

**WATER QUALITY OF THE APALACHICOLA-
CHATTAHOOCHEE-FLINT AND OCMULGEE RIVER BASINS
RELATED TO FLOODING FROM TROPICAL STORM
ALBERTO; PESTICIDES IN URBAN AND AGRICULTURAL
WATERSHEDS; AND NITRATE AND PESTICIDES IN
GROUND WATER, GEORGIA, ALABAMA, AND FLORIDA**

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CONVERSION FACTORS, VERTICAL DATUM, AND ACRONYMS

CONVERSION FACTORS

	<u>Length</u>	
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	<u>Area</u>	
square mile (mi ²)	2.590	square kilometer
acre	0.4047	hectare
	<u>Volume</u>	
gallon (gal)	3.785	liter
	<u>Flow</u>	
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second
	<u>Mass</u>	
pound	4.536	kilogram
tons (short)	0.9072	megagram

VERTICAL DATUM

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929 -- a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called “Sea Level Datum of 1929”.

ACRONYMS

ACF	Apalachicola-Chattahoochee-Flint
EPA	U.S. Environmental Protection Agency
HA	Health Advisory
MCL	Maximum Contaminant Level
NAWQA	National Water Quality Assessment Program
USGS	U.S. Geological Survey

WATER QUALITY OF THE APALACHICOLA-CHATTAHOOCHEE-FLINT AND OCMULGEE RIVER BASINS RELATED TO FLOODING FROM TROPICAL STORM ALBERTO; PESTICIDES IN URBAN AND AGRICULTURAL WATERSHEDS; AND NITRATE AND PESTICIDES IN GROUND WATER

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ABSTRACT

This report presents preliminary information on water quality in the Flint, Apalachicola, and Ocmulgee River basins during record flooding caused by tropical storm Alberto, July 1994. It also compares the types and concentrations of pesticides present in surface waters draining predominantly agricultural and urban watersheds, and presents preliminary information on the occurrence of nitrate and commonly used pesticides in the shallow ground water associated with agricultural land use in the southern Apalachicola-Chattahoochee-Flint (ACF) River basin.

During the period July 3-7, 1994, tropical storm Alberto as much as 28 inches of rain fell onto parts of southwestern and central Georgia and southeastern Alabama causing record flooding on the Flint and Ocmulgee Rivers and several of their tributaries. Much of the topsoil eroded during intensive rainfall and flooding probably was redeposited in extensive floodplains within the river basins. The suspended sediment transported from the basins was comprised mostly of silt- and clay-sized material. Total nitrogen concentrations were lower, and total phosphorus concentrations were higher than median concentrations in samples collected prior to the flood. Much of the nitrogen load was in the form of organic nitrogen generally derived from organic detritus, rather than nitrate derived from other sources, such as fertilizer. Floodwaters transported a large part of the mean annual load of total phosphorus and organic nitrogen and a lesser part of the mean annual load of nitrite plus nitrate. Fourteen herbicides, five insecticides, and one fungicide commonly used in agricultural and urban areas were detected in floodwaters of the Flint, Apalachicola, and Ocmulgee Rivers. Concentrations of nitrate nitrogen and detected pesticides were below EPA standards and guidelines for drinking water. However, concentrations of the insecticides chlorpyrifos, carbaryl, and diazinon approached or exceeded guidelines for protection of aquatic life.

Water-quality samples were collected at nearly weekly intervals from March 1993 through April 1994 from one urban and two agricultural watersheds in the ACF River basin, and the samples analyzed for 84 commonly used pesticides. More pesticides were detected and at generally higher concentrations in water from the urban watershed than the agricultural watersheds. A greater number of pesticides were detected throughout much of the year in the urban watershed than the agricultural watersheds. Median concentrations of all pesticides detected in water from each watershed were below EPA drinking-water standards and guidelines. However, median concentrations of the insecticides chlorpyrifos and diazinon exceeded guidelines for protection of aquatic life.

Thirty-eight wells were installed in surficial aquifers adjacent to and downgradient of farm fields within agricultural areas of southwestern Georgia and adjacent areas of Alabama and Florida. Four reference wells were installed in forested areas to represent background water-quality conditions. The surficial aquifers were selected for sampling rather than deeper, regional aquifer systems because they are the uppermost water-bearing zones and are more susceptible to contamination. Even though regional aquifers are generally used for domestic- and public-water supplies, and for irrigation, degradation of water quality in the surficial aquifers serves as an early warning of potential contamination of regional aquifers. Nitrate concentrations were less than 3 mg/L as N (indicating minimal effect of human activities) in water from about two-thirds of the wells in agricultural areas. Water from the remaining agricultural wells had elevated nitrate concentrations in one or two samples, probably the result of human activity, and nitrate concentrations in two of these wells exceeded the EPA drinking-water standards. Water samples from eight agricultural wells had pesticide concentrations above method detection limits, but maximum concentrations were below EPA drinking-water standards or guidelines.

INTRODUCTION

This report presents three chapters that describe preliminary information from data-collection programs supported by the U.S. Geological Survey's (USGS) National Water-Quality Assessment (NAWQA) Program. A focus of the program is nonpoint-source inputs of nutrients, suspended sediments, and commonly used pesticides. The first chapter describes chemical and suspended-sediment concentrations and loads in surface waters of the Apalachicola-Chattahoochee-Flint (ACF) and Ocmulgee River basins during record flooding caused by tropical storm Alberto, July 1994 (fig. 1). Although the Ocmulgee River basin is not a part of the ACF River basin NAWQA study, it is included here to document water-quality conditions during record flooding in both basins. The second chapter compares the types and amounts of pesticides present in surface waters draining predominantly agricultural and urban watersheds. The third chapter presents information on the occurrence of nitrate and commonly used pesticides in the shallow ground water associated with agricultural land use in the southwestern ACF River basin. Data included in analyses in chapters two and three were collected from March 1993 through April 1994 as a part of the ACF River basin NAWQA program. Data described in each of the chapters are related to standards for drinking water and aquatic organisms to provide perspective.

In 1991, the USGS began full-scale implementation of the NAWQA program. Three major objectives of the program are to provide a consistent description of current water-quality conditions for a large part of the Nation's water resources; define long-term trends (or lack thereof); and identify, describe, and explain the major factors that affect observed water-quality conditions and trends (Leahy and others, 1990). The NAWQA program, when fully implemented, will include investigations of hydrologic systems in 60 study units that include parts of most major river basins and aquifer systems in the United States. Study units range in size from 1,200 to about 65,000 square miles (mi^2), and incorporate 60 to 70 percent of the Nation's water use and population served by public water-supply systems. The Apalachicola-Chattahoochee-Flint (ACF) River basin was among the first 20 NAWQA study units selected for study under the full-scale implementation plan.

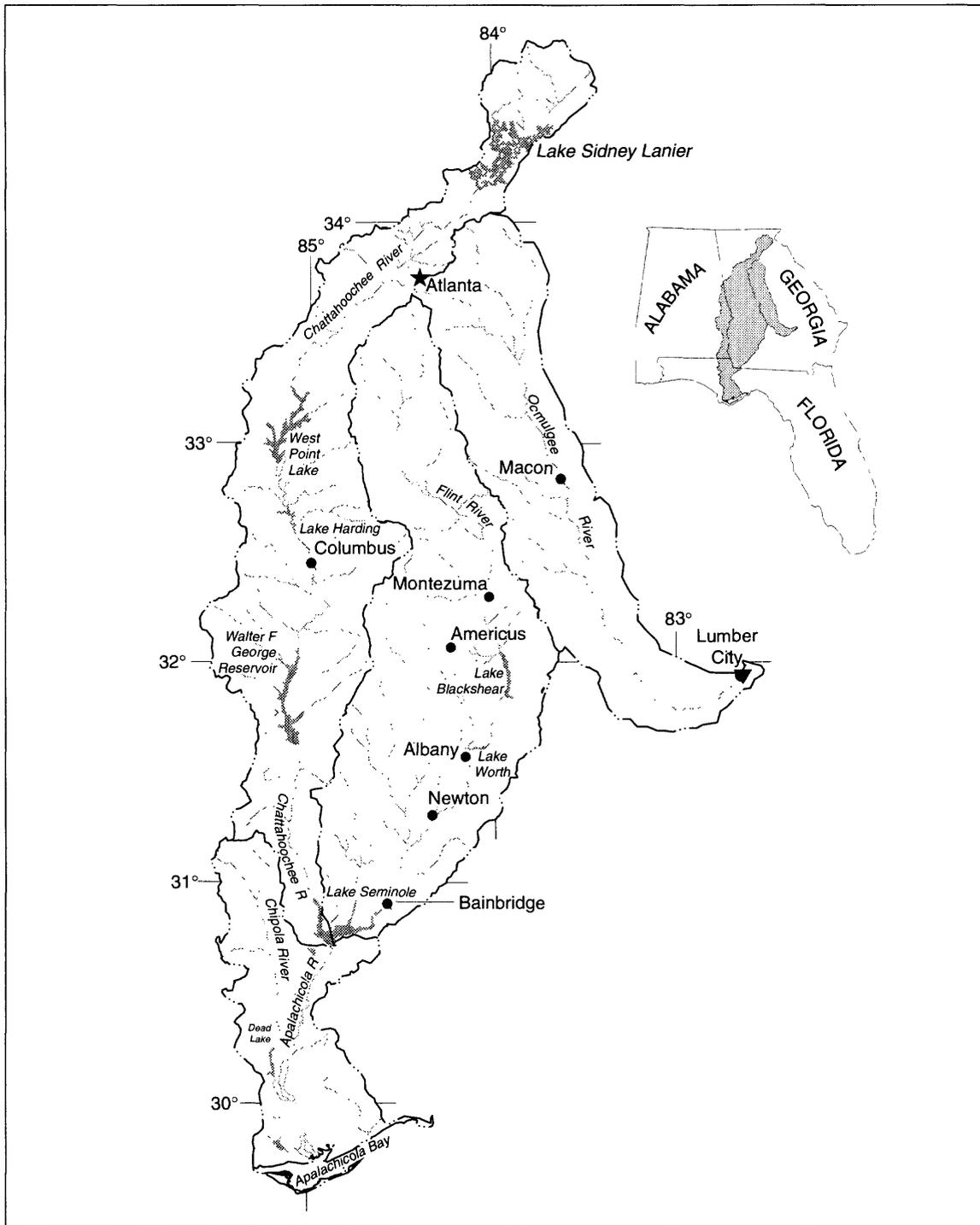
The ACF River basin drains about 19,600 mi^2 in western Georgia, southeastern Alabama, and the Florida panhandle. The study area is comprised of the Chattahoochee and Flint River drainages that meet in Lake Seminole to form the Apalachicola River. The Apalachicola River flows through Florida into the Apalachicola Bay, and discharges into the Gulf of Mexico. Sixteen reservoirs have altered natural stream flow and riverine ecosystems within the study area. Six reservoirs have storage capacity enough to affect

downstream flows, and to affect nutrient and suspended-sediment concentration and transport. The Ocmulgee River basin lies to the east of the ACF River basin and drains about 5,180 mi^2 .

One of the tasks of the NAWQA program is to design and implement an integrated assessment of surface- and ground-water quality as it relates to point- and nonpoint-source contributions from various land uses. Forest and agriculture are dominant land uses and land covers within the ACF River basin, accounting for 59 and 29 percent of the ACF River basin, respectively (fig. 2). Most agricultural land in the Upper and Middle Chattahoochee and Upper Flint River subbasins is used for pastures and, to a lesser extent, poultry production; while most agricultural land in the southern ACF River basin is used for row crops and, to a lesser extent, orchards. Urban land use accounted for 5.3 percent of the study area. In 1990, the population of the ACF River basin was about 2.64 million people, 60 percent of which lived in the Metropolitan Atlanta area (U.S. Bureau of Census, 1991a,b,c). Wetland areas accounted for about 5.4 percent of the entire basin. Agricultural and urban land uses are of particular interest within the ACF River basin because they have the greatest potential effect on the physical, chemical, and biological quality of the surface- and ground-water resources.

The NAWQA program is focusing on the occurrence and distribution of nutrients, suspended sediments, and pesticides in the Nation's water resources. Nutrients, particularly nitrogen and phosphorus, are important because their concentrations regulate or limit the productivity of organisms in freshwater-aquatic systems. High concentrations of nitrogen and phosphorus can adversely affect surface-water quality through eutrophication (abundant accumulation of nutrients causing excessive aquatic-plant growth) and toxicity to aquatic life. High concentrations of nitrate, primarily in ground water, can be toxic to infants and warm-blooded animals that drink the water. Nutrient inputs to the ACF River basin generally are from municipal wastewater-treatment facilities, animal manure, fertilizer, and atmospheric deposition. Nutrients in water samples collected as a part of this report, their detection limits, and applicable water-quality standards are listed in table 1.

Suspended sediment is important because high concentrations can reduce light penetration and visibility for aquatic organisms. Suspended sediment also causes abrasion of fish gills, alters aquatic habitat by covering rocks and gravel necessary for many aquatic organisms to survive, and acts as a hydrophobic chemical carrier. Suspended-sediment inputs to the ACF River basin generally are from erosion of land that has been disturbed because of construction or farming practices, resuspension of sediments from stream and river bottoms during floods, or from erosion of river banks.



Base from U.S. Geological Survey digital files

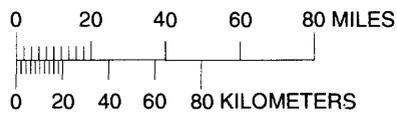
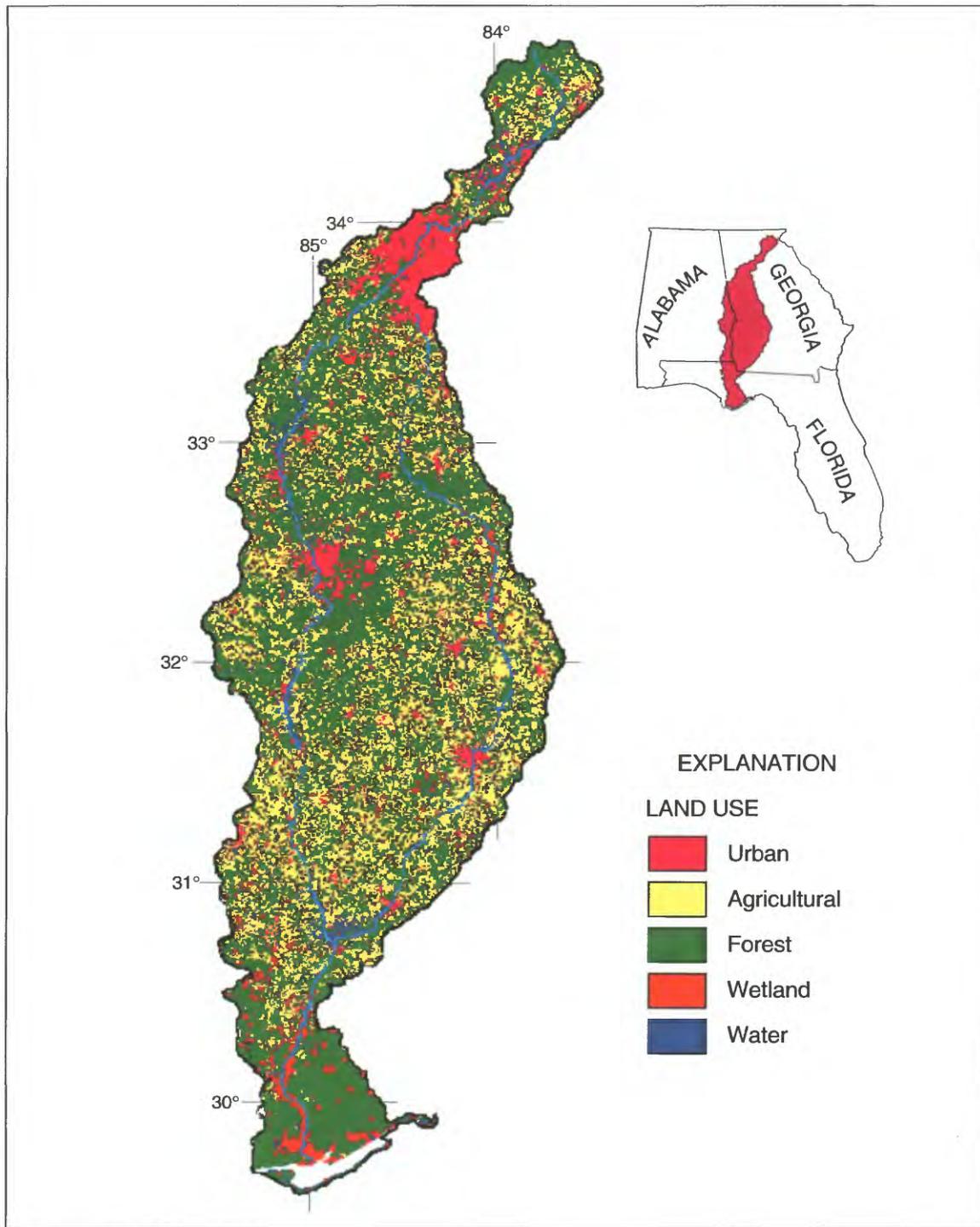


Figure 1. Location of Apalachicola-Chattahoochee-Flint and Ocmulgee River basins in parts of Georgia, Alabama, and Florida.



Base from U.S. Geological Survey digital files

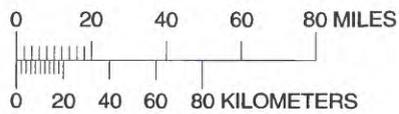


Figure 2. Land use of Apalachicola-Chattahoochee-Flint River basin in parts of Georgia, Alabama, and Florida.

Table 1: Nutrients analyzed for in surface- and ground-water samples collected in the Apalachicola-Chattahoochee-Flint and Ocmulgee River basins, March 1993 through July 1994

[MCL, maximum contaminant level; mg/L, milligrams per liter; --, no drinking-water standard available]

Nutrient	Detection limit (mg/L)	MCL ^{1/} (mg/L)
Nitrite nitrogen, dissolved	0.01	1
Nitrate + nitrite nitrogen, dissolved	.05	10
Ammonia nitrogen, dissolved	.01	--
Ammonia + organic nitrogen, dissolved	.20	--
Ammonia + organic nitrogen, total ^{2/}	.20	--
Orthophosphate as phosphorus, dissolved	.01	--
Dissolved phosphorus	.01	--
Total phosphorus ^{2/}	.01	--

^{1/} U.S. Environmental Protection Agency, primary drinking-water standards (1993).

^{2/} Only analyzed for in surface-water samples.

The term pesticide refers to groups of organic compounds designed to control pests, such as weeds (herbicides), insects (insecticides), fungi (fungicides), and so forth. Pesticides in surface and ground waters at concentrations that exceed standards can be harmful to human and aquatic health. Pesticide inputs to the ACF River basin generally are from applications to cropland, orchards, in and around buildings, lawns and gardens, golf courses, parks, and roadways.

Filtered water samples collected throughout the NAWQA program are analyzed by the USGS National Water Quality Laboratory using two broad-spectrum analytical methods to identify and quantify concen-

trations of 84 pesticides (50 herbicides, 33 insecticides, and 1 fungicide) that have been commonly used throughout the United States. Many of these compounds are used for weed and insect control in the ACF River basin. However, the analytical methods do not include some commonly used pesticides, such as paraquat, methanearsonate, glyphosate, DSMA, MSMA, and several chlorophenoxy herbicides. Therefore, it should not be assumed that these pesticides are not applied in the basin or are not present in the surface and ground waters. Pesticides detected in water samples collected from March 1993 through July 1994 in the ACF and Ocmulgee River basins are listed in table 2. The table also includes method-detection limits for each pesticide and selected water-quality standards and guidelines. In many instances, pesticide concentrations were reported below the established method detection limits when concentrations were not significantly outside the calibration and all criteria were met for a positive result. The method detection limits are used as the default for reporting values when no analyte was detected.

The principal human-health risks associated with select pesticides in drinking water is an increased chance of contracting cancer (Nowell and Resek, 1994). 2,4-D is an example of a pesticide detected in waters within the ACF River basin that has an estimate of cancer risk from drinking water (table 3). The estimated risk is based on the assumption that if a 70 kilogram adult drank 2 liters of water per day containing 100 µg/L of 2,4-D during an average 70-year life span, that person would increase their chances of contracting cancer by 1 in a million (Nowell and Resek, 1994, p. 88). The highest measured 2,4-D concentration in samples collected to date (July 1994) was 0.63 µg/L. The assessment of risk associated with human activities is very complex; however, table 3 helps to put into perspective the risk associated with 2,4-D in water as related to other selected human activities. This perspective is not intended to minimize the importance of detecting harmful chemicals in the water resources of the ACF River basin, but rather to point out that even though there should be concern that pesticides are present, they are present at very low concentrations and generally do not pose serious health concerns.

Table 2. Pesticides detected in surface- and/or ground-water samples collected in the Apalachicola-Chattahoochee-Flint River basin, March 1993 through July 1994
 [µg/L, micrograms per liter; MCL, maximum contaminant level; MCLG, maximum contaminant level goal; Lifetime HA, Lifetime health advisory; --, no standard or guideline available]

Chemical name	Trade name(s)	Method detection limit (µg/L)	Standards or guidelines for human and aquatic health			
			MCL ^{1/} (µg/L)	MCLG ^{2/} (µg/L)	Lifetime HA ^{3/} (µg/L)	Protection of aquatic life ^{4/} (µg/L)
Herbicides						
Alachlor	Lasso	0.009	2	0	--	--
Atrazine	Aatrex	.017	3	3	3	5/2
Deethylatrazine	degradation product of Atrazine	.003	--	--	--	--
Benfluralin ^{6/}	Flubalex	.013	--	--	--	--
Bentazon ^{6/}	Basagran	.05	--	20	20	--
Bromacil ^{6/}	Bromacil	.05	--	--	90	--
Butylate ^{6/}	Sutan +	.008	--	--	350	--
Cyanazine ^{6/}	Bladex	.013	--	1	1	5/2
DCPA ^{6/}	Dacthal	.004	--	--	4,000	--
Ethafuralin ^{6/}	Sonalan	.013	--	--	--	--
Fluometuron	Cotoron	.05	--	--	90	--
MCPA ^{6/}	MCPA and many other names	.05	--	--	7/4	--
Metolachlor	Dual	.009	--	--	100	5/8
Metribuzin ^{6/}	Lexone, Sencor	.012	--	--	200	5/1
Napropamide ^{6/}	Naproquard, Devrinol	.010	--	--	--	--
Norflurazon ^{6/}	Zorial	.05	--	--	--	--
Oryzalin ^{6/}	Snapshot, Surflan	.05	--	--	--	--
Pendimethalin ^{6/}	Prowl, Squadron	.018	--	--	--	--
Prometon ^{6/}	Pramitol	.008	--	--	8/100	--
Pronamide ^{6/}	Kerb	.009	--	--	50	--
Simazine ^{6/}	Princep, Aquazine	.008	4	4	4	10
Tebuthiuron ^{6/}	Spike, Graslan	.003	--	--	500	--
Triclopyr ^{6/}	Garlon, Turflon	.05	--	--	--	--
Trifluralin ^{6/}	Treflan	.012	--	--	7/2	--
2,4-D ^{6/}	2,4-D and many other names	.05	70	70	70	3.0
2,4-DB ^{6/}	2,4-DB	.05	--	--	--	--
Insecticides						
Carbaryl ^{6/}	Sevin	.05	--	--	700	.02
Chlorpyrifos ^{6/}	Lorsban, Dursban	.005	--	--	20	.001
p,p'-DDE ^{9/}	degradation product of DDT	.02	--	--	--	--
Diazinon ^{6/}	Diazinon, Spectracide	.008	--	--	0.6	.009
Ethoprop ^{6/}	Ethoprop	.012	--	--	--	--
Fonofos	Dyfonate	.008	--	--	10	--
Lindane ^{6/}	Lindane	.011	.2	.2	.2	.02
Malathion	Malathion	.014	--	--	7/100	.008
Propoxur ^{6/}	Propoxur, Aprocarb	.05	--	--	3	--
Fungicide						
Chlorothalonil	Bravo, Daconil, Termil	.05	--	--	--	--

^{1/}Maximum contaminant level is the maximum permissible level of a contaminant in water that is delivered to any user of a public water system. This is an enforceable standard, established on the basis of health effects, organoleptic effects (effects on taste and color), treatment feasibility, cost of treatment, and analytical detection, and is set as close to the MCLG as is feasible (U.S. Environmental Protection Agency, 1993; Nowell and Resek, 1994, p. 16).

^{2/}Maximum contaminant level goal is a non-enforceable concentration of a drinking-water contaminant that is protective of adverse human-health effects and allows an adequate margin of safety. For known or probable human carcinogens, MCLG is set at zero. For noncarcinogens, MCLG is equivalent to the lifetime health advisory when both values are final (U.S. Environmental Protection Agency, 1993, Nowell and Resek, 1994, p. 17).

^{3/}Lifetime health advisory is considered protective of noncarcinogenic adverse health effects of a 70 kilogram adult consuming 2 liters of water per day for a period of 70 years (U.S. Environmental Protection Agency, 1993). For noncarcinogens, the lifetime health advisory and MCLG are the same when both values are final (Nowell and Resek, 1994, p. 19-20).

^{4/}Recommended maximum concentration in freshwater to protect aquatic life (Goolsby and others, 1993; Kent and others, 1991; National Academy of Sciences and National Academy of Engineering, 1973; Nowell and Resek, 1994; Pauli and others, 1990, 1991a,b; Trotter and others, 1990).

^{5/}Canadian Government (Environment Canada) water-quality guideline for aquatic life.

^{6/}Detected only in surface-water quality samples.

^{7/}To be conservative, lowest of two different lifetime health advisories printed in various EPA publications is listed (Nowell and Resek, 1994).

^{8/}Assessment is under review (Nowell and Resek, 1994, p. 77).

Table 3. Estimated risks associated with selected human activities
[$\mu\text{g/L}$, micrograms per liter]

Lifetime Chance of Death (50-year lifetime)^{1/}	
Motor vehicle accident	17,000 in 1 million
Drowning	2,500 in 1 million
Fire	2,000 in 1 million
Electrocution	370 in 1 million
Lightning	35 in 1 million
Lifetime Chance of Contracting Cancer (70-year lifetime)	
Cigarette smoking ^{1/}	80,000 in 1 million
Air pollution ^{1/}	1,000 in 1 million
Drinking 2 liters of water per day that contained 100 $\mu\text{g/L}$ 2,4-D ^{2/, 3/}	1 in 1 million

^{1/}Crouch and Wilson (1984).

^{2/}Nowell and Resek (1994).

^{3/}Water-quality criteria for the protection of human health: a 70 kilogram adult drinking 2 liters of water per day would increase risk of contracting cancer by 1 in one million over an average life span of 70 years (U.S. Environmental Protection Agency, 1986).

Acknowledgments

The USGS gratefully acknowledges the cooperation of farmers and homeowners for providing access to their land for installation of monitor wells. Appreciation also is extended to personnel with the Georgia State Highway Patrol and the Georgia Forestry Commission, Baker-Mitchell Unit, for their assistance during the flooding following tropical storm Alberto. The authors also wish to recognize the priority analyses performed by the personnel of the USGS National Water-Quality Laboratory, Arvada, Co., under the direction of William R. White.

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CHAPTER 1: SEDIMENT AND AGRICULTURAL CHEMICALS IN FLOODWATERS FROM TROPICAL STORM ALBERTO IN JULY 1994

During the period July 3-7, 1994, tropical storm Alberto moved northward from the Gulf of Mexico, across the Florida panhandle, and into parts of southwestern and central Georgia and southeastern Alabama. Parts of central and southwest Georgia received as much as 28 inches of rainfall during the storm (fig. 3) causing record flooding on the Flint and Ocmulgee Rivers and several of their tributaries. To assess the water quality and mass transport related to the flood, personnel from the USGS Georgia and Florida Districts sampled streams in the affected areas of the Flint, Apalachicola, and Ocmulgee Rivers from July 6-26. This chapter presents a brief description and summary of the data collected from the flood and preliminary findings related to mass transport of sediment, nutrients, and selected pesticides.

Flood-related deaths totaled 31 in Georgia, and 2 in Alabama (Jerry Curnutt, National Weather Service, written commun., 1994). Fifty-five counties in Georgia, 10 in Alabama, and 13 in Florida were declared disaster areas. Urban areas, such as Macon, Montezuma, Americus, Albany, Newton, and Bainbridge, were severely flooded. Cost estimates to repair damaged property and infrastructure totaled hundreds of millions of dollars. Initial estimates of farmland damaged by intensive rainfall or inundated by floodwaters were as much as 400,000 acres (Clark Weaver, U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, written commun., 1994).

Runoff and flooding of urban and agricultural areas can result in transport of industrial chemicals, untreated sewage, and agricultural chemicals by floodwaters; and subsequent deposition of sediment and transport of contaminants into flooded areas and downstream reservoirs, river mouths, or estuaries. Contaminants in floodwaters can render the water unsuitable for drinking or for aquatic life. Deposition of sediment and associated contaminants in floodplains and river mouths or estuaries can impair crop production, aquatic habitats, and fisheries.

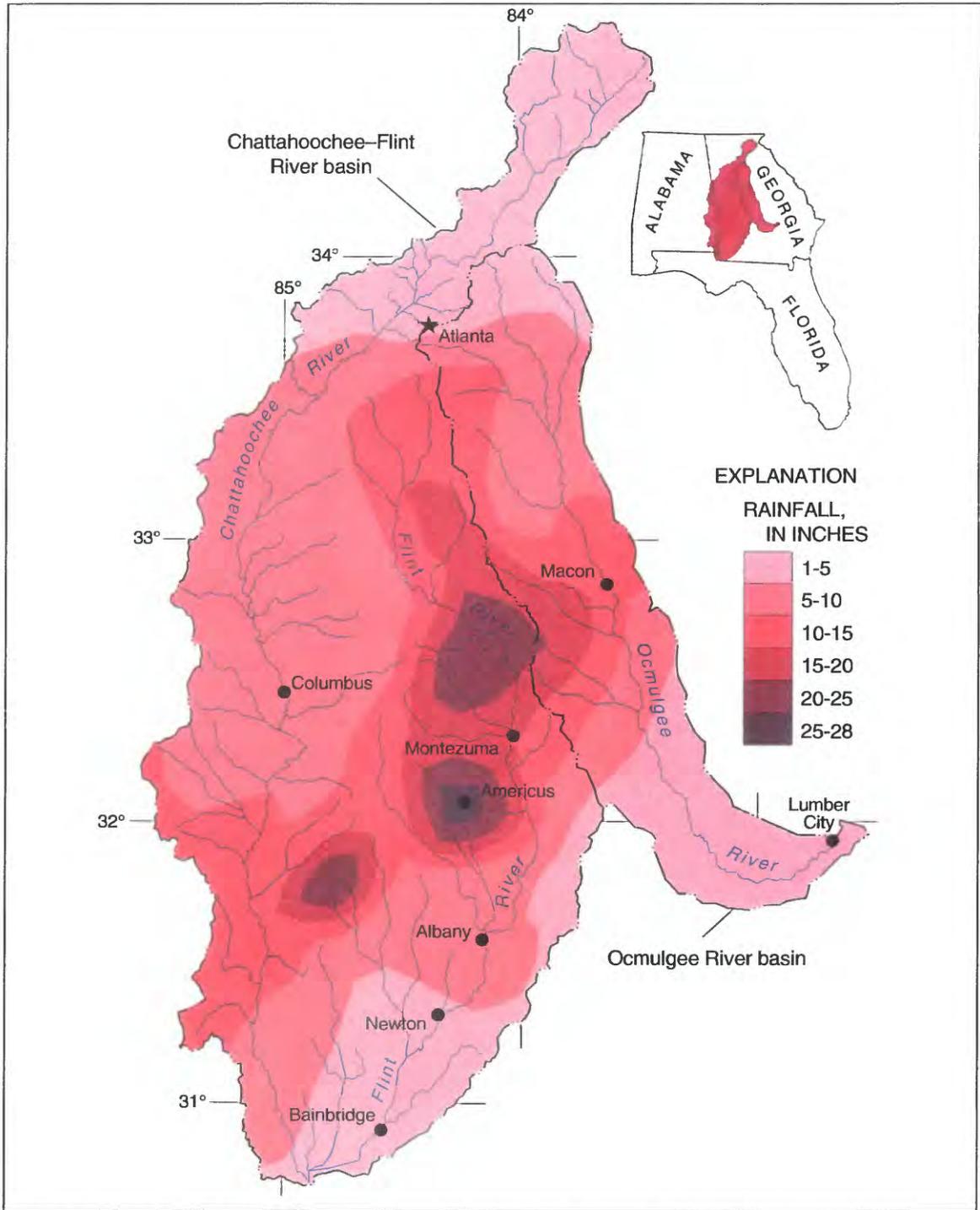
During flooding caused by tropical storm Alberto, water-quality samples were collected from locations on the Flint River, six tributaries to the Flint River, the Apalachicola River, and the Ocmulgee River. One or two samples were collected at each of these locations (fig. 4). Intensive data collection was performed at furthest downstream locations available on the Flint River (19 samples at Newton) and Ocmulgee River (8 samples at Lumber City). The purpose of this more intensive monitoring was to assess changes in water-quality conditions and mass transport at these points for the duration of the flood.

Sediment

During periods of intensive rainfall, the resulting runoff and flooding often causes extensive erosion from upland areas and resuspension of sediments in streambeds and floodplains. Loss of topsoil from upland areas can damage land by incision of gullies and can reduce the productivity of cropland. Eroded topsoil and resuspended sediments in rivers and streams can affect aquatic life. Deposition of sediment and contaminants in rivers and estuaries can have a negative effect on the navigational use of waterways and may render the water resource unsuitable for use as drinking water or for aquatic life.

Sand was a minor component of the suspended sediment transported during the flood on the basis of multiple-interval, depth-integrated samples collected at mainstem and tributary sites (table 4). However, during the flooding, water depths in the channel and floodplain of the Flint River at Montezuma, Kinchafoonee Creek near Dawson, and Flint River at Newton, exceeded the depth limit of 15 feet for the D-77 sampler. Because the depth limits were exceeded, the measured suspended-sediment concentrations might be less than actual concentrations. Sediment concentrations in samples collected during the flood were not substantially different from samples collected through the normal annual range of flow conditions. However, the instantaneous and cumulative sediment loads were substantial based on the record water discharges at most sites.

The highest measured suspended-sediment concentrations were at or near bankfull conditions as floodwaters were rising on the Flint River at Newton and the Ocmulgee River at Lumber City (fig. 5). Samples collected above bankfull conditions contained less suspended sediment and sand than samples collected at bankfull conditions. This decrease at higher stages could be the result of trapping of sediment in densely vegetated floodplains and deposition of sand in the mouths of tributary streams that were in backwater from the mainstem. The cumulative sediment loads for the Flint and Ocmulgee Rivers were 110,000 and 83,800 tons, respectively. Yields of suspended sediment also were slightly higher at 60 and 51 pounds per acre, respectively. Suspended-sediment data prior to the flood are not sufficient to estimate historic sediment loads in Flint River at Newton and Ocmulgee River at Lumber City. The cumulative load of suspended sediment likely is small in comparison to quantities that were redistributed within the drainage areas, with much of the material deposited in the extensive floodplains along the Flint and Ocmulgee Rivers upstream of these locations.



Base from U.S. Geological Survey digital files

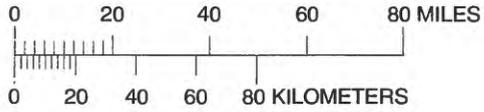
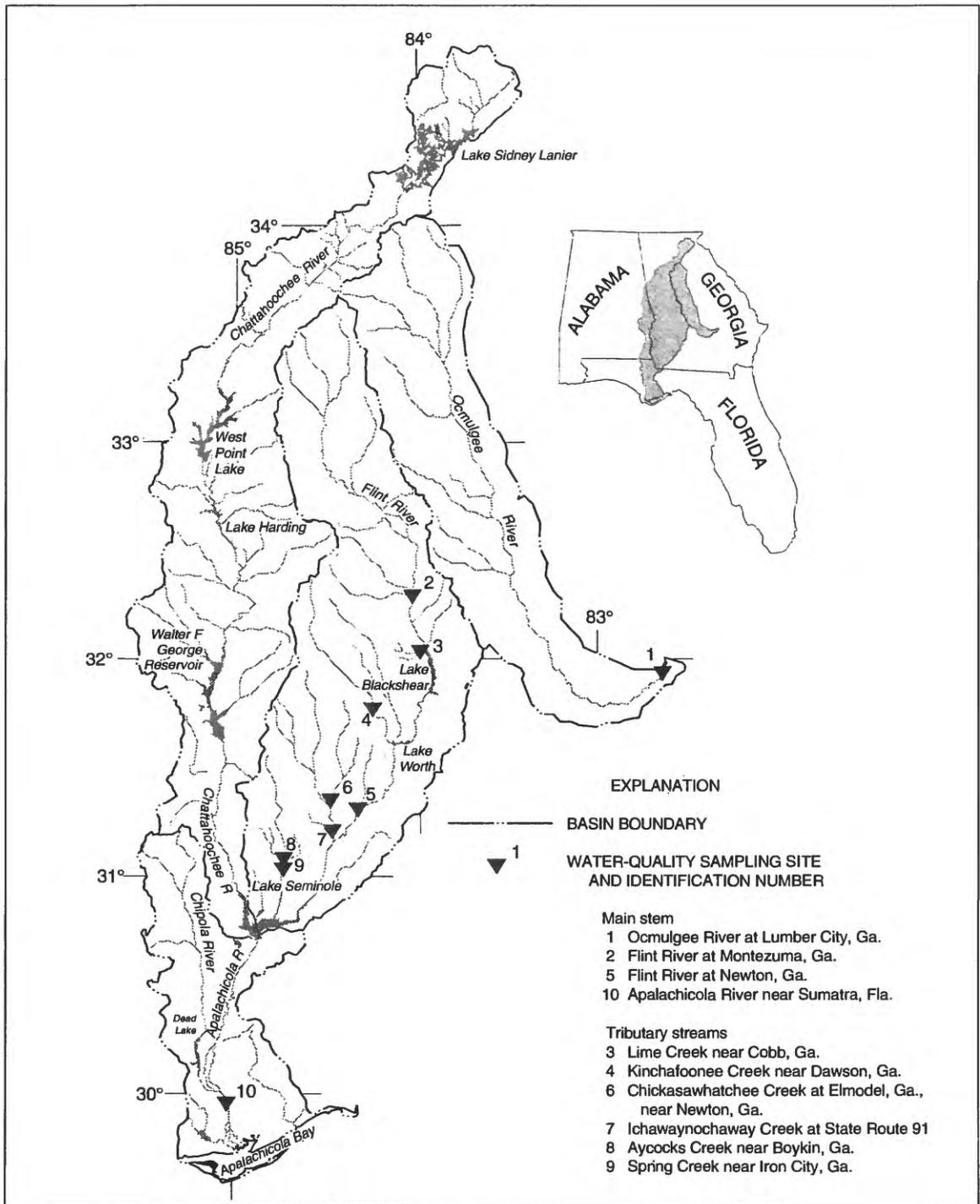


Figure 3. Cumulative precipitation during tropical storm Alberto, July 3-7, 1994 (data from U.S. Bureau of Commerce, National Weather Service).



Base from U.S. Geological Survey digital files

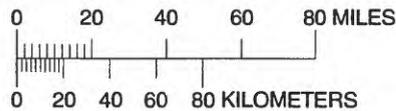


Figure 4. Location of sites sampled during flooding caused by tropical storm Alberto, July 6-26, 1994.

Table 4. Hydrologic and suspended-sediment data for selected river and tributary sampling locations in the Ocmulgee, Flint, and Apalachicola River basins during flooding caused by tropical storm Alberto, July 1994 (All discharges are provisional and subject to revision.)

[mi², square miles; ft³/s, cubic feet per second; mg/L, milligrams per liter; mm, millimeter; --, no data; >, greater than; <, less than]

Site name	Drainage area (mi ²)	Peak discharge July 1994		Selected suspended-sediment and related data collected during flooding, July 1994			
		Date	Discharge (ft ³ /s)	Sampling date(s) ^{1/}	Discharge(s) (ft ³ /s) ^{1/}	Concentration(s) (mg/L) ^{1/}	Percent(s) finer than 0.062 mm ^{1/}
<i>Ocmulgee River basin</i>							
Ocmulgee River at Lumber City, Ga.	5,180	07-15-94	93,800	07-07-94 to 07-25-94	4,470 to 93,200	12 to 142	-- --
<i>Flint River basin</i>							
Flint River at Montezuma, Ga.	2,900	07-08-94	136,000	07-06-94	^{2/} 58,000	93	91
Lime Creek near Cobb, Ga.	62	07-06-94	^{3/} >920	07-05-94 07-05-94	358 837	63 150	98 98
Kinchafoonee Creek near Dawson, Ga.	527	07-07-94	24,000	07-07-94	^{2/} 24,000	62	99
Flint River at Newton, Ga.	5,740	07-13-94	100,000	07-06-94 to 07-26-94	11,100 to 100,000	12 to 72	80 to 100
Chickasawhatchee Creek at Elmodel, Ga.	320	07-08-94	16,000	07-07-94	3,510	23	99
Ichawaynochaway Creek at State Route 91 near Newton, Ga.	1,020	--	^{4/} >33,000	07-07-94	10,900	36	96
Aycocks Creek near Boykin, Ga.	105	07-08-94	1,110	07-05-94	447	22	99
Spring Creek near Iron City, Ga.	485	07-08-94	13,000	07-08-94	13,000	27	88
<i>Apalachicola River basin</i>							
Apalachicola River near Sumatra, Fla.	19,200	07-14-94	221,000	07-17-94 07-21-94	173,000 138,000	-- --	-- --

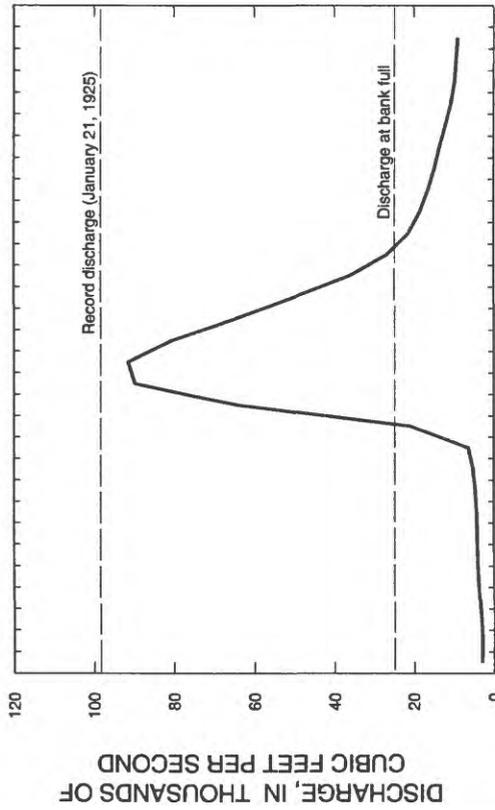
^{1/} Ranges based on 8 suspended-sediment samples at Ocmulgee River at Lumber City and 19 suspended-sediment samples at Flint River at Newton.

^{2/} Estimated discharge.

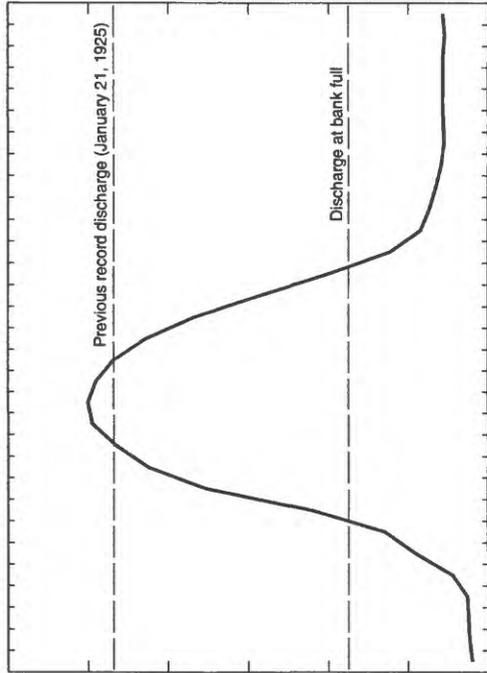
^{3/} Gage destroyed by floodwaters July 5, 1994. Peak gage height was 23.92 feet, which may have been affected by backwater from Lake Blackshear. Previous peak discharge of 920 ft³/s was at a gage height of 14 feet.

^{4/} Discharge measured July 7, 1994, prior to peak discharge.

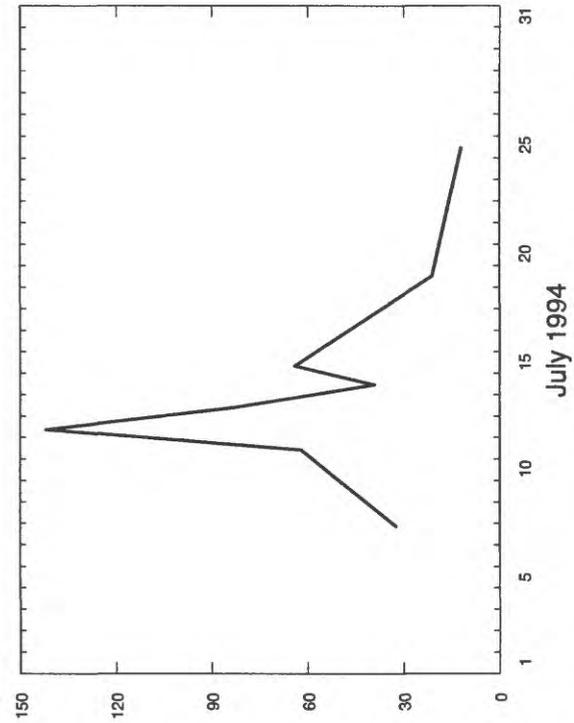
Ocmulgee River at Lumber City, Georgia



Flint River at Newton, Georgia



SUSPENDED SEDIMENT CONCENTRATION,
IN MILLIGRAMS PER LITER



SUSPENDED SEDIMENT FRACTION FINER
THAN 0.062 MILLIMETERS, IN PERCENT

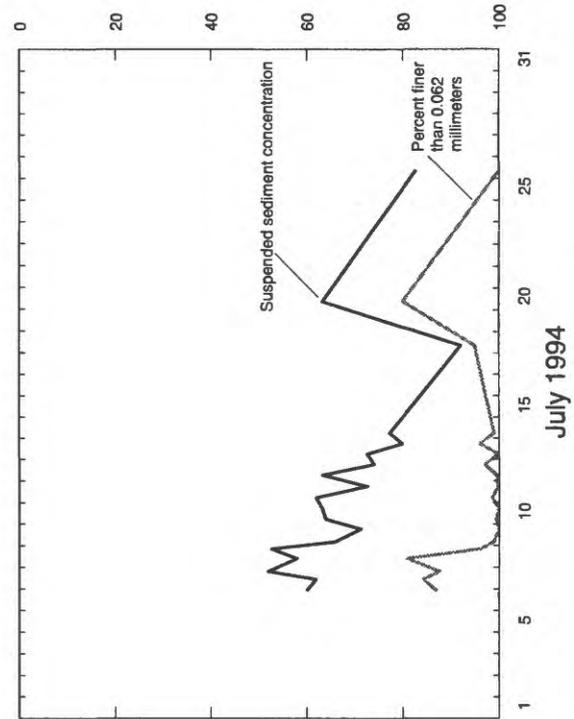


Figure 5. Discharge and suspended-sediment concentrations in Flint River at Newton, Georgia, and Ocmulgee River at Lumber City, Georgia, during flooding caused by tropical storm Alberto, July 1994.

Nutrients

Runoff from upland areas and floodwaters that inundate lowlands contain substantial quantities of the essential plant nutrients nitrogen and phosphorus. These nutrients are derived from numerous sources, including fertilizer or animal manure on cropland; discharges from wastewater-treatment facilities; and sediment and organic detritus in streambeds and floodplains. High concentrations of nitrite, nitrate, and ammonia may render water unsuitable for consumption. High concentrations of nitrogen and phosphorus can encourage excessive plant growth and possible eutrophication of large water bodies, such as Lake Seminole.

Total nitrogen concentrations in water samples collected during the flood (table 5) were only slightly lower than median concentrations from data collected prior to the flood (E.A. Frick and G.R. Buell, U.S. Geological Survey, written commun., 1994). However, much of the nitrogen present in floodwaters was in the form of dissolved and suspended organic nitrogen, with much lower than normal concentrations of dissolved nitrate. Organic detritus washed off upland areas and floodplains were probably the principal source of organic nitrogen in floodwaters.

Water samples collected throughout the flood from the Flint River at Newton and the Ocmulgee River at Lumber City illustrate a decrease in nitrate concentrations and increases in suspended organic nitrogen and suspended phosphorus at discharges above flood stage (fig. 6). Return to bankfull conditions toward the end of the flood on the Flint and Ocmulgee Rivers was marked by the highest concentrations of ammonia and the presence of mostly dissolved forms of phosphorus and organic nitrogen. This water-quality pattern in the channel is consistent with large return flows of water that had moved from the channel to the floodplain at higher stages.

Concentrations of dissolved and suspended phosphorus (table 5) were slightly higher than median concentrations from data collected prior to the flood. Much of the phosphorus present during peak discharges was associated with suspended material rather than in solution, except in Aycocks Creek. Nutrient data collected at the Flint River at Newton and Ocmulgee River at Lumber City illustrate an increase in phosphorus concentrations during the flood (fig. 6).

Floodwaters on the Flint and Ocmulgee Rivers transported a substantial part of the mean annual loads of phosphorus and organic plus ammonia nitrogen; and a lesser part of the mean annual load of nitrate plus nitrite (fig. 7) (E.A. Frick and G.R. Buell, U.S. Geological Survey, written commun., 1994). These large loads from the flood were due, in part, to the large volume of runoff. Seven inches of runoff during the flood in the Flint River at Newton was about 45 percent of the mean annual discharge for the 63-year period of record. The 4.6 inches of runoff in the Ocmulgee River at Lumber City was 32 percent of the mean annual discharge for the 57-year period of record (Stokes and McFarlane, 1994). Nutrient loads were higher in the Flint River than the Ocmulgee River. This is probably because there was more runoff from the Flint River basin than the Ocmulgee River basin, and a greater proportion of the runoff was from agricultural land in the Flint River basin. A greater proportion of the runoff was from forested areas in the Ocmulgee River basin.

Pesticides

Pesticides are widely used in suburban and urban areas. The pesticides present in runoff and streams following storms can be from numerous sources, including applications to agricultural land, turf, gardens, roadsides, and maintained right of ways. However, given the magnitude of the flooding, additional sources may be from stored pesticides at farms, homes, and businesses that were flooded. When pesticides are present in streams, they can make the water unsuitable for human consumption or adversely effect aquatic life. However, the concentrations that result in such impairments vary widely from compound to compound (table 2).

Fourteen herbicides, five insecticides, and one fungicide used in agricultural or urban areas were detected in one or more water samples collected at or near peak discharges from mainstem and tributary sites (tables 6 and 7). The compounds detected include those used on cropland, noncropland, cropland and turf, and several compounds that are widely used in urban and agricultural settings. Urban areas situated along the Flint and Ocmulgee Rivers likely are the principal sources of carbaryl, diazinon, malathion, and prometon, because they were not detected in most tributary streams that drain primarily agricultural areas.

Table 5. Nutrient data for selected river and tributary sampling locations in the Ocmulgee, Flint, and Apalachicola River basins during flooding caused by tropical storm Alberto, July 1994 [mg/L, milligrams per liter; N, nitrogen; P, phosphorus; >, greater than; <, less than]

Site name	Sampling date(s) ^{1/}	Nitrogen			Phosphorus		
		Concentration(s) ^{1/}	Percent(s) ^{1/} of total nitrogen	Concentration(s) ^{1/}	Percent(s) ^{1/} of total phosphorus	Dissolved phosphorus	
		Total nitrogen (mg/L as N)	Total organic nitrogen	Dissolved nitrate	Total phosphorus (mg/L as P)		
Ocmulgee River basin							
Ocmulgee River at Lumber City, Ga.	07-07-94 to 07-25-94	0.52 to .87	>45 to 91	<6 to 52	0.05 to .16	8 to 57	
Flint River basin							
Flint River at Montezuma, Ga.	07-06-94	.60	>90	<7	.11	<9	
Lime Creek near Cobb, Ga.	07-05-94 07-05-94	.97 1.28	70 64	27 27	.13 .24	31 29	
Kinchafoonee Creek near Dawson, Ga.	07-07-94	.50	>88	<9	.14	<7	
Flint River at Newton, Ga.	07-06-94 to 07-26-94	.46 to 1.04	32 to 86	<9 to 60	.06 to .17	<6 to 83	
Chickasawhatchee Creek at Elmodel, Ga.	07-07-94	.55	>89	8	.03	33	
Ichawaynochaway Creek at State Route 91 near Newton, Ga.	07-07-94	.59	>83	14	.08	25	
Aycocks Creek near Boykin, Ga.	07-05-94	.77	>64	34	.04	100	
Spring Creek near Iron City, Ga.	07-08-94	.60	>82	15	.07	14	
Apalachicola River basin							
Apalachicola River near Sumatra, Fla.	07-17-94 07-21-94	.65 .66	72 70	22 23	.09 .06	11 <17	

^{1/}Ranges based on 8 nutrient samples at Ocmulgee River at Lumber City and 19 nutrient samples at Flint River at Newton.

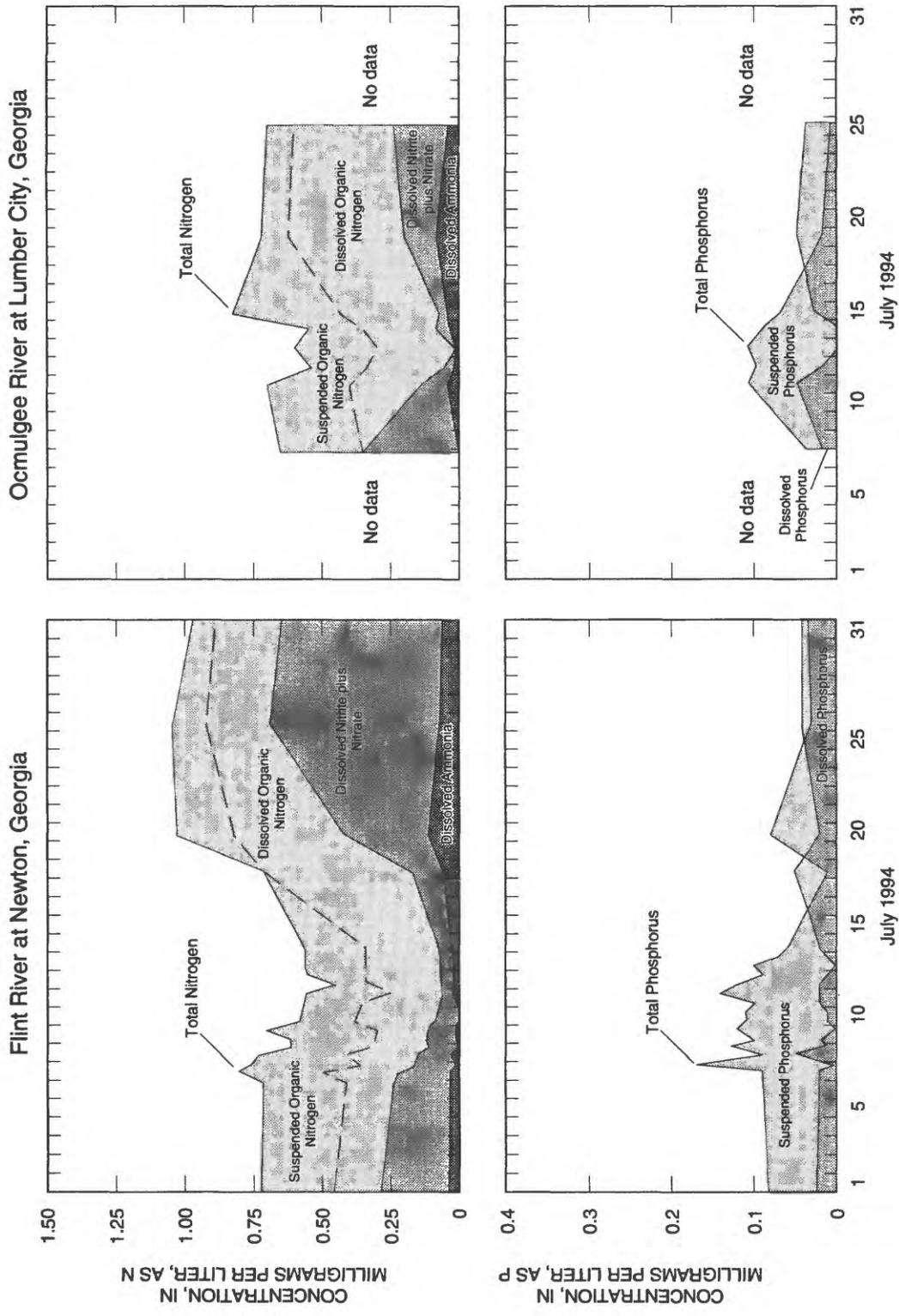


Figure 6. Nutrient concentrations in Flint River at Newton, Georgia, and Ocmulgee River at Lumber City, Georgia, during flooding caused by tropical storm Alberto, July 1994.

Table 6. Herbicide-concentration data for selected river and tributary sampling locations in the Ocmulgee, Flint, and Apalachicola River basins during flooding caused by tropical storm Alberto, July 1994
[<, less than; --, no data]

Site name	Sampling dates(s) ^{1/2}	Herbicide concentration(s) ^{1/2} (in micrograms per liter)													
		Alachlor	Atrazine	Deethyl-atrazin	Ben-tazon	Cyana-zine	Fluome-turon	Meto-lachlor	Metri-buzin	Norflu-razon	Prome-ton	Simazine	Tebu-thiuron	Triflur-ain	2,4-D
<i>Ocmulgee River basin</i>															
Ocmulgee River at Lumber City, Ga.	07-07-94 to 07-25-94	<0.009	2/0.012 to .027	2/0.002 to <.007	<0.05	<0.013 to .053	2/0.03 to .07	2/0.006 to .011	2/0.009 to <.012	>.05	2/0.006 to .025	0.009 to .054	0.016 to .12	<0.012	<0.05
<i>Flint River basin</i>															
Flint River at Montezuma, Ga.	07-06-94	<0.009	2/0.012	<0.007	<0.05	<0.013	2/0.04	<0.009	<0.012	<0.05	<0.008	2/0.005	<0.015	<.012	<.05
Lime Creek near Cobb, Ga.	07-05-94 to 07-05-94	2/.006 to <.009	.017 to .038	.004 to .005	2/.03 to .12	.40 to .77	.60 to .36	.052 to .34	.031 to .024	<.05 to 2/.03	<.008 to <.008	2/.004 to 2/.006	<.015 to <.015	<.012 to .013	<.05 to <.05
Kinchafoonee Creek near Dawson, Ga.	07-07-94	.022	.038	.004	<.05	.072	.06	.096	.019	<.05	<.008	<.008	.085	<.012	<.05
Flint River at Newton, Ga.	07-06-94 to 07-26-94	2/.006 to .021	2/.016 to .054	2/.002 to <.007	2/.04 to <.05	.034 to .1	2/.02 to .07	2/.008 to .043	2/.007 to .023	<.05 to <.05	2/.006 to .014	2/.005 to .013	2/.009 to .055	2/.005 to <.012	<.05 to .09 to <.05
Chickasawhatchie Creek at Elmodel, Ga.	07-07-94	.013	.024	.005	<.05	.29	.06	.059	<.012	<.05	<.008	<.008	<.015	<.012	<.05
Ichawaynochaway Creek at State Route 91 near Newton, Ga.	07-07-94	.023	.093	.005	<.05	.25	.09	.037	.015	<.05	<.008	<.008	.045	<.012	<.05
Aycocks Creek near Boykin, Ga.	07-05-94	.009	.036	.007	2/.03	.048	<.05	.057	<.012	<.05	<.008	<.008	<.015	<.012	2/.03
Spring Creek near Iron City, Ga.	07-08-94	<.009	.098	.007	<.05	.46	.27	.100	<.012	<.05	<.008	<.008	<.015	<.012	<.05
<i>Apalachicola River basin</i>															
Apalachicola River channel near Sumatra, Fla.	07-17-94 to 07-21-94	2/.005 to 2/.005	.024 to .021	2/.002 to <.005	<.05 to <.05	.062 to .055	2/.03 to 2/.03	.018 to .014	2/.006 to <.012	<.05 to <.05	<.008 to .011	.010 to .009	2/.012 to <.015	<.012 to <.012	<.05 to <.05

^{1/2}Ranges based on 8 pesticide samples at Ocmulgee River at Lumber City and 19 pesticide samples at Flint River at Newton.
^{2/2}Concentration is less than the method detection limit.

Table 7. Insecticide- and fungicide-concentration data for selected river and tributary sampling locations in the Ocmulgee, Flint, and Apalachicola River basins during flooding caused by tropical storm Alberto, July 1994 {<, less than]

Site name	Sampling dates(s) ^{1/}	Concentration(s) ^{1/} (in micrograms per liter)					
		Insecticides					Fungicide
		Carbaryl	Chlorpyrifos	Diazinon	Fonofos	Malathion	Chlorothalonil
Ocmulgee River basin							
Ocmulgee River at Lumber City, Ga.	07-07-94 to 07-25-94	^{2/} 0.003 to <.046	<.005	^{2/} 0.004 to .008	<.008	<.014	<.05
Flint River basin							
Flint River at Montezuma, Ga.	07-06-94	<.046	<.005	<.008	<.008	<.01	<.05
Lime Creek near Cobb, Ga.	07-05-94 07-05-94	<.046 ^{2/} .006	<.008 <.008	<.008 <.008	<.008 ^{2/} .004	^{2/} .009 <.014	<.05 <.05
Kinchafoonee Creek near Dawson, Ga.	07-07-94	<.046	.011	<.008	.067	<.01	<.05
Flint River at Newton, Ga.	07-06-94 to 07-26-94	^{2/} .007 to <.046	<.005 to .015	^{2/} .004 to .012	^{2/} .002 to .014	^{2/} .007 to .044	.04 to <.05
Chickasawhatchee Creek at Elmodel, Ga.	07-07-94	<.046	<.005	<.008	.059	<.01	<.05
Ichawaynochaway Creek at State Route 91 near Newton, Ga.	07-07-94	<.046	<.005	<.008	.075	<.01	<.05
Aycocks Creek near Boykin, Ga.	07-05-94	<.046	.099	<.008	^{2/} .003	<.014	<.05
Spring Creek near Iron City, Ga.	07-08-94	<.046	.009	<.008	.16	<.01	<.05
Apalachicola River basin							
Apalachicola River near Sumatra, Fla.	07-17-94 07-21-94	^{2/} .005 <.046	<.008 <.008	^{2/} .006 .009	^{2/} .005 ^{2/} .003	<.014 <.014	<.05 <.05

^{1/}Ranges based on 8 pesticide samples at Ocmulgee River at Lumber City and 19 pesticide samples at Flint River at Newton.

^{2/}Concentration is less than the method detection limit.

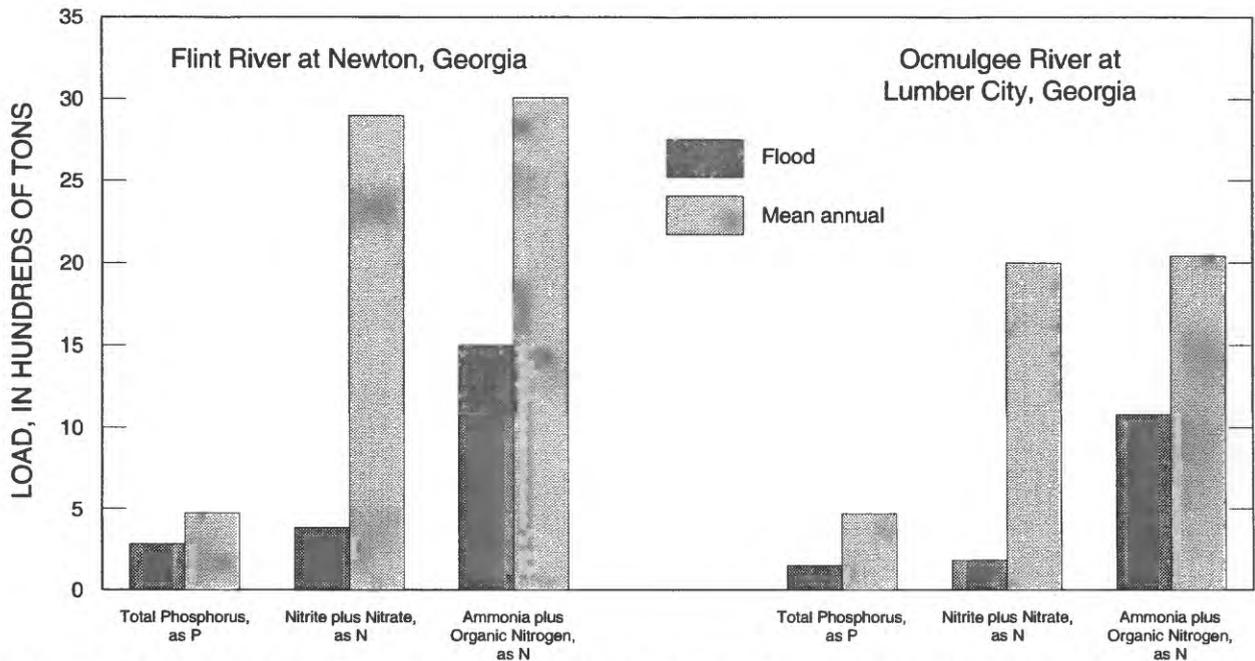


Figure 7. Nutrient loads in Flint River at Newton, Georgia, and Ocmulgee River at Lumber City, Georgia, during flooding caused by tropical storm Alberto, July 1994.

Concentrations of herbicides in floodwater generally were well below applicable drinking-water standards or guidelines, as well as guidelines for protecting aquatic life (table 2). Cyanazine was measured at highest concentrations relative to drinking-water standards or guidelines, at 77 percent of the lifetime health-advisory level (table 2). The insecticide diazinon was detected at concentrations as high as 18 percent of the lifetime health-advisory level. Concentrations of the insecticides chlorpyrifos, carbaryl, and diazinon, however, did approach or exceed guidelines intended for protecting aquatic life (National Academy of Sciences/National Academy of Engineering, 1973) in samples from the Flint and Ocmulgee Rivers as well as the Apalachicola River near Sumatra, Fla., just 20.6 river miles upstream of Apalachicola Bay.

The herbicides alachlor, atrazine, cyanazine, fluometuron, and metolachlor, primarily used for weed control on cropland, were measured at higher concentrations in the Flint River at Newton than the Ocmulgee River at Lumber City (table 6). The herbicides prometon and tebuthiuron, used for weed control on noncropland areas were measured at higher concentrations in the Ocmulgee River at Lumber City than the Flint River at Newton.

The highest measured concentrations of most pesticides in the Flint River at Newton were observed from 4 to 6 days prior to the peak discharge (figs. 8-10). This is indicative of an early flush of pesticides in the initial runoff from this basin. However, measured concentrations of several pesticides in the Ocmulgee were highest in a sample collected during baseflow conditions three days prior to flooding at Lumber City (fig. 11). The open circles shown at the method detection limits in figures 8 through 11 indicate samples with unknown concentrations between zero and the method detection limit.

Cumulative loads were computed for seven herbicides and one insecticide (diazinon) that were present throughout much of the flood either in the Flint River at Newton or the Ocmulgee River at Lumber City (fig. 12). The amount of these pesticides used in the basins is not known. However, the flood loads of each of these compounds is very small relative to the 7.6 million pounds of herbicides and 3.7 million pounds of insecticides applied throughout Georgia each year (Gianessi and Puffer, 1990, 1992).

In summary, much of the topsoil eroded during intensive rainfall and flooding in the Flint and Ocmulgee River basins probably was redeposited in extensive floodplains within the basins. The suspended sediment transported from the basins was comprised mostly of silt- and clay-sized material. In floodwaters, total nitrogen concentrations were lower, and total phosphorus concentrations were higher than median concentrations in samples collected prior to the flood. Much of the nitrogen load was in the form of organic nitrogen generally derived from organic detritus, rather than nitrate derived from other sources, such as fertilizer. Floodwaters transported a large part of the mean annual load of total phosphorus and organic nitrogen and a lesser part of the mean annual load of nitrite plus nitrate. Fourteen herbicides, five insecticides, and one fungicide commonly used in urban and agricultural areas were detected in floodwaters of the Ocmulgee, Flint, and Apalachicola Rivers. Concentrations of nitrate nitrogen and detected pesticides were below EPA standards and guidelines for drinking water. However, concentrations of the insecticides chlorpyrifos, carbaryl, and diazinon approached or exceeded guidelines for protection of aquatic life.

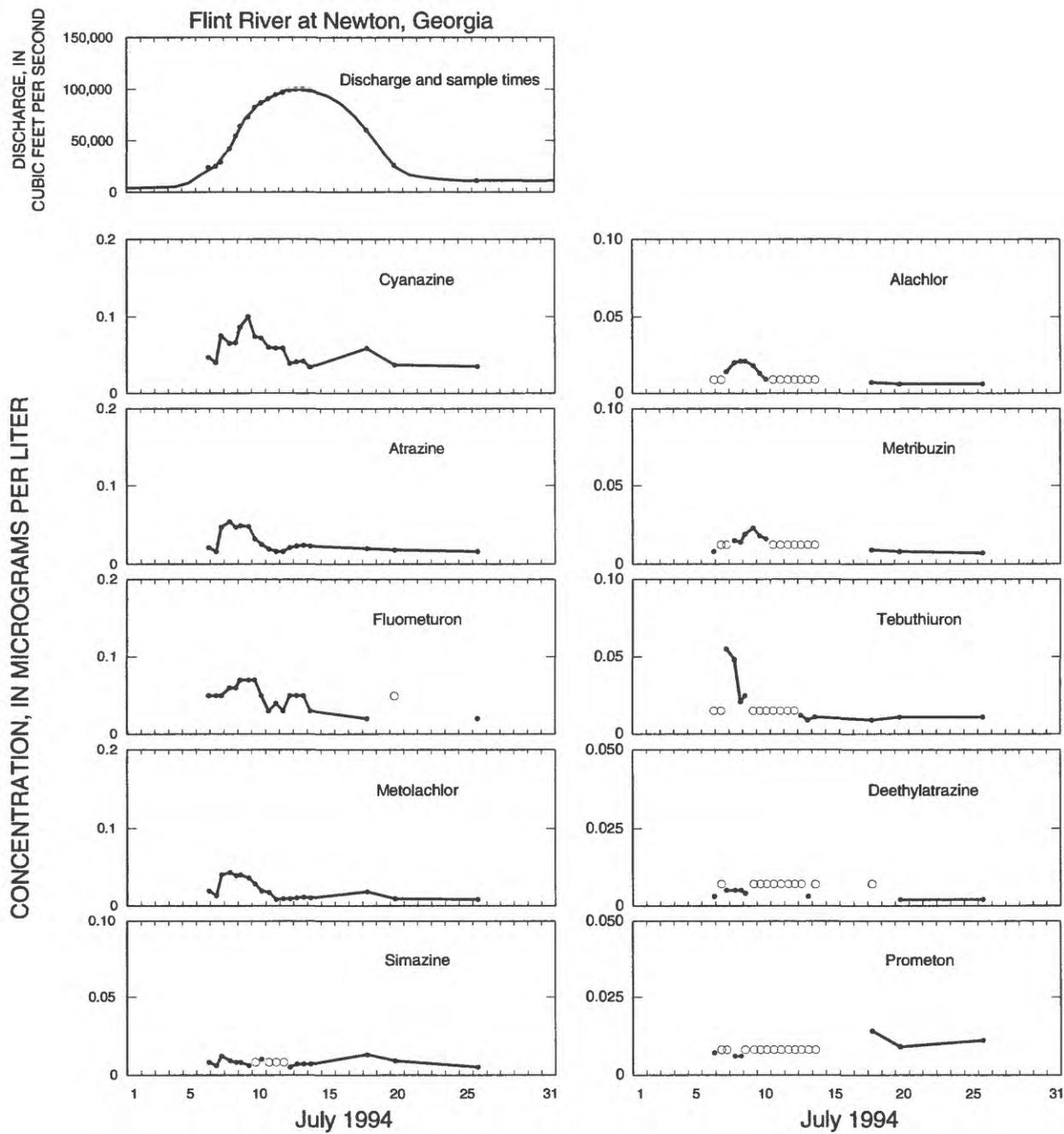


Figure 8. Discharge and herbicide concentrations in Flint River at Newton, Georgia, during flooding caused by tropical storm Alberto, July 1994. Open circles indicate unknown concentration is between zero and method detection limit for that sample.

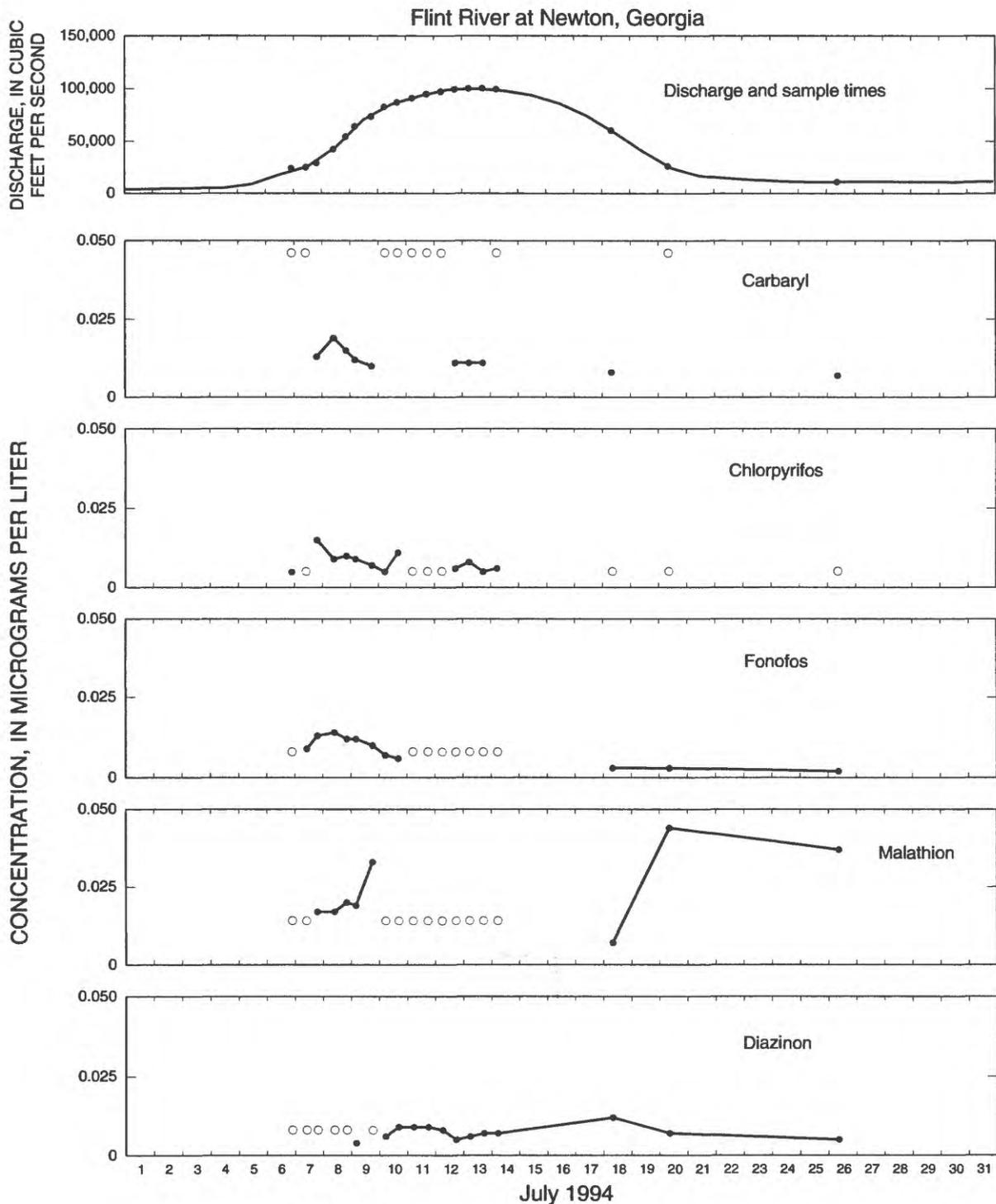


Figure 9. Discharge and insecticide concentrations in Flint River at Newton, Georgia, during flooding caused by tropical storm Alberto, July 1994. Open circles indicate unknown concentration is between zero and method detection limit for that sample.

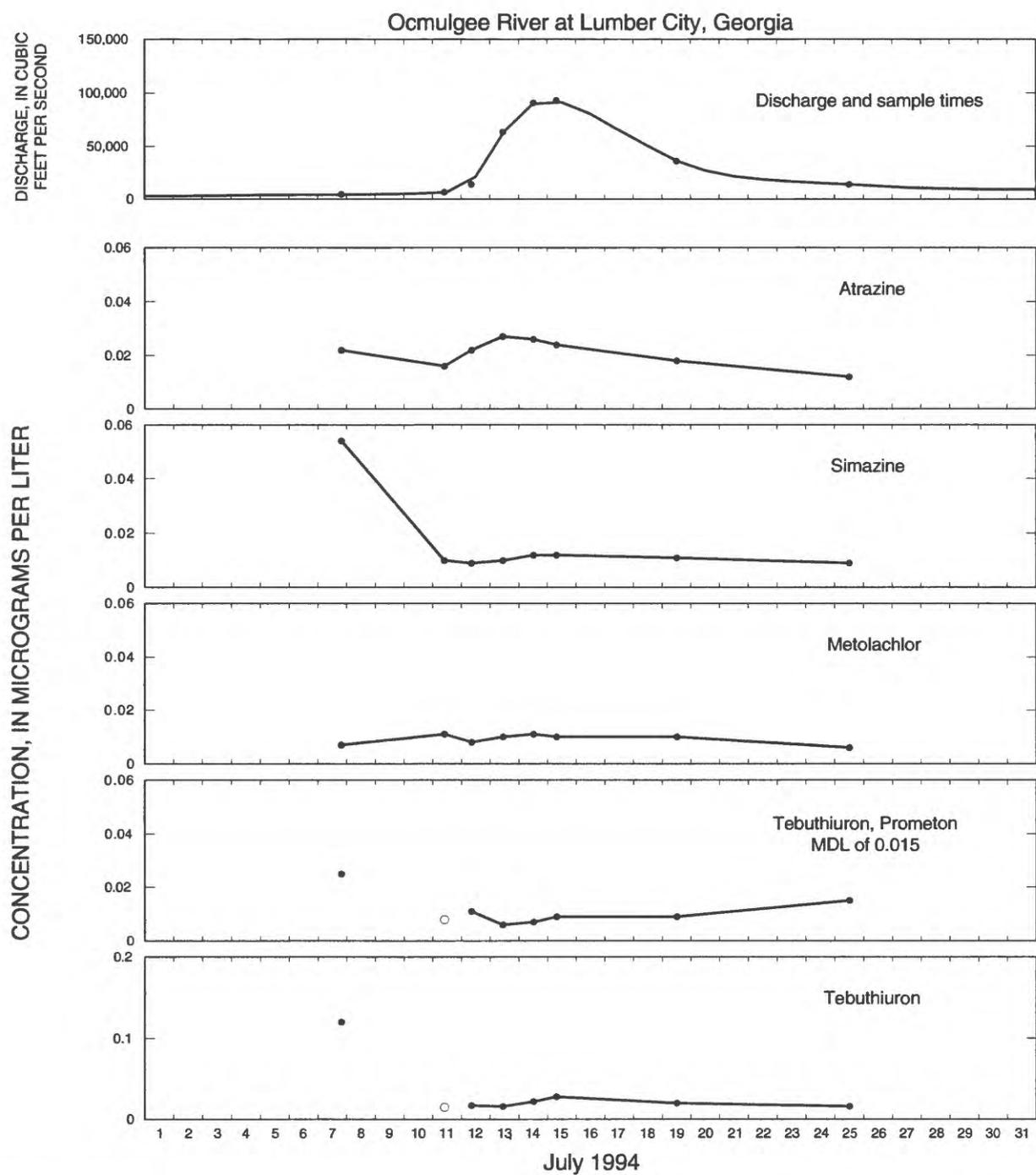


Figure 10. Discharge and herbicide concentrations in Ocmulgee River at Lumber City, Georgia, during flooding caused by tropical storm Alberto, July 1994. Open circles indicate unknown concentration is between zero and method detection limit for that sample.

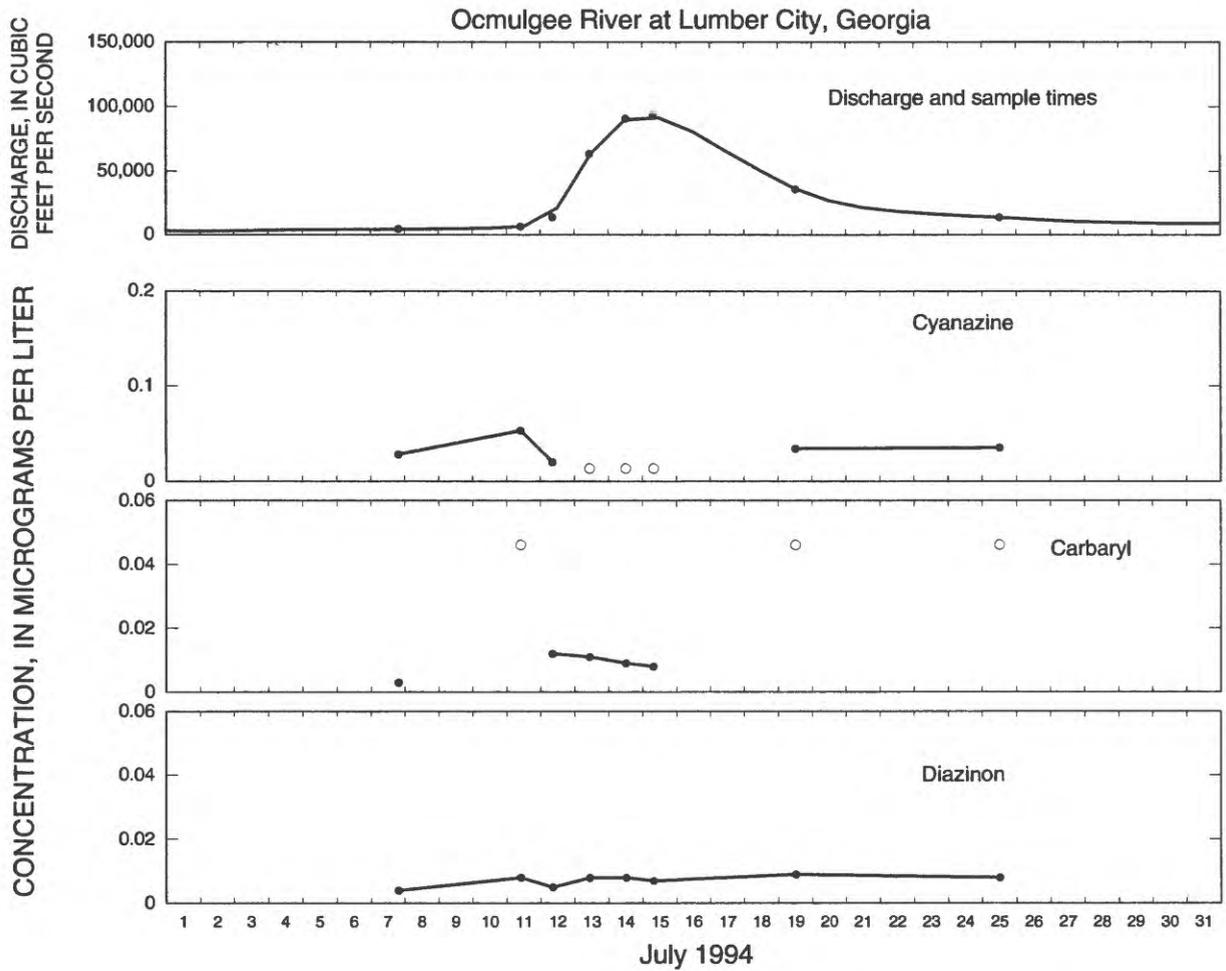


Figure 11. Discharge and insecticide concentrations in Ocmulgee River at Lumber City, Georgia, during flooding caused by tropical storm Alberto, July 1994. Open circles indicate unknown concentration is between zero and method detection limit for that sample.

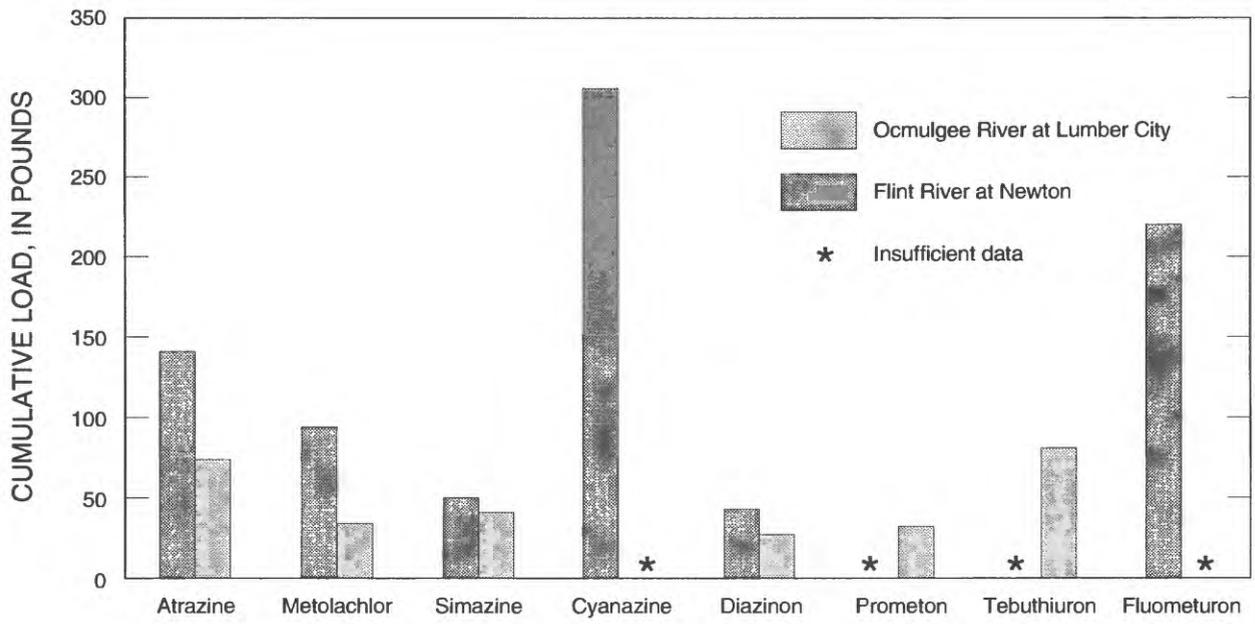


Figure 12 . Cumulative loads of selected pesticides in Flint River at Newton, Georgia, and Ocmulgee River at Lumber City, Georgia, during flooding caused by tropical storm Alberto in July, 1994.

CHAPTER 2: PESTICIDES IN SELECTED URBAN AND AGRICULTURAL WATERSHEDS OF THE CHATTAHOOCHEE AND FLINT RIVER BASINS

This chapter presents a brief summary of the occurrence of selected pesticides in streams draining parts of three small (31 to 105 square miles) urban and agricultural watersheds located in the Chattahoochee and Flint River Basins. The summary is based on stream water-quality data collected at nearly weekly intervals from March 1993 through April 1994. Water samples were analyzed for a total of 84 pesticides that have been commonly used throughout the United States and include many of the compounds used in urban and agricultural areas of Georgia. The three watersheds studied were Sope Creek, an urban watershed in the Atlanta Metropolitan area, and Lime and Aycocks Creeks, agricultural watersheds in southwest Georgia (fig. 13). The Sope Creek watershed has primarily urban land use, mostly single and multifamily homes, offices, and commercial areas; whereas the Lime Creek and Aycocks Creek watersheds are primarily agricultural and forested land (table 8).

Pesticide use is ubiquitous in suburban areas; thus, there are numerous potential sources of pesticides that might enter streams draining these areas. Sources include applications of:

- herbicides, insecticides, and fungicides to lawns, gardens, parks, and golf courses;
- insecticides and fungicides to shrubs and trees;
- insecticides for control of insects that invade or damage structures (such as termites and cockroaches);

- herbicides for vegetation control on noncropland, including areas along fence lines and roads, in parking lots, right-of-way for railroads, power lines, and pipelines; and
- herbicides to control algal or other aquatic vegetation growth in ponds and swimming pools.

Pesticides present in surface runoff or ground water that discharges to streams in urban areas can render streams unusable for drinking water or aquatic life.

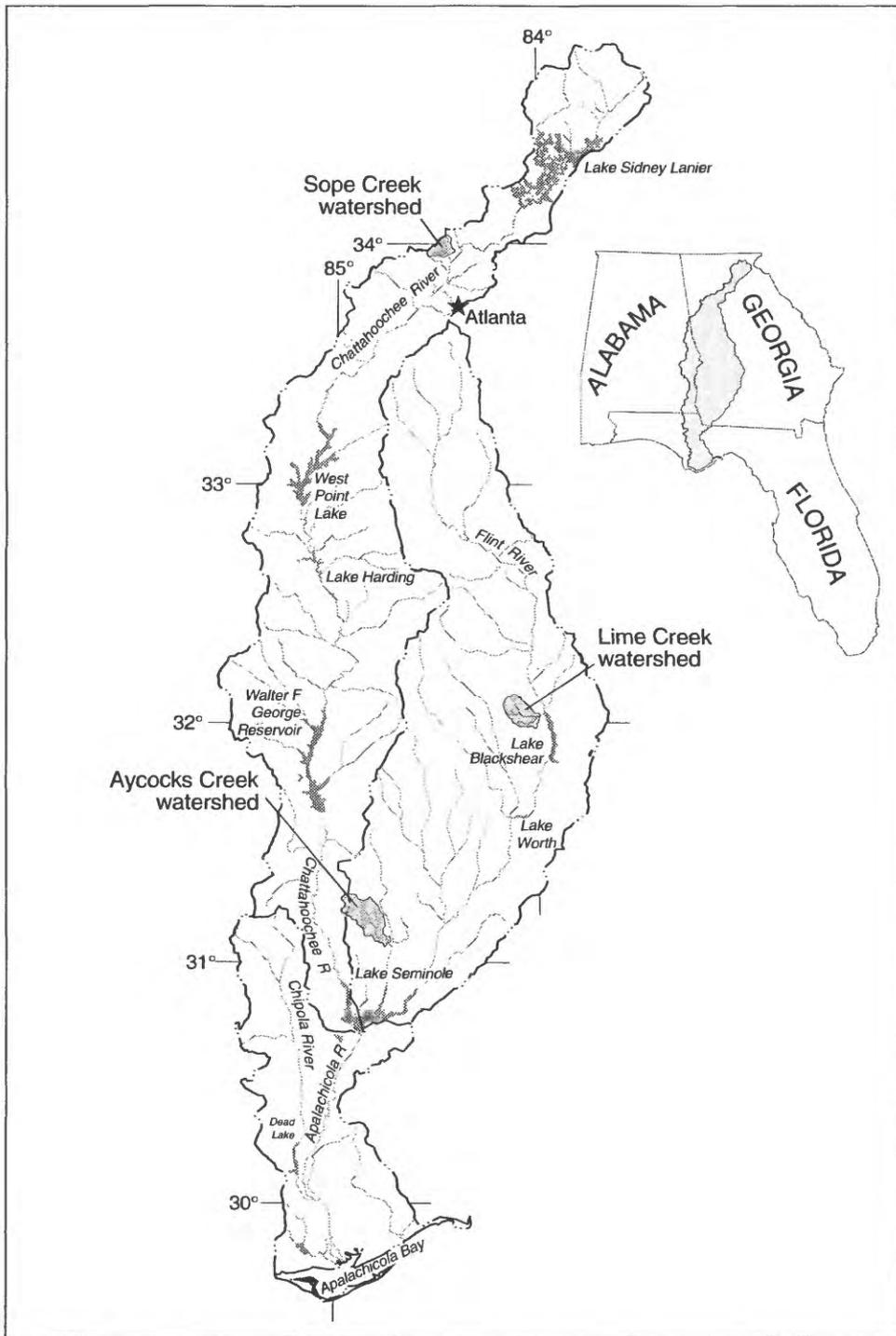
More pesticides were detected and at generally higher concentrations in water from the urban watershed than in the agricultural watersheds. A total of 18 herbicides and 7 insecticides were detected in water samples from the urban watershed (table 9). These compounds are used to control weeds on turf, and vegetation along fences, roads, and other rights-of-way; and insects in numerous areas in the watershed. The highest concentration for one pesticide, simazine, exceeded the EPA MCL (table 2); however, median concentrations (table 9) for all pesticides detected were well below applicable standards and guidelines for drinking water. Simazine, atrazine, and diazinon had the highest median concentrations relative to drinking-water standards and guidelines. The median simazine and atrazine concentrations were 3 and 1 percent of the MCL, respectively. The median diazinon concentration was 3 percent of the lifetime health-advisory level for diazinon. However, maximum concentrations of most insecticides detected, and median concentrations of chlorpyrifos and diazinon exceeded guidelines for protection of aquatic life.

Table 8. Land use, physiographic province, and hydrogeologic setting of selected watersheds in the Apalachicola-Chattahoochee-Flint River basin
[mi², square miles]

Name of watershed	Drainage area (mi ²)	Years of land-use data	Land use, in percent					Physiographic province	Hydrogeologic setting
			Agricultural	Forested	Urban	Wetland	Water		
Sope Creek	30	1972-75, updated with 1990 data ^{1/}	5	12	83	0	<1	Piedmont	fractured metamorphic rocks
Lime Creek	62	^{2/} 1988-90	46	34	0	20	<1	Coastal Plain	clastic sedimentary rocks
Aycocks Creek	105	^{2/} 1988-90	46	43	0	9	2	Coastal Plain	carbonate sedimentary rocks

^{1/}Digital data from the Atlanta Regional Commission. U.S. Geological Survey land-use and land-cover data (1979,1980), updated in 1990 by aerial photography, satellite imagery, and other sources.

^{2/}Digital data from the Georgia Department of Natural Resources, Georgia Department of Community Affairs. Land-cover classification performed by ERDAS, Inc., Atlanta, Georgia, using 1988-90 Landsat Thematic Mapper bands 3, 4, and 5.



Base from U.S. Geological Survey digital files

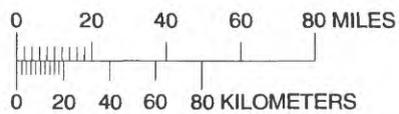


Figure 13. Location of Sope, Lime, and Aycocks Creek watersheds.

Table 9. Pesticides in water samples from Sope Creek watershed, March 1993 through March 1994
[µg/L, micrograms per liter; <less than]

Sope Creek watershed, 57 samples			
Analyte	Water samples having detectable concentrations (in percent)	Median concentration (µg/L)	Maximum concentration (µg/L)
<i>Herbicides</i>			
Alachlor	4	<0.009	0.052
Atrazine	95	.031	.38
Benfluralin	18	<.013	.022
Bromacil	2	<.05	.06
DCPA	5	<.004	^{2/} .003
MCPA ^{1/}	23	<.05	.42
Metolachlor	18	<.009	.068
Napropamide	7	<.010	.021
Oryzalin ^{1/}	2	<.05	.08
Pendimethalin	49	<.018	.24
Prometon	60	.008	.86
Pronamide	12	<.009	.021
Simazine	95	.14	8.2
Tebuthiuron	61	^{2/} .011	.16
Trichlopyr ^{1/}	4	<.05	.23
Trifluralin	19	<.012	.019
2,4-D ^{1/}	29	<.05	.63
2,4-DB ^{1/}	2	<.05	.39
<i>Insecticides</i>			
Carbaryl	63	^{2/} .010	.22
Chlorpyrifos	65	.008	.051
Diazinon	89	.020	.45
Ethoprop	2	<.012	^{2/} .010
Lindane	2	<.011	.048
Malathion	16	<.010	.052
Propoxur ^{1/}	2	<.05	.26

^{1/}Only 48 samples analyzed.

^{2/} Concentration is less than the method detection limit.

Several pesticides were present in Sope Creek throughout much of the sampling period, but highest concentrations corresponded to their principal application periods (fig. 14). Atrazine and simazine, commonly used to control winter annual weeds on turf, were at highest measured concentrations in December and February. Pendimethalin and 2,4-D, used for postemergent control of weeds on turf, were at highest measured concentrations during March and April. Prometon and tebuthiuron, used to control vegetation on

noncropland, were at highest measured concentrations in March and May. The highest measured concentrations of each of the insecticides was in May.

The principal sources of pesticides in agricultural watersheds are from herbicides, insecticides, and fungicides applied to crop land and orchards. However, additional herbicides are applied along roadsides and other rights of way. A broad range of pesticides are applied around homes and farms. Pesticides present in surface runoff or ground water that discharges to streams in agricultural areas can render the water unsuitable for drinking water or aquatic life.

Most herbicides detected in the Lime and Aycocks Creek watersheds (table 10) are used primarily for control of weeds on crop land. Additional herbicides used for vegetation control in noncropland areas were also detected. A total of 17 herbicides and 4 insecticides were detected in samples collected from these watersheds. The insecticides detected are used on a number of crops and on orchards as well as for use at homes. None of the samples had pesticide concentrations that exceeded applicable standards or guidelines for drinking water. However, carbaryl was detected in 2 samples at concentrations that exceed guidelines for protection of aquatic life (table 2). Median concentrations for all compounds detected were below the method detection limits, and below standards and guidelines for drinking water and protection of aquatic life.

Pesticides were present in Lime and Aycocks Creek watersheds with greatest frequency from March through July (figs. 15 and 16). This frequency corresponds with the principal application periods for preemergent and postemergent herbicides and foliar applications of insecticides. Atrazine and metolachlor were the most persistent throughout the year. Prometon and tebuthiuron, used for weed control on noncropland, also were present during the growing season in Lime and Aycocks Creek. Highest measured concentrations of these compounds was in May.

Compound	Months											
	M	A	M	J	J	A	S	O	N	D	J	F
Herbicides												
Alachlor												
Atrazine												
Benfluralin												
Bromacil												
DCPA												
MCPA												
Metolachlor												
Napropamide												
Oryzalin												
Pendimethalin												
Prometon												
Pronamide												
Simazine												
Tebuthiuron												
Trichlopyr												
Trifluralin												
2,4-D												
2,4-DB												
Insecticides												
Carbaryl												
Chlorpyrifos												
Diazinon												
Ethoprop												
Lindane												
Malathion												
Propoxur												

EXPLANATION

- Month when maximum concentration was measured
- Month when pesticides were detected in 1 or more samples

Figure 14.--Seasonal distribution of pesticides in Sope Creek, an urban watershed, March 1993 through March 1993.

Table 10. Pesticides detected in water samples collected from March 1993 through April 1994 from Lime and Aycocks Creeks
 [$\mu\text{g/L}$, micrograms per liter; <, less than; --, not applicable]

Analyte	Lime Creek, 57 samples			Aycocks Creek, 34 samples		
	Water samples having detectable concentrations (in percent)	Median concentration ($\mu\text{g/L}$)	Maximum concentration ($\mu\text{g/L}$)	Water samples having detectable concentrations (in percent)	Median concentration ($\mu\text{g/L}$)	Maximum concentration ($\mu\text{g/L}$)
<i>Herbicides</i>						
Alachlor	19	<0.009	0.011	12	<0.009	0.023
Deethylatrazine	4	<.02	^{1/} .004	9	<.002	^{1/} .004
Atrazine	58	^{1/} .006	.16	50	^{1/} .003	.12
Benfluralin	4	<.013	.013	0	--	--
Bentazon ^{2/}	2	<.05	.07	0	--	--
Butylate	2	<.008	^{1/} .002	9	<.008	.022
Cyanazine	7	<.013	.22	0	--	--
Ethafuralin	2	<.013	.016	3	<.013	.021
Fluometuron	2	<.05	.07	0	--	--
Metolachlor	56	^{1/} .003	.038	85	^{1/} .004	.055
Metribuzin	2	<.012	.016	0	--	--
Pendimethalin	4	<.018	^{1/} .009	0	--	--
Prometon	12	<.008	.12	6	<.008	.22
Simazine	37	<.010	.16	0	--	--
Tebuthiuron	18	<.015	.050	3	<.015	^{1/} .007
Trifluralin	11	<.012	.18	3	<.012	.014
2,4-D ^{2/}	2	<.05	.12	0	--	--
<i>Insecticides</i>						
Carbaryl	5	<.046	^{1/} .021	3	<.046	^{1/} .033
Ethoprop	2	<.012	^{1/} .010	0	--	--
Fonofos	11	<.008	1.2	0	--	--
Malathion	2	<.010	^{1/} .007	0	--	--

^{1/}Concentration is below method detection limit.

^{2/} Only 45 samples analyzed.

Compound	Months											
	M	A	M	J	J	A	S	O	N	D	J	F
Herbicides												
Alachlor	■	■	■	■	■	■	■	■	■	■	■	■
Atrazine	■	■	■	■	■	■	■	■	■	■	■	■
Benfluralin	■	■	■	■	■	■	■	■	■	■	■	■
Bentazon	■	■	■	■	■	■	■	■	■	■	■	■
Butylate	■	■	■	■	■	■	■	■	■	■	■	■
Cyanazine	■	■	■	■	■	■	■	■	■	■	■	■
Deethylatrazine	■	■	■	■	■	■	■	■	■	■	■	■
Fluometuron	■	■	■	■	■	■	■	■	■	■	■	■
Metolachlor	■	■	■	■	■	■	■	■	■	■	■	■
Metribuzin	■	■	■	■	■	■	■	■	■	■	■	■
Pendimethalin	■	■	■	■	■	■	■	■	■	■	■	■
Prometon	■	■	■	■	■	■	■	■	■	■	■	■
Simazine	■	■	■	■	■	■	■	■	■	■	■	■
Tebuthiuron	■	■	■	■	■	■	■	■	■	■	■	■
Trifluralin	■	■	■	■	■	■	■	■	■	■	■	■
2,4-D	■	■	■	■	■	■	■	■	■	■	■	■
Insecticides												
Carbaryl	■	■	■	■	■	■	■	■	■	■	■	■
Ethoprop	■	■	■	■	■	■	■	■	■	■	■	■
Fonofos	■	■	■	■	■	■	■	■	■	■	■	■
Malathion	■	■	■	■	■	■	■	■	■	■	■	■

EXPLANATION

- Month when maximum concentration was measured
- Month when pesticides were detected in 1 or more samples

Figure 15. Graph showing seasonal distribution of pesticides in Lime Creek, an agricultural watershed, March 1993 through April 1994.

Compound	Months											
	M	A	M	J	J	A	S	O	N	D	J	F
Herbicides												
Alachlor	■	■	■	■	■	■	■	■	■	■	■	■
Atrazine	■	■	■	■	■	■	■	■	■	■	■	■
Butylate	■	■	■	■	■	■	■	■	■	■	■	■
Deethylatrazine	■	■	■	■	■	■	■	■	■	■	■	■
Metolachlor	■	■	■	■	■	■	■	■	■	■	■	■
Prometon	■	■	■	■	■	■	■	■	■	■	■	■
Tebuthiuron	■	■	■	■	■	■	■	■	■	■	■	■
Trifluralin	■	■	■	■	■	■	■	■	■	■	■	■
Insecticides												
Carbaryl	■	■	■	■	■	■	■	■	■	■	■	■

EXPLANATION

- Month when maximum concentration was measured
- Month when pesticides were detected in 1 or more samples
- No samples collected during month because there was no flow

Figure 16. Seasonal distribution of pesticides in Aycocks Creek, an agricultural watershed, March 1993 through April 1994.

It is difficult to determine what pesticide-management practices could reduce the quantities of pesticides reaching streams in urban and agricultural areas because, at this time, not enough is known of the fate and the transport pathways of these pesticides. However, the following suggestions by the Cooperative Extension Service, University of Georgia, College of Agriculture and Environmental Sciences (Murphy, 1993) for safe pesticide use can lessen risks of contaminating ground water and streams:

- observe all directions, restrictions and precautions on pesticide labels; it is dangerous, wasteful and illegal to do otherwise;
- store all pesticides in original containers with labels intact and behind locked doors;
- use pesticides at correct label dosage and intervals to avoid illegal residues or injury to plants and animals;
- apply pesticides carefully to avoid drift or contamination of non-target areas;
- dispose of surplus pesticides and containers in accordance with label instructions so that contamination of water and other hazards will not result;
- follow directions on the pesticide label regarding restrictions as required by State and Federal Laws and Regulations;
- avoid any action that may threaten an endangered species or its habitat.

In summary, more pesticides were detected and at generally higher concentrations in water from the urban watershed than in the agricultural watersheds. More pesticides were detected throughout much of the year in the urban watershed than in the agricultural watersheds. Median concentrations of all pesticides detected in water from each watershed were below EPA drinking-water standards and guidelines. However, median concentrations of the insecticides chlorpyrifos and diazinon exceeded guidelines for protection of aquatic life.

CHAPTER 3: NITRATE AND PESTICIDES IN SHALLOW GROUND WATER IN SOUTHWESTERN GEORGIA AND ADJACENT AREAS OF ALABAMA AND FLORIDA

A part of the ACF NAWQA River basin study is designed to determine the chemical quality of shallow ground water in areas of agricultural land use. Field sites were randomly selected within the agricultural area of southwestern Georgia and adjacent areas of Alabama and Florida. Thirty-eight wells were installed in surficial aquifers (fig. 17) adjacent to and downgradient of farm fields. Four additional reference wells were installed in forested areas to represent background water-quality conditions. Monitoring-well depths range from 14 to 71 feet below land surface. The surficial aquifers were selected for sampling rather than deeper, regional aquifer systems because they are the uppermost water-bearing zones and are more susceptible to contamination. However, it is the regional aquifers that are generally used for domestic- and public-water supplies, and irrigation. Degradation of water quality in the surficial aquifers serves as an early warning of potential contamination of regional aquifers.

Ground-water samples were collected during late summer 1993, and again during early spring 1994, to represent low and high water-table conditions, respectively. The depth to water table in monitoring wells ranged from 8 to 67 feet below land surface in the summer of 1993. Water levels in the 31 wells sampled twice had a median rise of almost 9 feet from the late summer to the early spring sampling, and changes in water levels during this time period ranged from a 3-foot decline to a 30-foot rise.

Most ground-water samples were analyzed for nutrients, pesticides, volatile organic compounds, major ions, and organic carbon. Radon and tritium were analyzed for in more than one half of the wells. Concentrations of dissolved nitrate and pesticides are the most likely compounds to have elevated concentrations as a result of agricultural applications of fertilizers and pesticides; and therefore, are the focus of this chapter.

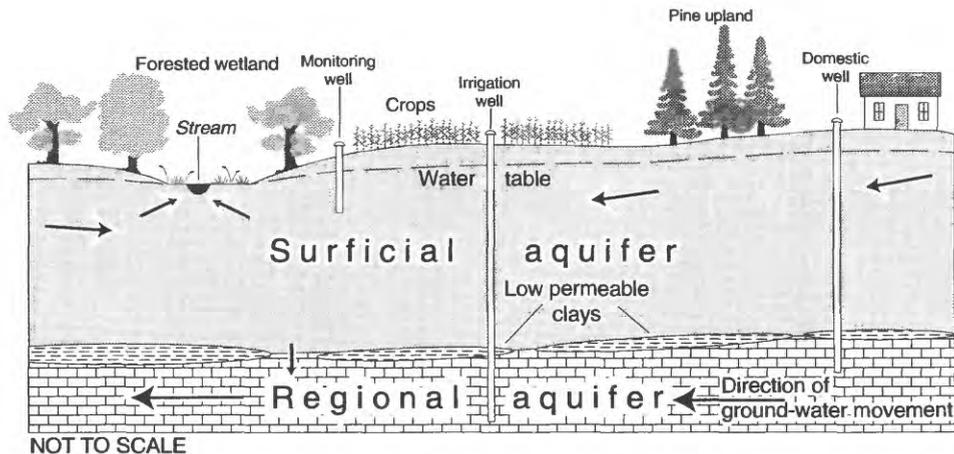


Figure 17. Diagrammatic section showing location of monitoring wells in relation to hydrologic and land-use setting.

When monitoring wells were sampled in late summer 1993, peanuts were the most common crop grown adjacent to or near the monitoring wells, followed by corn, cotton, soybeans, wheat, sorghum, millet, and watermelon. Fallow fields, pasture, pine stands, or woods also were on one or more sides of most wells. When monitoring wells were resampled in early spring 1994, most fields had crops of winter wheat, rye, and other grains. However, some fields had been recently planted in corn, peanuts, cotton, grain, and watermelon, some had been left fallow since fall of 1993, and some had been recently plowed and prepared for planting.

Elevated concentrations of nitrate pose a possible health risk when present in drinking-water supplies. Nitrate is the only major nutrient in ground water for which a MCL (10 mg/L as nitrogen) has been established for drinking water. A nationwide evaluation of the areal extent of nitrate in ground water based on more than 87,000 wells (Madison and Brunett, 1985, p. 95) defined the following ranges of nitrate concentrations:

- less than detection to 3 mg/L -- concentrations that range from background to concentrations that may or may not represent human activities,
- 3 to 10 mg/L -- elevated concentrations probably resulting from human activities,
- more than 10 mg/L -- concentrations exceed MCL for drinking-water standards set by the U.S. Environmental Protection Agency (1993).

Nitrate concentrations in shallow ground water can vary widely seasonally and spatially. More than twice as many monitoring wells had higher nitrate concentrations in early spring 1994 than in late summer 1993. Based on the above three-ranges of nitrate concentrations, 5 out of 31 wells sampled twice had nitrate concentrations indicating different possible levels of human influence on nitrate concentrations in summer 1993 from spring 1994. Ranges of nitrate concentrations based on the maximum concentrations measured in each well, the most conservative case, are shown in figure 18. Nitrate concentrations were less than 3 mg/L as N in 25 of 38 agricultural wells and in the four reference wells. Thirteen agricultural wells had elevated nitrate concentrations in one or two samples, probably the result of human activity, and two of these wells exceeded the EPA drinking-water standards either in late summer 1993 or early spring 1994.

Recommended application rates of nitrogen fertilizer vary widely, from zero pounds per year for peanuts and soybeans (which replenish available nitrogen in soil from fixation of atmospheric sources), up to 150 to 180 pounds per year for corn (Dr. Glen Harris, University of Georgia, Cooperative Extension Service, oral commun., 1994). However, the distribution

of crops grown adjacent to monitoring wells with elevated nitrate concentrations were similar to the distribution of crops grown adjacent to monitoring wells without elevated nitrate concentrations. In addition to the types and rotations of crops grown and fertilizer application rates, other factors which can affect nitrate concentrations include depth of water table below land surface, depth of screened interval relative to water-table depth, position of screened interval relative to recharge and discharge areas for ground water, soil characteristics, climatic conditions, proximity to wetland buffers, and farming and irrigation practices.

Elevated concentrations of pesticides pose a possible health risk when present in drinking-water supplies. Pesticides were not detected in ground water from reference wells. Four herbicides, one degradation product of a detected herbicide, two insecticides, and a degradation product of an insecticide banned by EPA were detected in ground water collected from agricultural wells, but concentrations were below available drinking-water standards and guidelines (table 11). One or more of these pesticides were detected at measurable concentrations in 16 of 38 agricultural wells and 8 of these wells had pesticide concentrations above method detection limits (fig. 19). Maximum concentrations of alachlor and atrazine were 28 percent and 14 percent, respectively, of the MCL for these herbicides. Alachlor is used predominantly on corn and soybeans, and in agricultural areas, atrazine is applied predominantly to corn. Concentrations of all other pesticides detected in shallow ground water were well below one percent of existing human-health advisories. The herbicides detected in shallow ground water are four of the five herbicides most used (in terms of pounds per year of active ingredient) in agricultural areas within the ACF River basin in 1990 (Susan M. Stell, U.S. Geological Survey, written commun., 1993). Methanearsonate, the second most used herbicide on agricultural land, was not analyzed for. A similar ranking of insecticide use within the ACF River basin is not available; however, malathion and fonofos are commonly used. P,P'-DDE, a degradation product of the insecticide DDT, was detected at very low concentrations. The use of DDT in the United States has been banned by EPA since January 1973, primarily because of its persistence and toxicity.

In summary, nitrate concentrations were less than 3 mg/L as N (indicating minimal effect of human activities) in water from about two-thirds of the wells in agricultural areas. Water from the remaining agricultural wells had elevated nitrate concentrations in one or two samples, probably the result of human activity, and nitrate concentrations in two of these wells exceeded the EPA drinking-water standards. Water samples from eight agricultural wells had pesticide concentrations above method detection limits but maximum concentrations were below EPA drinking-water standards or guidelines.

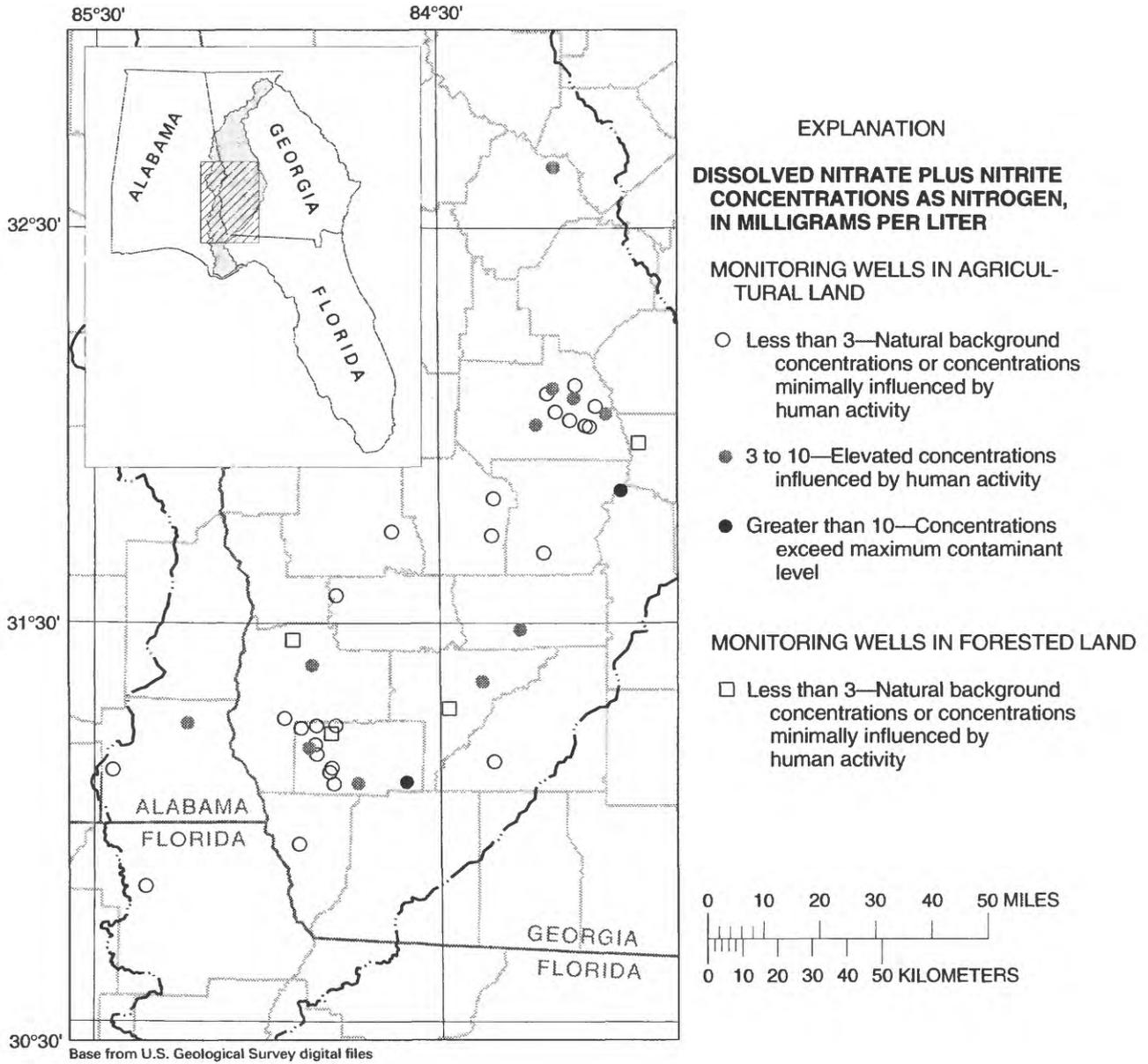


Figure 18. Nitrates in ground water in the Apalachicola–Chattahoochee–Flint River basin.

Table 11. Pesticides in shallow ground water from 38 wells in agricultural areas of the Apalachicola-Chattahoochee-Flint River basin, August 1993 through April 1994 [$\mu\text{g/L}$, micrograms per liter; MDL; maximum contaminant limit; --, no standard or guideline available]

Chemical name of pesticide	Principal uses of pesticide	Maximum contaminant level ^{1/} ($\mu\text{g/L}$)	Lifetime health advisory ^{2/} ($\mu\text{g/L}$)	Number of wells (samples) having		Maximum concentration ($\mu\text{g/L}$)	Maximum concentration as a percent of Maximum contaminant level
				Detectable concentrations	Concentrations at or above MDL		
Herbicides							
Alachlor	peanuts, corn, soybeans	2	--	4 (6)	3 (3)	0.55	28
Atrazine	corn, turf	3	3	10 (13)	4 (5)	.42	14
Atrazine-Deethyl	degradation product of Atrazine	--	--	5 (6)	3 (3)	.072	--
Fluometuron	cotton	--	90	3 ^{1/2} (2)	3 ^{1/2} (2)	.10	--
Metolachlor	peanuts, corn, soybeans	--	100	8 (12)	4 (5)	.52	--
Insecticides							
p,p'-DDE	degradation product of DDT ^{4/}	--	--	2 (2)	0 (0)	<.02	--
Fonofos	peanuts, corn	--	10	1 (1)	1 (1)	.009	--
Malathion	used ubiquitously in agricultural and urban settings	--	100	1 (1)	0 (0)	<.014	--

^{1/}Maximum contaminant level is the maximum permissible level of a contaminant in water that is delivered to any user of a public water system. This is an enforceable standard, established on the basis of health effects, organoleptic effects (effects on taste and color), treatment feasibility, cost of treatment, and analytical detection, and is set as close to the MCLG as is feasible (U.S. Environmental Protection Agency, 1993; Nowell and Resek, 1994, p. 16).

^{2/}Lifetime health advisory is considered protective of noncarcinogenic adverse health effects of a 70 kilogram adult consuming 2 liters of water per day for a period of 70 years (U.S. Environmental Protection Agency, 1993). For noncarcinogens, the lifetime health advisory and the MCLG are the same when both values are final (Nowell and Resek, 1994, p. 19-20).

^{3/}Data are not yet available for fluometuron samples collected in April 1994.

^{4/}DDT was widely used prior to being banned in the United States by the U.S. Environmental Protection Agency as of January 1, 1973.

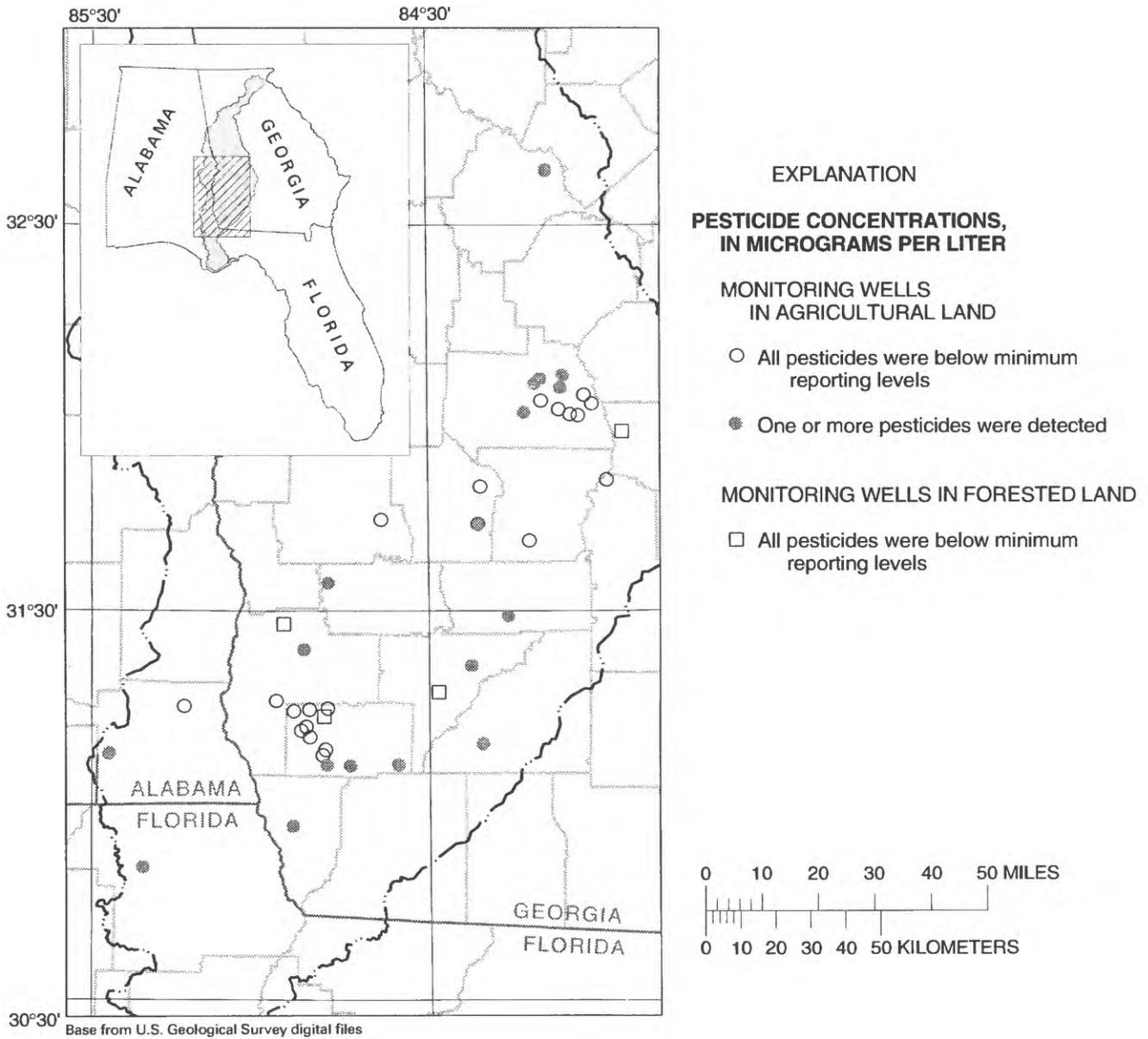


Figure 19. Pesticides in ground water in the Apalachicola–Chattahoochee–Flint River basin.

SUMMARY

This report presents three chapters that summarize preliminary information from data-collection programs supported by the USGS NAWQA Program. The first chapter describes chemical and suspended-sediment concentrations and loads in surface waters of the ACF and Ocmulgee River basins during record flooding caused by tropical storm Alberto, July 1994. Although the Ocmulgee River basin is not a part of the ACF River basin NAWQA study, it is included here to document water-quality conditions during record flooding in both basins. The second chapter compares the types and amounts of pesticides present in surface waters draining predominantly agricultural and urban watersheds. The third chapter presents information on the occurrence of nitrate and commonly used pesticides in the shallow ground water associated with agricultural land use in the southern ACF River basin.

During the period July 3-7, 1994, tropical storm Alberto moved northward from the Gulf of Mexico, across the Florida panhandle, and into parts of southwestern and central Georgia and southeastern Alabama. Parts of central and southwest Georgia received as much as 28 inches of rainfall during the storm causing record flooding on the Flint and Ocmulgee Rivers and several of their tributaries. Much of the topsoil eroded during intensive rainfall and flooding in the Flint and Ocmulgee River basins probably was redeposited in extensive floodplains within the basins. The suspended sediment transported from the basins was comprised mostly of silt- and clay-sized material. In floodwaters, total nitrogen concentrations were lower, and total phosphorus concentrations were higher than median concentrations in samples collected prior to the flood. Much of the nitrogen load was in the form of organic nitrogen generally derived from organic detritus, rather than nitrate derived from other sources, such as fertilizer. Floodwaters transported a large part of the mean annual load of total phosphorus and organic nitrogen and a lesser part of the mean annual load of nitrite plus nitrate. Fourteen herbicides, five insecticides, and one fungicide commonly used in urban and agricultural areas were detected in floodwaters of the Flint, Apalachicola, and Ocmulgee Rivers. Concentrations of nitrate nitrogen and detected pesticides were below U.S. Environmental

Protection Agency (EPA) standards and guidelines for drinking water. However, concentrations of the insecticides chlorpyrifos, carbaryl, and diazinon approached or exceeded guidelines for protection of aquatic life.

Water-quality samples were collected at nearly weekly intervals from March 1993 through April 1994 from an urban watershed and two agricultural watersheds in the ACF River basin, and the samples analyzed for 84 commonly used pesticides. More pesticides were detected and at generally higher concentrations in water from the urban watershed than in the agricultural watersheds. A greater number of pesticides were detected throughout much of the year in the urban watershed than in the agricultural watersheds. Median concentrations of all pesticides detected in water from each watershed were below EPA drinking-water standards and guidelines. However, median concentrations of the insecticides chlorpyrifos and diazinon exceeded guidelines for protection of aquatic life.

Thirty-eight wells were installed in surficial aquifers adjacent to and downgradient of farm fields within the agricultural area of southwestern Georgia and adjacent areas of Alabama and Florida. Four reference wells were installed in forested areas to represent background water-quality conditions. The surficial aquifers were selected for sampling rather than deeper, regional aquifer systems because they are the uppermost water-bearing zones and are more susceptible to contamination. Even though regional aquifers are generally used for domestic- and public-water supplies, and for irrigation, degradation of water quality in the surficial aquifers serves as an early warning of potential contamination of regional aquifers. Nitrate concentrations were less than 3 mg/L as N (indicating minimal effect of human activities) in water from about two-thirds of the wells in agricultural areas. Water from the remaining agricultural wells had elevated nitrate concentrations in one or two samples, probably the result of human activity, and nitrate concentrations in two of these wells exceeded the EPA drinking-water standards. Water samples from eight agricultural wells had pesticide concentrations above method detection limits, but maximum concentrations were below EPA drinking-water standards or guidelines.

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