, pesticide degradation products, chlorophyll, suspended sediment, and physical parameters. **To determine how often and how much of a constituent is found, over time, in response to different seasonal or land-use patterns.**	Includes one small urban basin (Dawson Creek), one large agricultural basin (3 sites in the Mermentau River Basin), 4 mixed agricultural/urban sites, and one reference site (Whiskey Chitto).	8	Biweekly during February–June, monthly rest of year 1999–2000, monthly in 2001.
Synoptic study—Agricultural herbicides	Nutrients, major ions, organic carbon, pesticides, pesticide metabolites, chlorophyll, suspended sediment, and physical parameters. **To evaluate concentrations and sources of agrichemicals, especially atrazine.**	Includes sites on the Mississippi and Atchafalaya Rivers, as well as smaller streams and bayous in southeastern Louisiana.	17	Every 6 weeks from March to August 1999.
Synoptic study—Agricultural insecticides	Nutrients, major ions, organic carbon, pesticides, pesticide metabolites, chlorophyll, suspended sediment, and physical parameters. **To evaluate concentrations and sources of agrichemicals, especially fipronil.**	Streams draining basins from 15 to 1,702 square miles along a gradient of agricultural land-use intensity.	17	Water, monthly February–June 2000. Bed sediment once in August–September 2000.
		Stream Ecology		
Aquatic biota—Fixed sites	Algal, benthic invertebrate, and fish communities. Stream habitat conditions. **To characterize aquatic biota in relation to habitat and water quality.**	Sites located at intensive water-quality sites.	8	Once in 1999 and once in 2001.
Streambed sediments and fish tissue—Fixed sites	Organochlorine pesticides and semi-volatile organic compounds in sieved sediment and whole fish. Trace elements in sieved sediment and fish livers. Mercury in muscle tissue. **To measure concentrations of contaminants in relation to different land uses.**	Eight at intensive fixed sites. 13 additional sites representing agricultural, urban, mixed, and unimpacted land uses.	21	Once in June–September 1998.
Aquatic biota—Agricultural insecticide study	Nutrients, major ions, organic carbon, pesticides, pesticide metabolites, chlorophyll, streamflow, suspended sediment, and physical parameters. **To evaluate effects of agrichemicals, especially fipronil, on aquatic invertebrate communities.**	Sites located in areas of high and low agricultural intensity, and small and large basin size in the Mermentau River Basin, and one reference site (Whiskey Chitto) in the Calcasieu River Basin.	19	Once in March 2001.
		Ground-Water Chemistry		
Agricultural land-use study, Chicot aquifer system	Water-level, physical parameters, nutrients, major ions, organic carbon, trace elements, pesticides, pesticide metabolites, CFCs (for age-dating), radon. **To determine the effects of land use on shallow ground-water quality in this sole-source aquifer system.**	27 shallow monitor wells in areas where shallow sands of the Chicot aquifer system are overlain by rice and rowcrop agriculture.	27	Once in January–September 2000.

Study component	What data are collected and why	Types of sites sampled	Number of sites sampled	Sampling frequency and period
		Ground-Water Chemistry—Continued		
Major Aquifer Survey—Chicot aquifer system	Water-level, physical parameters, nutrients, major ions, organic carbon, trace elements, pesticides, pesticide metabolites, VOCs, tritium, radon. **To broadly assess the quality of ground water withdrawn for domestic use from this sole-source aquifer system.**	30 domestic wells screened at various depths in the Chicot aquifer system.	30	Once in June 2000–February 2001.
Major Aquifer Survey—Chicot equivalent aquifer system	Water-level, physical parameters, nutrients, major ions, organic carbon, trace elements, pesticides, pesticide metabolites, VOCs, tritium, radon. **To broadly assess the quality of ground water withdrawn for domestic use from this sole-source aquifer system.**	30 domestic wells screened at various depths in the Chicot equivalent aquifer system.	30	Once in February–September 2001.
Urban land-use study—Lafayette, La.	Water-level, physical parameters, nutrients, major ions, organic carbon, trace elements, pesticides, pesticide metabolites, VOCs, CFCs (for age-dating), radon. **To evaluate the effects of residential-commercial development on shallow ground-water quality.**	28 shallow monitor wells in areas where the Chicot aquifer system is overlain by residential-commercial areas developed in the last 30 years. Two wells were installed in undeveloped areas to serve as reference wells for the two land-use studies.	28	Once in December 2001–February 2002.

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Glossary

Algae Chlorophyll-bearing nonvascular, primarily aquatic species that have no true roots, stems, or leaves; most algae are microscopic, but some species can be as large as vascular plants.

Alluvium Deposits of clay, silt, sand, gravel or other particulate rock material left by a river in a streambed, on a flood plain, delta, or at the base of a mountain.

Ammonia A compound of nitrogen and hydrogen (NH_3) that is a common byproduct of animal waste. Ammonia readily converts to nitrate in soils and streams.

Aquatic-life guidelines Specific levels of water quality which, if reached, may adversely affect aquatic life. These are nonenforceable guidelines issued by a governmental agency or other institution.

Aquifer A water-bearing layer of soil, sand, gravel, or rock that will yield usable quantities of water to a well.

Background concentration A concentration of a substance in a particular environment that is indicative of minimal influence by human (anthropogenic) sources.

Bed sediment The material that temporarily is stationary in the bottom of a stream or other watercourse.

Benthic invertebrates Insects, mollusks, crustaceans, worms, and other organisms without a backbone that live in, on, or near the bottom of lakes, streams, or oceans.

Bioaccumulation The net accumulation of a substance by an organism as a result of uptake from all environmental sources, including gills, epithelial tissues, and dietary sources.

Biomass The amount of living matter, in the form of organisms, present in a particular habitat, usually expressed as weight per unit area.

Chlordane-Octachloro-4,7-methanotetrahydroindane An organochlorine insecticide no longer registered for use in the United States Technical chlordane is a mixture in which the primary components are *cis*- and *trans*-chlordane, *cis*- and *trans*-nonachlor, and heptachlor.

Community In ecology, the species that interact in a common area.

Concentration The amount or mass of a substance present in a given volume or mass of sample. Usually expressed as microgram per liter (water sample) or micrograms per kilogram (sediment or tissue sample).

Confining layer A layer of sediment or lithologic unit of low permeability that bounds an aquifer.

Contamination Degradation of water quality compared to original or natural conditions due to human activity.

Cubic foot per second (ft^3/s, or cfs) Rate of water discharge representing a volume of 1 cubic foot passing a given point during 1 second, equivalent to approximately 7.48 gallons per second or 448.8 gallons per minute or 0.02832 cubic meter per second.

Degradation products Compounds resulting from transformation of an organic substance through chemical, photochemical, and/or biochemical reactions.

Denitrification A process by which oxidized forms of nitrogen such as nitrate (NO_3^-) are reduced to form nitrites, nitrogen oxides, ammonia, or free nitrogen: commonly brought about by the action of denitrifying bacteria and usually resulting in the escape of nitrogen to the air.

DDT Dichloro-diphenyl-trichloroethane. An organochlorine insecticide no longer registered for use in the United States.

Discharge Rate of fluid flow passing a given point at a given moment in time, expressed as volume per unit of time.

Dissolved constituent Operationally defined as a constituent that passes through a 0.45-micrometer filter.

Dissolved solids Amount of minerals, such as salt, that are dissolved in water; amount of dissolved solids is an indicator of salinity or hardness.

Drainage basin The portion of the surface of the Earth that contributes water to a stream through overland runoff, including tributaries and impoundments.

Drinking-water standard or guideline A threshold concentration in a public drinking-water supply, designed to protect human health. As defined here, standards are U.S. Environmental Protection Agency regulations that specify the maximum contamination levels for public water systems required to protect the public welfare; guidelines have no regulatory status and are issued in an advisory capacity.

Ecoregion An area of similar climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables.

Endocrine system The collection of ductless glands in animals that secrete hormones, which influence growth, gender and sexual maturity.

EPT richness index An index based on the sum of the number of taxa in three insect orders, Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), that are composed primarily of species considered to be relatively intolerant to environmental alterations.

Eutrophication The process by which water becomes enriched with plant nutrients, most commonly phosphorus and nitrogen.

Fertilizer Any of a large number of natural or synthetic materials, including manure and nitrogen, phosphorus, and potassium compounds, spread on or worked into soil to increase its fertility.

Ground water In general, any water that exists beneath the land surface, but more commonly applied to water in fully saturated soils and geologic formations.

Habitat The part of the physical environment where plants and animals live.

Herbicide A chemical or other agent applied for the purpose of killing undesirable plants. See also Pesticide.

Insecticide A substance or mixture of substances intended to destroy or repel insects.

Intensive site Basic fixed sites with increased sampling frequency during selected seasonal periods and analysis of dissolved pesticides for 1 year.

Intolerant organisms Organisms that are not adaptable to human alterations to the environment and thus decline in numbers where human alterations occur. See also Tolerant species.

Invertebrate An animal having no backbone or spinal column. See also Benthic invertebrate.

Loess Homogeneous, fine-grained sediment made up primarily of silt and clay, and deposited over a wide area (probably by wind).

Median The middle or central value in a distribution of data ranked in order of magnitude. The median is also known as the 50th percentile.

Micrograms per liter (µg/L) A unit expressing the concentration of constituents in solution as weight (micrograms) of solute per unit volume (liter) of water; equivalent to one part per billion in most streamwater and ground water. One thousand micrograms per liter equals 1 mg/L.

Midge A small fly in the family Chironomidae. The larval (juvenile) life stages are aquatic.

Milligrams per liter (mg/L) A unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water; equivalent to one part per million in most streamwater and ground water. One thousand micrograms per liter equals 1 mg/L.

Monitoring well A well designed for measuring water levels and testing ground-water quality.

Nitrate An ion consisting of nitrogen and oxygen (NO_3^-). Nitrate is a plant nutrient and is very mobile in soils.

Nonpoint source A pollution source that cannot be defined as originating from discrete points such as pipe discharge. Areas of fertilizer and pesticide applications, atmospheric deposition, manure, and natural inputs from plants and trees are types of nonpoint source pollution.

Nutrient Element or compound essential for animal and plant growth. Common nutrients in fertilizer include nitrogen, phosphorus, and potassium.

Organochlorine compound Synthetic organic compounds containing chlorine. As generally used, term refers to compounds containing mostly or exclusively carbon, hydrogen, and chlorine. Examples include organochlorine insecticides, polychlorinated biphenyls, and some solvents containing chlorine.

Pesticide A chemical applied to crops, rights of way, lawns, or residences to control weeds, insects, fungi, nematodes, rodents or other "pests."

pH The logarithm of the reciprocal of the hydrogen ion concentration (activity) of a solution; a measure of the acidity (pH less than 7) or alkalinity (pH greater than 7) of a solution; a pH of 7 is neutral.

Phosphorus A nutrient essential for growth that can play a key role in stimulating aquatic growth in lakes and streams.

Picocurie (pCi) One trillionth (10^{-12}) of the amount of radioactivity represented by a curie (Ci). A curie is the amount of radioactivity that yields 3.7×10^{10} radioactive disintegrations per second (dps). A picocurie yields 2.22 disintegrations per minute (dpm) or 0.037 dps.

Polychlorinated biphenyls (PCBs) A mixture of chlorinated derivatives of biphenyl, marketed under the trade name Aroclor with a number designating the chlorine content (such as Aroclor 1260). PCBs were used in transformers and capacitors for insulating purposes and in gas pipeline systems as a lubricant. Further sale for new use was banned by law in 1979.

Polycyclic aromatic hydrocarbon (PAH) A class of organic compounds with a fused-ring aromatic structure. PAHs result from incomplete combustion of organic carbon (including wood), municipal solid waste, and fossil fuels, as well as from natural or anthropogenic introduction of uncombusted coal and oil. PAHs include benzo(a)pyrene, fluoranthene, and pyrene.

Radon A naturally occurring, colorless, odorless, radioactive gas formed by the disintegration of the element radium; damaging to human lungs when inhaled.

Riparian Areas adjacent to rivers and streams with a high density, diversity, and productivity of plant and animal species relative to nearby uplands.

Runoff Excess rainwater or snowmelt that is transported to streams by overland flow, tile drains, or ground water.

Secondary maximum contaminant level (SMCL) The maximum contamination level in public water systems that, in the judgment of the U.S. Environmental Protection Agency (USEPA), are required to protect the public welfare. SMCLs are secondary (nonenforceable) drinking-water regulations established by the USEPA for contaminants that may adversely affect the odor or appearance of such water.

Semivolatile organic compound (SVOC) Operationally defined as a group of synthetic organic compounds that are solvent-extractable and can be determined by gas chromatography/mass spectrometry. SVOCs include phenols, phthalates, and polycyclic aromatic hydrocarbons (PAHs).

Sole-source aquifer A ground-water system that supplies at least 50 percent of the drinking water to a particular human population; the term is used to denote special protection requirements under the Safe Drinking Water Act and may be used only by approval of the U.S. Environmental Protection Agency.

Species Populations of organisms that may interbreed and produce fertile offspring having similar structure, habits, and functions.

Species diversity An ecological concept that incorporates both the number of species in a particular sampling area and the evenness with which individuals are distributed among the various species.

Species (taxa) richness The number of species (taxa) present in a defined area or sampling unit.

Streamflow A type of channel flow, applied to that part of surface runoff in a stream whether or not it is affected by diversion or regulation.

Suspended sediment Particles of rock, sand, soil, and organic detritus carried in suspension in the water column, in contrast to sediment that moves on or near the streambed.

Taxon (plural taxa) Any identifiable group of taxonomically related organisms.

Tolerance value A numerical indication on a 0 to 10 scale of the sensitivity of organisms to many types of stress associated with stream disturbance.

Tolerant species Those species that are adaptable to (tolerant of) human alterations to the environment and often increase in number when human alterations occur.

Total DDT The sum of DDT and its metabolites (breakdown products), including DDD and DDE.

Trace element An element found in only minor amounts (concentrations less than 1.0 milligram per liter) in water or sediment; includes arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc.

Triazine herbicide A class of herbicides containing a symmetrical triazine ring (a nitrogen-heterocyclic ring composed of three nitrogens and three carbons in an alternating sequence). Examples include atrazine, propazine, and simazine.

Turbidity Reduced clarity of surface water because of suspended particles, usually sediment.

Unconfined aquifer An aquifer whose upper surface is a water table; an aquifer containing unconfined ground water.

Volatile organic compounds (VOCs) Organic chemicals that have a high vapor pressure relative to their water solubility. VOCs include components of gasoline, fuel oils, and lubricants, as well as organic solvents, fumigants, some inert ingredients in pesticides, and some by-products of chlorine disinfection.

Water-quality guidelines Specific levels of water quality which, if reached, may adversely affect human health or aquatic life. These are nonenforceable guidelines issued by a governmental agency or other institution.

Wetlands Ecosystems whose soil is saturated for long periods seasonally or continuously, including marshes, swamps, and ephemeral ponds.

Withdrawal The act or process of removing; such as removing water from a stream for irrigation or public water supply.

Appendix—Water-Quality Data from the Acadian-Pontchartrain Drainages in a National Context

Concentrations and detection frequencies of the most commonly detected constituents, constituents that exceed a drinking-water standard or aquatic-life guideline, or constituents that are of regulatory or scientific importance are presented below. Plots of other pesticides, nutrients, VOCs, and trace elements assessed in the Acadian-Pontchartrain Drainages are available at our Web site at:

http://water.usgs.gov/nawqa/graphs

These summaries of chemical concentrations and detection frequencies from the Acadian-Pontchartrain Drainages are compared to findings from 51 NAWQA Study Units investigated from 1991 to 2001 and to water-quality benchmarks for human health, aquatic life, fish-eating wildlife, or prevention of nuisance plant growth. These graphical summaries provide a comparison of chemical concentrations and detection frequencies between (1) surface- and ground-water resources; (2) agricultural, urban, and mixed land uses; and (3) shallow ground water and aquifers commonly used as a source of drinking water.

For example, the graph for atrazine shows that detections and concentrations in the Acadian-Pontchartrain Drainages generally are (1) higher than national findings in urban streams and streams in areas of mixed land use; (2) sometimes in excess of the USEPA drinking-water standard in agricultural and urban streams; and (3) greater in streams than in ground water.

NOTE to users:

- The analytical detection limit varies among the monitored chemicals; thus, frequencies of detections are not comparable among chemicals.
- It is important to consider the frequency of detection along with concentration. For example, cyanazine was detected more frequently in mixed land use streams in the Acadian-Pontchartrain Drainages than in mixed land use streams nationwide (87 percent compared to 39 percent) but generally was detected at lower concentrations.

CHEMICALS IN WATER

Concentrations and detection frequencies, Acadian-Pontchartrain Drainages, 1999–2001

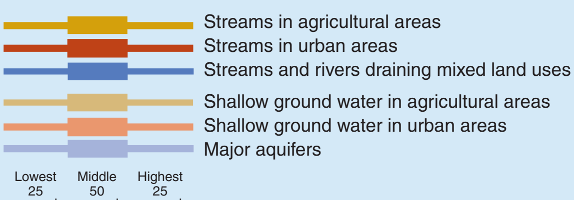
◆ Detected concentration in Study Unit

66 38 Frequencies of detection, in percent. Detection frequencies were not censored at any common reporting limit. The left-hand column is the study-unit frequency and the right-hand column is the national frequency

- - Not measured or sample size less than two

12 Study-unit sample size. For ground water, the number of samples is equal to the number of wells sampled

National ranges of detected concentrations, by land use, in 51 NAWQA Study Units, 1991–2001—Ranges include only samples in which a chemical was detected



National water-quality benchmarks

National benchmarks include standards and guidelines related to drinking-water quality, criteria for protecting the health of aquatic life, and the desired goal for preventing nuisance plant growth due to phosphorus. Sources include the U.S. Environmental Protection Agency and the Canadian Council of Ministers of the Environment

| Drinking-water quality (applies to ground water and surface water)

| Protection of aquatic life (applies to surface water only)

| Prevention of nuisance plant growth in streams

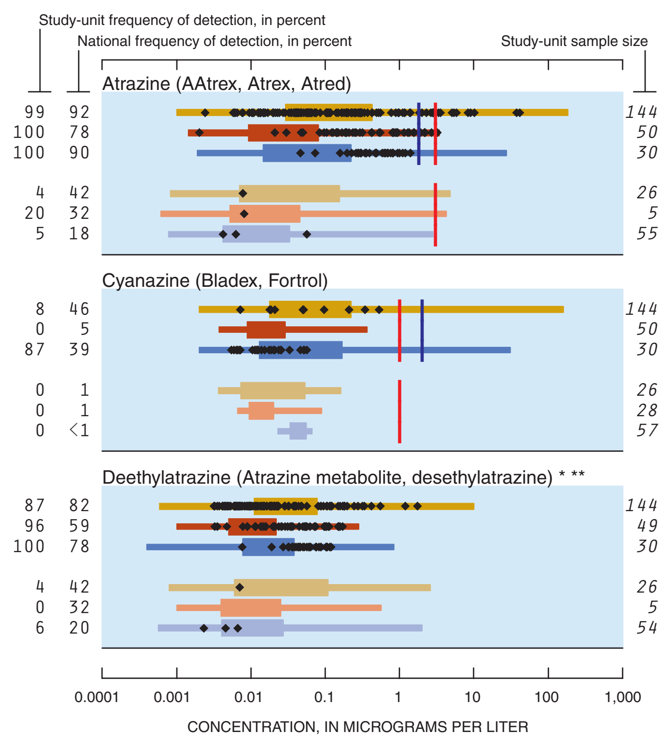
* No benchmark for drinking-water quality

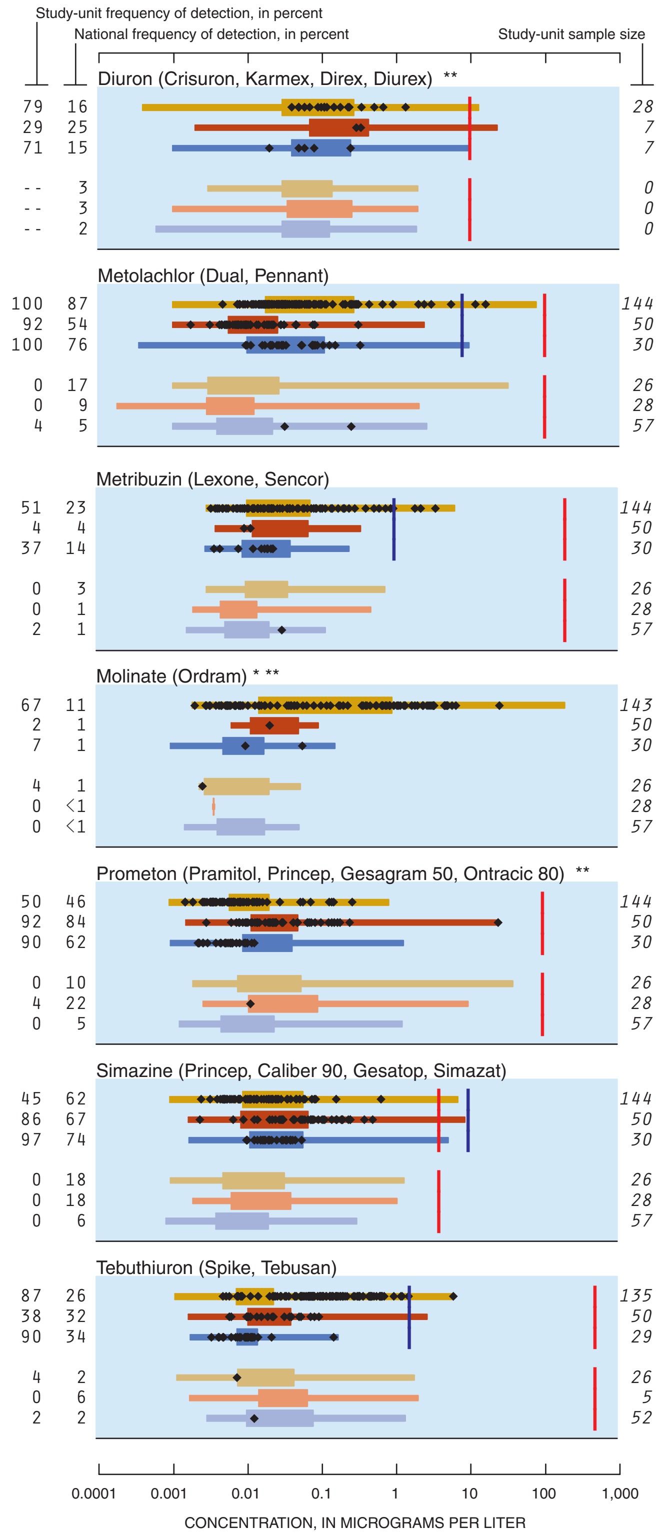
** No benchmark for protection of aquatic life

Quality-control data for these analytes indicate relatively frequent low-level contamination of samples during sample processing for analysis. Results for these analytes cannot, therefore, be presented using the generalized methods that were applied to other analytes in this Appendix. Analysis of results for analytes potentially affected by contamination requires special statistical treatment beyond the scope of this report. For more information about these analytes and how to interpret data on their occurrence and concentrations, please contact the appropriate NAWQA Study Unit.

Trace elements in ground water: aluminum, barium, boron, cadmium, chromium, cobalt, copper, lithium, nickel, strontium, zinc
SVOCs in bed sediment: phenol, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, di-*n*-butylphthalate, diethylphthalate
Insecticides in water: *p,p'*-DDE

Pesticides in water—Herbicides





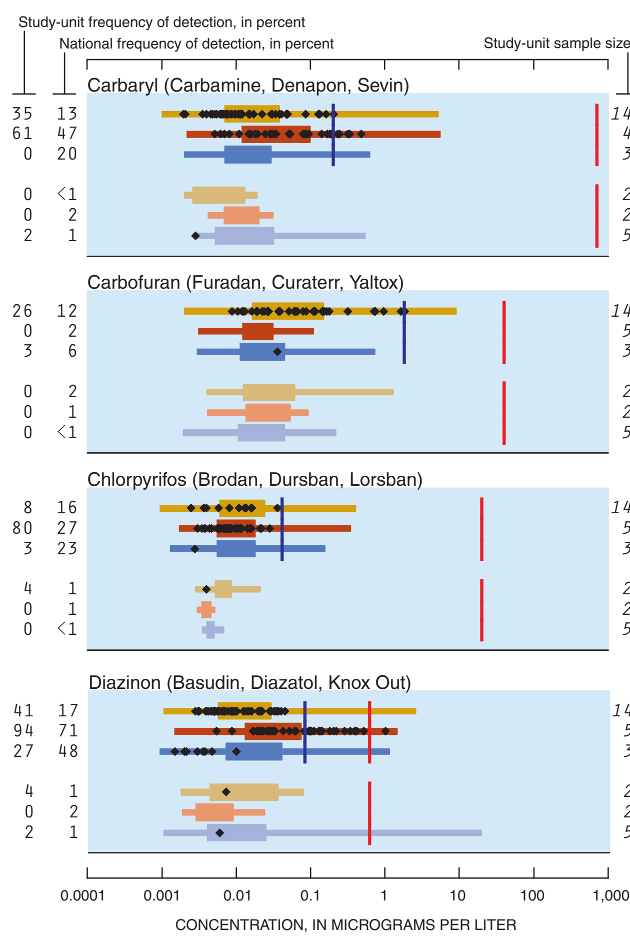
Other herbicides detected

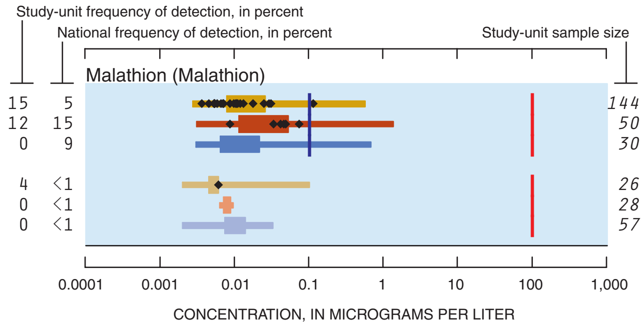
Acetochlor (Harness Plus, Surpass) * **
Alachlor (Lasso, Bronco, Lariat, Bullet) **
Benfluralin (Balan, Benefin, Bonalan, Benefex) * **
Bromacil (Hyvar X, Urox B, Bromax)
2,4-D (Aqua-Kleen, Lawn-Keep, Weed-B-Gone)
DCPA (Dacthal, chlorthal-dimethyl) **
Dicamba (Banvel, Dianat, Scotts Proturf)
Dichlorprop (2,4-DP, Seritox 50, Kildip) * **
EPTC (Eptam, Farmarox, Alirox) * **
Fluometuron (Flo-Met, Cotoran, Cottonex, Meturon) **
Napropamide (Devrinol) * **
Pendimethalin (Pre-M, Prowl, Weedgrass Control, Stomp, Herbadox) * **
Picloram (Grazon, Tordon)
Propachlor (Ramrod, Satecid) **
Propanil (Stam, Stampede, Wham, Surcopur, Prop-Job) * **
Terbacil (Sinbar) **
Thiobencarb (Bolero, Saturn, Benthiocarb, Abolish) * **
Triclopyr (Garlon, Grandstand, Redeem) * **
Trifluralin (Treflan, Gowan, Tri-4, Trific, Trilin)

Herbicides not detected

Chloramben, methyl ester (Amiben methyl ester) * **
Acifluorfen (Blazer, Tackle 2S) **
Bentazon (Basagran, Bentazone, Bendioxide) **
Bromoxynil (Buctril, Brominal) *
Butylate (Sutan +, Genate Plus, Butilate) **
Clopyralid (Stinger, Lontrel, Reclaim) * **
2,4-DB (Butyrac, Butoxone, Embutox Plus) *
Dacthal mono-acid (Dacthal metabolite) * **
2,6-Diethylaniline (metabolite of Alachlor) * **
Dinoseb (Dinosebe)
Ethalfluralin (Sonalan, Curbit) * **
Fenuron (Fenulon, Fenidim) * **
Linuron (Lorox, Linex, Sarclex, Linurex, Afalon) *
MCPA (Rhomene, Rhonox, Chiptox)
MCPB (Thistrol) * **
Neburon (Neburea, Neburyl, Noruben) * **
Norflurazon (Evital, Predict, Solicam) * **
Oryzalin (Surflan, Dirimal) * **
Pebulate (Tillam, PEBC) * **
Pronamide (Kerb, Propyzamid) **
Propham (Tuberite) **
2,4,5-T
2,4,5-TP (Silvex, Fenoprop)
Triallate (Far-Go, Avadex BW, Tri-allate) *

Pesticides in water—Insecticides





Other insecticides detected

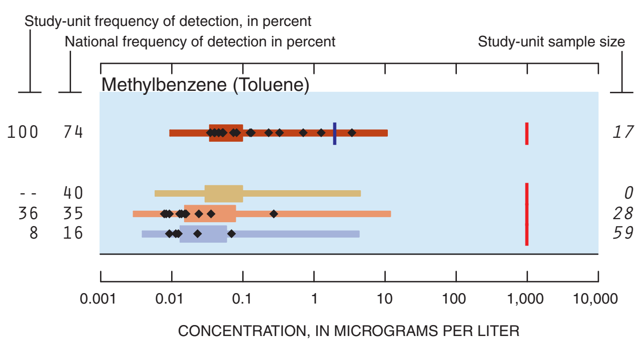
Dieldrin (Panoram D-31, Octalox)
Ethoprop (Mocap, Ethoprophos) * **
gamma-HCH (Lindane, gamma-BHC, Gammexane)
Methyl parathion (Penncap-M, Folidol-M, Metacide, Bladan M) **

Insecticides not detected

Aldicarb (Temik, Ambush, Pounce)
Aldicarb sulfone (Standak, aldoxycarb)
Aldicarb sulfoxide (Aldicarb metabolite)
Azinphos-methyl (Guthion, Gusathion M) *
Disulfoton (Disyston, Di-Syston, Frumin AL, Solvirex, Ethylthiodemeton) **
Fonofos (Dyfonate, Capfos, Cudgel, Tycap) **
alpha-HCH (alpha-BHC, alpha-lindane) **
3-Hydroxycarbofuran (Carbofuran metabolite) * **
Methiocarb (Slug-Geta, Grandslam, Mesurol) * **
Methomyl (Lanox, Lannate, Acinate) **
Oxamyl (Vydate L, Pratt) **
Parathion (Roethyl-P, Alkron, Panthion) *
cis-Permethrin (Ambush, Astro, Pounce) * **
Phorate (Thimet, Granutox, Geomet, Rampart) * **
Propargite (Comite, Omite, Ornamite) * **
Propoxur (Baygon, Blattanex, Unden, Proprotox) * **
Terbufos (Contraven, Counter, Pilarfox) **

Volatile organic compounds (VOCs) in water

These graphs represent data from 32 Study Units, sampled from 1994 to 2001



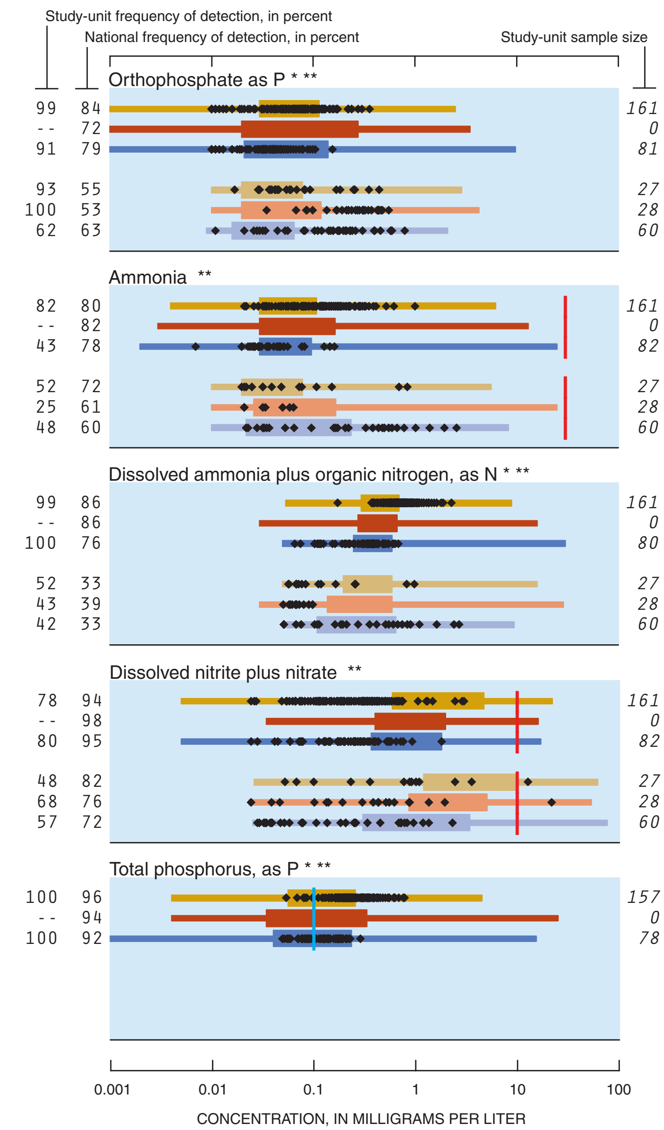
Other VOCs detected

Acetone (Acetone) * **
Benzene
Bromodichloromethane (Dichlorobromomethane) **
2-Butanone (Methyl ethyl ketone (MEK)) **
Carbon disulfide * **
Chloromethane (Methyl chloride) **
1,4-Dichlorobenzene (*p*-Dichlorobenzene, 1,4-DCB)
Dichlorodifluoromethane (CFC 12, Freon 12) **
Dichloromethane (Methylene chloride)
1,2-Dimethylbenzene (*o*-Xylene) **
1,3 & 1,4-Dimethylbenzene (*m-&p*-Xylene) **
Ethylbenzene (Phenylethane)
2-Ethyltoluene (*o*-Ethyltoluene) * **
p-Isopropyltoluene (*p*-Cymene, 1-Isopropyl-4-methylbenzene) * **
Methyl *tert*-butyl ether (MTBE) **
4-Methyl-2-pentanone (Methyl isobutyl ketone (MIBK)) * **
Naphthalene
Tetrachloroethene (Perchloroethene)
Tetrahydrofuran (Diethylene oxide) * **
1,2,3,5-Tetramethylbenzene (Isodurene) * **
Trichloroethene (TCE)
Trichlorofluoromethane (CFC 11, Freon 11) **
Trichloromethane (Chloroform)
1,2,3-Trimethylbenzene (Hemimellitene) * **
1,2,4-Trimethylbenzene (Pseudocumene) * **
1,3,5-Trimethylbenzene (Mesitylene) * **
tert-Amyl methyl ether (TAME) * **

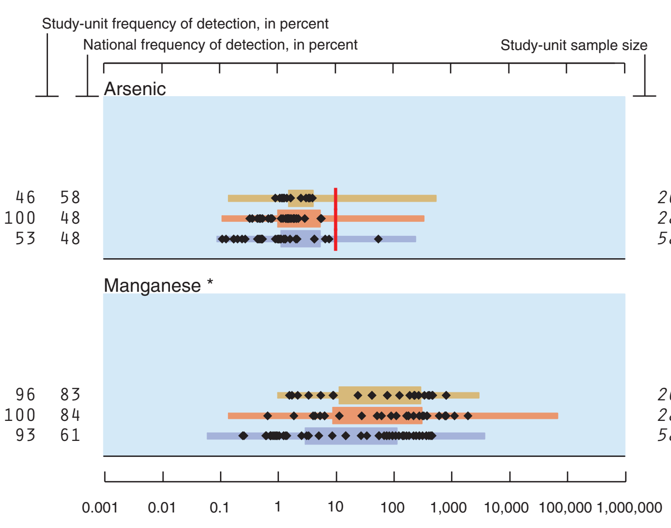
VOCs not detected

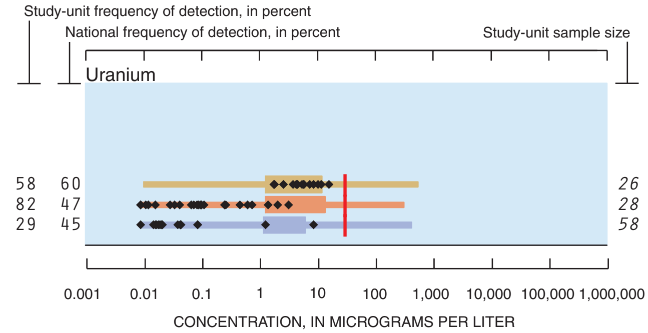
Bromobenzene (Phenyl bromide) * **
Bromochloromethane (Methylene chlorobromide) **
Bromoethene (Vinyl bromide) * **
Bromomethane (Methyl bromide) **
n-Butylbenzene (1-Phenylbutane) * **
sec-Butylbenzene ((1-Methylpropyl)benzene) * **
tert-Butylbenzene ((1,1-Dimethylethyl)benzene) * **
3-Chloro-1-propene (3-Chloropropene) * **
1-Chloro-2-methylbenzene (*o*-Chlorotoluene) **
1-Chloro-4-methylbenzene (*p*-Chlorotoluene) **
Chlorobenzene (Monochlorobenzene)
Chloroethane (Ethyl chloride) * **
Chloroethene (Vinyl chloride) **
1,2-Dibromo-3-chloropropane (DBCP, Nemagon) **
Dibromochloromethane (Chlorodibromomethane) **
1,2-Dibromoethane (Ethylene dibromide, EDB) **
Dibromomethane (Methylene dibromide) * **
trans-1,4-Dichloro-2-butene ((Z)-1,4-Dichloro-2-butene) * **
1,3-Dichlorobenzene (*m*-Dichlorobenzene)
1,2-Dichloroethane (Ethylene dichloride)
1,1-Dichloroethane (Ethylidene dichloride) * **
1,1-Dichloroethene (Vinylidene chloride) **
trans-1,2-Dichloroethene ((E)-1,2-Dichlorothene) **
cis-1,2-Dichloroethene ((Z)-1,2-Dichloroethene) **
1,2-Dichloropropane (Propylene dichloride) **
2,2-Dichloropropane * **
1,3-Dichloropropane (Trimethylene dichloride) * **
trans-1,3-Dichloropropene ((E)-1,3-Dichloropropene) **
cis-1,3-Dichloropropene ((Z)-1,3-Dichloropropene) **
1,1-Dichloropropene * **
Diethyl ether (Ethyl ether) * **
Diisopropyl ether (Diisopropylether (DIPE)) * **
Ethenylbenzene (Styrene) **
Ethyl methacrylate (Ethyl methacrylate) * **
Ethyl *tert*-butyl ether (Ethyl-t-butyl ether (ETBE)) * **
1,1,2,3,4,4-Hexachloro-1,3-butadiene (Hexachlorobutadiene)
1,1,1,2,2,2-Hexachloroethane (Hexachloroethane) **
2-Hexanone (Methyl butyl ketone (MBK)) * **
Iodomethane (Methyl iodide) * **
Isopropylbenzene (Cumene) * **
Methyl acrylonitrile (Methacrylonitrile) * **
Methyl methacrylate (Methyl-2-methacrylate) * **
Methyl-2-propenoate (Methyl acrylate) * **
2-Propenenitrile (Acrylonitrile) **
n-Propylbenzene (Isocumene) * **
1,1,2,2-Tetrachloroethane **
1,1,1,2-Tetrachloroethane (1,1,1,2-TeCA) **
Tetrachloromethane (Carbon tetrachloride)
1,2,3,4-Tetramethylbenzene (Prehnitene) * **
Tribromomethane (Bromoform) **
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113, CFC 113) * **
1,2,4-Trichlorobenzene
1,2,3-Trichlorobenzene (1,2,3-TCB) *
1,1,1-Trichloroethane (Methylchloroform) **
1,1,2-Trichloroethane (Vinyl trichloride) **
1,2,3-Trichloropropane (Allyl trichloride) **

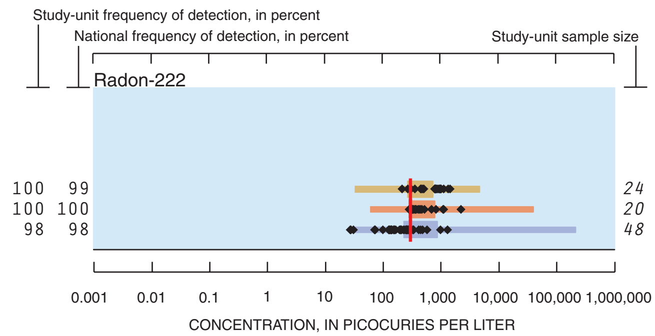
Nutrients in water



Trace elements in ground water







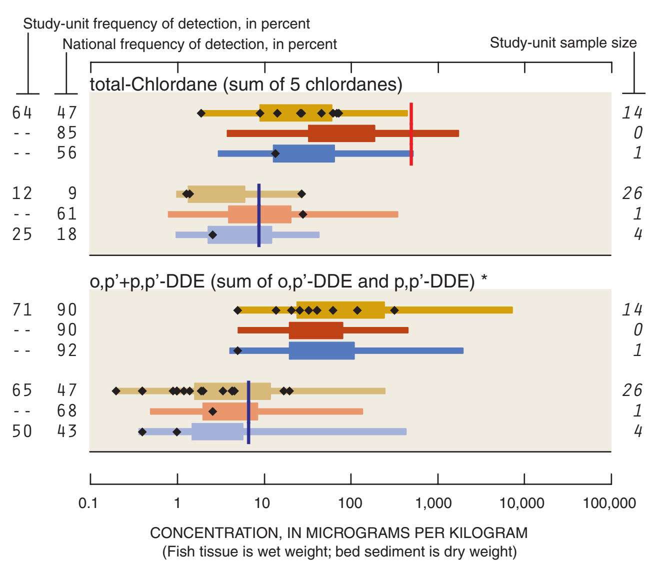
Other trace elements detected

Antimony
Beryllium
Lead
Molybdenum
Selenium
Thallium
Vanadium *

Trace element not detected

Silver

Organochlorines in fish tissue (whole body) and bed sediment



CHEMICALS IN FISH TISSUE AND BED SEDIMENT

Concentrations and detection frequencies, Acadian-Pontchartrain Drainages, 1999–2001—Study-unit frequencies of detection are based on small sample sizes; the applicable sample size is specified in each graph

◆ Detected concentration in Study Unit

66 38 Frequencies of detection, in percent. Detection frequencies were not censored at any common reporting limit. The left-hand column is the study-unit frequency and the right-hand column is the national frequency

-- Not measured or sample size less than two

12 Study-unit sample size

National ranges of concentrations detected, by land use, in 51 NAWQA Study Units, 1991–2001—Ranges include only samples in which a chemical was detected

- Fish tissue from streams in agricultural areas
- Fish tissue from streams in urban areas
- Fish tissue from streams draining mixed land uses
- Sediment from streams in agricultural areas
- Sediment from streams in urban areas
- Sediment from streams draining mixed land uses

Lowest 25 percent | Middle 50 percent | Highest 25 percent

National benchmarks for fish tissue and bed sediment

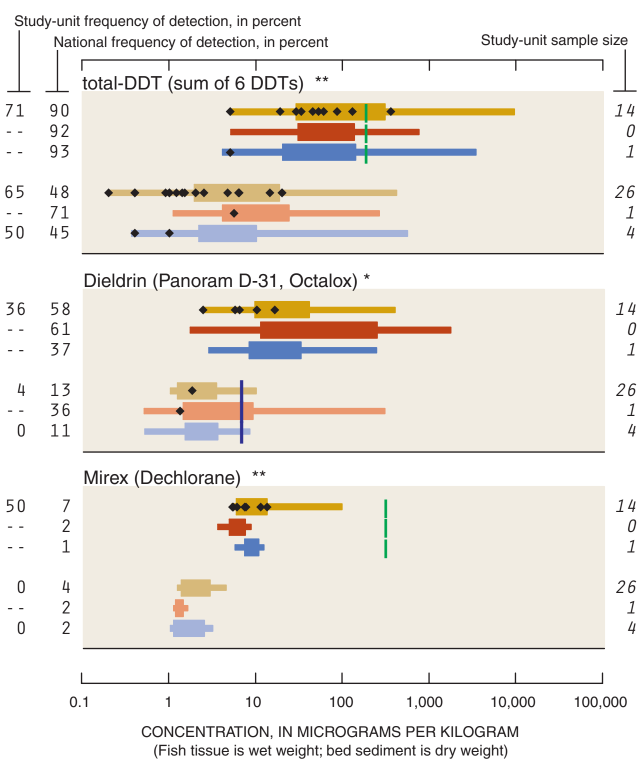
National benchmarks include standards and guidelines related to criteria for protection of the health of fish-eating wildlife and aquatic organisms. Sources include the U.S. Environmental Protection Agency, other Federal and State agencies, and the Canadian Council of Ministers of the Environment.

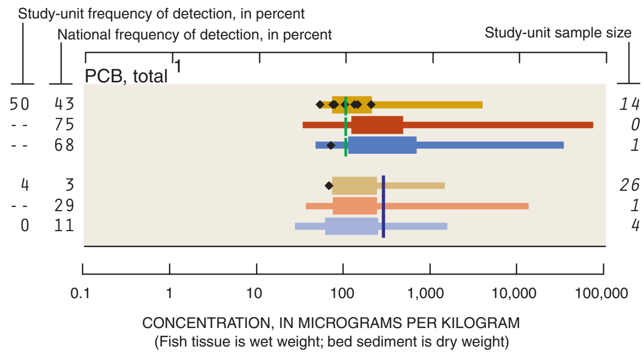
| Protection of fish-eating wildlife (applies to fish tissue)

| Protection of aquatic life (applies to bed sediment)

* No benchmark for protection of fish-eating wildlife

** No benchmark for protection of aquatic life





[1] The national detection frequencies for total PCB in sediment are biased low because about 30 percent of the samples nationally had elevated detection limits compared to this Study Unit. See http://water.usgs.gov/nawqa/ for additional information.

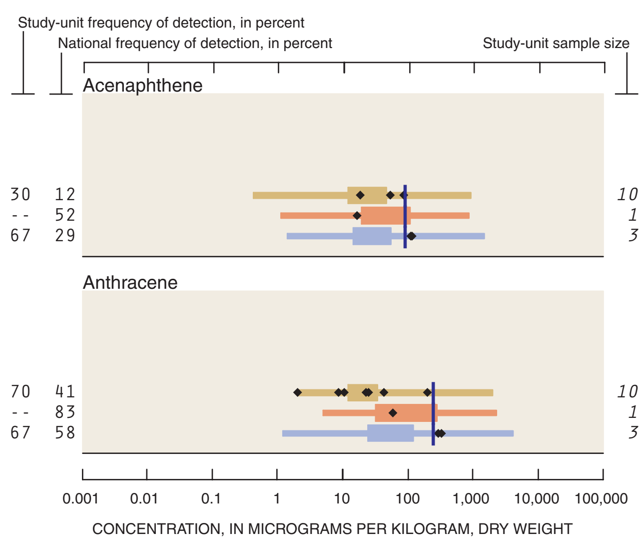
Other organochlorines detected

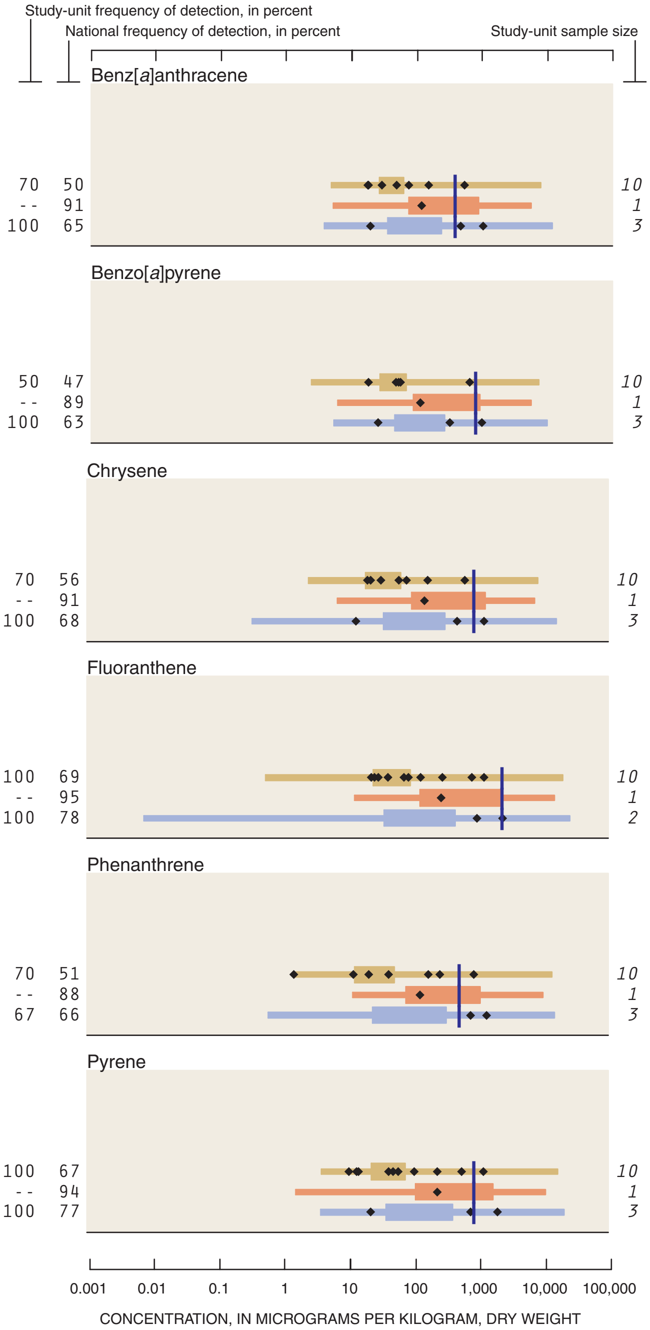
o,p'+*p,p'*-DDD (sum of *o,p'*-DDD and *p,p'*-DDD) *
p,p'-DDE * **
o,p'+*p,p'*-DDT (sum of *o,p'*-DDT and *p,p'*-DDT) *
Dieldrin+aldrin (sum of dieldrin and aldrin) **
Heptachlor epoxide (Heptachlor metabolite) *
Heptachlor+heptachlor epoxide **
Hexachlorobenzene (HCB) **
Pentachloroanisole (PCA, pentachlorophenol metabolite) * **

Organochlorines not detected

Chloroneb (chloronebe, Demosan) * **
DCPA (Dacthal, chlorthal-dimethyl) * **
Endosulfan I (alpha-Endosulfan, Thiodan) * **
Endrin (Endrine)
gamma-HCH (Lindane, gamma-BHC, Gammexane) *
Total HCH (sum of alpha, beta, gamma, and delta-HCH) **
Isodrin (Isodrine, Compound 711) * **
p,p'-Methoxychlor (Marlate, methoxychlore) * **
o,p'-Methoxychlor * **
cis-Permethrin (Ambush, Astro, Pounce) * **
trans-Permethrin (Ambush, Astro, Pounce) * **
Toxaphene (Camphechlor, Hercules 3956) * **

Semivolatile organic compounds (SVOCs) in bed sediment





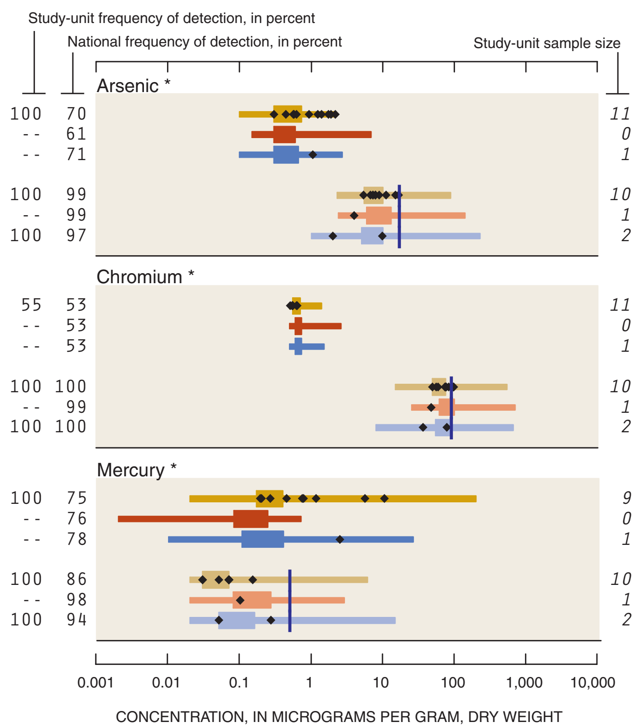
Other SVOCs detected

Acenaphthylene
Acridine **
Anthraquinone **
Benzo[*b*]fluoranthene **
Benzo[*g,h,i*]perylene **
Benzo[*k*]fluoranthene **
9*H*-Carbazole **
4-Chloro-3-methylphenol **
p-Cresol **
Di-*n*-octylphthalate **
Dibenz[*a,h*]anthracene
Dibenzothiophene **
1,4-Dichlorobenzene (*p*-Dichlorobenzene, 1,4-DCB) **
1,2-Dimethylnaphthalene **
1,6-Dimethylnaphthalene **
2,6-Dimethylnaphthalene **
3,5-Dimethylphenol **
Dimethylphthalate **
9*H*-Fluorene (Fluorene)
Indeno[1,2,3-*c,d*]pyrene **
Isoquinoline **
1-Methyl-9*H*-fluorene **
2-Methylanthracene **
4,5-Methylenephenanthrene **
1-Methylphenanthrene **
1-Methylpyrene **
Naphthalene
Phenanthridine **
2,3,6-Trimethylnaphthalene **

SVOCs not detected

C8-Alkylphenol **
Azobenzene **
Benzo[*c*]cinnoline **
2,2-Biquinoline **
4-Bromophenyl-phenylether **
bis (2-Chloroethoxy)methane **
bis (2-Chloroethyl)ether **
2-Chloronaphthalene **
2-Chlorophenol **
4-Chlorophenyl-phenylether **
1,2-Dichlorobenzene (*o*-Dichlorobenzene, 1,2-DCB) **
1,3-Dichlorobenzene (*m*-Dichlorobenzene) **
2,4-Dinitrotoluene **
Isophorone **
Nitrobenzene **
N-Nitrosodi-*n*-propylamine **
N-Nitrosodiphenylamine **
Pentachloronitrobenzene **
Quinoline **
1,2,4-Trichlorobenzene **

Trace elements in fish tissue (livers) and bed sediment



Other trace elements detected

Cadmium *
Copper *
Lead *
Nickel * **
Selenium *
Zinc *

Coordination with agencies and organizations in the Acadian-Pontchartrain Drainages was integral to the success of this water-quality assessment. We thank those who served as members of our liaison committee.

Federal Agencies
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
National Park Service
Natural Resources Conservation Service

State Agencies
Louisiana Department of Environmental Quality
Louisiana Department of Natural Resources
Louisiana Department of Agriculture and Forestry

Universities
Louisiana State University, Baton Rouge

Other public and private organizations
The Nature Conservancy
Lake Pontchartrain Basin Foundation
Coalition to Restore Coastal Louisiana
Barataria-Terrebonne National Estuary Program

We thank the following individuals for contributing to this effort.

We thank Mr. Murphy Cormier for continued access to Bayou Lacassine. We also thank the many landowners who allowed the USGS to install monitoring wells, sample existing wells on their property, and those that allowed us access to sampling sites.

Billy Justus (USGS) played a major role in the collection and identification of fish community data.

Field work to collect water-quality samples required a sustained commitment from many USGS personnel. The dedication shown by Van Bergeron and Lane Simmons to execute demanding sampling schedules is greatly appreciated.

Rod deWeese (USGS, Biological Resources Discipline) aided in the collection of ecology samples and provided helpful technical advice, both in the field and during report preparation.

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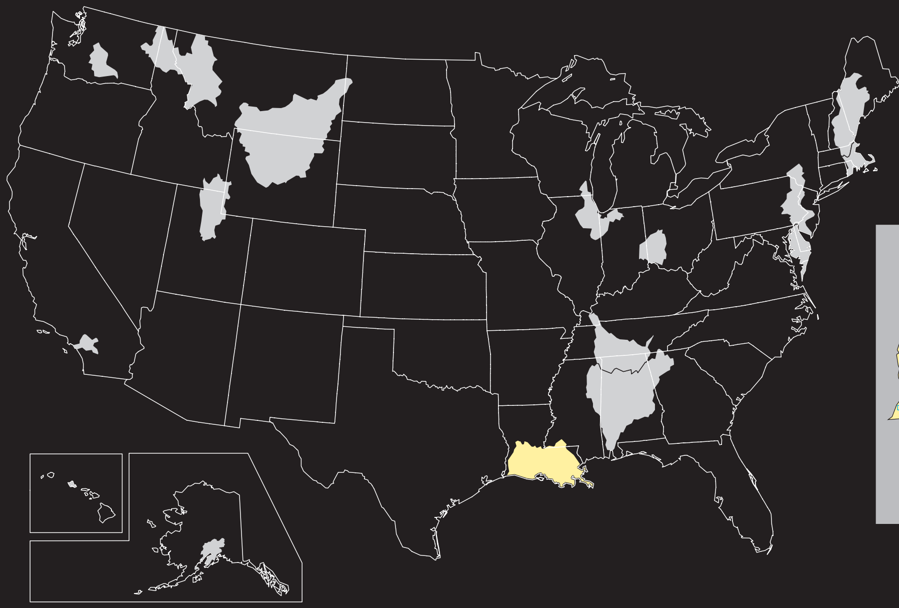
Illustrations, report layout, and editorial changes through numerous revisions were skillfully and artfully rendered by Sue Roberts. Editorial reviews by Jim Wilson, Betty Palcsak, and Mary Kidd improved the readability of the manuscript.

NAWQA

National Water-Quality Assessment (NAWQA) Program
Acadian-Pontchartrain Drainages



Demcheck and others— Water Quality in the Acadian-Pontchartrain Drainages
U.S. Geological Survey Circular 1232

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