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QUALITY OF WATER FROM SHALLOW WELLS IN THE RICE-GROWING AREA IN SOUTHWESTERN LOUISIANA, 1999 THROUGH 2001

NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

Water-Resources Investigations
Report 03-4050

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

Cover photographs

Left: Crawfish/rice field, Acadia Parish, Louisiana
Upper right: Rice, Pointe Coupee Parish, near Livonia, Louisiana
Lower right: Pumping well in rice field, Acadia Parish
(Photographs by Dennis K. Demcheck, U.S. Geological Survey)

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By Roland W. Tollett and Robert B. Fendick, Jr.

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

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

http://water.usgs.gov/nawqa

FOREWORD

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

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

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

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

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

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

Robert M. Hirsch
Associate Director for Water

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, DATUMS, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
acre	0.4047	hectare
foot (ft)	0.3048	meter (m)
inch (in.)	25.4	millimeter (mm)
mile (mi)	1.609	kilometer (km)
million gallons per day (Mgal/d)	0.04381	cubic meter per second

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

Horizontal coordinate information is referenced to the North American Datum of 1927.

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

Abbreviated water-quality units:
micrograms per liter (µg/L)
microsiemens per centimeter at 25 degrees Celsius (µS/cm)
milligrams per liter (mg/L)
nephelometric turbidity units (NTU)
picocuries per liter (pCi/L)
picograms per kilogram (pg/kg)
standard units (S.U.)

Quality of Water from Shallow Wells in the Rice-Growing Area in Southwestern Louisiana, 1999 through 2001

By Roland W. Tollett and Robert B. Fendick, Jr.

ABSTRACT

In 1999-2001, the U.S. Geological Survey installed and sampled 27 shallow wells in the rice-growing area in southwestern Louisiana as part of the Acadian-Pontchartrain Study Unit of the National Water-Quality Assessment Program. The purpose of this report is to describe the quality of water from shallow wells in the rice-growing area and to relate that water quality to natural and anthropogenic activities, particularly rice agriculture. Ground-water samples were analyzed for general ground-water properties and about 150 water-quality constituents, including major inorganic ions, trace elements, nutrients, dissolved organic carbon (DOC), pesticides, radon, chlorofluorocarbons, and selected stable isotopes.

Dissolved-solids concentrations for 17 wells exceeded the U.S. Environmental Protection Agency secondary maximum contaminant level of 500 milligrams per liter (mg/L) for drinking water. Concentrations for major inorganic ions, trace elements, and pesticides generally were less than the maximum contaminant levels for drinking water. Two major inorganic ions, sulfate and chloride, and two trace elements, iron and manganese, had concentrations that were greater than the secondary maximum contaminant levels. Three nutrient concentrations were greater than 2 mg/L, a level that might indicate contamination from human activities, and one nutrient concentration (that for nitrite plus nitrate as nitrogen) was greater than the maximum contaminant level of 10 mg/L for drinking water. The median concentration for DOC was 0.5 mg/L, indicating naturally-occurring DOC conditions in the study area. Thirteen pesticides and 7 pesticide degradation products were detected in 14 of the 27 wells sampled. Bentazon, 2,4-D, and molinate (three rice herbicides) were detected in water from four, one, and one wells, respectively, and malathion (a rice insecticide) was detected in water from one well. Low-level concentrations and few detections of nutrients and pesticides indicated that ground-water quality was affected slightly by anthropogenic activities. Quality-control samples, including field blanks, replicates, and spikes, indicated no bias in ground-water data from collection or analysis.

Radon concentrations for 22 of the 24 wells sampled were at or greater than the U.S. Environmental Protection Agency proposed maximum contaminant level of 300 picocuries per liter. Chlorofluorocarbon concentrations in selected wells indicated the apparent ages of the ground water varied with depth and water level and ranged from about 17 to 49 years. The stable isotopes of hydrogen and oxygen in water molecules indicated the origin of ground water in the study area was rainwater that originated near the study area and that few geochemical or physical processes influenced the stable isotopic composition of the shallow ground water.

The Spearman rank correlation was used to determine whether significant correlations existed between physical properties, selected chemical constituents, the number of pesticides detected, and the apparent age of water. The depth to ground water was positively correlated to the well depth and inversely correlated to dissolved solids and other constituents, such as radon, indicating the ground water was under unconfined or semiconfined conditions and more dilute with increasing depth. As the depth to ground water increased, the concentrations of dissolved solids and other constituents decreased, possibly because the deeper sands had a greater transmittal of ground water, which, over time, would flush out, or dilute, the concentrations of dissolved solids in the natural sediments. The apparent age of water was correlated inversely with nitrite plus nitrate concentration, indicating that as the apparent age increased, the nitrite plus nitrate concentration decreased. No significant correlations existed between the number of pesticides detected and any of the physical or chemical properties of the ground water.

INTRODUCTION

Ground water is one of the Nation's most important resources and is the source of drinking water for about 50 percent of the population, or about 130 million United States residents (U.S. Geological Survey, 1999b). Because ground water is used for public-water supplies and because of the potential for ground water to affect surface-water quality and ecological and recreational resources, degradation of ground-water quality as a result of anthropogenic activities is a major concern. Therefore, in 1991, the U.S. Geological Survey (USGS) began full implementation of the National Water-Quality Assessment (NAWQA) Program to describe the status and trends in the quality of the Nation's surface- and ground-water resources and to determine the natural and human-related factors that affect water quality (Hirsch and others, 1988; Gilliom and others, 1995). Knowledge of the quality of the Nation's surface- and ground-water resources is important for the protection of human and aquatic health and for the management of land and water resources and the conservation and regulation of those resources. More than 50 major river basins or aquifer systems, referred to as Study Units, have been identified for investigation as part of the NAWQA Program. Together, these basins and aquifer systems include water resources available to more than 60 percent of the population and cover about one-half of the land area in the conterminous United States.

Ground-water studies in the NAWQA Program include (1) sub-unit surveys, designed to assess the water quality of major aquifer systems within a Study Unit; (2) land-use studies, designed to assess the quality of recently recharged ground water associated with regionally extensive combinations of land use and hydrogeologic conditions; and (3) flowpath studies, designed to examine specific relations among land-use practices, ground-water flow, contaminant occurrence and transport, and surface- and ground-water interactions (Gilliom and others, 1995). During 1997-2002, two sub-unit surveys (Chicot aquifer system and Chicot equivalent aquifer system) and two land-use studies (one agriculture study and one urban study) were completed for the Acadian-Pontchartrain (ACAD) Study Unit of the NAWQA Program. The ACAD Study Unit encompasses most of southern Louisiana and a small part of southwestern Mississippi (fig. 1).

A land-use study was begun in 1999 for the rice-growing area overlying the Chicot aquifer system in southwestern Louisiana in the ACAD Study Unit. Objectives of the study were to assess the occurrence and distribution of water-quality constituents in recently recharged ground water (generally less than 20- to 30-years old) associated with a major land use in the study area and to gain an understanding of the natural and human-related factors that affect ground-water quality. Data from the study can be compared to data from similar studies throughout the United States to assess the quality of the Nation's water resources, to determine any long-term changes in water quality, and to identify the natural and human-related factors that might affect water quality (Gilliom and others, 1998).

Rice was chosen for this land-use study because that crop accounts for the second largest crop acreage in southwestern Louisiana and because the rice-growing area in southwestern Louisiana overlies the Chicot aquifer system. The Chicot aquifer system is the primary source of water for irrigation and public-water supplies in the area and, in 1988, was declared a Sole Source Aquifer by the U.S. Environmental Protection Agency (USEPA) (U.S. Environmental Protection Agency, 2002c). This designation recognizes that the aquifer system is the sole or principal source of drinking water for the area and also recognizes that no alternative sources of drinking water are reasonably available should the aquifer become contaminated. Water in the Chicot aquifer system is vulnerable to the effects of land-surface activities in many areas of southwestern Louisiana because of shallow depths to ground water. Vertical leakage through the surficial confining unit that overlies the aquifer system and large ground-water withdrawals for irrigation near pumping centers might contribute to the potential for downward migration of contaminants to the aquifer underlying the rice-growing area.

Purpose and Scope

The purpose of this report is to describe the quality of water from 27 shallow wells in the rice-growing area in southwestern Louisiana and to relate that water quality to natural factors, such as well depth and depth to ground water, and human activities, such as pesticide and fertilizer use. Ground-water samples collected from 1999 through 2001 from the 27 wells were analyzed for 7 general ground-water properties, 10 major inorganic ions, 24 trace elements, 6 nutrients, dissolved organic carbon (DOC), 109 pesticides, radon, chlorofluorocarbons (CFCs), and selected stable isotopes. The Spearman rank correlation was used to determine whether significant correlations existed between physical properties, selected chemical constituents, the number of pesticides detected, and the apparent age of ground water. Although the shallow wells are not used as a drinking-water source, many of the constituents are regulated in public drinking-water supplies by the USEPA, and USEPA standards can be used as a frame of reference.

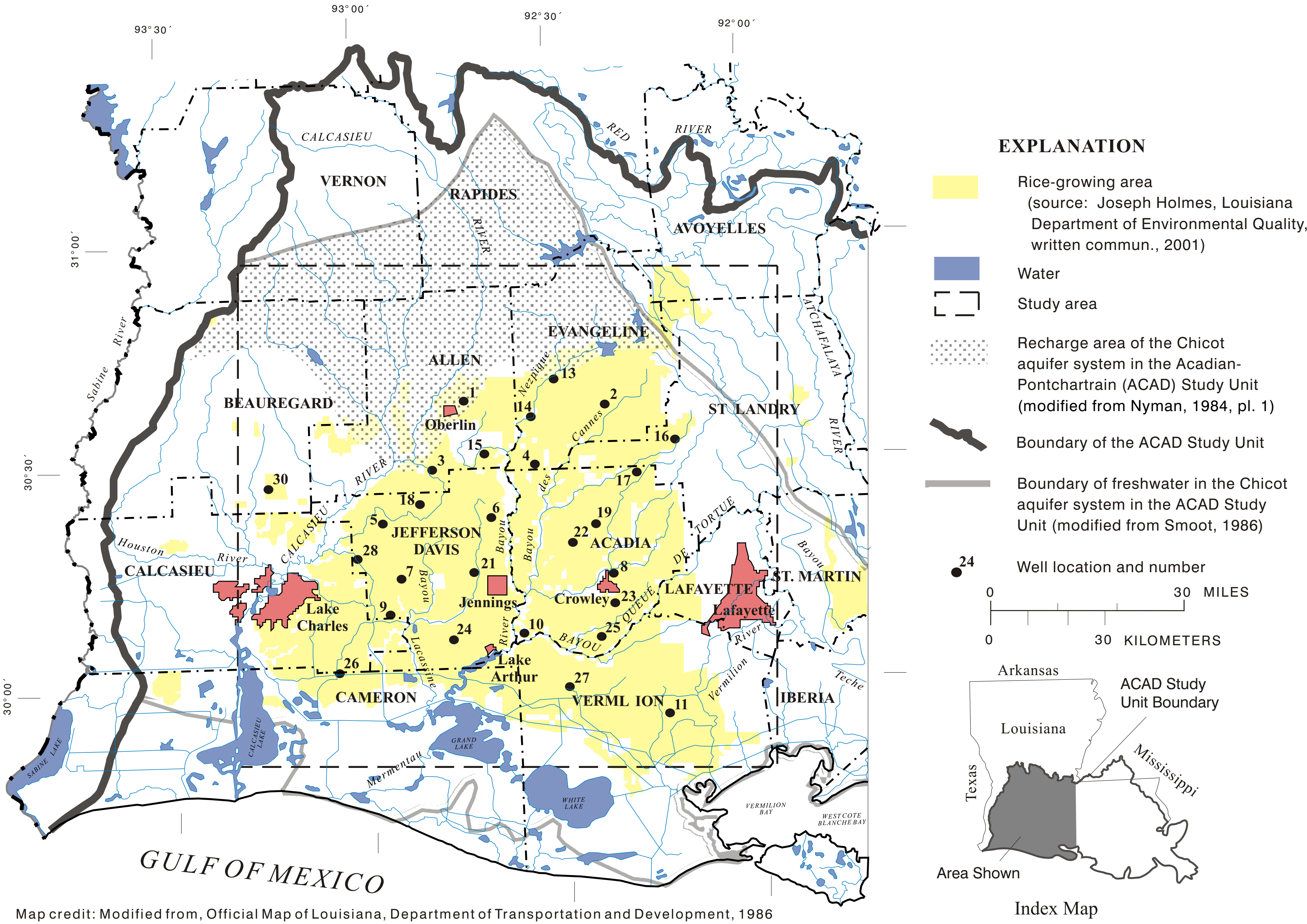


Figure 1. Study area and well locations in the rice-growing area in southwestern Louisiana in the Acadian-Pontchartrain Study Unit.

Acknowledgments

The authors express appreciation to the rice farmers and landowners in the study area for allowing the USGS to install and sample wells located on their property. The authors also wish to thank personnel from the Louisiana State University Agricultural Center, particularly Dr. J.A. Musick (Rice Research Station, Crowley, La.) and Dr. J.K. Saichuk (Louisiana State Cooperative Extension Service, Crowley, La.), and individual county agents in the study area for their cooperation and participation in determining locations to install wells.

DESCRIPTION OF STUDY AREA

The study area is located in southwestern Louisiana (fig. 1). Land-surface elevations in the rice-growing area range from about 5 to 80 ft above the NGVD 29. The region is drained primarily by Bayou Lacassine and the Calcasieu, Mermentau, and Vermilion Rivers.

Climate

The climate in southwestern Louisiana is humid and subtropical. The average annual rainfall for the area ranges from about 56 in. to 64 in. (Carlson, 1986, p. 253). The average annual rainfall for three selected stations in the rice-growing area for 1998-2000 was 51.4 in., about 10.2 in. less than the 30-year normal for 1971-2000 (Louisiana State Office of Climatology, written commun., 2000). Rainfall at the three stations--the Oberlin Fire Tower, Crowley Airport, and Lake Arthur Airport--was less than normal during 1999 and 2000. Annual rainfall ranged from 37.6 in. at the Crowley Airport in 1999 to 74.6 in. at the Lake Arthur Airport in 1998. The average annual temperature for the three stations for 1998-2000 was 69.5°F, which is 1.9°F higher than the 30-year normal for 1971-2000. Annual temperatures ranged from 68.3°F at the Oberlin Fire Tower in 2000 to 71.3°F at the Lake Arthur Airport in 2000.

Hydrogeologic Setting

The Chicot aquifer system is a thick sequence of interbedded clays, silts, sands, and gravels and underlies most of southwestern Louisiana and parts of eastern Texas. The sediments, deposited in deltaic and near-shore marine environments during the Pleistocene Epoch, dip and thicken southward to the Gulf Coast (Lovelace, 1999) and are characterized by massive beds of coarse sand and gravel separated by beds of clay. The sand beds generally are several hundred feet thick and are separated in places by thick discontinuous clays (Nyman and others, 1990). Recharge to the Chicot aquifer system (fig. 1) occurs from downward percolation of water in the outcrop area, through the Atchafalaya aquifer in the eastern part of the study area, and through surficial clay units, and, to a lesser extent, from upward leakage from the underlying Evangeline aquifer (Lovelace, 1999).

Shallow sands in the northern part of the study area are referred to as “undifferentiated sands” of the Chicot aquifer system (fig. 2) (Nyman and others, 1990). In the Lake Charles area, the Chicot aquifer system contains the “200-foot”, “500-foot”, and “700-foot” sands. East of the Lake Charles area in the rice-growing area, the Chicot aquifer system is divided into two major sand units, an “upper sand” and a “lower sand”. Prior to development, regional ground-water flow in the Chicot aquifer system generally was to the south-southeast (Nyman and others, 1990, p. 34). However, intensive use of ground water for rice irrigation in the central part of southwestern Louisiana and for industrial use in the Lake Charles area has affected the regional flow direction in many areas. Ground-water movement now is to the west in parts of the eastern part of the study area and to the north (from the Louisiana coast) in parts of the central part of the study area (Lovelace and others, 2002).

At the top of the Chicot aquifer system is a thick layer of clay that is a surficial confining unit. The confining unit is areally extensive throughout most of southwestern Louisiana and generally averages about 100 ft in thickness throughout most of the study area. However, the unit is more than 500 ft thick in parts of Calcasieu and Cameron Parishes (Jones and others, 1954, pl. 4). The surficial confining unit once was thought to be an impermeable layer, but ground-water model estimates indicate that as much as 6 in. per year of water, primarily from the surface, recharge the Chicot aquifer system near major pumping centers (Nyman and others, 1990, p. 33). Although the model estimates indicate slight permeability in the surficial confining unit, rice cultivation during the past 100 years has caused salts and fine clays to leach downward, forming a low-permeability horizon, or hardpan, in sediments underlying the rice fields (Lovelace, 1999, p. 9).

<table>
<tr><th rowspan="3">System</th><th rowspan="3">Series</th><th colspan="4">Hydrogeologic units</th></tr>
<tr><th rowspan="2">Aquifer system or confining unit</th><th colspan="3">Aquifers or confining units</th></tr>
<tr><th>Northern part of study area</th><th>Lake Charles area</th><th>Rice-growing area</th></tr>
<tr><td rowspan="3">Quaternary</td><td rowspan="3">Pleistocene</td><td rowspan="3">Chicot aquifer system or surficial confining unit</td><td rowspan="3">Shallow sands in confining unit and undifferentiated sands</td><td>Shallow sands in confining unit</td><td>Shallow sands in confining unit</td></tr>
<tr><td>“200-foot” sand</td><td>Upper sand</td></tr>
<tr><td>“500-foot” sand
“700-foot” sand</td><td>Lower sand</td></tr>
<tr><td rowspan="2">Tertiary</td><td>Pliocene
?</td><td colspan="4" rowspan="2">Evangeline aquifer</td></tr>
<tr><td>Miocene</td></tr>
</table>

Figure 2. Selected hydrogeologic units in southwestern Louisiana (modified from Lovelace and Lovelace, 1995, p. 10).

Land Use, Water Use, and Population

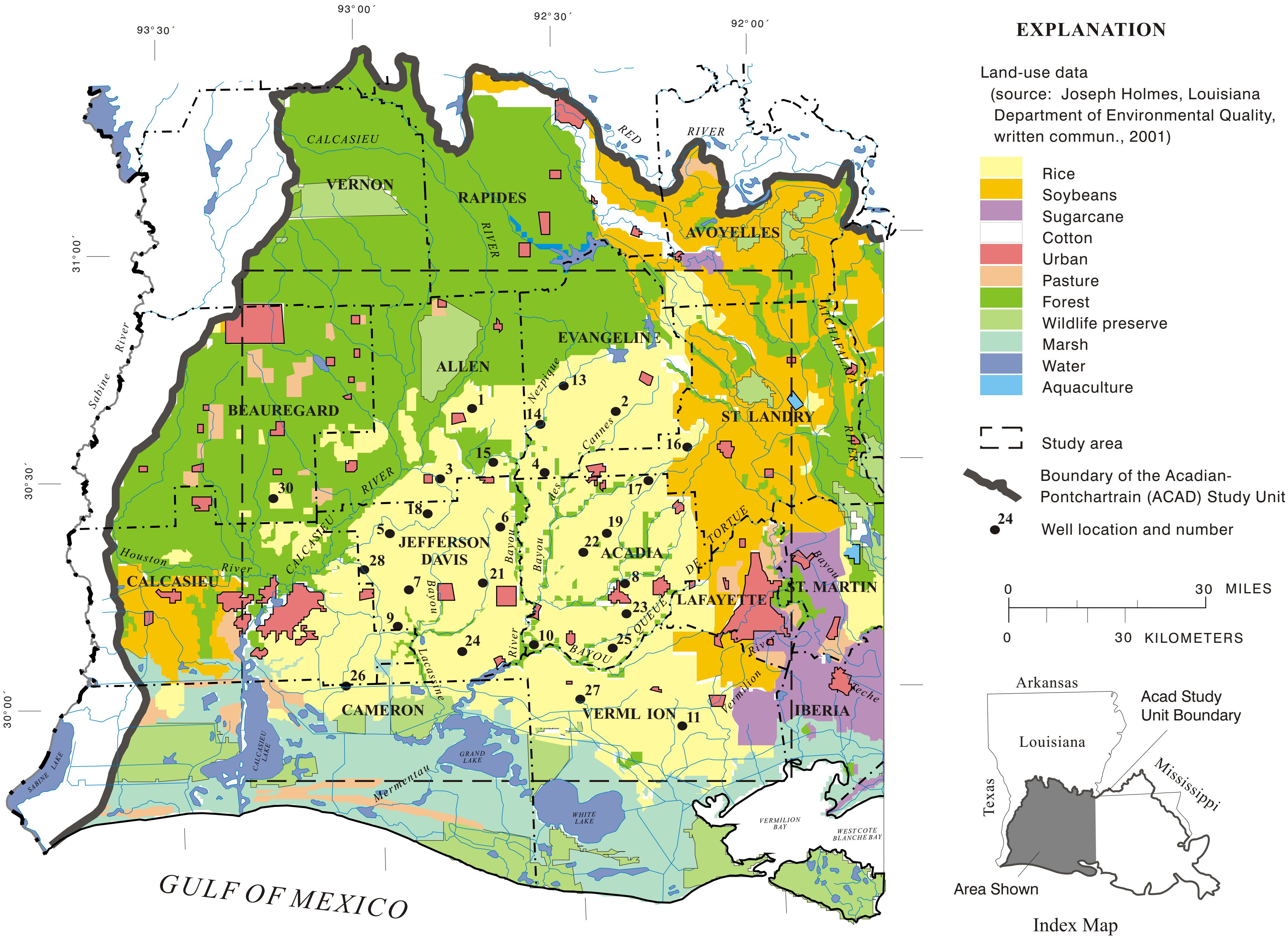
The rice-growing area in southwestern Louisiana includes all or parts of 12 parishes (fig. 3). Rice agriculture is the primary land use followed by forest, other crops, marsh, and urban. For 1992-96, the major crop grown was rice (about 428,000 acres) followed by soybeans (about 343,000 acres), corn (about 53,000 acres), and sugarcane (about 39,000 acres). For the same 5-year period, the number of acres planted in rice was largest in Vermilion Parish (about 95,000 acres), second largest in Acadia Parish (about 93,000 acres), and third largest in Jefferson Davis Parish (about 90,000 acres).

During 1999-2000, ground water in the rice-growing area was used primarily for rice irrigation and public supply. The Chicot aquifer system supplied 798 Mgal/d of ground water to the area. Of the total, 537 Mgal/d was used for rice irrigation (Sargent, 2002) and 89 Mgal/d was used for public supply. Ground-water withdrawals for rice irrigation were largest in Vermilion Parish (149 Mgal/d), second largest in Jefferson Davis Parish (132 Mgal/d), and third largest in Acadia Parish (125 Mgal/d). All other parishes each used about 40 Mgal/d or less of ground water for irrigation. The top two parishes for public-supply use were Calcasieu (24 Mgal/d) and Lafayette (21 Mgal/d) Parishes, which, combined, accounted for more than 50 percent of the total public-supply use. The Chicot aquifer system was not used for public supply in Avoyelles, Rapides, and Vernon Parishes. The remaining parishes each used 10 Mgal/d or less of ground water for public supply.

The rice-growing area is sparsely populated with the primary economic activity being agriculture. In 2000, the total population of the area was about 500,000 (U.S. Census Bureau, 2002). Lafayette Parish had the largest population (about 190,000), and Calcasieu Parish had the second largest population (about 175,000). All other parishes had populations of less than 100,000. Cameron Parish was the least populated and had less than 10,000 people. The two largest cities were Lafayette, which had a population of about 116,000, and Lake Charles, which had a population of about 72,000.

METHODS

The NAWQA guidelines used to design this study are described in Gilliom and others (1995). NAWQA ground-water protocols (Lapham and others, 1997; Koterba, 1998) were followed during data collection. Standardization of the data-collection protocols was intended to produce a nationally consistent data base for statistically valid interpretations. However, because of local conditions, modification of the national protocols sometimes was necessary. The following sections describe how the protocols were applied and, when necessary, how they were modified.



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

Figure 3. Major land-use types in the rice-growing area in southwestern Louisiana in the Acadian-Pontchartrain Study Unit.

Well-Site Selection

Well-site selection criteria followed the criteria published in Lapham and others (1997). The main criterion used for site selection was that the site be located on deposits that make up the Chicot aquifer system or surficial confining unit. Boundaries for the rice-growing area were obtained from the Louisiana State University Remote Sensing and Image Processing Laboratory. After the rice-growing area boundaries were determined, a computer-generated program (Scott, 1990) was used to divide the total rice area into 30 equal-area cells. The program then randomly selected sites located in each of the 30 cells. A field inventory of the potential sites was conducted to determine the approximate percentage of rice farmland within a 500-1,640 ft radius of each site. The Louisiana State University Agricultural Center's Rice Research Station in Crowley, La., then was contacted and asked to provide a list of landowners and rice farmers at or near the 30 sites. Letters were delivered to the landowners and rice farmers explaining the study and requesting permission to drill, install, and sample a well at that site. In a few cases, permission was not obtained to drill a well near the selected point; therefore, the search was expanded to nearby areas within the cell. A total of 27 wells were drilled in the rice-growing area in southwestern Louisiana (fig. 3).

Well Installation and Development

Shallow wells were drilled and installed by USGS personnel using a drill rig. The 27 wells installed in the rice-growing area were drilled between April and October 1999 using hollow-stem augers. All wells were constructed according to NAWQA guidelines described in Lapham and others (1997) and according to Louisiana State regulations (Louisiana Department of Environmental Quality and Louisiana Department of Transportation and Development, 2000). All wells were constructed using 2-inch outsidediameter polyvinyl chloride (PVC) flush, threaded casing and screens. Annular spaces around the well screens were sand packed, and then the annular spaces above the screened intervals were sealed with bentonite and filled with cement to land surface to prevent downward migration of surficial fluids. Cuttings formed during the drilling process were inspected visually by USGS personnel to describe the lithology at each drill site. Drilling equipment was pressure washed and steam cleaned before being moved to the next drilling site to prevent potential cross contamination between wells.

After installation, all wells were developed using a combination of pumping and surging to remove as much sediment as possible. The developing tools consisted of an electrically operated pump, 5/8-inch high-density polyethylene (HDPE) tubing, a PVC foot valve, and a PVC surge block. The tubing, foot valve, and surge block were dedicated to individual wells to prevent possible cross contamination. Wells were developed until the discharged water cleared. Development times ranged from about 2 hours to as many as 15 hours depending on the lithology and hydrologic properties of the screened interval.

Well-Construction Data and Measurement of Water Levels

Construction data for the 27 wells installed and sampled for this study are shown in table 1. The wells ranged in depth from 12.25 to 92 ft below land surface and had a median depth of 26 ft. Water levels ranged from 0.57 to 80.19 ft below land surface. Borehole lithology was determined from visual inspection of drill cuttings obtained from above the screened water-bearing sediment. Interlayering and changes in sediment size occurred on scales ranging from inches to tens of feet. Sediment sizes consisted of clay, silt, sand, and some gravel. Borehole lithology generally indicated an increase in coarse sediments in the northern part of the study area and an increase in coarse sediments with depth.

Sample Collection and Analysis

The 27 wells installed for this study were sampled from January through September 2000. All wells were sampled using a portable, stainless-steel submersible pump attached to a Teflon discharge line and Teflon-coated powerlines with stainless-steel fittings. Ground-water samples were collected and processed according to parts-per-billion-level protocols described in Koterba and others (1995). To minimize the risk of sample contamination, all sample collection and preservation took place in environmental chambers that consisted of clear polyethylene bags supported by a PVC frame that were dedicated for use at individual wells. The polyethylene bags that formed the sample-collection and -preservation chambers were replaced between each sample-collection site. After all samples were collected at a sample-collection site, sampling equipment was cleaned thoroughly using a progression of nonphosphate detergent wash, tap-water rinse, and deionized-water rinse. A final methanol rinse was used to clean the pesticide sampling equipment. All sampling equipment was stored in clean plastic bags or containers between sample-collection sites.

Table 1. Site information and well-construction data for selected shallow wells in the rice-growing area in southwestern Louisiana, 1999-2000

[ACAD, Acadian-Pontchartrain Study Unit of the National Water-Quality Assessment Program; DOTD, Department of Transportation and Development; USGS, U.S. Geological Survey; NGVD 29, National Geodetic Vertical Datum of 1929; P, plastic; 112CHCT, Chicot aquifer, undifferentiated; 112CHCTC, Chicot aquifer system surficial confining unit; 112CHCTS, Chicot aquifer, shallow sand unit]

ACAD well number	DOTD local well number	USGS site identification number	Date well constructed	Water-level measurement and sample date	Land-surface elevation above NGVD 29 (feet)	Casing material	Aquifer code	Well depth (feet)	Casing diameter (inches)	Water level (feet below land surface)	Depth to top of screen (feet)	Depth to bottom of screen (feet)	Sample depth (feet)
1	AL-5475Z	303839092435101	08-03-99	05-02-00	82	P	112CHCT	78.5	2	66.10	68.5	78.5	68
2	EV-5477Z	303741092213901	08-17-99	01-27-00	56	P	112CHCTC	25	2	4.20	14.5	24.5	14
3	AL-5477Z	302927092490001	08-04-99	05-25-00	46	P	112CHCT	68	2	55.21	58	68	60
4	EV-5482Z	302952092325501	08-04-99	01-26-00	46	P	112CHCTS	20	2	3.11	14.5	19.5	14
5	JD-6843Z	302220092570201	08-02-99	01-11-00	27	P	112CHCTC	35.5	2	2.17	30	35	29
6	JD-6844Z	302246092400101	08-19-99	01-25-00	36	P	112CHCTS	21	2	12.53	15.5	20.5	15
7	JD-6834Z	301451092541401	06-08-99	01-12-00	20	P	112CHCTC	26	2	15.59	20.5	25.5	20
8	AC-7869Z	301444092211501	05-04-99	01-13-00	24	P	112CHCTC	37.6	2	24.56	32.1	37.1	27
9	JD-6845Z	301003092561301	08-10-99	01-18-00	10	P	112CHCTC	31	2	8.28	25.5	30.2	25
10	AC-7977Z	300659092352901	10-18-99	02-09-00	5	P	112CHCTC	29.9	2	4.92	19.4	29.4	19
11	VE-10210Z	295531092132001	08-11-99	05-23-00	6	P	112CHCTC	24	2	20.15	18.5	23.5	22
13	EV-5470Z	304121092293301	05-05-99	02-15-00	60	P	112CHCTC	19	2	8.98	13.5	18.5	13
14	EV-5486Z	303616092331801	10-19-99	02-16-00	44	P	112CHCTS	21.8	2	11.02	16.3	21.3	16
15	AL-5479Z	303127092404801	08-18-99	05-11-00	53	P	112CHCT	92	2	80.19	82	92	83
16	SL-6706Z	303237092105501	04-29-99	02-01-00	59	P	112CHCTC	21.5	2	0.57	16	21	16
17	AC-7934Z	302821092171001	08-05-99	02-03-00	50	P	112CHCTC	27	2	2.50	21.5	26.5	21
18	JD-6909Z	302448092510501	10-05-99	05-09-00	40	P	112CHCTS	86	2	65.69	76	86	75
19	AC-7935Z	302132092234401	08-12-99	01-19-00	36	P	112CHCTC	26.5	2	4.61	16	26	15
21	JD-6835Z	301525092425701	06-09-99	05-10-00	22	P	112CHCTC	23	2	13.68	18	23	17
22	AC-7936Z	301906092272401	08-17-99	01-09-00	32	P	112CHCTC	30	2	9.87	19.5	29.5	19
23	AC-7976Z	301042092211101	09-09-99	02-17-00	21	P	112CHCTC	23.7	2	6.48	13.2	23.2	12
24	JD-6846Z	300626092462901	08-25-99	09-21-00	16	P	112CHCTS	74	2	60.10	64	74	63
25	AC-7938Z	300614092233001	08-11-99	02-10-00	17	P	112CHCTC	21	2	4.23	15.5	20.5	15
26	CN-5863Z	300216093042301	05-13-99	01-10-00	8	P	112CHCTS	12.25	2	2.93	6.75	11.75	6
27	VE-10211Z	295932092284401	08-10-99	02-08-00	7	P	112CHCTC	25.5	2	3.69	20	25	20
28	JD-6847Z	301737093010301	08-09-99	01-11-00	27	P	112CHCTC	25	2	7.34	19.5	24.5	19
30	BE-6230Z	302723093144201	05-27-99	09-28-00	70	P	112CHCTC	53	2	39.22	42.5	52.5	43

Before sample collection, the wells were purged of three casing volumes to remove stagnant water so that a sample representative of ground water in the aquifer could be obtained. After the stagnant water was removed, specific conductance, pH, temperature, and dissolved oxygen were measured about every 5 minutes in a flow-through chamber until stable readings were obtained. Turbidity also was measured using a portable turbidity meter. After stable readings were obtained for the physical properties, water was redirected to the clean sampling chamber where whole water and filtered samples were collected immediately. Whole water samples were analyzed for total constituents. Filtered samples were obtained by passing whole water through a 0.45-micrometer filter into the appropriate bottle. Filtered water was analyzed for dissolved constituents. Most ground-water samples were chilled and shipped to the USGS's National Water Quality Laboratory (NWQL) in Lakewood, Colo., for analysis. CFC and selected stable-isotope samples were analyzed at the USGS Laboratory in Reston, Va. Methods used to analyze the water samples are given in table 2.

Quality-Control Data Analysis

Quality-control (QC) data were collected to test sample-collection, sample-processing, and laboratory-analysis procedures. QC samples collected included field-blank samples, replicate environmental samples, and field- and laboratory-spiked samples (Mueller and others, 1997). Field-blank samples were collected to verify that cleaning procedures were sufficient and that collection and analysis procedures did not contaminate the samples. Replicate environmental samples were collected to assess the effects of sample-collection and laboratory-analysis procedures on measurement variability. The spiked samples (field and laboratory) were environmental samples that were injected with a known concentration of the analyte(s) of interest to determine the accuracy and precision of organic analyses, the stability of analytes during typical holding times, and whether characteristics of the environmental samples might interfere with the analysis of the analytes.

Field-blank samples were collected and analyzed at three wells for concentrations of major inorganic ions, trace elements, nutrients, DOC, and

Table 2. Methods used to analyze ground-water samples from selected shallow wells in the rice-growing area in southwestern Louisiana

[AA, Atomic absorption spectrometry; IC, Ion-exchange chromatography; ICP, Inductively-coupled plasma; MS, mass spectrometry; UV, ultraviolet; C, carbon; ECD, electron capture detector; ^{2}H, deuterium; ^{1}H, hydrogen; ^{18}O, oxygen-18; ^{16}O, oxygen-16]

Constituent	Analytical method	Reference
Major inorganic ions	AA, Colorimetry, or ICP	Fishman and Friedman (1989) and Fishman (1993)
Trace elements	AA or ICP-MS	Faires (1993), Garbarino (1999), and McLain (1993)
Nutrients	Colorimetry	Fishman (1993), Patton and Truitt (2000), and U.S. Environmental Protection Agency (1993)
Dissolved organic carbon	UV-persulfate oxidation and infrared spectrometry	Brenton and Arnett (1993)
Pesticides and degradation products	Solid-phase extraction using a C-18 cartridge and gas chromatography/mass spectrometry	Zaugg and others (1995)
	Determination of low concentrations of acetochlor in water by automated solid-phase extration and gas chromatography with mass selective detetection	Lindley and others (1996)
	Graphitized carbon-based solid-phase extraction and high-performance liquid chromatography/mass spectrometry	Furlong and others (2001)
Volatile organic compounds	Purge and trap capillary gas chromatography/mass spectrometry	Rose and Schroeder (1995)
Radon	Liquid scintillation	American Society for Testing and Materials (1996)
Chlorofluorocarbons	Gas chromatography with electron capture detector	Busenberg and Plummer (1992)
$^{2}H/^{1}H$	Hydrogen equilibrium and mass spectrometry	Coplen and others (1991)
$^{18}O/^{16}O$	Carbon dioxide equilibrium and mass spectrometry	Epstein and Mayeda (1953)

pesticides. The source solution for the field-blank samples was organic-free or inorganic-free water passed through all sampling equipment in the field and placed in the appropriate bottles. Few water-quality constituents analyzed for were detected in the field-blank samples. Major inorganic ion and DOC concentrations were less than the analytical reporting limits and most trace-element concentrations were at or less than the analytical reporting limits. Copper concentrations in two field-blank samples were 3.1 and 3.9 μg/L, slightly greater than the analytical reporting limits and greater than the concentrations in most of the environmental samples. No nutrients or pesticides were detected in the field-blank samples. Results of the field-blank sample analyses indicated cleaning procedures were adequate to prevent onsite and site-to-site contamination.

Replicate environmental samples were collected at four wells and analyzed for concentrations of all constituents. The relative percent difference between the environmental sample and the corresponding replicate sample was calculated by multiplying 100 times the absolute value of the difference in replicate concentrations and dividing by the summation of replicate concentrations. The relative percent difference between the environmental samples and the corresponding replicate samples was less than 5 percent for all constituents except potassium (6 percent), fluoride (8 percent), bromide (13 percent), nitrogen as ammonia (6 percent), and nitrogen as ammonia plus organic nitrogen (8 percent). Results of the replicate environmental sample analyses indicated an acceptable degree of laboratory precision and data collection reproducibility.

Field- and laboratory-spiked samples were collected from one well that best represented the average water conditions for all wells. Spike solutions that contained known amounts of pesticides were added to two replicate environmental samples in the field and to two environmental samples at the NWQL. The field-spiked samples were evaluated for 47 compounds, and the laboratory-spiked samples were evaluated for 107 compounds. Mean recovery of pesticides from the field-spiked and field-spiked replicate samples ranged from 63 to 104 percent. Mean recovery of pesticides from the laboratory-spiked and laboratory-spiked replicate samples was within the NWQL control limits. Results of the spiked-sample analyses indicated sampling and analysis procedures adequately detected the pesticides analyzed for and no major matrix interferences existed.

QUALITY OF WATER FROM SHALLOW WELLS IN THE RICE-GROWING AREA

The quality of water from the 27 shallow wells screened in the Chicot aquifer or surficial confining unit in the rice-growing area is presented in this section. The water-quality data are grouped by type (appendixes 1-7, at the back of the report): general ground-water properties; dissolved solids and major inorganic ions; trace elements; nutrients and DOC; pesticides and pesticide degradation products; and radon, CFCs, and selected stable isotopes.

The ground-water quality is discussed in the following sections in relation to USEPA drinking-water standards established for physical properties and chemical constituents that might have adverse effects on human health or affect the odor, appearance, or desirability of water (U.S. Environmental Protection Agency, 2002b). Although the shallow wells installed for this study are not used for a drinking-water source, concentrations of selected ground-water constituents in the water were compared to the USEPA Maximum Contaminant Levels (MCLs) and Secondary Maximum Contaminant Levels (SMCLs) to provide a frame of reference. An MCL is the maximum permissible level for a contaminant in drinking water that is delivered to any user of a public-water system, and an SMCL is a nonenforceable Federal guideline regarding aesthetic effects, such as taste or odor of drinking water, or cosmetic effects, such as tooth or skin coloration, caused by drinking water.

General Ground-Water Properties

Data for seven general ground-water properties (specific conductance, pH, air and water temperature, turbidity, dissolved oxygen, and alkalinity) were collected (appendix 1, at the back of the report). Measurements of the properties were made at the time of sample collection. The data were used to estimate ground-water conditions, such as clarity, redox state, acidity, salt content, and buffering capacity, at the time of sample collection.

A statistical summary for the ground-water properties is listed in table 3 along with applicable water-quality standards. The median value for specific conductance was 1,020 μS/cm, and values ranged from 227 to 3,160 μS/cm. The SMCL for pH is 6.5 to 8.5 standard units (U.S. Environmental Protection Agency, 2002b). Values for 5 of the 27 wells sampled were less than 6.5 standard units. The median value for turbidity was 2.0 NTU, and values for nine wells exceeded the MCL of 5.0 NTU (U.S. Environmental Protection Agency, 2002b). Dissolved oxygen concentrations were less than 1.0 mg/L in water from

Table 3. Summary statistics for general ground-water properties, dissolved solids, major inorganic ions, trace elements, nutrients, and dissolved organic carbon in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000

[Concentrations are dissolved unless noted. MCL, Maximum Contaminant Level; SMCL, Secondary Maximum Contaminant Level; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; ---, no value available; NTU, nephelometric turbidity units; mg/L, milligrams per liter; E, estimated; µg/L, micrograms per liter; ND, not detected; <, less than]

Property or constituent	Number of detections/ number of samples	Analytical reporting level	Median of all samples	Minimum detection	Maximum detection	Federal guideline or standard[a]		Number of values or concentrations exceeding drinking-water standard
						MCL	SMCL	
General ground-water properties								
Specific conductance, 25°C, in µS/cm	27/27	1	1,020	227	3,160	---	---	---
pH, in standard units	27/27	0.1	7.1	6.1	7.4	---	6.5-8.5	[b]5
Air temperature, in °C	27/27	1	21.0	9.0	33.0	---	---	---
Water temperature, in °C	27/27	0.1	21.5	17.0	27.1	---	---	---
Turbidity, in NTU	27/27	1.0	2.0	0	110	5.0	---	9
Dissolved oxygen, in mg/L	26/26	0.1	1.4	0.5	3.2	---	---	---
Alkalinity as $CaCO_3$, in mg/L	27/27	1	320	39	550	---	---	---
Dissolved solids and major inorganic ions, in mg/L								
Dissolved solids, residue on evaporation, 180°C	27/27	10	578	180	1,850	---	500	17
Calcium, as Ca	27/27	0.01	71	8.2	140	---	---	---
Magnesium, as Mg	27/27	0.01	30	3.8	61	---	---	---
Sodium, as Na	27/27	0.10	93	20	410	---	---	---
Potassium, as K	27/27	0.1	1.3	0.6	3.9	---	---	---
Bicarbonate, (calculated)	27/27	1	388	48	666	---	---	---
Sulfate, as SO_4	27/27	0.30	16	E0.3	270	---	250	1
Chloride, as Cl	27/27	0.30	120	12	830	---	250	7
Fluoride, as F	25/27	0.1	0.4	0.1	0.7	4.0	2.0	0
Bromide, as Br	27/27	0.03	0.4	0.1	2.2	---	---	---
Silica, as SiO_2	27/27	0.13	28	20	74	---	---	---
Trace elements, in µg/L								
Aluminum, as Al	14/27	1.0	1	1	20	---	50-200	0
Antimony, as Sb	0/27	0.048	ND	ND	ND	6	---	0
Arsenic, as As	12/27	0.18	3	E1	4	10	---	0
Barium, as Ba	27/27	1.0	220	16	850	2,000	---	0
Beryllium, as Be	0/27	0.06	ND	ND	ND	4	---	0
Boron, as B	11/11	7.0	30	10	60	---	---	---
Cadmium, as Cd	0/27	0.037	ND	ND	ND	5	---	0
Chromium, as Cr	11/27	0.8	1	E1	2	[c]100	---	0
Cobalt, as Co	5/27	0.015	1.5	1.1	3.4	---	---	---
Copper, as Cu	10/27	0.23	3.5	1	11	[d]1,300	1,000	0
Iron, as Fe	16/27	10	ND	10	6,500	---	300	3
Lead, as Pb	0/27	0.08	ND	ND	ND	15	---	0

Table 3. Summary statistics for general ground-water properties, dissolved solids, major inorganic ions, trace elements, nutrients, and dissolved organic carbon in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000--Continued

Property or constituent	Number of detections/ number of samples	Analytical reporting level	Median of all samples	Minimum detection	Maximum detection	Federal guideline or standard[a]		Number of values or concen-trations exceeding drinking-water standard
						MCL	SMCL	
Trace elements, in μg/L (continued)								
Lithium, as Li	11/11	0.30	20	0	60	---	---	---
Manganese, as Mn	25/27	2.2	100	E2	740	---	50	15
Mercury, as Hg[d]	1/26	0.011	<0.3	E0.2	E0.2	2	---	0
Molybdenum, as Mo	15/27	0.2	3	1	9	---	---	---
Nickel, as Ni	23/27	0.06	3	1	8	---	---	---
Selenium, as Se	8/27	0.33	6	1	29	50	---	---
Silver, as Ag	0/27	1.0	ND	ND	ND	---	100	0
Strontium, as Sr	11/11	0.08	180	20	430	---	---	---
Thallium, as Tl	0/11	0.041	ND	ND	ND	2	---	0
Uranium, as U	16/27	0.018	5.2	1.8	16	[e]20	---	0
Vanadium, as V	8/11	0.21	3.5	1.2	6.7	---	---	---
Zinc, as Zn	14/27	1.0	2	1	6	---	5,000	0
Nutrients and dissolved organic carbon, in mg/L								
Ammonia, as N	14/27	0.041	0.04	0.02	0.84	---	---	---
Ammonia plus organic nitrogen, as N	14/27	0.10	E0.06	E0.06	0.99	---	---	---
Nitrite plus nitrate, as N	13/27	0.047	0.87	0.05	13	10	---	1
Nitrite, as N	0/27	0.008	---	---	---	1.0	---	---
Phosphorus, as P	26/27	0.0044	0.05	E0.01	0.48	---	---	---
Orthophosphorus, as P	25/27	0.018	0.05	0.02	0.45	---	---	---
Dissolved organic carbon, as C	24/26	0.33	E0.5	E0.2	1.4	---	---	---

[a] U.S. Environmental Protection Agency, 2002b.

[b] Number of values less than 6.5 standard units.

[c] Total concentration.

[d] U.S. Environmental Protection Agency Maximum Contaminant Level Goal (MCLG).

[e] Under review.

10 of the 26 wells sampled and ranged from 0.5 to 3.2 mg/L (appendix 1, at the back of the report). The alkalinity, as $CaCO_3$, of the water ranged from 39 to 550 mg/L. Values for pH, specific conductance, and alkalinity were typical for the Chicot aquifer (Nyman, 1989).

Dissolved Solids and Major Inorganic Ions

The dissolved-solids and major inorganic ion concentrations for the 27 wells sampled are listed in appendix 2 (at the back of the report). A statistical summary for the dissolved solids and major inorganic ions is listed in table 3 with applicable water-quality standards. Dissolved solids are an important indicator of water quality and, in uncontaminated ground water, are the result of natural dissolution of rocks and minerals. Dissolved solids also are an important indicator of the suitability of water for drinking, irrigation, and industrial use. The dissolved-solids concentrations for the 27 wells sampled ranged from 180 to 1,850 mg/L and had a median of 578 mg/L, slightly greater than the 500-mg/L SMCL (U.S. Environmental Protection Agency, 2002b). Water from 17 wells had dissolved-solids concentrations that were greater than the SMCL. Although ground water containing more than 500 mg/L dissolved solids is undesirable for drinking water and irrigation, it is used in many areas where less-mineralized water is not available.

Major inorganic ions were the primary constituents of dissolved solids in water from the 27 wells (appendix 2, at the back of the report). The major inorganic ions consisted of the positively charged cations--calcium, magnesium, sodium, and potassium; the negatively charged anions--bicarbonate, sulfate, chloride, fluoride, and bromide; and one uncharged ion--silica. The 250-mg/L SMCL for sulfate (U.S. Environmental Protection Agency, 2000b) was exceeded in water from one well, and the 250-mg/L SMCL for chloride was exceeded in water from seven wells (table 3).

Water types were classified by the percentages of major inorganic ions in the water. Because the potassium concentrations were low, those concentrations were added to the sodium concentrations before the water types were classified. Water types were classified as mixed cation mixed anion (18 wells), mixed cation bicarbonate (5 wells), mixed cation chloride (2 wells), and sodium mixed anion (2 wells). Mixed cation types had two or more cations for which the percent of each was greater than 20 percent of the total cations. Mixed anion types had two or more anions for which the percent of each was greater than 20 percent of the total anions. The mineral ratios (percentages), in milliequivalents per liter, of the cations (calcium, magnesium, and sodium plus potassium) and anions (bicarbonate, sulfate, and chloride plus fluoride) are shown in figure 4 (Hem, 1985). Sodium was the highest percentage cation in 20 wells, calcium was the highest in 6 wells, and magnesium was the highest in 1 well. Bicarbonate was the highest percentage anion in 20 wells, and chloride was the highest in 7 wells. Sulfate concentrations were low in most of the ground-water samples. The highest percentage cation and the highest percentage anion for each well are shown in figure 5. The many different water types in the study area reflect the high degree of lithologic variation in the shallow sediments of southwestern Louisiana.

Trace Elements

The trace-element concentrations in water from the 27 wells sampled are listed in appendix 3 (at the back of the report). A statistical summary for the trace elements is listed in table 3 with 16 established and 2 proposed USEPA drinking-water standards. Trace elements occur naturally in water at concentrations of less than 1,000 mg/L (Drever, 1988, p. 326). Most of the trace elements detected in ground water are metals or semimetallic elements produced from the weathering of minerals. Concentrations of all trace elements detected in this study, except iron, were less than 1,000 mg/L (appendix 3, at the back of the report), and most were less than the drinking-water standards. Of the 24 trace elements analyzed for, 6 (antimony, beryllium, cadmium, lead, silver, and thallium) were not detected in the ground-water samples. Barium was the only trace metal detected in water from all 27 wells. The barium concentrations ranged from 16 to 850 mg/L and had a median of 220 mg/L (table 3). All barium concentrations were less than the SMCL of 2,000 mg/L (U.S. Environmental Protection Agency, 2002b). The maximum iron concentration was 6,500 mg/L, and concentrations for three wells exceeded the SMCL of 300 mg/L (U.S. Environmental Protection Agency, 2002b). Manganese concentrations for 15 wells exceeded the SMCL of 50 mg/L, and the maximum concentration was 740 mg/L. Mercury was detected in water from one well, and the estimated concentration for that well was 0.2 mg/L.

Nutrients

The nutrient concentrations in water from the 27 wells sampled are listed in appendix 4 (at the back of the report). A statistical summary for the nutrients is listed in table 3 with applicable water-quality standards. Nutrients are nitrogen- or phosphorus-containing compounds that are necessary for plant growth and important for animal nutrition (Mueller and others, 1995). Although these compounds do occur naturally, concentrations in ground or surface water can be increased through human activities such as fertilizer applications, sewerage and septic effluent,

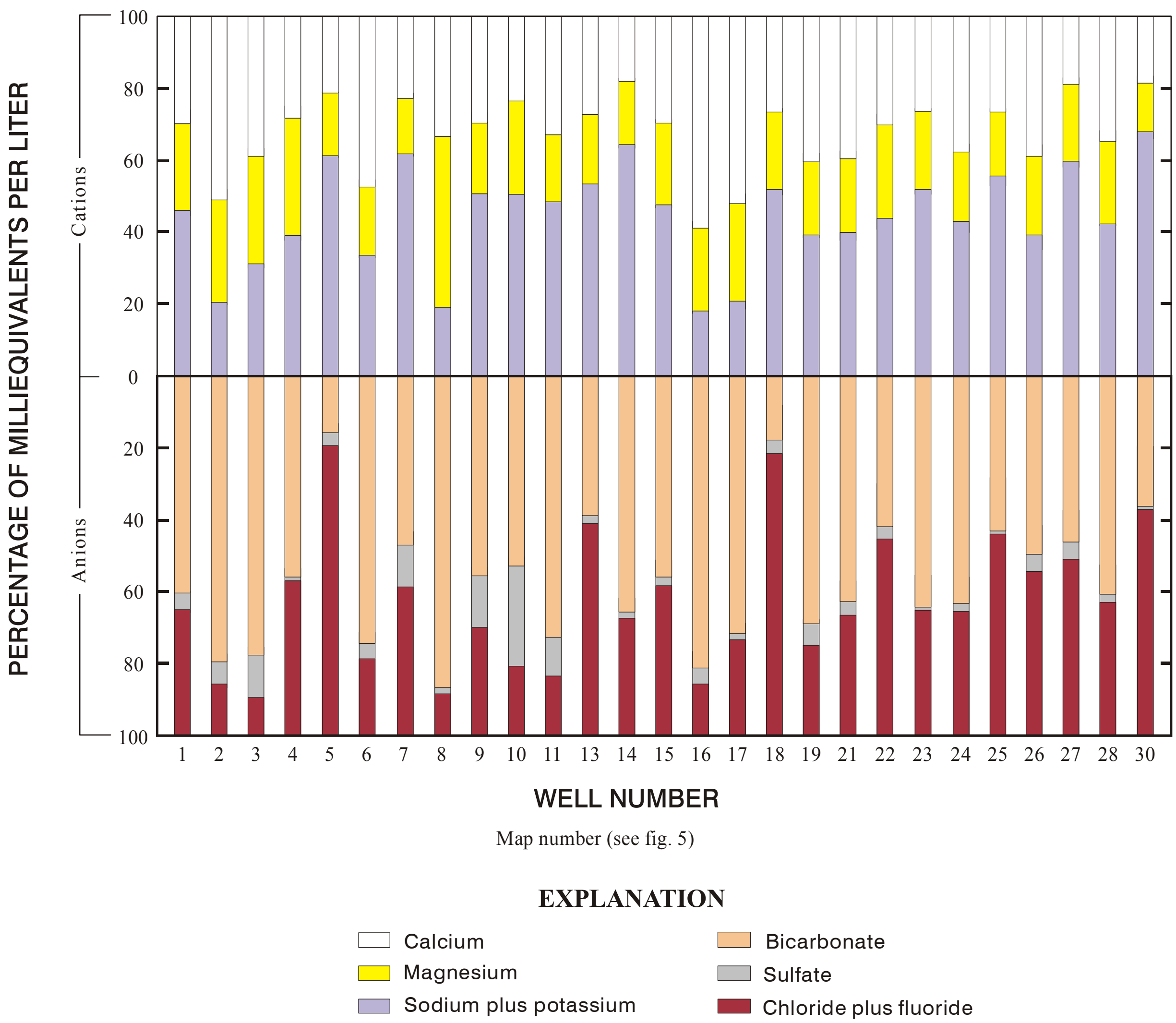


Figure 4. Percentages of major inorganic ions in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000.

and atmospheric deposition from industrial emissions. Excessive nutrient concentrations may cause adverse human-health effects, such as methemoglobinemia (blue baby syndrome) (Hem, 1985, p. 125), and excessive nitrogen and phosphorus concentrations may cause adverse environmental effects, such as eutrophication of surface-water bodies (Hem, 1985, p. 126-128). Nitrite and nitrate concentrations in uncontaminated water usually are relatively small (generally less than 2 mg/L), and larger concentrations of several milligrams per liter indicate possible contamination from human activities (Mueller and Helsel, 1996).

Nutrient concentrations for three wells were greater than 2 mg/L (appendix 4, at the back of the report). Ammonia and ammonia plus organic nitrogen each were detected in water from 14 (52 percent) of the 27 wells sampled. Ammonia concentrations ranged from 0.02 to 0.84 mg/L. The median ammonia plus organic nitrogen concentration was an estimated 0.06 mg/L (table 3). The nitrite plus nitrate concentration for one well was 13 mg/L which exceeded the MCL of 10 mg/L (U.S. Environmental Protection Agency, 2002b), and was the only nutrient concentration that was greater than the drinking-water standard. The nitrite concentration for the same well was less than 0.01 mg/L (appendix 4, at the back of the report), so all of the nitrite plus nitrate was assumed to be nitrate. The elevated nitrate concentration can be attributed to a previous land use in the area (chicken and pig yard), and, thus, may not be attributed to rice-growing practices. Nitrite was not detected in any of the ground-water samples. Phosphorus and orthophosphorus concentrations ranged from 0.01 mg/L (an estimated value) to 0.48 mg/L and had medians of 0.05 mg/L (table 3).

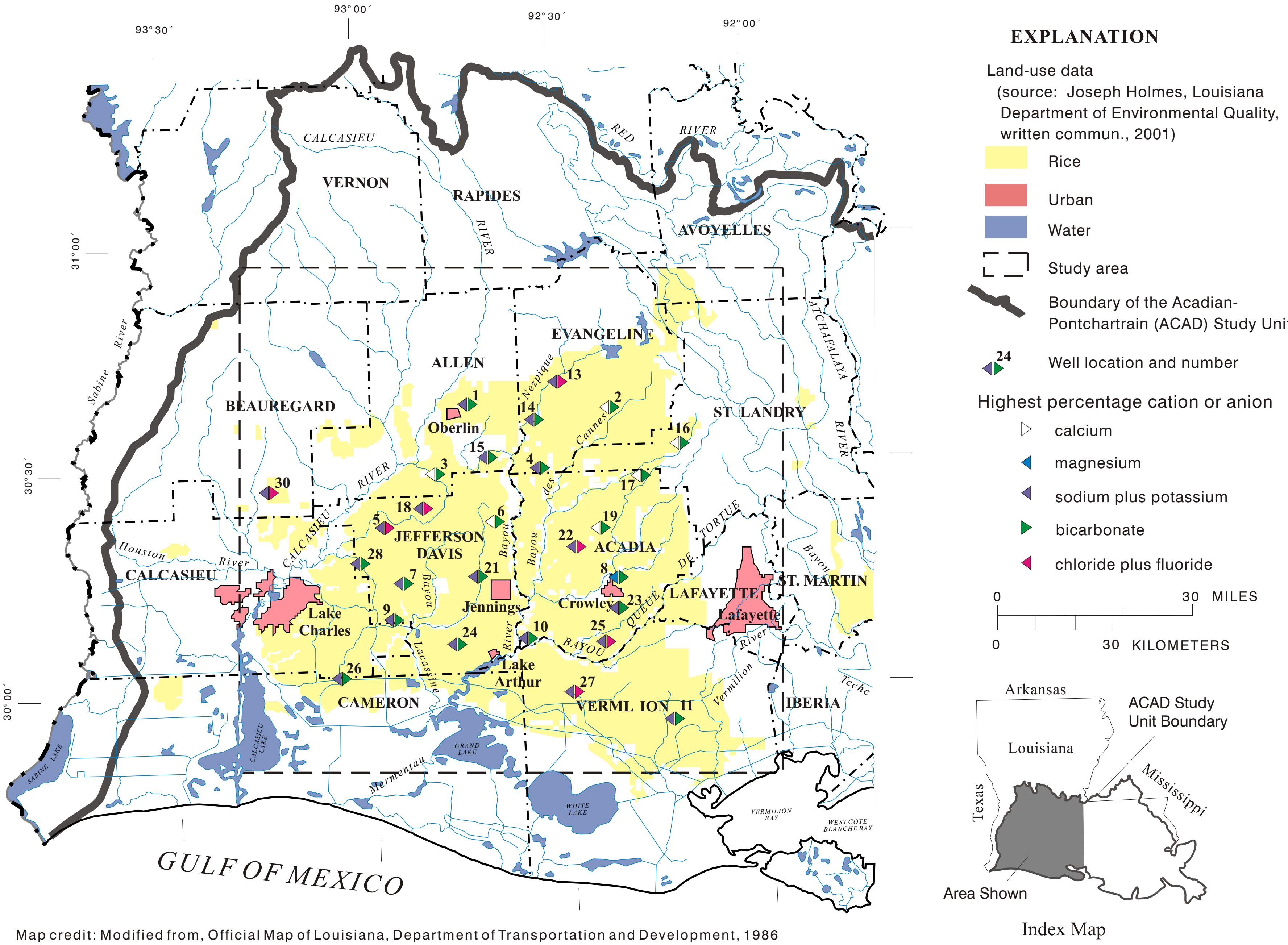


Figure 5. Highest percentage cations and anions in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000.

Dissolved Organic Carbon

The amount of organic carbon present in ground water can have a substantial effect on microbial communities in an aquifer and, in turn, affect the concentration of redox-sensitive species such as dissolved oxygen, trace elements, and nutrients. DOC was measured for 26 wells, and all concentrations were less than or equal to 1.4 mg/L (appendix 4, at the back of the report). DOC concentrations ranged from 0.2 mg/L (an estimated value) to 1.4 mg/L and had an estimated median of 0.5 mg/L (table 3). According to Drever (1997, p. 107), DOC concentrations of about 0.5 mg/L typically occur naturally in ground water, and concentrations can increase with human activity. The median concentration of 0.5 mg/L in water from wells in this study probably indicates naturally-occurring DOC conditions.

Pesticides

Pesticides are chemicals used to control unwanted vegetation, insects, and fungi. They are applied primarily to cropland in rural areas but also are used on lawns, gardens, and rights-of-way. The widespread use of pesticides creates the potential for the movement of pesticides or their degradation products into shallow ground water. The presence of pesticides in ground water indicates an impact from human activities on ground-water quality and is a human-health concern for those using ground water as a drinking-water supply.

Pesticides were detected in water from 14 of the 27 wells sampled (fig. 6). One compound was detected in water from eight wells, and two compounds were detected in water from three wells. Water from the remaining three wells had three, four, or six detected compounds. The maximum concentration for the pesticides and pesticide degradation products was an estimated value of 0.704 μg/L (imazaquin), and all concentrations were less than the drinking-water standards (U.S. Environmental Protection Agency, 2002b). Of the 92 pesticides analyzed for (appendix 5, at the back of the report), 13 were detected in the ground-water samples; and, of the 17 degradation products analyzed for (appendix 6, at the back of the report), 7 were detected in the ground-water samples (fig. 7). Of the pesticides detected, four commonly were used on rice crops in the study area (Dr. J.K. Saichuk, Louisiana State Cooperative Extension Service, oral commun., 2000). Bentazon, 2,4-D, and molinate (three rice herbicides) were detected in water from four, one, and one wells, respectively, and malathion (a rice insecticide) was detected in water from one well. Two rice insecticide degradation products (fipronil RPA and fipronil sulfone) were detected in water from one well (well 26), but no concentrations of these fipronil degradation products were detected upon resampling. Only two insecticides (diazinon and malathion), one herbicide (atrazine), one herbicide degradation product [3 (4-chlorophenyl)-1-methyl urea], and one insecticide degradation product (fipronil sulfone) had concentrations that were greater than estimated values. Of the 20 compounds detected, only four--bentazon, imazaquin, *p,p'*-DDE, and deethyldeisopropylatrazine--were detected in water from more than one well. Bentazon, which was detected in 4 (15 percent) of the 27 wells sampled, was the most frequently detected pesticide and had an estimated maximum concentration of 0.15 μg/L (table 4).

In water from one well (well 11), the concentration of atrazine (0.008 μg/L) was slightly greater than the concentration of deethylatrazine (estimated 0.007 μg/L), one of its degradation products. A greater concentration of the parent product than of the degradation product might indicate the parent product was recently input into the environment (Townsend and Young, 1999). Concentrations of selected nutrients (nitrite plus nitrate, phosphorus, and orthophosphorus) and DOC were slightly greater in water from well 11 than in water from most of the other wells. The greater concentrations of selected nutrients, DOC, and pesticides indicated agricultural or domestic activities had an effect on the quality of water from well 11; however, all concentrations of constituents in the water from well 11 were much less than the drinking-water standards (U.S. Environmental Protection Agency, 2002b). The presence of rice and other pesticides in the shallow ground water indicates the hardpan beneath the rice fields is not preventing downward movement in all areas.

Radon

Radon is a naturally-occurring radioactive element that produces a radioactive isotope, radon-222, as a gas. Radon is a byproduct of the natural decay of uranium that is present in small quantities in certain rock and sediment types. Radon gas is soluble in water and is transported in ground water. The USEPA has an MCL for radon in ground water of 300 pCi/L for states without a Multimedia Mitigation (MMM) program and an Alternate Maximum Contaminant Level (AMCL) of 4,000 pCi/L for states with an MMM program (U.S. Environmental Protection Agency, 2002b). When radon gas is exposed to air, such as when ground water is pumped from an aquifer and used for indoor use, the radon diffuses into the air

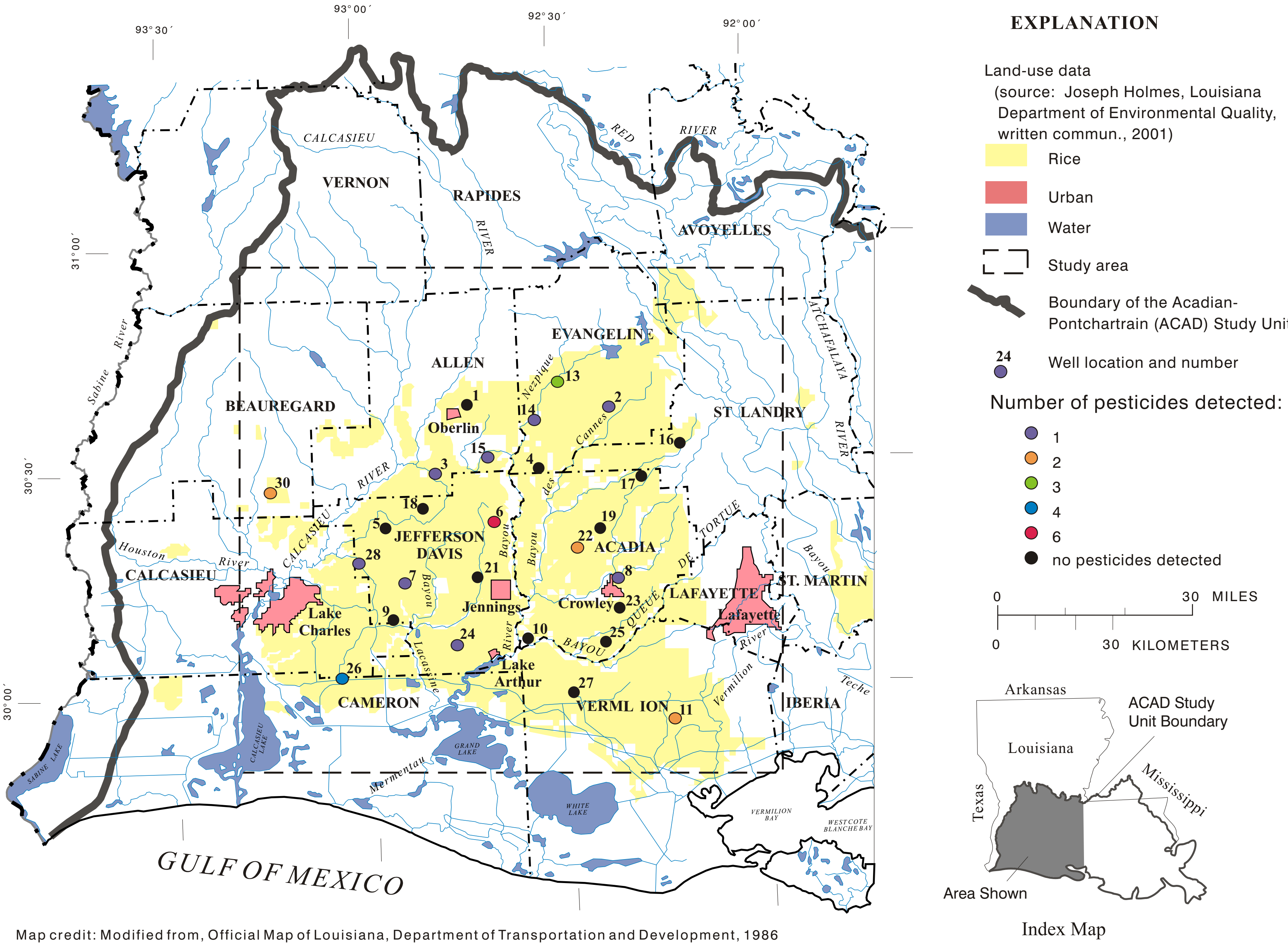


Figure 6. Number of pesticide and pesticide degradation products detected in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000.

Table 4. Concentrations of pesticide and pesticide degradation products in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000

[All concentrations are in micrograms per liter. MCL, Maximum Contaminant Level; E, estimated; ---, no value available; HA, Health Advisories established by U.S. Environmental Protection Agency]

Pesticide or pesticide degradation product	Number of detections/ number of samples	Analytical reporting level	Minimum detection	Maximum detection	Drinking-water standard	Type of standard	Number of concen-trations exceeding drinking-water standard
Atrazine	1/28	0.001	0.008	0.008	3	MCL[a]	0
Bentazon	4/28	0.02	E0.01	E0.15	---	---	---
Chlorimuronethyl	1/28	0.37	E0.008	E0.008	---	---	---
Chlorpyrifos	1/28	0.004	E0.004	E0.004	---	---	---
2,4-D	1/28	0.08	E0.01	E0.01	70	MCL[a]	0
Diazinon	1/28	0.002	0.007	0.007	---	---	---
Diuron	1/28	0.08	E0.0007	E0.0007	10	HA[a]	0
Flumetsulam	1/28	0.866	E0.0437	E0.0437	---	---	---
Imazaquin	2/28	0.103	E0.015	E0.704	---	---	---
Malathion	1/28	0.005	0.006	0.006	---	---	---
Metalaxyl	1/28	0.057	E0.005	E0.005	---	---	---
Molinate	1/28	0.004	E0.003	E0.003	---	---	---
Tebuthiuron	1/28	0.010	E0.008	E0.008	---	---	---
p,p'-DDE (DP of DDT)	2/28	0.006	E0.001	E0.002	---	---	---
Deethylatrazine (DP of atrazine)	1/28	0.002	E0.008	E0.008	---	---	---
Deethyldeisopropylatrazine (DP of atrazine)	3/28	0.06	E0.004	E0.02	---	---	---
Fipronil RPA (DP of fipronil)	1/28	0.005	E0.001	E0.001	---	---	---
Fipronil sulfone (DP of fipronil)	1/28	0.001	0.005	0.005	---	---	---
2-Hydroxyatrazine (DP of atrazine)	1/28	0.193	E0.066	E0.066	---	---	---
3 (4-chlorophenyl)-1-methyl urea (DP of neburon)	1/28	0.915	0.2056	0.2056	---	---	---

[a] U.S. Environmental Protection Agency, 2002b.

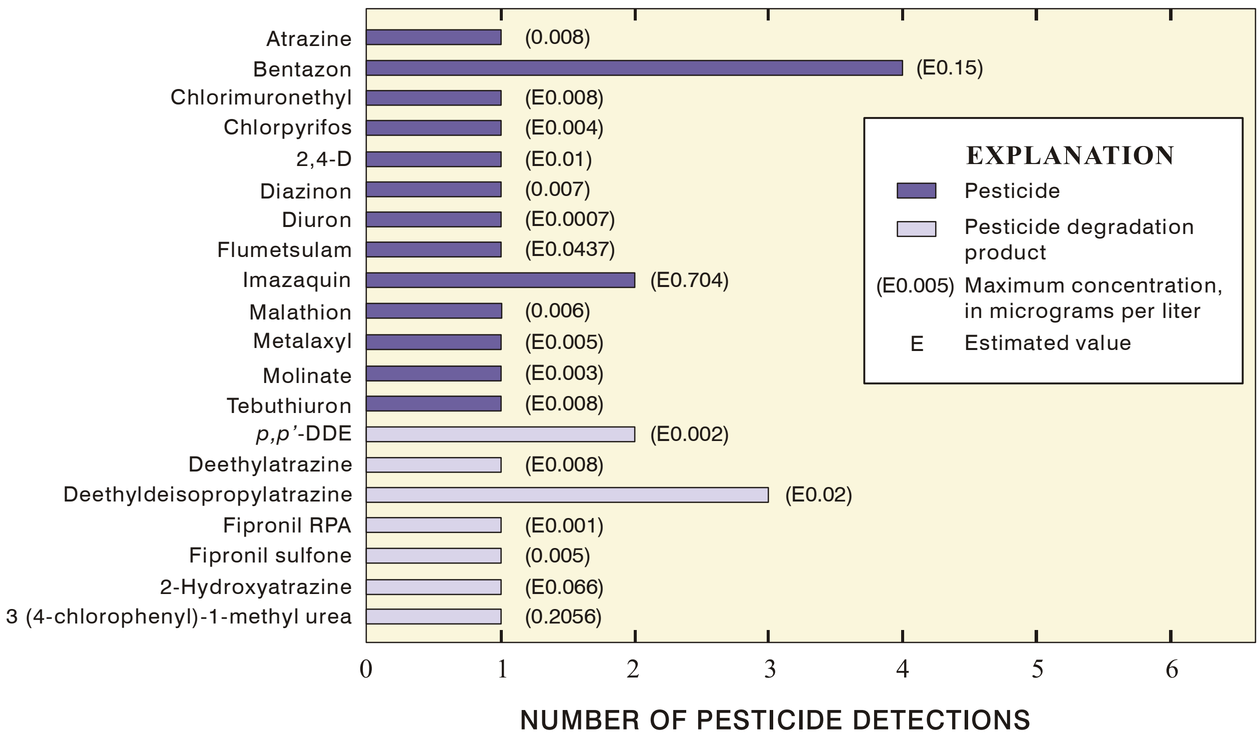


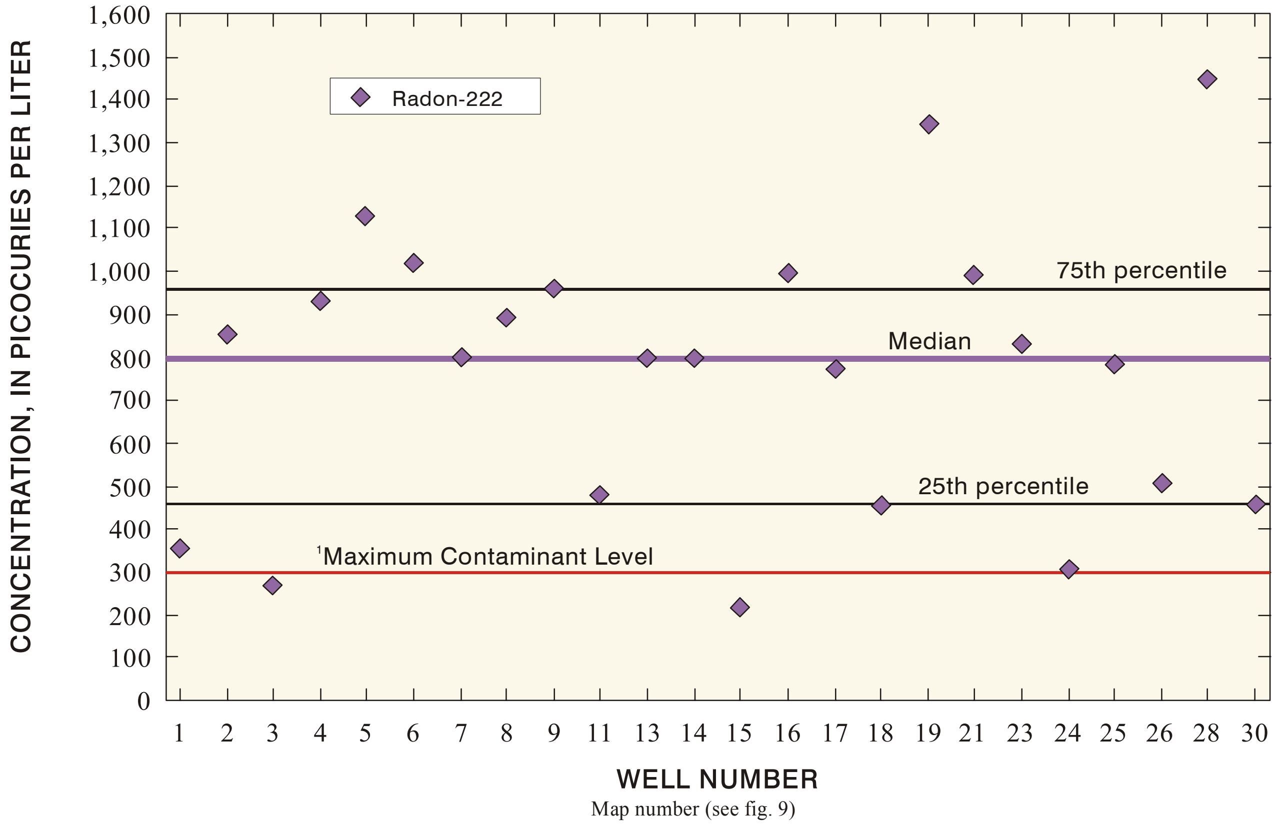
Figure 7. Frequency of pesticides and pesticide degradation products in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000.

where it can be inhaled. Only about 1 to 2 percent of radon in indoor air comes from drinking water (U.S. Environmental Protection Agency, 2002a). Although the entire State of Louisiana is classified in the lowest national risk zone, Zone 3 (Louisiana Department of Environmental Quality, 1990), for radon, a 1990 survey of Louisiana homes indicated 10 of 1,314 homes had elevated levels (greater than 4 pCi/L) of radon in the indoor air.

Radon-222 (radon) was detected in water from 24 of the 27 wells sampled (appendix 7, at the back of the report). The minimum radon concentration in the ground-water samples was 216 pCi/L, and the maximum radon concentration was 1,450 pCi/L (fig. 8). The median radon concentration was 800 pCi/L, and the 25th and 75th percentiles occurred at 456 and 961 pCi/L, respectively (fig. 8). Radon concentrations for 22 of the 24 wells were at or greater than the MCL and all were less than the AMCL (fig. 9) (U.S. Environmental Protection Agency, 2002b). The effects that the elevated radon concentrations in ground water might have on domestic and public-water supplies and on indoor air quality are unknown.

Chlorofluorocarbons (Apparent Age of Ground Water)

CFCs were used to estimate the apparent age of water in 21 of the 27 wells sampled (appendix 7). CFCs are stable, synthetic organic compounds developed in the early 1930's to replace ammonia and sulfur dioxide in the refrigeration process (Plummer and Friedman, 1999). Production of dichlorodifluoromethane (CFC-12) began in 1931 and was followed by production of trichlorofluoromethane (CFC-11) in 1936. Many other CFCs have been produced since that time. The presence of measurable concentrations of CFCs in a water sample indicates the sample contains some water that was recharged after 1940 (post-1940 water). Chemical processes, such as microbial degradation and sorption during transit, and physical processes, such as mixing with older water, can affect the concentration of CFCs; thus, the term apparent is used to qualify the age term. The apparent age of water from the 21 wells ranged from about 17 to 49 years (fig. 10) and had a median of 38 years. The apparent ages indicated the water in the 21 wells was recharged sometime since the 1940's and contaminants transported with recharge water might not be detected for several years or decades in water sampled from the wells.



[1]Source: U.S. Environmental Protection Agency, 2002b

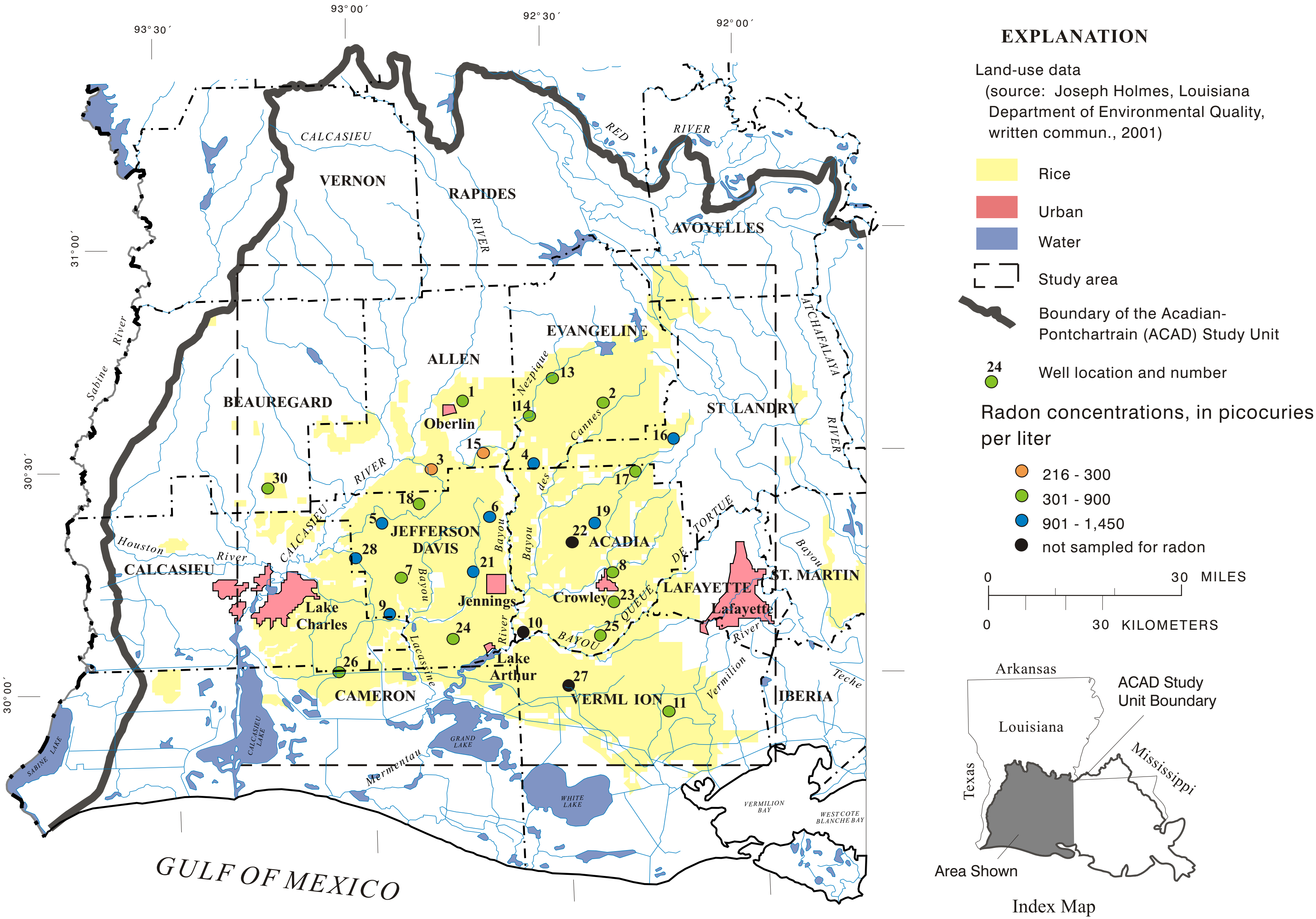
Figure 8. Radon concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01.

Stable Isotopes

Stable isotopes of hydrogen and oxygen in water molecules were used to determine the sources of shallow ground water in the rice-growing area in southwestern Louisiana. The two stable isotopes of hydrogen are ^{1}H and ^{2}H (deuterium, D), and the two stable isotopes of oxygen are ^{16}O and ^{18}O. The isotopic compositions of hydrogen and oxygen in a water sample are reported in terms of the differences of the D/H and $^{18}O/^{16}O$ ratios relative to the Vienna Standard Mean Ocean Water (VSMOW) (Faure, 1986, p. 431). A delta (δ) notation, expressed as per mil (parts per thousand), is used to describe the relation of the abundance of a particular isotope to the standard.

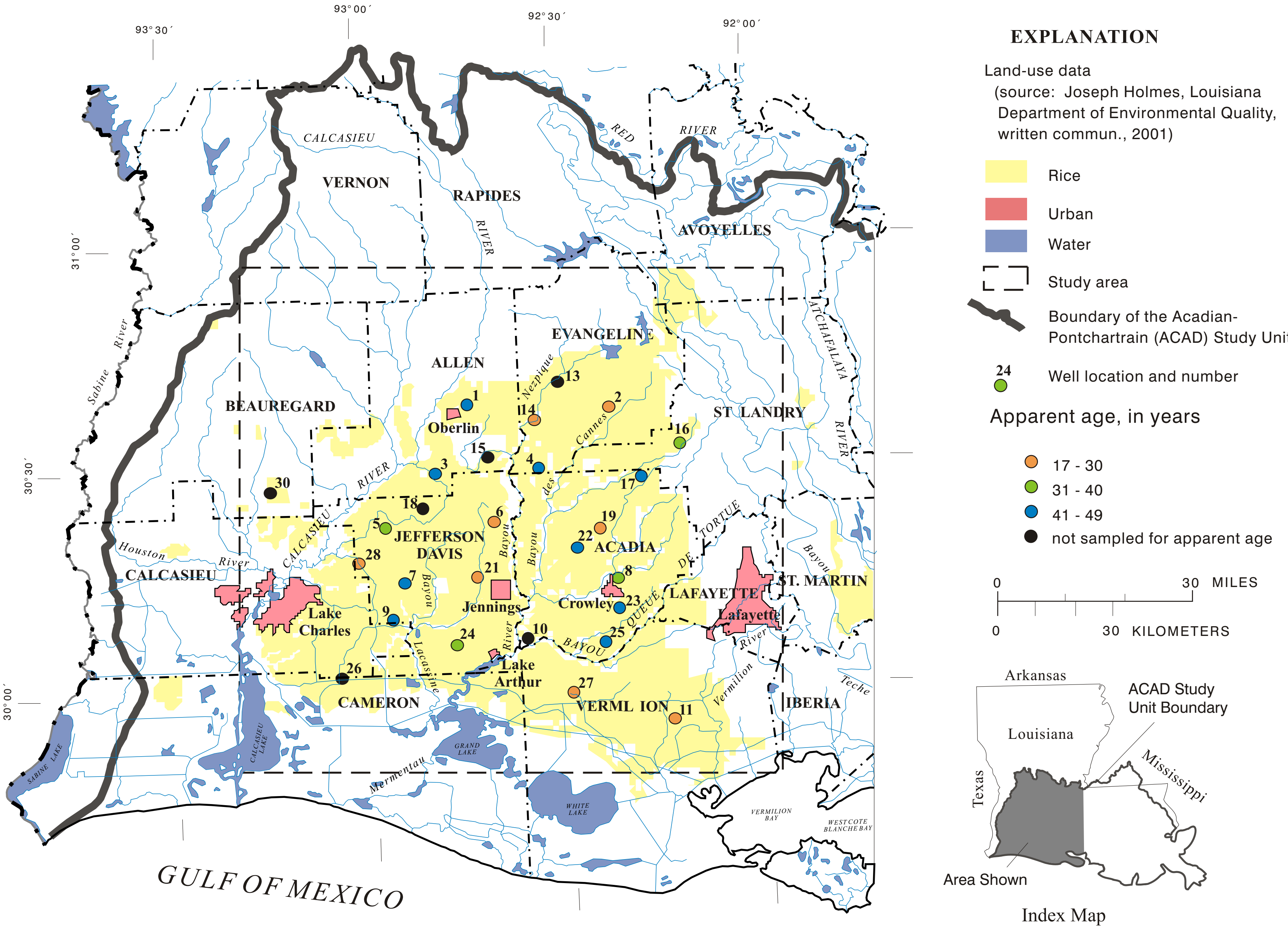
Ocean water is enriched in the heavy stable isotopes of hydrogen and oxygen (D and ^{18}O) relative to the light stable isotopes (H and ^{16}O) and is the source for most rain. The rain forms in a cloud by condensation of water vapor, and the first raindrops to fall are enriched in D and ^{18}O, similar to ocean water. As the moist air mass moves away (inland) from its source (ocean), the continuing preferential removal of D and ^{18}O in the rainfall causes enrichment of ^{1}H and ^{16}O in the air mass, and δD and $\delta^{18}O$ become progressively more negative. Craig (1961) used a large number of analyses of meteoric waters collected at different latitudes to determine that this isotopic fractionation process is related linearly and is represented as the Global Meteoric Water Line (GMWL) on plots of δD and $\delta^{18}O$ (fig. 11).

The hydrogen 2/1 ratio, or δD, in the shallow wells in the rice-growing area ranged from -10.0 to -19.7 per mil (appendix 7, at the back of the report), and the oxygen ratio, or $\delta^{18}O$, ranged from -1.69 to -4.04 per mil. The values plotted very near the GMWL. The enrichment of the heavy stable isotopes indicated that the origin of the ground water was rainwater that originated near the study area (a possible source is the Gulf of Mexico), and the close proximity of the stable isotopes to the GMWL indi-



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

Figure 9. Radon concentration in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01.



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

Figure 10. Apparent ages of water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01.

cated that few geochemical or physical processes, such as evaporation, influenced the stable isotopic composition of the shallow ground water (Faure, 1986, p. 431).

Statistical Correlations of Physical Properties and Chemical Constituents

The Spearman rank correlation (SAS Institute Inc., 1990) was used to determine whether significant correlations existed between physical properties, selected chemical constituents, the number of pesticides detected, and the apparent age of ground water. Correlation analysis assesses not only the relation between two variables but also the strength of the relation (Helsel and Hirsch, 1993, p. 210-217). The Spearman rank correlation was chosen because water-quality data usually are not normally distributed and the number of samples was greater than 20 (Helsel and Hirsch, 1993, p. 217-218).

Correlation tests calculate a probability statistic (p-value) and a correlation coefficient (rho). The probability statistic relates to a confidence level. The 95-percent confidence level used in this report indicated a 95-percent probability (p equal to or less than 0.05) that a correlation was statistically significant. The correlation coefficient describes the strength of the correlation and how the parameters (physical properties and chemical constituents) vary. For this report, parameters that had correlation coefficients of 0.6 or greater were considered strongly correlated, parameters that had correlation coefficients between 0.4 and 0.6 were considered moderately correlated, and parameters that had correlation coefficients of 0.4 or less were considered weakly correlated. A positive correlation coefficient means that as the value of one parameter increases, the value of the other parameter also increases. A negative correlation coefficient means that as the value of one parameter decreases, the value of the other parameter increases (Helsel and Hirsch, 1993, p. 209-211).

Correlations between physical properties (depth to ground water and well depth), selected chemical constituents (major inorganic ions, trace elements, and nutrients), the number of pesticides detected, and the apparent age of ground water were determined and are listed in table 5. Major-ion and trace-element concentrations that were less than the analytical reporting level were assigned a value of one-half the reporting limit so they would not have a rank equal to that of a measured value.

Correlations reflected the natural geochemical evolution of ground water in the study area. The depth to ground water was positively correlated to the well depth, indicating the ground water was under uncon-

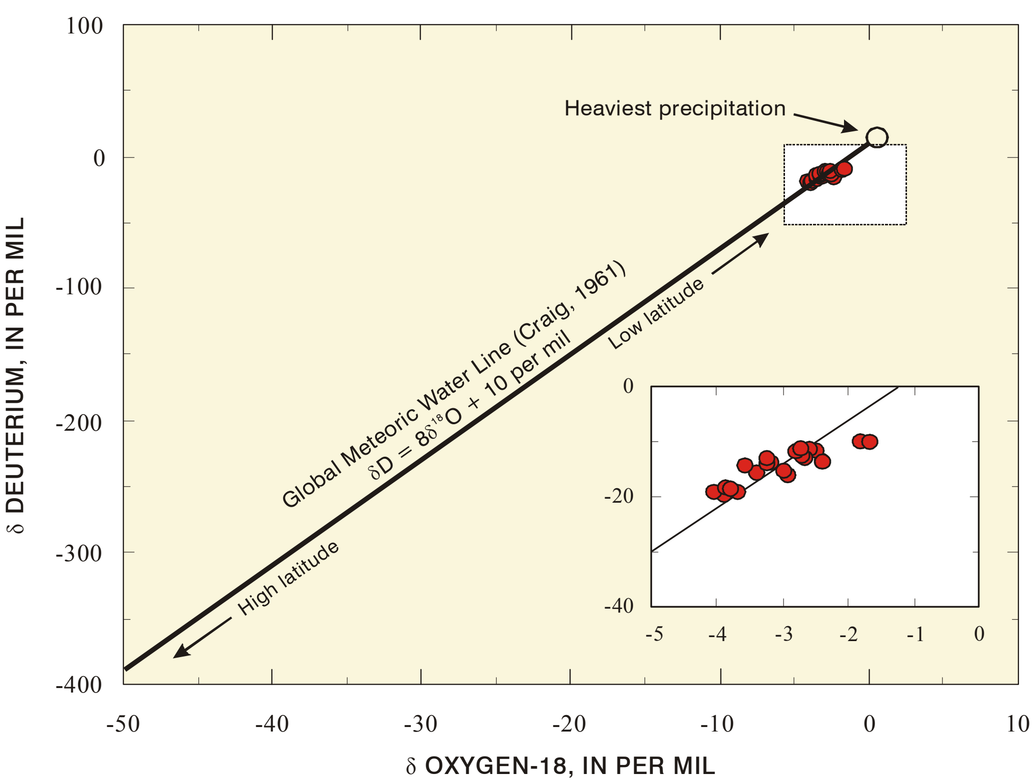


Figure 11. Relation between delta (δ) deuterium and δ oxygen-18 in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000 (Craig, 1961; Faure, 1986).

fined or semiconfined conditions. As the depth to ground water increased, the concentrations of dissolved solids and the other constituents listed in table 5 decreased. A possible explanation is that the flow rate was greater in the deeper sands, and, over time, the sediments were flushed and the concentrations of dissolved solids in the ground water decreased. The correlations with the radon concentration might be explained in a similar manner (Wanty and Nordstrom, 1993, p. 433). In addition to being inversely correlated to the depth to ground water, the radon concentrations were correlated inversely with well depth and the apparent age of ground water. Radon concentrations correlated positively with specific conductance, pH, and bicarbonate and alkalinity concentrations indicating that radon concentrations generally decreased in the deeper ground water similar to the other dissolved constituents. The apparent age of ground water was correlated inversely with nitrite plus nitrate concentration, indicating that as the apparent age increased, the nitrite plus nitrate concentration decreased. This might have been a result of changes in agriculture and domestic practices or a result of natural processes, such as greater dissolution and movement of naturally-occurring nitrogen sources (organic matter) in the higher transmissivity, or higher yield, deep wells. No correlations existed between the number of pesticides detected and any of the physical or chemical properties of the ground water.

SUMMARY AND CONCLUSIONS

The purpose of this report is to describe quality of water from shallow wells in the rice-growing area and to relate that water quality to natural and anthropogenic influences. In 1999-2001, the U.S. Geological Survey (USGS) installed and sampled 27 shallow wells in the Chicot aquifer system in the rice-growing area in southwestern Louisiana as part of the Acadian-Pontchartrain Study Unit of the National Water-Quality Assessment Program. The study area overlies the Chicot aquifer system, which is the primary source of water for irrigation and public-water supplies in the area and is vulnerable to the effects of surface activities because of the lack of a continuous confining unit throughout the region. Wells were installed at shallow depths in the Chicot aquifer system or surficial confining unit and ranged in depths from 12.25 to 92 ft below land surface. Water levels ranged from 0.57 to 80.19 ft below land surface.

Quality-control samples, including field-blank samples, replicate environmental samples, and field- and laboratory-spiked samples, were collected to test sample-collection and -processing procedures. Few water-quality constituents analyzed for were detected in the field-blank samples. The variability between the environmental samples and the corresponding replicate

Table 5. Results of Spearman rank correlation test for physical properties and selected chemical constituents in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

[<, less than; >, greater than]

Variables	Number of sample pairs	Probability statistic	Correlation coefficient
Depth to ground water and well depth	27	0.002	0.58
Depth to ground water and specific conductance	27	.014	- .47
Depth to ground water and pH	27	.032	- .41
Depth to ground water and alkalinity	27	.016	- .46
Depth to ground water and dissolved solids	27	.014	- .47
Depth to ground water and calcium	27	< .001	- .63
Depth to ground water and magnesium	27	.011	- .48
Depth to ground water and iron	27	.008	.50
Depth to ground water and uranium	27	.023	- .43
Depth to ground water and radon	24	.001	- .62
Radon concentration and well depth	24	.027	- .45
Radon concentration and specific conductance, pH, bicarbonate, and alkalinity	24	< .057	> .39
Radon concentration and apparent age of ground water	18	.016	- .56
Apparent age of ground water and nitrite plus nitrate concentration	20	< .001	- .70

samples typically was less than 5 percent, indicating an acceptable degree of laboratory precision and reproducibility. Mean recoveries of pesticides from the field-spiked and field-spiked replicate samples ranged from 63 to 104 percent, and mean recoveries from the laboratory-spiked and laboratory-spiked replicate samples were within the USGS National Water Quality Laboratory control limits. Results of the spiked-sample analyses indicated sampling and analysis procedures adequately detected the pesticides analyzed for and no major matrix interferences existed. Quality-control samples indicate no bias in ground-water data from collection or analysis.

Ground-water samples were analyzed for general ground-water properties and about 150 water-quality constituents, including major inorganic ions, trace elements, nutrients, dissolved organic carbon (DOC), pesticides, radon, chlorofluorocarbons, and selected stable isotopes. General ground-water properties were typical of those obtained in previous studies of the Chicot aquifer. Dissolved-solids concentrations for 17 wells exceeded the U.S. Environmental Protection Agency secondary maximum contaminant level (SMCL) of 500 milligrams per liter (mg/L) for drinking water. Major inorganic ion concentrations generally were less than their respective maximum contaminant levels (MCLs) for drinking water. The 250-mg/L SMCL for sulfate was exceeded in water from one well, and the 250-mg/L SMCL for chloride was exceeded in water from seven wells.

Concentrations of all trace elements, except iron, were less than 1,000 micrograms per liter (mg/L), and most were less than the drinking-water standards. Iron concentrations for 3 wells and manganese concentrations for 15 wells exceeded their respective SMCLs of 300 and 50 mg/L. Only three nutrient concentrations were greater than 2 mg/L, a level that might indicate contamination from human activities, and only one nutrient concentration (that for nitrite plus nitrate as nitrogen) was greater than a respective MCL. The elevated nitrate concentration could be attributed to a previous land use in the area (chicken and pig yard), and, thus, may not be attributed to rice-growing practices. DOC concentrations had a median of 0.5 mg/L, which indicated naturally-occurring DOC conditions in the study area.

Of the 92 pesticides analyzed for, 13 were detected in the ground-water samples; and of the 17 pesticide degradation products analyzed for, 7 were detected in the ground-water samples. At least one pesticide was detected in 14 of the 27 wells sampled. All pesticides and pesticide degradation products detected had concentrations that were less than U.S. Environmental Protection Agency drinking-water standards. Bentazon, 2,4.-D, and molinate (three rice herbicides) were detected in water from four, one, and one wells, respectively, and malathion (a rice insecticide) was detected in water from one well. One well had low concentrations of atrazine, deethlyatrazine, nitrate, phosphorus, orthophosphorus, and DOC, indicating a possible effect from agricultural or domestic activities. The presence of rice and other pesticides in the shallow ground water indicates that the hardpan the beneath rice fields is not preventing downward movement in all areas.

Radon concentrations for 22 of the 24 wells sampled were at or greater than the U.S. Environmental Protection Agency proposed MCL of 300 picocuries per liter. Chlorofluorocarbons were used to estimate the apparent age of water in 21 of the 27 wells sampled. Ages varied with depth and water level and ranged from about 17 to 49 years. The median age was about 38 years. Stable isotopes of hydrogen and oxygen in water molecules indicated that the origin of ground water in the study area was rainwater that originated near the study area and that few geochemical or physical processes influenced the stable isotopic composition of the shallow ground water.

The Spearman rank correlation was used to determine whether significant correlations existed between physical properties, selected chemical constituents, the number of pesticides detected, and the apparent age of water. The depth to ground water was positively correlated to the well depth, indicating the ground water was under unconfined or semiconfined conditions. The depth to ground water was inversely correlated to specific conductance, pH, and alkalinity, dissolved solids, calcium, magnesium, uranium, and radon concentrations. As the depth to ground water increased, the concentrations of dissolved solids and other constituents decreased, possibly because the deeper sands had a greater ability to transmit ground water, which, over time, would flush out, or dilute, the concentrations of dissolved solids and other constituents in the natural sediments. The apparent age of water was correlated inversely with nitrite plus nitrate concentration, indicating that as the apparent age increased, the nitrite plus nitrate concentration decreased. No correlations existed between the number of pesticides detected and any of the physical or chemical properties of the ground water.

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APPENDIXES

1. General ground-water properties in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

2. Dissolved solids and major inorganic ion concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

3. Trace-element concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

4. Nutrients and dissolved organic carbon concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

5. Pesticide concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

6. Concentrations of pesticide degradation products in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

7. Radon, chlorofluorocarbons, and stable isotope concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

Appendix 1. General ground-water properties in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

[ACAD, Acadian-Pontchartrain Study Unit of the National Water-Quality Assessment Program; DOTD, Department of Transportation and Development; USGS, U.S. Geological Survey; µS/cm, microsiemens per centimeter at 25 degrees Celsius; S.U., standard units; ºC, degrees Celsius; mm Hg, millimeters of mercury; NTU, nephelometric turbidity units; mg/L, milligrams per liter; <, less than; ---, no data]

ACAD well number	DOTD local well number	USGS site identification number	Sample date	Specific conductance, field (µS/cm)	Specific conductance, lab (µS/cm)	pH, field (S.U.)	pH, lab (S.U.)	Air temperature (ºC)	Water temperature (ºC)	Air pressure (mm Hg)	Turbidity (N.T.U.)	Dissolved oxygen (mg/L)	Dissolved oxygen (percent)	Acid neutralizing capacity, fixed end-point titration, field (mg/L as $CaCO_3$)	Alkalinity, incremental titration, field (mg/L as $CaCO_3$)	Alkalinity, fixed end-point titration, laboratory (mg/L as $CaCO_3$)	Sample flow rate (gallons per minute)	Pump period (minutes)
1	AL-5475Z	303839092435101	05-02-00	227	233	6.1	6.4	21.0	20.7	762	0	2.3	31	63	64	68	0.14	90
2	EV-5477Z	303741092213901	01-27-00	867	870	7.1	7.1	9.0	19.5	767	6.0	2.5	27	370	370	390	0.15	50
3	AL-5477Z	302927092490001	05-25-00	317	331	6.4	6.8	33.0	24.0	758	20	1.2	14	120	120	110	0.15	35
4	EV-5482Z	302952092325501	01-26-00	1,150	1,170	7.2	7.5	15.0	20.4	769	<1.0	1.4	16	330	330	330	0.14	45
5	JD-6843Z	302220092570201	01-11-00	3,160	3,100	6.6	6.7	19.0	21.1	764	1.0	0.9	10	230	230	240	0.16	95
6	JD-6844Z	302246092400101	01-25-00	715	710	7.2	7.3	18.0	21.5	766	14	1.4	16	270	270	270	0.15	45
7	JD-6834Z	301451092541401	01-12-00	1,930	1,950	7.1	7.2	21.0	22.3	762	2.0	<1.0	<12	490	470	490	0.15	35
8	AC-7869Z	301444092211501	01-13-00	960	961	7.1	7.3	21.0	22.3	769	<30	3.2	23	480	480	490	0.12	65
9	JD-6845Z	301003092561301	01-18-00	1,420	1,440	7.1	7.2	23.0	20.5	767	1.0	0.5	6	420	420	430	0.15	75
10	AC-7977Z	300659092352901	02-09-00	1,860	1,870	7.1	7.1	12.0	20.0	770	5.0	1.5	17	540	550	560	0.14	85
11	VE-10210Z	295531092132001	05-23-00	540	536	6.5	6.7	33.0	27.1	759	1.0	2.8	35	190	190	200	0.08	65
13	EV-5470Z	304121092293301	02-15-00	619	625	6.1	6.1	21.0	21.5	764	38	1.9	22	120	110	110	0.15	45
14	EV-5486Z	303616092331801	02-16-00	1,340	1,360	7.4	7.4	25.0	22.1	766	25	0.6	7	460	460	470	0.17	75
15	AL-5479Z	303127092404801	05-11-00	510	524	6.6	6.7	30.0	22.6	759	1.0	1.5	17	130	140	140	0.16	80
16	SL-6706Z	303237092105501	02-01-00	648	664	7.1	7.2	10.0	19.6	768	<1.0	0.9	10	270	280	290	0.17	90
17	AC-7934Z	302821092171001	02-03-00	911	920	7.0	7.4	13.0	20.7	767	2.0	1.5	17	340	340	350	0.14	60
18	JD-6909Z	302448092510501	05-09-00	1,690	1,720	6.2	6.4	31.0	21.8	759	1.0	2.9	34	140	130	140	0.14	60
19	AC-7935Z	302132092234401	01-19-00	795	788	6.8	7.0	27.0	22.3	761	<1.0	1.8	20	270	270	280	0.15	60
21	JD-6835Z	301525092425701	05-10-00	1,020	1,040	7.2	7.4	33.0	22.6	756	4.0	2.7	32	310	320	340	0.18	45
22	AC-7936Z	301906092272401	01-09-00	1,810	1,790	7.0	7.2	19.0	21.1	759	8.0	0.6	7	360	360	370	0.17	45
23	AC-7976Z	301042092211101	02-17-00	1,150	1,160	7.2	7.4	28.0	22.9	764	2.0	1.3	15	380	380	320	0.14	50
24	JD-6846Z	300626092462901	09-21-00	675	678	7.3	7.8	29.0	22.6	759	1.3	0.9	10	210	210	210	0.12	80
25	AC-7938Z	300614092233001	02-10-00	1,420	1,430	7.2	7.4	20.0	21.2	763	3.0	0.7	7	300	300	310	0.15	55
26	CN-5863Z	300216093042301	01-10-00	1,870	1,860	7.0	7.0	18.0	19.0	761	1.0	0.7	8	480	470	370	0.15	60
27	VE-10211Z	295932092284401	02-08-00	2,220	2,300	7.1	7.3	14.0	21.2	772	110	3.0	35	530	530	540	0.17	75
28	JD-6847Z	301737093010301	01-11-00	1,180	1,160	7.3	7.3	26.0	22.8	764	2.0	0.6	7	370	360	380	0.14	60
30	BE-6230Z	302723093144201	09-28-00	250	255	6.2	6.3	27.0	17.0	---	<30	---	---	46	39	46	0.12	55

Appendix 2. Dissolved solids and major inorganic ion concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

[All concentrations are dissolved. Numbers below the chemical names are the Chemical Abstracts Service (CAS) numbers. ACAD, Acadian-Pontchartrain Study Unit of the National Water-Quality Assessment Program; DOTD, Department of Transportation and Development; USGS, U.S. Geological Survey; ºC, degrees Celsius; mg/L, milligrams per liter;<, less than; E, estimated]

ACAD well number	DOTD local well number	USGS site identification number	Sample date	Dissolved residue at 180ºC (mg/L) no CAS number	Calcium (mg/L as Ca) 7440-70-2	Magnesium (mg/L as Mg) 7439-95-4	Sodium (mg/L as Na) 7440-23-5	Potassium (mg/L as K) 7440-09-7	Bicarbonate (calculated) (mg/L as HCO_3) no CAS number	Sulfate (mg/L as SO_4) 14808-79-8	Chloride (mg/L as Cl) 16887-00-6	Fluoride (mg/L as F) 16984-48-8	Bromide (mg/L as Br) 24959-67-9	Silica (mg/L as SiO_2) 7631-86-9
1	AL-5475Z	303839092435101	05--02-00	180	13	6.1	22	1.6	78	5.0	26	<0.1	0.1	58
2	EV-5477Z	303741092213901	01-27-00	520	99	33	45	0.9	451	28	48	0.4	0.4	30
3	AL-5477Z	302927092490001	05-25-00	240	23	10	20	2.2	144	17	12	0.2	0.1	74
4	EV-5482Z	302952092325501	01-26-00	634	66	46	100	0.9	399	6.1	180	0.5	1.0	26
5	JD-6843Z	302220092570201	01-11-00	1,850	120	61	410	1.3	277	49	830	0.5	2.2	50
6	JD-6844Z	302246092400101	01-25-00	425	69	17	55	0.8	332	15	55	0.2	0.3	35
7	JD-6834Z	301451092541401	01-12-00	1,150	89	36	280	1.0	569	110	290	0.6	1.1	23
8	AC-7869Z	301444092211501	01-13-00	574	70	61	44	1.9	582	10	45	0.7	0.2	27
9	JD-6845Z	301003092561301	01-18-00	856	86	35	170	1.8	510	100	160	0.6	0.7	24
10	AC-7977Z	300659092352901	02-09-00	1,180	91	60	220	3.6	666	270	140	0.3	0.3	27
11	VE-10210Z	295531092132001	05-23-00	357	36	12	60	1.2	234	27	31	<0.1	0.1	57
13	EV-5470Z	304121092293301	02-15-00	335	29	13	64	1.9	134	5.8	120	<0.1	0.5	20
14	EV-5486Z	303616092331801	02-16-00	764	49	29	200	1.0	555	11	160	0.4	0.6	27
15	AL-5479Z	303127092404801	05-11-00	310	28	13	51	1.2	168	5.5	73	0.3	0.4	46
16	SL-6706Z	303237092105501	02-01-00	387	80	19	28	0.6	338	16	34	0.2	0.1	32
17	AC-7934Z	302821092171001	02-03-00	508	98	31	45	1.1	417	4.5	91	0.3	0.3	32
18	JD-6909Z	302448092510501	05-09-00	1,020	78	40	180	1.7	161	25	420	0.2	1.2	48
19	AC-7935Z	302132092234401	01-19-00	465	64	19	71	1.5	332	23	70	0.3	0.3	30
21	JD-6835Z	301525092425701	05-10-00	578	81	25	93	0.7	388	18	120	0.5	0.8	25
22	AC-7936Z	301906092272401	01-09-00	1,000	101	54	170	1.9	434	28	330	0.5	1.4	26
23	AC-7976Z	301042092211101	02-17-00	644	61	30	140	1.3	468	1.6	150	0.5	0.5	26
24	JD-6846Z	300626092462901	09-21-00	381	48	15	62	1.7	256	7.0	81	0.1	0.3	28
25	AC-7938Z	300614092233001	02-10-00	776	71	29	170	1.2	370	4.2	280	0.5	0.8	28
26	CN-5863Z	300216093042301	01-10-00	1,080	140	48	170	0.9	578	43	310	0.6	1.0	28
27	VE-10211Z	295932092284401	02-08-00	1,260	84	59	310	3.9	643	52	400	0.7	1.0	25
28	JD-6847Z	301737093010301	01-11-00	664	81	32	110	1.4	445	10	160	0.7	0.4	23
30	BE-6230Z	302723093144201	09-28-00	180	8.2	3.8	34	0.8	48	E0.3	48	<0.1	0.2	53

Appendix 3. Trace-element concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

[Concentrations are dissolved unless noted. ACAD, Acadian-Pontchartrain Study Unit of the National Water-Quality Assessment Program (NAWQA); DOTD, Department of Transportation and Development; USGS, U.S. Geological Survey; μg/L, micrograms per liter; numbers below the chemical names are the Chemical Abstracts Service (CAS) numbers; <, less than; ---, no data; E, estimated]

ACAD well number	DOTD local well number	USGS site identification number	Sample date	Aluminum (μg/L as Al) 7429-90-5	Antimony (μg/L as Sb) 7440-36-0	Arsenic (μg/L as As) 7440-38-2	Barium (μg/L as Ba) 7440-39-3	Beryllium (μg/L as Be) 7440-41-7	Boron (μg/L as B) 7440-42-8	Cadmium (μg/L as Cd) 7440-43-9	Chromium (μg/L as Cr) 740-47-3	Cobalt (μg/L as Co) 7440-48-4	Copper (μg/L as Cu) 7440-50-8	Iron (μg/L as Fe) 7439-89-6
1	AL-5475Z	303839092435101	05-02--00	<1	<1	<1	98	<1	20	<1	<1	2.4	<1	20
2	EV-5477Z	303741092213901	01-27-00	<1	<1	<2	410	<1	---	<1	E.4	<1.0	<1	E9
3	AL-5477Z	302927092490001	05-25-00	<17	<2	<2	100	<2	10	<2	<1	<2.0	<2	6,500
4	EV-5482Z	302952092325501	01-26-00	2	<1	E2	360	<1	---	<1	<1	<1.0	1	<10
5	JD-6843Z	302220092570201	01-11-00	6	<2	3	180	<2	---	<2	E1	3.4	<2	540
6	JD-6844Z	302246092400101	01-25-00	<1	<1	E1	350	<1	---	<1	1	<1.0	4	20
7	JD-6834Z	301451092541401	01-12-00	1	<1	<2	48	<1	---	<1	E1	<1.0	<1	<10
8	AC-7869Z	301444092211501	01-13-00	5	<1	<2	820	<1	---	<1	2	<1.0	<1	E8
9	JD-6845Z	301003092561301	01-18-00	1	<1	E1	150	<1	---	<1	<1	1.1	<1	20
10	AC-7977Z	300659092352901	02-09-00	1	<1	<2	37	<1	---	<1	<2	<1.0	11	10
11	VE-10210Z	295531092132001	05-23-00	<9	<1	4	180	<1	50	<1	E1	<1.0	<1	<10
13	EV-5470Z	304121092293301	02-15-00	<1	<1	<1	180	<1	10	<1	<1	<1.0	7	E8
14	EV-5486Z	303616092331801	02-16-00	2	<1	1	280	<1	60	<1	2	<1.0	2	E7
15	AL-5479Z	303127092404801	05-11-00	<1	<1	2	160	<1	20	<1	<1	<1.0	<1	820
16	SL-6706Z	303237092105501	02-01-00	1	<1	E1	250	<1	---	<1	<1	<1.0	8	E6
17	AC-7934Z	302821092171001	02-03-00	<1	<1	<2	380	<1	---	<1	<1	<1.0	1	<10
18	JD-6909Z	302448092510501	05-09-00	1	<1	4	410	<1	20	<1	<1	<1.0	<1	30
19	AC-7935Z	302132092234401	01-19-00	1	<1	<2	270	<1		<1	<1	<1.0	2	<10
21	JD-6835Z	301525092425701	05-10-00	<19	<1	<1	16	<1	30	<1	E1	1.5	<1	<10
22	AC-7936Z	301906092272401	01-09-00	<1	<1	<2	850	<1	---	<1	<1	<1.0	<1	<10
23	AC-7976Z	301042092211101	02-17-00	1	<1	1	540	<1	40	<1	<1	<1.0	4	<10
24	JD-6846Z	300626092462901	09-21-00	<1	<1	4	220	<1	40	<1	E1	<1.0	<1	80
25	AC-7938Z	300614092233001	02-10-00	<1	<1	E1	210	<1	---	<1	<1	<1.0	<1	E5
26	CN-5863Z	300216093042301	01-10-00	<1	<1	<2	250	<1	---	<1	E1	1.3	<1	<10
27	VE-10211Z	295932092284401	02-08-00	1	<1	<2	160	<1	---	<1	<2	<1.0	3	<10
28	JD-6847Z	301737093010301	01-11-00	<1	<1	<2	640	<1	---	<1	<1	<1.0	<1	<10
30	BE-6230Z	302723093144201	09-28-00	1	<1	<1	110	<1	30	<1	1	<1.0	<1	20

Appendix 3. Trace-element concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01 --Continued

ACAD well number	Lead (µg/L as Pb) 7439-92-1	Lithium (µg/L as Li) 7439-93-2	Manganese (µg/L as Mn) 7439-96-5	Mercury, total (µg/L as Hg) 7439-37-6	Molybdenum (µg/L as Mo) 7439-98-7	Nickel (µg/L as Ni) 7440-02-0	Selenium (µg/L as Se) 7782-49-2	Silver (µg/L as Ag) 7440-22-4	Strontium (µg/L as Sr) 7440-24-6	Thallium (µg/L as Tl) 7440-28-0	Uranium (µg/L as U) 7440-61-0	Vanadium (µg/L as V) 7440-62-2	Zinc (µg/L as Zn) 7440-66-6
1	<1	10	73	---	<1	4	<1	<1	130	<0.9	<1.0	2.0	2
2	<1	---	2	<0.3	<1	3	<2	<1	---	---	2.6	---	<1
3	<2	30	360	<0.3	<2	<2	<2	<2	190	<2	<2.0	<2.0	5
4	<1	---	48	<0.3	2	2	E2	<1	---	---	3.8	---	<1
5	<2	---	450	<0.3	<2	4	<2	<2	---	---	4.4	---	3
6	<1	---	E2	<0.3	<1	2	<2	<1	---	---	<1.0	---	<1
7	<1	---	120	<0.3	3	1	E2	<1	---	---	4.9	---	1
8	<1	---	100	<0.3	7	5	14	<1	---	---	11	---	2
9	<1	---	740	<0.3	9	2	<2	<1	---	---	10	---	1
10	<1	---	220	<0.3	5	3	<2	<1	---	---	16	---	2
11	<1	10	180	<0.3	<1	3	<1	<1	180	<0.9	<1.0	4.5	<3
13	<1	10	4	E0.2	<1	2	4	<1	160	<0.9	<1.0	1.6	1
14	<1	50	<2	<0.3	3	2	<1	<1	400	<0.9	5.8	6.6	<1
15	<1	20	380	<0.3	<1	<1	1	<1	150	<0.9	<1.0	<1.0	<1
16	<1	---	210	<0.3	2	3	<2	<1	---	---	1.8	---	<1
17	<1	---	9	<0.3	1	<1	<2	<1	---	---	1.8	---	<1
18	<1	60	360	<0.3	<1	6	29	<1	420	<0.9	<1.0	6.7	<1
19	<1	---	4	<0.3	<1	<1	<2	<1	---	---	<1.0	---	<1
21	<1	0	<2	<0.3	<1	2	<1	<1	20	<0.9	<1.0	<1.0	<5
22	<1	---	9	<0.3	2	8	6	<1	---	---	5.8	---	1
23	<1	30	40	<0.3	3	2	<1	<1	430	<0.9	4.6	4.4	1
24	<1	20	400	<0.3	4	1	<1	<1	290	<0.9	<1.0	2.6	<1
25	<1	---	24	<0.3	4	2	E1	<1	---	---	4.4	---	6
26	<1	---	390	<0.3	2	6	<2	<1	---	---	8.6	---	1
27	<1	---	210	<0.3	4	7	<2	<1	---	---	7.5	---	2
28	<1	---	270	<0.3	2	7	<2	<1	---	---	5.5	---	<1
30	<1	10	3	<0.3	<1	3	<1	<1	50	<0.9	<1.0	1.2	5

Appendix 4. Nutrients and dissolved organic carbon concentratons in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

[All concentrations are dissolved. ACAD, Acadian-Pontchartrain Study Unit of the National Water-Quality Assessment Program (NAWQA); DOTD, Department of Transportation and Development; USGS, U.S. Geological Survey; mg/L, milligrams per liter; numbers below the chemical names are the Chemical Abstracts Service (CAS) numbers; <, less than; E, estimated; ---, no data.]

ACAD well number	DOTD local well number	USGS site identification number	Sample date	Nitrogen, ammonia (mg/L as N) 7664-41-7	Nitrogen, ammonia plus organic nitrogen (mg/L as N) 17778-88-0	Nitrogen, nitrite plus nitrate (mg/L as N) no CAS number	Nitrogen, nitrite (mg/L as N) 14797-65-0	Phosphorus (mg/L as P) 7732-14-0	Orthophosphorus (mg/L as P) 14265-44-2	Carbon, organic (mg/L as C) no CAS number
1	AL-5475Z	303839092435101	05-02-00	0.02	<0.10	<0.05	<0.01	0.21	0.19	E0.2
2	EV-5477Z	303741092213901	01-27-00	<0.02	<0.10	0.90	<0.01	0.04	0.04	0.5
3	AL-5477Z	302927092490001	05-25-00	0.07	E0.08	<0.05	<0.01	<0.01	<0.01	0.6
4	EV-5482Z	302952092325501	01-26-00	0.02	<0.10	<0.05	<0.01	0.06	0.03	0.6
5	JD-6843Z	302220092570201	01-11-00	<0.02	<0.10	<0.05	<0.01	0.02	0.06	<0.3
6	JD-6844Z	302246092400101	01-25-00	<0.02	<0.10	3.6	<0.01	0.07	0.06	0.6
7	JD-6834Z	301451092541401	01-12-00	<0.02	<0.10	<0.05	<0.01	0.11	0.09	E0.6
8	AC-7869Z	301444092211501	01-13-00	0.03	<0.10	0.10	<0.01	0.04	0.04	0.9
9	JD-6845Z	301003092561301	01-18-00	0.11	E0.09	<0.05	<0.01	0.17	0.17	---
10	AC-7977Z	300659092352901	02-09-00	0.70	0.83	<0.05	<0.01	0.04	0.04	0.7
11	VE-10210Z	295531092132001	05-23-00	0.08	0.11	0.77	<0.01	0.48	0.45	1.4
13	EV-5470Z	304121092293301	02-15-00	<0.02	0.26	0.23	<0.01	E0.01	<0.01	E0.2
14	EV-5486Z	303616092331801	02-16-00	<0.02	<0.10	1.1	<0.01	0.08	0.08	E0.2
15	AL-5479Z	303127092404801	05-11-00	0.03	<0.10	<0.05	<0.01	0.31	0.35	E0.2
16	SL-6706Z	303237092105501	02-01-00	<0.02	<0.10	0.36	<0.01	0.06	0.04	0.4
17	AC-7934Z	302821092171001	02-03-00	0.02	<0.10	<0.05	<0.01	0.05	0.04	E0.2
18	JD-6909Z	302448092510501	05-09-00	<0.02	<0.10	0.87	<0.01	0.28	0.26	<0.3
19	AC-7935Z	302132092234401	01-19-00	<0.02	0.26	2.4	<0.01	0.04	0.04	0.6
21	JD-6835Z	301525092425701	05-10-00	<0.02	E0.07	1.0	<0.01	0.05	0.04	0.6
22	AC-7936Z	301906092272401	01-09-00	0.04	E0.07	13	<0.01	0.05	0.05	E0.6
23	AC-7976Z	301042092211101	02-17-00	0.05	E0.07	<0.05	<0.01	0.06	0.06	E0.2
24	JD-6846Z	300626092462901	09-21-00	0.15	0.17	<0.05	<0.01	0.25	0.25	0.6
25	AC-7938Z	300614092233001	02-10-00	<0.02	E0.06	<0.05	<0.01	0.08	0.07	E0.2
26	CN-5863Z	300216093042301	01-10-00	0.03	0.12	<0.05	<0.01	0.03	0.03	E1
27	VE-10211Z	295932092284401	02-08-00	0.84	0.99	<0.05	<0.01	0.03	0.03	E0.3
28	JD-6847Z	301737093010301	01-11-00	<0.02	<0.10	0.05	<0.01	0.02	0.02	E0.6
30	BE-6230Z	302723093144201	09-28-00	<0.02	E0.06	0.07	<0.01	0.09	0.08	E0.2

Appendix 5. Pesticide concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

[All concentrations are total recoverable and are in micrograms per liter. Detections are shown in bold. ACAD, Acadian-Pontchartrain Study Unit of the National Water-Quality Assessment Program (NAWQA); DOTD, Department of Transportation and Development; USGS, U.S. Geological Survey; numbers below the chemical names are the Chemical Abstracts Service (CAS) numbers; <, less than; ---, no data; E, estimated]

ACAD well number	DOTD local well number	USGS site identification number	Sample date	Acetochlor H 34256-82-1	Acifluorfen H 50594-66-6	Alachlor H 15972-60-8	Aldicarb I 116-06-3	Atrazine H 1912-24-9	Azinphos-methyl I 86-50-0	Bendiocarb I 22781-23-3	Benfluralin H 1861-40-1	Benomyl (carbamate?) F 17804-35-2	Bensulfuron methyl 83055-99-6
1	AL-5475Z	303839092435101	05-02-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
2	EV-5477Z	303741092213901	01-27-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
3	AL-5477Z	302927092490001	05-25-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
4	EV-5482Z	302952092325501	01-26-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
5	JD-6843Z	302220092570201	01-11-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
6	JD-6844Z	302246092400101	01-25-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
7	JD-6834Z	301451092541401	01-12-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
8	AC-7869Z	301444092211501	01-13-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
9	JD-6845Z	301003092561301	01-18-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
10	AC-7977Z	300659092352901	02-09-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
11	VE-10210Z	295531092132001	05-23-00	<0.002	<0.06	<0.002	<0.08	**0.008**	<0.001	<0.061	<0.002	<0.022	<0.0482
13	EV-5470Z	304121092293301	02-15-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
14	EV-5486Z	303616092331801	02-16-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
15	AL-5479Z	303127092404801	05-11-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.010	<0.061	<0.002	<0.022	<0.0482
16	SL-6706Z	303237092105501	02-01-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
17	AC-7934Z	302821092171001	02-03-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
18	JD-6909Z	302448092510501	05-09-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
19	AC-7935Z	302132092234401	01-19-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
21	JD-6835Z	301525092425701	05-10-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
22	AC-7936Z	301906092272401	01-09-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
23	AC-7976Z	301042092211101	02-17-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
24	JD-6846Z	300626092462901	09-21-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
25	AC-7938Z	300614092233001	02-10-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
26	CN-5863Z	300216093042301	01-10-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
26	CN-5863Z	300216093042301	05-10-00	<0.002	---	<0.002	---	<0.001	<0.001	---	<0.002	---	---
27	VE-10211Z	295932092284401	02-08-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
28	JD-6847Z	301737093010301	01-26-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482
30	BE-6230Z	302723093144201	09-28-00	<0.002	<0.06	<0.002	<0.08	<0.001	<0.001	<0.061	<0.002	<0.022	<0.0482

Appendix 5. Pesticide concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01--Continued

ACAD well number	Bentazon H 25057-89-0	Bromacil H 314-40-9	Bromoxynil H 1689-84-5	Butylate H 2008-41-5	Carbaryl I 63-25-2	Carbofuran I 1563-66-2	Chloramben methyl ester H 133-90-4	Chlorimuron ethyl H 90982-32-4	Chlorothalonil F 1897-45-6	Chlorpyrifos I 2921-88-2	Clopyralid H 1702-17-6	Cyanazine H 21725-46-2	Cycloate H 1134-23-2	2,4-D H 94-75-7
1	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
2	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
3	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
4	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
5	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
6	E0.07	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
7	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
8	E0.11	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
9	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
10	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
11	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
13	E0.01	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
14	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	E0.008	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
15	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
16	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
17	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
18	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
19	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
21	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
22	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	E0.004	<0.04	<0.004	<0.05	<0.08
23	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
24	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	**E0.01**
25	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
26	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
26	---	---	---	<0.002	<0.003	<0.003	---	---	---	<0.004	---	<0.004	---	---
27	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
28	E0.15	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08
30	<0.02	<0.08	<0.06	<0.002	<0.003	<0.003	<0.11	<0.037	<0.05	<0.004	<0.04	<0.004	<0.05	<0.08

Appendix 5. Pesticide concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01--Continued

ACAD well number	Dacthal (DCPA) H 1861-32-1	Dacthal, monoacid H 887-54-7	2,4-DB H 94-82-6	Diazinon I 333-41-5	Dicamba H 1918-00-9	Dichlorprop H 120-36-5	Dieldrin I 60-57-1	Dinoseb H 88-85-7	Diphenamid H 957-51-7	Disulfoton I 298-04-4	Diuron H 330-54-1	2,4-D methyl ester H 1928-38-7	EPTC H 759-94-4	Ethalfluralin H 55283-68-6	Ethopropos I 13194-48-4
1	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
2	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
3	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
4	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
5	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
6	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
7	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
8	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
9	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
10	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
11	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
13	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	E0.007	<0.086	<0.002	<0.004	<0.003
14	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
15	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
16	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
17	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
18	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
19	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
21	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
22	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
23	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
24	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
25	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
26	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
26	<0.002	---	---	<0.002	---	---	<0.001	---	---	<0.017	---	---	<0.002	<0.004	<0.003
27	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
28	<0.002	<0.07	<0.05	<0.002	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003
30	<0.002	<0.07	<0.05	**0.007**	<0.10	<0.05	<0.001	<0.04	<0.06	<0.017	<0.08	<0.086	<0.002	<0.004	<0.003

Appendix 5. Pesticide concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01--Continued

ACAD well number	Fenuron H 101-42-8	Fipronil I 120068-37-3	Flumetsulam H 98967-40-9	Fluometuron H 2164-17-2	Fonofos I 944-22-9	HCH, alpha I 319-84-6	Imazaquin H 81335-37-7	Imazethapyr H 81335-77-5	Imidacloprid I 13826-41-3	Lindane I 58-89-9	Linuron H 330-55-2	Malathion I 121-75-5	MCPA H 94-74-6	MCPB H 94-81-5	Metalaxyl F 57837-19-1
1	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	<0.088	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
2	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	E0.704	---	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
3	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	<0.088	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
4	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	---	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
5	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	<0.088	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
6	<0.07	<0.004	E0.0437	<0.06	<0.003	<0.002	<0.103	---	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	E0.005
7	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	E0.015	<0.088	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
8	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	---	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
9	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	---	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
10	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	---	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
11	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	<0.088	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
13	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	<0.088	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
14	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	<0.088	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
15	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	<0.088	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
16	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	---	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
17	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	---	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
18	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	<0.088	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
19	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	---	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
21	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	<0.088	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
22	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	---	<0.1060	<0.004	<0.002	**0.006**	<0.06	<0.06	<0.057
23	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	<0.088	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
24	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	<0.088	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
25	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	<0.088	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
26	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	---	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
26	---	<0.004	---	---	<0.003	<0.002	---	---	---	<0.004	<0.002	<0.005	---	---	---
27	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	---	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
28	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	---	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057
30	<0.07	<0.004	<0.0866	<0.06	<0.003	<0.002	<0.103	<0.088	<0.1060	<0.004	<0.002	<0.005	<0.06	<0.06	<0.057

Appendix 5. Pesticide concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01--Continued

ACAD well number	Methiocarb I 2032-65-7	Methomyl I 16752-77-5	Methyl parathion I 298-00-0	Metolachlor H 51218-45-2	Metribuzin H 21087-64-9	Metsulfuron methyl H 74223-64-6	Molinate H 2212-67-1	Napropamide H 15299-99-7	Neburon H 555-37-3	Nicosulfuron H 111991-09-4	Norflurazon H 27314-13-2	Oryzalin H 19044-88-3	Oxamyl I 23135-22-0	Parathion I 56-38-2
1	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
2	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
3	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	E0.003	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
4	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
5	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
6	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
7	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
8	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
9	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
10	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
11	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
13	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
14	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
15	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
16	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
17	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
18	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
19	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
21	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
22	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
23	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
24	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
25	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
26	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
26	---	---	<0.006	<0.002	<0.004	---	<0.004	<0.003	---	---	---	---	---	<0.004
27	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
28	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004
30	<0.08	<0.08	<0.006	<0.002	<0.004	<0.1138	<0.004	<0.003	<0.07	<0.065	<0.08	<0.07	<0.02	<0.004

Appendix 5. Pesticide concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01--Continued

ACAD well number	Pebulate H 1114-71-2	Pendimethalin H 40487-42-1	cis-Permethrin I 52341-33-0	Phorate I 298-02-2	Picloram H 1918-02-1	Prometon H 1610-18-0	Pronamide H 23950-58-5	Propachlor H 1918-16-7	Propanil H 709-98-8	Propargite I 2312-35-8	Propham H 122-42-9	Propiconazole F 60207-90-1
1	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
2	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
3	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
4	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
5	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
6	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
7	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
8	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
9	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
10	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
11	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
13	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
14	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
15	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
16	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
17	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
18	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
19	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
21	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
22	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
23	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
24	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
25	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
26	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
26	<0.004	<0.004	<0.005	<0.002	---	<0.018	<0.003	<0.007	<0.004	<0.013	---	---
27	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
28	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064
30	<0.004	<0.004	<0.005	<0.002	<0.07	<0.018	<0.003	<0.007	<0.004	<0.013	<0.07	<0.064

Appendix 5. Pesticide concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01--Continued

ACAD well number	Propoxur I 204-043-8	Siduron H 1982-49-6	Simazine H 122-34-9	Sulfometuron methyl H 74222-97-2	Tebuthiuron H 34014-18-1	Terbacil H 5902-51-2	Terbufos I 13071-79-9	Thiobencarb H 28249-77-6	Tri-allate H 2303-17-5	Tribenuron methyl H 101200-48-0	Triclopyr H 55335-06-3	Trifluralin H 1582-09-8
1	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
2	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
3	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
4	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
5	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
6	<0.06	<0.093	<0.005	<0.039	E0.008	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
7	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
8	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
9	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
10	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
11	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
13	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
14	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
15	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
16	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
17	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
18	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
19	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
21	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
22	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
23	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
24	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
25	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
26	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
26	---	---	<0.005	---	<0.010	<0.007	<0.013	<0.002	<0.001	---	---	<0.002
27	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
28	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002
30	<0.06	<0.093	<0.005	<0.039	<0.010	<0.007	<0.013	<0.002	<0.001	<0.07	<0.10	<0.002

Appendix 6. Concentrations of pesticide degradation products in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

[All concentrations are total recoverable and are in micrograms per liter. Detections are shown in bold. ACAD, Acadian-Pontchartrain Study Unit of the National Water-Quality Assessment Program (NAWQA); DOTD, Department of Transportation and Development; USGS, U.S. Geological Survey; DP, parent compound in parenthesis of degradation product; numbers below the chemical names are the Chemical Abstracts Service (CAS) numbers; <, less than; ---, no data; E, estimated]

ACAD well number	DOTD local well number	USGS site identification number	Sample date	Aldicarb sulfone DP (aldicarb) 1646-88-4	Aldicarb sulfoxide DP (aldicarb) 1646-87-3	3-hydroxy-carbofuran DP (carbofuran) 16655-82-6	DDE, p,p′ DP (DDT) 72-55-9	Deethylatrazine DP (atrazine) 6190-65-4	Deethyldeisopropyl-atrazine DP (atrazine) 3397-62-4	Deisopropyl-atrazine DP (atrazine) 1007-28-9	2,6-diethyl-aniline DP (alachlor) 579-66-8
1	AL-5475Z	303839092435101	05-02-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
2	EV-5477Z	303741092213901	01-27-00	<0.16	---	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
3	AL-5477Z	302927092490001	05-25-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
4	EV-5482Z	302952092325501	01-26-00	<0.16	---	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
5	JD-6843Z	302220092570201	01-11-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
6	JD-6844Z	302246092400101	01-25-00	<0.16	---	<0.06	<0.006	<0.001	E0.02	<0.07	<0.003
7	JD-6834Z	301451092541401	01-12-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
8	AC-7869Z	301444092211501	01-13-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
9	JD-6845Z	301003092561301	01-18-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
10	AC-7977Z	300659092352901	02-09-00	<0.16	---	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
11	VE-10210Z	295531092132001	05-23-00	<0.16	<0.03	<0.06	<0.006	E0.008	<0.06	<0.07	<0.003
13	EV-5470Z	304121092293301	02-15-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
14	EV-5486Z	303616092331801	02-16-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
15	AL-5479Z	303127092404801	05-11-00	<0.16	<0.03	<0.06	<0.006	<0.001	E0.01	<0.07	<0.003
16	SL-6706Z	303237092105501	02-01-00	<0.16	---	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
17	AC-7934Z	302821092171001	02-03-00	<0.16	---	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
18	JD-6909Z	302448092510501	05-09-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
19	AC-7935Z	302132092234401	01-19-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
21	JD-6835Z	301525092425701	05-10-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
22	AC-7936Z	301906092272401	01-09-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
23	AC-7976Z	301042092211101	02-17-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
24	JD-6846Z	300626092462901	09-21-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
25	AC-7938Z	300614092233001	02-10-00	<0.16	<0.03	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
26	CN-5863Z	300216093042301	01-10-00	<0.16	<0.03	<0.06	<0.006	<0.001	E.004	<0.07	<0.003
26	CN-5863Z	300216093042301	05-10-00	---	---	---	E0.001	<0.001	---	---	<0.003
27	VE-10211Z	295932092284401	02-08-00	<0.16	---	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
28	JD-6847Z	301737093010301	01-26-00	<0.16	---	<0.06	<0.006	<0.001	<0.06	<0.07	<0.003
30	BE-6230Z	302723093144201	09-28-00	<0.16	<0.03	<0.06	E0.002	<0.001	<0.06	<0.07	<0.003

Appendix 6. Concentrations of pesticide degradation products in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01--Continued

ACAD well number	2,6-diethyl-aniline DP (alachlor) 579-66-8	Desulfinyl-fipronil DP (fipronil) no CAS number	Fipronil RPA 105048 DP (fipronil) no CAS number	Fipronil sulfide DP (fipronil) 120067-83-6	Fipronil sulfone DP (fipronil) 120068-36-2	2-Hydroxy-atrazine DP (atrazine) 2163-68-0	3-Keto-carbofuran DP (carbofuran) 16709-30-1	Methomyl oxime DP (methomyl) 16752-77-5	3 (4-chlorophenyl) -1- Methyl urea DP (neburon) 5352-88-5	Oxamyl oxime DP (oxamyl) 23135-22-0
1	<0.003	<0.010	<0.005	<0.010	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
2	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
3	<0.003	<0.010	<0.005	<0.010	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
4	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
5	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.2000	<0.0915	<0.064
6	<0.003	---	<0.005	---	<0.001	E0.066	<0.072	<0.0102	<0.0915	<0.064
7	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
8	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.2000	<0.0915	<0.064
9	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.2000	<0.0915	<0.064
10	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
11	<0.003	<0.010	<0.005	<0.010	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
13	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.0102	**0.2056**	---
14	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.0102	<0.0915	---
15	<0.003	<0.010	<0.005	<0.010	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
16	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
17	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
18	<0.003	<0.010	<0.005	<0.010	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
19	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.2000	<0.0915	<0.064
21	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
22	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.2000	<0.0915	<0.064
23	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.0102	<0.0915	---
24	<0.003	<0.010	<0.005	<0.010	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
25	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.0102	<0.0915	---
26	<0.003	---	E0.001	---	**0.005**	<0.193	<0.072	<0.2000	<0.0915	<0.064
26	<0.003	---	<0.005	---	<0.001	---	---	---	---	---
27	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
28	<0.003	---	<0.005	---	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064
30	<0.003	<0.010	<0.005	<0.010	<0.001	<0.193	<0.072	<0.0102	<0.0915	<0.064

Appendix 7. Radon, chlorofluorocarbons, and stable isotope concentrations in water from selected shallow wells in the rice-growing area in southwestern Louisiana, 2000-01

[ACAD, Acadian-Pontchartrain Study Unit of the National Water-Quality Assessment Program (NAWQA); DOTD, Department of Transportation and Development; USGS, U.S. Geological Survey; pCi/L, picocuries per liter; numbers below the chemical names are the Chemical Abstracts Service (CAS) numbers; pg/kg, picograms per kilogram; 2/1, ^{1}H and ^{2}H; 18/16, $^{18}O/^{16}O$, ---, no data]

ACAD well number	DOTD local well number	USGS site identification number	Sample date	Sample time	Radon 222, total (pCi/L) 14859-67-7	Radon-222, 2-sigma precision estimate (pCi/L)	CFC-11 trichloro-fluoro-methane (pg/kg) 75-69-4	CFC-113 trichlorotri-fluoroethane (pg/kg) 76-13-1	CFC-12 dichlorodi-fluorometh-ane (pg/kg) 75-71-1	Apparent modeled ground-water sample age	Hydrogen, 2 / 1 ratio per mil, no CAS number	Oxygen, 18 / 16 ratio per mil, no CAS number
1	303839092435101	AL-5475Z	5/2/00	1200	354	24	---	---	---	---	---	---
1	303839092435101	AL-5475Z	3/6/01	1300	---	---	2	0	7	48	-19.2	-4.04
2	303741092213901	EV-5477Z	1/27/00	1000	852	28	---	---	---	---	---	---
2	303741092213901	EV-5477Z	2/28/01	1200	---	---	90	10	100	26	-11.9	-2.50
3	302927092490001	AL-5477Z	5/25/00	1000	268	19	---	---	---	---	---	---
3	302927092490001	AL-5477Z	3/7/01	1100	---	---	10	0	10	43	-13.0	-2.68
4	302952092325501	EV-5482Z	1/26/00	1100	933	29	---	---	---	---	---	---
4	302952092325501	EV-5482Z	2/28/01	0900	---	---	20	0	10	43	-19.1	-3.68
5	302220092570201	JD-6843Z	1/11/00	1000	1,130	32	---	---	---	---	---	---
5	302220092570201	JD-6843Z	2/14/01	0900	---	---	30	---	30	37	-18.4	-3.87
6	302246092400101	JD-6844Z	1/25/00	1100	1,020	30	---	---	---	---	---	---
6	302246092400101	JD-6844Z	2/21/01	1100	---	---	200	20	100	23	-11.3	-2.72
7	301451092541401	JD-6834Z	1/12/00	1000	799	27	---	---	---	---	---	---
7	301451092541401	JD-6834Z	2/20/01	1100	---	---	8	0	8	49	-15.3	-3.00
8	301444092211501	AC-7869Z	1/13/00	1100	889	29	---	---	---	---	---	---
8	301444092211501	AC-7869Z	2/15/01	1000	---	---	5	0	20	38	-11.2	-2.58
9	301003092561301	JD-6845Z	1/18/00	1000	961	30	---	---	---	---	---	---
9	301003092561301	JD-6845Z	2/27/01	1200	---	---	5	0	10	44	-10.0	-1.69
11	295531092132001	VE-10210Z	5/23/00	1400	481	24	---	---	---	---	---	---
11	295531092132001	VE-10210Z	2/19/01	1200	---	---	20	2	60	29	-14.0	-3.16
13	304121092293301	EV-5470Z	2/15/00	1100	799	27	---	---	---	---	---	---
14	303616092331801	EV-5486Z	2/16/00	1100	800	30	---	---	---	---	---	---
14	303616092331801	EV-5486Z	3/2/01	1100	---	---	200	20	100	21	-13.5	-2.42
15	303127092404801	AL-5479Z	5/11/00	1000	216	20	---	---	---	---	---	---
16	303237092105501	SL-6706Z	2/1/00	0900	995	30	---	---	---	---	---	---
16	303237092105501	SL-6706Z	2/26/01	0900	---	---	20	3	40	35	-19.7	-3.92
17	302821092171001	AC-7934Z	2/3/00	1000	776	27	---	---	---	---	---	---
17	302821092171001	AC-7934Z	2/26/01	1200	---	---	10	0	10	46	-15.9	-2.91
18	302448092510501	JD-6909Z	5/9/00	1100	453	23	---	---	---	---	---	---
19	302132092234401	AC-7935Z	2/26/01	1400	1,340	34	100	20	100	17	-10.1	-1.80
21	301525092425701	JD-6835Z	5/10/00	1400	991	31	---	---	---	---	---	---
21	301525092425701	JD-6835Z	2/21/01	0900	---	---	100	20	200	19	-11.9	-2.82
22	301906092272401	AC-7936Z	2/14/01	1200	---	---	7	2	20	42	-13.2	-3.26
23	301042092211101	AC-7976Z	2/17/00	1200	828	27	---	---	---	---	---	---
23	301042092211101	AC-7976Z	2/15/01	1200	---	---	6	0	6	46	-14.3	-3.58
24	300626092462901	JD-6846Z	9/21/00	1400	303	22	---	---	---	---	---	---
24	300626092462901	JD-6846Z	2/27/01	1000	---	---	20	---	60	31	-18.5	-3.79
25	300614092233001	AC-7938Z	2/10/00	1000	780	28	---	---	---	---	---	---
25	300614092233001	AC-7938Z	2/19/01	0900	---	---	10	0	7	46	-15.5	-3.40
26	300216093042301	CN-5863Z	1/10/00	1400	509	22	---	---	---	---	---	---
27	295932092284401	VE-10211Z	3/9/01	1100	---	---	100	20	80	27	-12.0	-2.78
28	301737093010301	JD-6847Z	1/11/00	1500	1,450	34	---	---	---	---	---	---
28	301737093010301	JD-6847Z	2/13/01	1800	---	---	70	7	100	27	-13.7	-3.26
30	302723093144201	BE-6230Z	9/28/00	0800	456	23	---	---	---	---	---	---