CHOCTAWHATCHEE, PEA AND YELLOW RIVERS
WATERSHED MANAGEMENT PLAN

CHOCTAWHATCHEE, PEA AND YELLOW RIVERS
WATERSHED MANAGEMENT AUTHORITY

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Choctawhatchee, Pea and Yellow Rivers Comprehensive Watershed Management Plan

Information Series 82

By
Amye S. Hinson, Alana L. Rogers, and Marlon R. Cook

Published by the

Geological Survey of Alabama
Tuscaloosa, Alabama, USA

Tuscaloosa, Alabama
2015

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August 27, 2015

The Honorable Robert Bentley
Governor of Alabama
Montgomery, Alabama

Dear Governor Bentley:

It is with pleasure that I make available to you this report entitled *Choctawhatchee, Pea and Yellow Rivers Comprehensive Watershed Management Plan*, by Amye S. Hinson, Alana L. Rogers, and Marlon R. Cook, which has been published as Information Series 82 by the Geological Survey of Alabama.

The Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority initiated development of a comprehensive watershed management plan to consolidate, into one source, the water-related natural resource issues in the Choctawhatchee, Pea and Yellow River Watershed, available scientific knowledge and data, and outline future water management options for the watershed. Preparation of the management plan was guided by a steering committee of representatives from natural resource agencies and non-governmental organizations in the state. It represents the most current science and will be annually updated.

Information included in the Watershed Management Plan provides a framework for the Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority to assist federal, state, and local officials and agencies in addition to local stakeholders in protecting and preserving the natural resources in the Choctawhatchee, Pea and Yellow River Watershed, while guiding prudent management of resources required for economic development and improved quality of life for residents in southeast Alabama.

Respectfully,

Berry H. (Nick) Tew, Jr.
State Geologist

DISCLAIMER

This document includes general information about the Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority (CPYRWMA) and its programs and contains no representations regarding the laws and regulations that govern the CPYRWMA. Alabama law and/or administrative rules will supersede any information in conflict.

All information provided in this document is believed to be correct; however, no liability is assumed for errors in substance or form of any of the data or facts contained therein and/or contributed by outside sources for inclusion in the document.

Some of the views and opinions expressed in said document are those of the contributors and do not necessarily reflect the official policy or position of the authors unless so designated by authorizing documents.

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EXECUTIVE SUMMARY

The "watershed management authority" concept was established in 1991 by the Alabama Legislature through Public Law 91-602 with the intent that said entities "protect and manage the watersheds of this state." The Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority was the first, and is currently the only, watershed management authority created under this legislation. The Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority jurisdiction covers approximately 2,328,000 acres in all or parts of ten southeastern Alabama counties. Its mission is "developing and executing plans and programs relating to any phase of conservation of water, water usage, flood prevention, flood control, water pollution control, wildlife habitat protection, agricultural and timberland protection, erosion prevention, and control of erosion, floodwater and sediment damages."

The Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority has commissioned more than 25 major water resource scientific assessments and many remediation and educational projects, coordinated stakeholder involvement in southeast Alabama water issues, and partnered with local, state, and federal water-related entities on several water resource initiatives. The Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority also operates the only basin-wide Flood Warning System in the State of Alabama. It consists of 21 gauging sites in eight counties that continuously monitor precipitation and/or stream levels. The National Weather Service utilizes data from the Flood Warning System to determine potential flood threats and to issue flood forecasts for streams and rivers in the region.

The Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority initiated development of a comprehensive Watershed Management Plan to consolidate, into one source, the water-related natural resource issues in the Choctawhatchee, Pea and Yellow River Watershed, available scientific knowledge and data, and outline future management options for the watershed. Preparation of the management plan was guided by a steering committee of representatives from natural resource agencies and non-governmental organizations in the state. It represents the most current science and will be maintained and updated annually to include the latest available data for each topic.

Information included in the Watershed Management Plan provides a framework for the Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority to assist federal, state, and local officials and agencies in addition to local stakeholders in protecting and preserving the natural resources in the Choctawhatchee, Pea and Yellow River Watershed, while guiding prudent development of resources required for economic development and improved quality of life for residents in southeast Alabama. Many times, local governments (cities and counties) lack sufficient

information to make informed decisions concerning environmental or economic issues. This document provides a wealth of informative data that can be used to guide planning and development decisions. It also contains detailed data from more than 300 references covering 32 categories of watershed topics including current demographics, land use, water quantity, quality and conservation, biological resources, economic impacts, interstate issues, education, and climate change. A complete list of topics is found in the table of contents.

The Watershed Management Plan also provides recommendations for action items pertaining to each addressed topic as well as options for policy development for selected topics to address implementation of management strategies. A list of recommendations and possible policy options is found in table 3 of the document.

As a state agency created to plan and implement water resource development and protection strategies, the Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority is well suited for a role as coordinator of regional water resource management plans and implementation. By design, its governing body is a board of local stakeholders, all of whom reside in the watershed, making local decisions to help ensure water-related issues are consistently addressed within the watershed boundaries. An organizational structure for future water resource management will most likely include policy initiatives coordinated by a statewide agency working with a regional agency, such as the Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority to implement water management strategies on the local level.

For 24 years, the Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority has been a leader in promoting and addressing environmental, economic, and cultural issues to insure that citizens have a quality of life expected by those who live and work in southeast Alabama. The Choctawhatchee, Pea and Yellow Rivers Watershed Management Plan is the next step in fulfilling that role by providing the best available watershed information for a foundation of knowledge in support of strategic planning for the future.

VISION FOR FUTURE LOCAL/REGIONAL WATER RESOURCE MANAGEMENT PLANNING

The "watershed management authority" concept was established in 1991 by the Alabama Legislature through Public Law 91-602 with the intent that said entities "protect and manage the watersheds of this state". The Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority (CPYRWMA) was the first, and is currently the only, watershed management authority created under this legislation. The CPYRWMA jurisdiction covers approximately 2,328,000 acres in all or parts of ten southeastern Alabama counties. Its mission is *"developing and executing plans and programs relating to any phase of conservation of water, water usage, flood prevention, flood control, water pollution control, wildlife habitat protection, agricultural and timberland protection, erosion prevention, and control of erosion, floodwater and sediment damages."*

Governor Robert Bentley formed the Alabama Water Agency Working Group (AWAWG) in 2011 and tasked it with taking steps necessary for development of a water resource management plan for Alabama. Toward this goal, the AWAWG completed the 2013 report "*Mapping the Future of Alabama Water Resources Management: Policy Options and Recommendations*." One of the next steps in this process is to establish Focus Area Panels (FAPs) composed of experts in various water resource issues. The goal of the FAPs is to formulate specific recommendations for various facets of water resource management.

One of the panels on which the CPYRWMA serves is the Local/Regional Planning FAP. This panel will identify current state water-related organizations and make recommendations concerning activities related to implementation of water management policies. It will also recommend an organizational structure for implementation of future water management policy and law at the local, regional, and state levels.

As a state agency created to plan and implement water resource development and protection strategies, the CPYRWMA is well suited for a role as coordinator of regional water resource management plans and implementation. It has commissioned more than 25 major water resource scientific assessment and numerous remediation and educational projects, coordinated stakeholder involvement in southeast Alabama water issues, and partnered with local, state, and federal water-related entities on numerous water resource initiatives.

An organizational structure for regional/local water management policy implementation will include water resource management policy initiatives coordinated by a statewide agency working with the CPYRWMA as the regional water resource management agency. Regional water resource management through the CPYRWMA, in a non-regulatory management scheme, will involve collection of additional data and regular revisions to existing information including scientific,

water use, future water demand estimates, and water source development. The CPYRWMA will work closely with all water users through local partnerships with the Alabama Rural Water Association, its public water-supply system members, the Alabama Department of Agriculture and Industries, the Alabama Farmers Federation, the Soil & Water Conservation Districts, the Natural Resource Conservation Service, local farmers, and individual industries in the region.

Regional water resource management under a regulated system will involve close coordination of the CPYRWMA with the state water management agency to implement water source development and water use through a regulation process. The CPYRWMA will work with local partners to assess water supply needs and water source development strategies that will protect water quality and availability. The CPYRWMA will use water resource information (quality and quantity) to evaluate local water resource needs and availability. The CPYRWMA will work with local partners to assist local water users with regulatory requirements and will work with the state water management agency with decisions related to enforcement of regulations.

For 24 years, the CPYRWMA has been a leader in promoting and addressing water quality and quantity issues to insure the citizens of southeast Alabama have plentiful, high quality water and that habitats and streams are protected for a quality of life expected by those who live and work in that region of Alabama.

ABBREVIATIONS

Alphabetically arranged by "Term" Column

Term	Abbreviation
Alabama Cooperative Extension System	ACES
Alabama Department of Agriculture and Industries	ADAI
Alabama Department of Conservation and Natural Resources	ADCNR
Alabama Department of Economic and Community Affairs Office of Water Resources	ADECA OWR
Alabama Department of Environmental Management	ADEM
Alabama Department of Public Health	ADPH
Alabama Drought Assessment and Planning Team	ADAPT
Alabama Emergency Management Agency	AEMA
Alabama Farmers Federation	ALFA
Alabama Flood Risk Information System	AL FRIS
Alabama Forestry Commission	AFR
Alabama Rural Water Association	ARWA
Alabama Scenic River Trail	ASRT
Alabama Water Agencies Working Group	AWAWG
Alabama, Coosa, and Tallapoosa Rivers	ACT
American Water Resources Association	AWRA
Animal Feeding Operations	AFOs
Apalachicola, Chattahoochee, and Flint Rivers	ACF
Auburn University	AU
Below land surface	bls
Best Management Practices	BMPs
Biochemical Oxygen Demand	BOD
Bioretention cells	BRCs
Choctawhatchee, Pea and Yellow Rivers watersheds	CPYRW
Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority	CPYRWMA
Clean Water Partnership	CWP
Coastal Management Plan	CMP
Coastal Zone Management Act	CZMA
Commission for Environmental Cooperation	CEC
Comprehensive Environmental Response, Compensation and Liability Act	CERCLA
Comprehensive Wildlife Conservation Strategy	CWCS
Concentrated Animal Feeding Operations	CAFOs
Conservation Reserve Program	CRP
Conservation Stewardship Program	CSP

Term	Abbreviation
Cooperative Conservation Partnership Initiative	CCPI
Cubic feet per second	cfs
Dissolved oxygen	DO
Emergency Watershed Protection Program	EWP
Environmental Quality Incentives Program	EQIP
Federal Emergency Management Agency	FEMA
Federal Energy Regulatory Commission	FERC
Feet	ft
Feet per mile	ft/mi
Feet per second	ft/s
Fish and Wildlife	F&W
Flood Insurance Rate Map	FIRM
Flood Mitigation Assistance	FMA
Flood Warning System	FWS
Florida Department of Environmental Protection	FDEP
Gallons per day per square mile	$gal/d/mi^2$
Gallons per minute	gpm
Geological Survey of Alabama	GSA
Geological Survey of Alabama Groundwater Assessment Program	GSA GAP
Georgia Department of Natural Resources	GDNR
Intergovernmental Panel on Climate Change	IPCC
Leaking Underground Storage Tank	LUST
Letters of Map Revision	LOMR
Low impact development	LID
Maximum contaminant levels	MCLs
Mean sea level	MSL
Micrograms per liter	µg/L
Milligrams per liter	mg/L
Million gallons per day	mgd
Million gallons per year	mgy
Monitoring and Impact Group	MIG
Multi-Resolution Land Characteristics Consortiums	MRLC
Municipal Separate Stormwater Sewer Systems	MS4s
National Drought Mitigation Center	NDMC
National Flood Insurance Program	NFIP
National Land Cover Data	NLCD
National Oceanic and Atmospheric Administration	NOAA
National Pollutant Discharge Elimination System	NPDES
National Weather Service	NWS
Net potential productive intervals	NPPIs
Palmer Drought Severity Index	PDSI

Term	Abbreviation
Parts per million	ppm
Picocuries per liter	pCi/L
Polychlorinated biphenyls	PCBs
Representative Concentration Pathway	RCP
Risk Mapping, Assessment, and Planning	Risk MAP
Southern Environmental Law Center	SELC
Southwest Florida Water Management District	SWFWMD
Spontaneous potential	SP
Square miles	mi^2
Strategic Habitat Units	SHUs
Strategic River Reach Units	SRRUs
Total dissolved solids	TDS
Total maximum daily loads	TMDL
Total suspended solids	TSS
U.S. Army Corps of Engineers	USACE
U.S. Department of Agriculture	USDA
U.S. Department of Agriculture Natural Resources Conservation Service	USDA NRCS
U.S. Environmental Protection Agency	USEPA
U.S. Fish and Wildlife Service	USFWS
U.S. Geological Survey	USGS
U.S. Nuclear Regulatory Commission	USNRC
Underground Injection Control	UIC
Underground Storage Tank	UST
Unnamed Tributary	UT
Wastewater Treatment Plant	WWTP
Watershed Management Plan	WMP
Watts per square meter	Wm^{-2}
Web-based Hydrograph Analysis Tool	WHAT
Wetland Reserve Program	WRP
Wildlife Habitat Incentive Program	WHIP

INTRODUCTION

The Choctawhatchee, Pea and Yellow Rivers watersheds (CPYRW) cover a significant portion of southeast Alabama and contain a diverse and abundant assemblage of natural resources. The Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority (CPYRWMA) was created by the Alabama Legislature (Public Law 91-602) in 1991 to *"develop and execute plans and programs relating to any phase of conservation of water, water usage, flood prevention, flood control, water pollution control, wildlife habitat protection, agricultural and timberland protection, erosion prevention, and control of erosion, floodwater and sediment damages."* For more than two decades, the CPYRWMA has commissioned and funded scientific assessments, assisted local entities with water resource issues and initiatives, and has provided educational assistance and materials to local governments and citizens. As a next major step in watershed management, the CPYRWMA initiated the development of a Watershed Management Plan designed to consolidate watershed natural resource issues, available scientific data, and future management options for the watershed. Preparation of the Watershed Management Plan was guided by an advisory committee made up of representatives from all state natural resource agencies.

The information in this document provides a framework for the CPYRWMA to assist federal and state agencies, local officials, and stakeholders in protecting and preserving the natural resources in the CPYRW with the goal of assisting in the prudent development of resources needed for economic development and improved quality of life for residents in southeast Alabama. The document contains information on current demographics, land use, water quantity and quality, conservation, biological resources, and educational outreach. It includes recommendations, management strategies, and policy options for addressing numerous water-related issues. Although the document is intended to be comprehensive, reality dictates that there are issues and data that were inadvertently omitted. Therefore, annual updates to the document will be made to include omitted information and new available data.

BOARD STRUCTURE OF THE CHOCTAWHATCHEE, PEA AND YELLOW RIVERS WATERSHED MANAGEMENT AUTHORITY

The CPYRWMA is governed by a Board of Directors composed of sixteen volunteer directors representing the counties within the watershed boundaries. The Board presently consists of one Resident Director from each county and six At-Large Directors. The Watershed Management Authority concept is closely tied with Soil and Water Conservation Districts. Public Law 91-602 Section 9-10A-6 states that petitions to create Watershed Management Authorities must be filed with the Board of Supervisors of the Soil and Water Conservation District (SWCD) for counties containing watersheds included in the petition. The law (Section 9-10A-9, 10) also states that the SWCD Board of Supervisors shall determine the number of Directors and shall elect or appoint Directors to the Watershed Management Authority.

Directors serve four-year terms, receive no salaries but are reimbursed for actual and necessary expenditures incurred in the performance of their duties. The current membership and structure of the Board of Directors is shown in table 1. The Board appoints an unspecified number of volunteer technical advisors from local governments, state and federal agencies, private industry, and individual citizens. Current technical advisors are listed in table 2. The advisory committee to the Watershed Management Plan is listed in Appendix 1.

Table 1.—CPYRWMA Staff Members and Board of Directors.

Staff Members		
Title		Name
Executive Director		Barbara Gibson
Flood Warning System Specialist		Don Hyde
Board of Directors		
County	Title	Board Member
Barbour	Resident Director	Carl Garner
Barbour	At-Large Director	Jack Pelfrey
Bullock	Resident Director	Randolph Hall
Coffee	Resident Director	Kenneth Boswell
Coffee	At-Large Director	Josh Carnley
Covington	Resident Director	Glen Zorn
Covington	At-Large Director	Harold Elmore
Crenshaw	Resident Director	Ronnie D. Hudson
Dale	Resident Director	Donald K. Hallford
Dale	At-Large Director	Steve Stevens
Geneva	Resident Director	Millard Powell
Geneva	At-Large Director	Donnie Chesteen
Henry	Resident Director	Margaret Bowden
Houston	Resident Director	Joe R. Carothers, Jr.
Pike	Resident Director	Randy Hale
Pike	At-Large Director	Joe Murphy

Table 2.—CPYRWMA Technical Advisors.

Name	Agency
Ken Weathers	ADCNR, Freshwater & Fisheries Division
Nicholas Granger	Alabama Forestry Commission
Alan Boothe	Alabama Legislature, Pike County
Carl Sanders	Alabama Peanut Producers Association
Kathy Horne	Alabama Rural Water Association
Billy Mayes	City of Dothan
Randy Morris	City of Dothan
Angie Jay	City of Dothan
Thomas Agee	Dale County Extension Office
Dr. Bennett L. Bearden	Director, Water Policy & Law Institute, University of Alabama
Charlie Clark	Farm Service Agency
Marlon Cook	Geological Survey of Alabama
Doug Ward	Individual
Estus Walker	Individual
Mayor Bob Bunting	Individual
Dennis Crowe	Individual
Dr. Jack Mills	Individual
Kenneth Sanders	Individual
William C. “Bill” Stone	Individual
Dr. Bruce Donaldson	Individual
District Conservationist	NRCS, Barbour County
District Conservationist	NRCS, Coffee County
District Conservationist	NRCS, Covington County
District Conservationist	NRCS, Crenshaw County
District Conservationist	NRCS, Dale County
District Conservationist	NRCS, Geneva County
District Conservationist	NRCS, Henry County
District Conservationist	NRCS, Houston County
District Conservationist	NRCS, Pike County
Max Davis	South Alabama Electric Cooperative
Steve Musser	USDA - NRCS

WATERSHED ISSUES AND RECOMMENDATIONS

The following watershed management plan is formatted with a framework of pertinent issues for the CPYRWMA to use in developing strategies and policies to preserve and protect natural resources in the CPYRW and to assist federal, state, and local agencies and entities in economic development initiatives to enhance the quality of life for all watershed residents. To achieve these goals, recommendations and water policy options are identified and discussed throughout the document. Table 3 provides a summary of issues and recommendations and policy options for consideration by the CPYRWMA Board of Directors.

DESCRIPTION OF WATERSHEDS

A watershed is an area of land that catches water which drains or seeps into a marsh, stream, river, lake, or groundwater. By U.S. Environmental Protection Agency (USEPA) standards, a watershed is defined as an area of land where all of the water that is under it or drains off of it goes into the same place. A watershed approach is the most effective framework to address water resource challenges. Watersheds supply drinking water, provide recreational opportunities, and sustain life and ecological health. According to the USEPA, more than $450 billion in food, fiber, manufactured goods, and tourism depend on clean water and healthy watersheds. Watersheds represent the most logical basis for managing water resources because they are defined by natural hydrology, are geographically focused, include region specific stressors, involve all stakeholders, and strategically address priority water resource goals (USEPA, 2014a).

The Choctawhatchee River originates as two separate forks (East Fork and West Fork) in wetlands near Clayton in Barbour County. The East and West Forks flow through areas with more species of trees than any other forest in temperate North America (CPYRWMA, 2014). Near Ozark in central Dale County, the forks merge to form the Choctawhatchee River which flows southwest for about 48 miles to Geneva. The Choctawhatchee River is one of the longest free-flowing rivers remaining in Alabama. Its main tributary, the Pea River, joins the Choctawhatchee just below Geneva, near the Florida state line. The Pea River watershed drains the area immediately west of the Choctawhatchee River and begins in Bullock County south of Union Springs. The Pea River flows southwestward for approximately 68 miles to Elba (northwest Coffee County), southward for 30 miles into Geneva County, then gradually eastward, briefly flowing into Florida before joining the Choctawhatchee River south of Geneva. The Yellow River drains the area west of the Pea River, originates in southern Crenshaw County, and flows southward through Coffee and Covington Counties. The Yellow River exits Alabama in southern Covington County near Florala, joins the Blackwater River, and eventually reaches Blackwater Bay, near Pensacola, Florida (CPYRWMA, 2014).

Table 3.—Summary of recommendations and policy options.

Water/Energy Nexus
The CPYRWMA should cooperate with ADECA OWR to develop estimates of water usage related to energy production within the CPYRW and monitor hydropower generation and potential water-resource impacts.
A state-implemented water management plan and associated regulations should include consumptive and non-consumptive water-use data.
Water Quantity—Groundwater
CPYRWMA should cooperate with ADECA OWR, Geological Survey of Alabama (GSA), ADAI, and ARWA to establish dialogs with groundwater users concerning sustainable yields for each aquifer.
A state-implemented water management plan and associated regulations should include development guidelines for sustainable groundwater production.
Water Quantity—Surface Water
CPYRWMA should cooperate with ADECA OWR, GSA, ADAI, and Alabama Department of Environmental Management (ADEM) to establish dialogs with current and potential future surface-water users concerning surface-water production and protection.
A state-implemented water management plan and associated regulations should include establishment of policies to protect the quantity and quality of streams and impoundments.
Instream Flow
CPYRWMA should cooperate with Alabama Water Agencies Working Group (AWAWG), Alabama Department of Conservation and Natural Resources (ADCNR), and GSA regarding stream discharge monitoring and instream flow assessments, and should continue cooperation with USGS in low flow assessments.
A state-implemented water management plan and associated regulations should include provisions for establishing stream flow guidelines.
Drought Impacts
As a member of the state drought mitigation team, the CPYRWMA should take a leading role in southeast Alabama for monitoring drought conditions, drought information distribution, dialog with key local stakeholders, and implementation of local drought mitigation initiatives.
A state-implemented water management plan and associated regulations should include current state drought classification methodology, drought monitoring, water availability and impacts, and impact mitigation.
Estimation of Water Use and Demand—Groundwater and Surface Water Interaction
Strategies to maintain historic rates of base flow, including limitations on shallow (unconfined) groundwater production and protection of recharge areas, should be developed.
A state-implemented water management plan should address groundwater and surface-water interaction with guidelines for the protection of historic base flows.
Stream Discharge Gauges
Further studies are needed to rate stream discharge for the CPYRWMA flood warning system gauges.
The current flood warning system should be expanded with additional stream and precipitation gauges.

Table 3.—Summary of recommendations and policy options—continued.

GSA Real-Time Groundwater Monitoring System
The CPYRWMA should cooperate with GSA to expand the GSA real-time groundwater monitoring program in southeast Alabama.
A state-implemented water management plan should include a groundwater monitoring program.
Precipitation Monitoring
The current flood warning system precipitation gauges should be expanded and data made available to key stakeholders in near real-time on the CPYRWMA website.
A state-implemented water management plan should include groundwater, surface-water, climate (temperature and precipitation), and soil moisture monitoring systems.
National Soil Moisture Data
The CPYRWMA should submit a request to USDA NRCS for the installation of soil monitoring stations within the CPYRW.
Interstate Surface Water and Contamination Transport
The CPYRWMA should cooperate with ADEM to establish a monitoring program to evaluate local surface-water quality and maintain a surface-water quality database to identify water quality trends for the CPYRW.
Identification of Future Water Sources—Surface Water
The CPYRWMA should cooperate with ADECA OWR, ADEM, and GSA to establish a procedure for development of future surface-water resources based on need, availability, and environmental impacts.
A state-implemented water management plan should establish a process for future surface-water source development.
Identification of Future Water Sources—Groundwater
Existing hydrogeologic data and optimum well spacing guidelines should be used in conjunction with current and future water use and demand estimates to determine locations, well specifications, and sustainable production rates for future groundwater source development.
A state-implemented water management plan should establish a process for future groundwater source development that addresses pre-determined well spacing, sustainable production rates, and groundwater use priority designations.
Identification of Future Water Sources—Hybrid Water Sources
Water source planning will be required to determine areas with inadequate groundwater supplies, so that surface-water sources can be evaluated and developed.
A state-implemented water management plan should address future water needs and source development.
Water Source Sustainability
The CPYRWMA should take the lead role in water conservation education, development, and implementation of conservation guidelines in cooperation with local water users and governments.
A state-implemented water management plan should address water resource development and use as related to sustainability, conservation, and efficiency standards.
Water Reuse
ADEM should develop and implement water reuse regulations.
A state-implemented water management plan should address the reuse of treated wastewaters.

Table 3.—Summary of recommendations and policy options—continued.

303(d) List of Impaired Waters
The CPYRWMA and local entities in cooperation with ADEM should be aware of the current 303(d) listed streams and develop strategies to improve water quality and remove streams from the list.
General Ecosystem Conditions
The CPYRWMA should establish a dialog with responsible parties regarding current biological and ecosystem resources and future preservation strategies.
Irrigation
The CPYRWMA should work with GSA, ADECA OWR, USDA NRCS, and Soil and Water Conservation Districts and the Irrigation Association of Alabama to identify sources of irrigation, encourage more acreage under sustainable irrigation, and to monitor potential water quantity and quality impacts.
A state-implemented water management plan should address irrigation needs and developments and address competition for limited water sources.
Irrigation Tax Credits
The CPYRWMA should monitor water-resource needs and conditions and recommend additional incentive programs to efficiently develop and protect water resources.
Nutrients
The CPYRWMA should continue to commission water-quality monitoring projects to track conditions related to nutrient concentrations and sedimentation rates and disclose findings to regulatory authorities and local stakeholders.
Recreational Use
The CPYRWMA should create funding and development strategies for increased recreational use of water resources.
Forestry Issues
The CPYRWMA should coordinate with the Alabama Forestry Commission (AFC) to educate and encourage stakeholders to follow recommendations set forth by the AFC as discussed in the plan.
A state-implemented water management plan should include links between forestry and water-quality and -quantity issues.
Flood Preparedness
The CPYRWMA flood warning system should be expanded with river/rain gauges (at least one in each county). Annual flood preparedness seminars should be developed and offered to residents within the CPYRW.
Education
Education initiatives should include development of a water conservation guide, enhanced website design, legislative delegation briefings, school watershed education initiatives, workshops for the CPYRWMA Board of Directors, development and hosting conferences and symposia, coordinating interagency efforts, and providing an information distribution plan.
Additional legislative funding should be requested by the CPYRWMA for assistance with the cost of educational issues.
A state-implemented water management plan should include educational components including water availability and conservation to be implemented on the local level.

GEOGRAPHIC SETTING

The CPYRW encompasses approximately 3,636 square miles (mi^2) in parts of 10 counties of southeast Alabama. Table 4 lists each county, and its land area in square miles within the watershed (U.S. Census Bureau, 2002). Plate 1 illustrates the watershed area relative to adjacent states and includes hydrologic unit boundaries for each subwatershed.

Table 4.—Land area by county in the CPYRW study area (modified from U.S. Census Bureau, 2002).

County	Square Miles	Acres
Barbour	436	279,040
Bullock	157	100,480
Coffee	678	433,920
Covington	601	384,640
Crenshaw	28	17,920
Dale	563	360,320
Geneva	571	365,440
Henry	171	109,440
Houston	98	62,720
Pike	334	213,760
Totals	**3,637**	**2,327,680**

The northern boundary of the CPYRW begins at the headwaters of the Pea River at Bluff Creek between Union Springs and Midway in Bullock County. The western boundary follows the eastern boundary of the Conecuh River watershed through Pike and Crenshaw Counties. The southwestern boundary is formed by the Yellow River watershed in portions of Covington and Crenshaw Counties. The southern boundary is the Alabama-Florida state line from near Florala in Covington County eastward to central Houston County. The eastern boundary is the drainage divide between the Choctawhatchee and Chattahoochee River watersheds and extends from Barbour County southward through central Henry and Houston Counties (fig. 1).

PHYSIOGRAPHY AND TOPOGRAPHY

The CPYRW lies within the East Gulf Coastal Plain physiographic section of Alabama and is characterized by gently rolling hills, sharp ridges, prairies, and alluvial flood plains (Clean Water Partnership (CWP) and Geological Survey of Alabama (GSA), 2005). The highest elevations are in the northern portion of the watershed where ridge crests are approximately 640 feet (ft) above mean sea level (MSL). Elevation data is expressed on the CPYRW Digital Elevation Model map below (Gesch, 2007) (fig. 2).

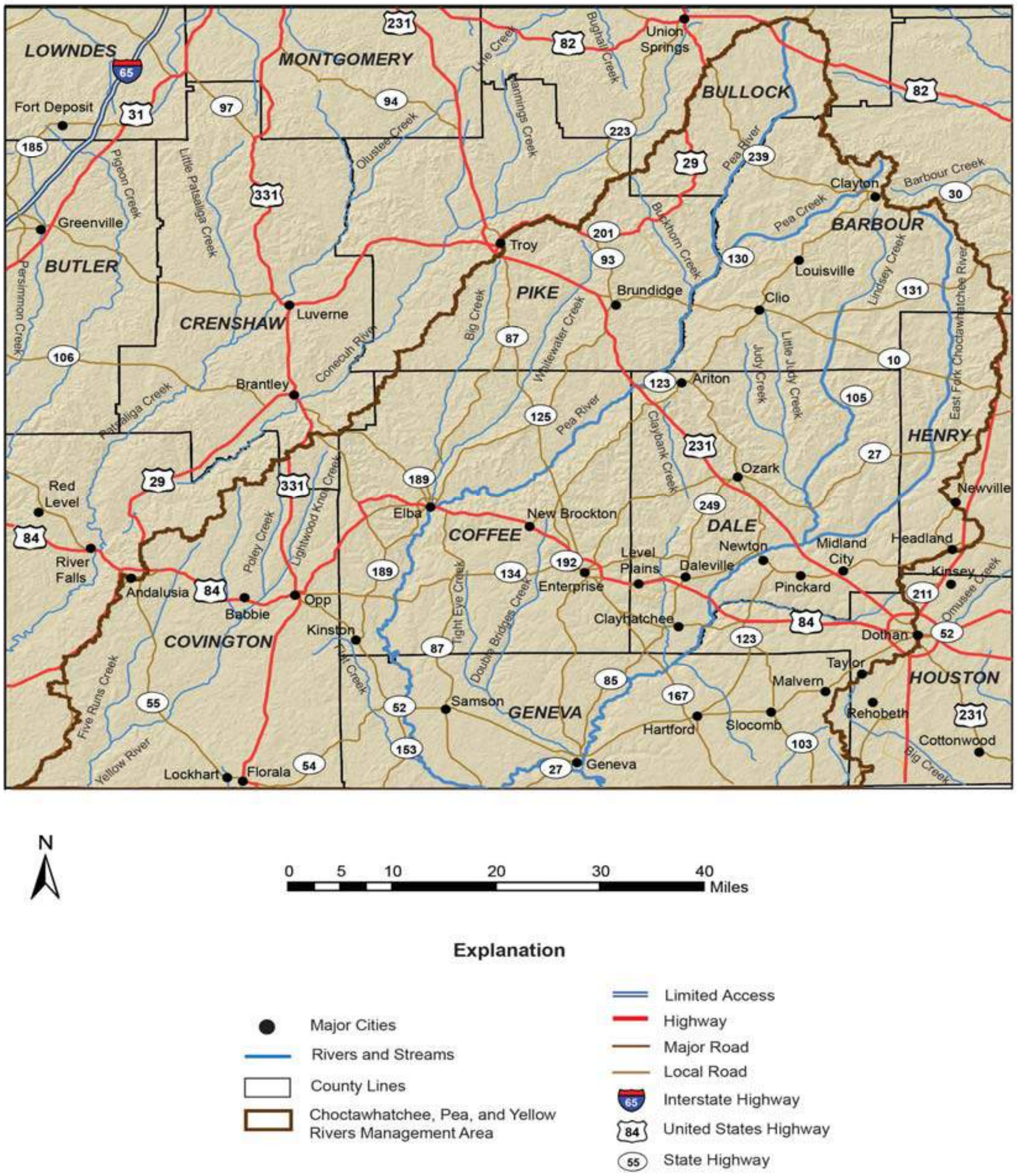

Figure 1.—CPYRWMA management area.

Geologic units underlying the Coastal Plain are of sedimentary origin and consist of sand, gravel, porous limestone, chalk, marl, and clay. These strata dip in the subsurface south-southwest at approximately 35 to 40 feet per mile (ft/mi) and strike generally westward. Some of the strata are more resistant to erosion and underlie broad saw-toothed ridges known as cuestas that slope gently to the south with steep north-facing slopes. Eight physiographic districts are delineated in the East Gulf Coastal Plain of Alabama including the Fall Line Hills, Black Belt, Chunnenuggee Hills, Southern Red Hills, Lime Hills, Dougherty Plain, Southern Pine Hills, and

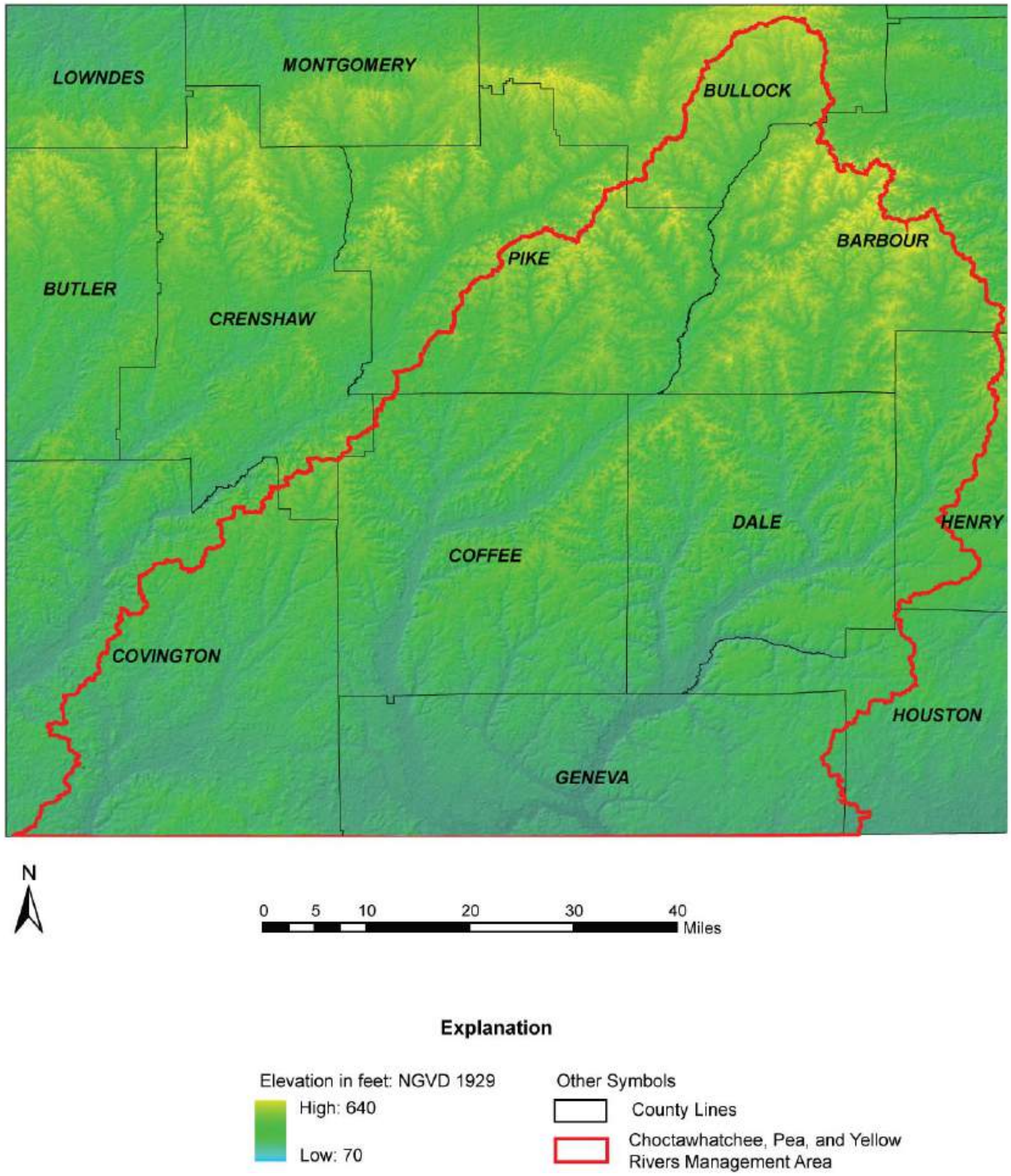

Figure 2.—Digital Elevation Model for the CPYRWMA management area (modified from Gesch, 2007.

Coastal Lowlands (Sapp and Emplaincourt, 1975). Four of these districts including Chunnenuggee Hills, Southern Red Hills, Dougherty Plain, and Southern Pine Hills are present in the CPYRW area (fig. 3).

The Chunnenuggee Hills district consists of a series of pine-forested sand hills developed on hardened beds of clay, sandstone, siltstone, and chalk. The CPYRWMA

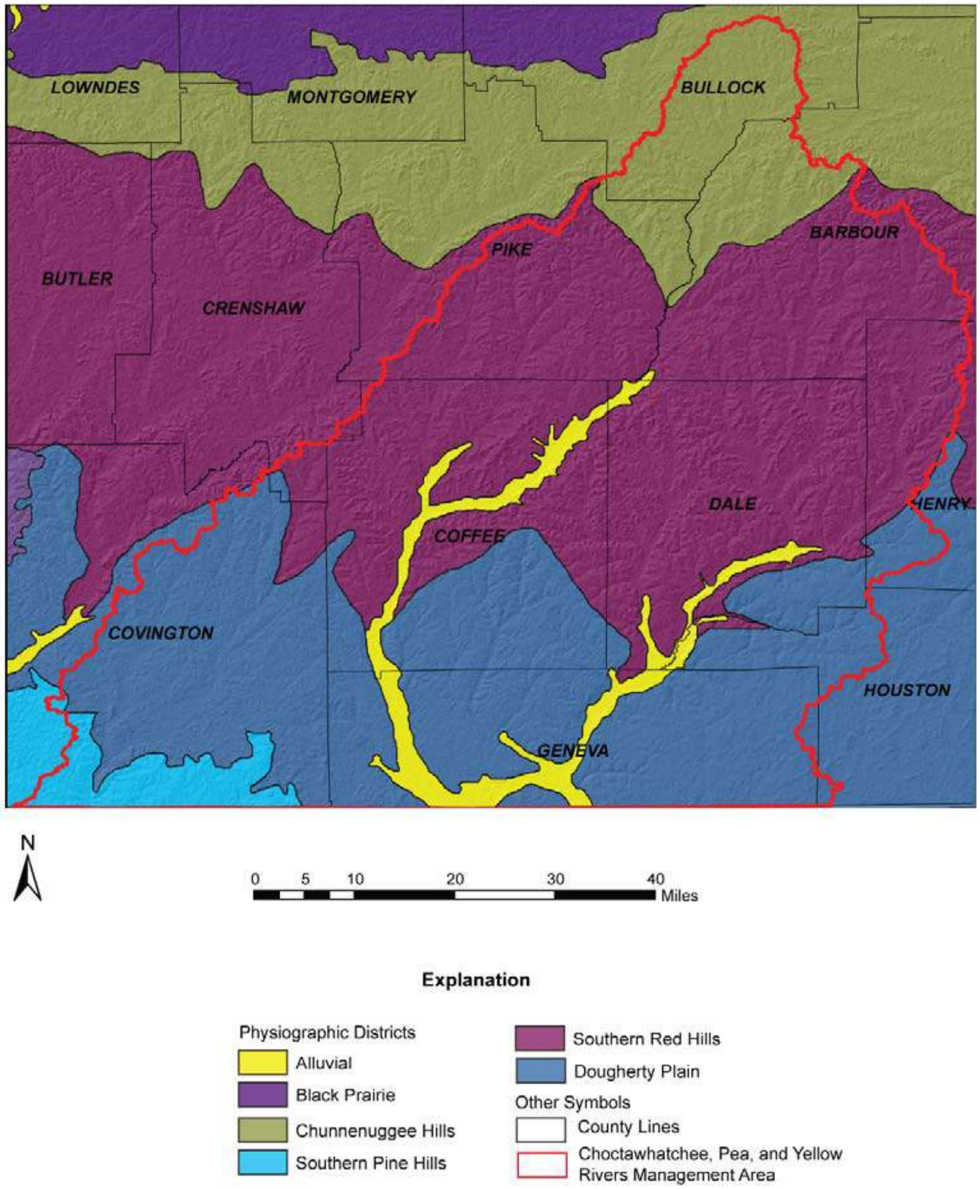

Figure 3.—Physiographic districts for the CPYRW study area.
(modified from Sapp and Emplaincourt, 1975).

management area northern boundary closely follows the Enon Cuesta. The headwaters of the Pea River are in Chunnenuggee Hills district on the south side of the Enon Cuesta.

The Southern Red Hills district extends in a belt more than 60 miles wide across the CPYRW area. The Southern Red Hills is characterized by cuesta type ridges with steep, serrate north slopes and gentle back slopes. Topographic relief in the Southern Red Hills is among the greatest in the Coastal Plain of Alabama. Streams in this area acquire upland characteristics with high gradient, hard-rock bottoms, and swifter

flows. The headwaters of the Choctawhatchee River are on the southern slope of the Ripley Cuesta in the Southern Red Hills.

The Dougherty Plain district or "wiregrass region" of the CPYRW area includes portions of Henry, Dale, Houston, Geneva, Coffee, Crenshaw, and Covington Counties. It is composed of limestone, sand, and clay. Active solution of the underlying limestone produces many shallow, flat-bottomed depressions that dot the landscape. Small headwater streams are noticeably absent from the Dougherty Plain because active limestone solution or *karst* transfers many of the drainages to underground channels. The name "wiregrass" originates from the common occurrence of needlerush in the wet, shallow depressions. The confluence of the Choctawhatchee and Pea Rivers occurs in the Dougherty Plain in southern Geneva County.

The Southern Pine Hills district in the CPYRW area includes extreme southern Covington County. Topography is low-relief with broad, rounded ridges and V-shaped valleys with sand and clay sediments. The portion of the region in Covington County has thin sand and clay sediments overlying limestone. In this area, karst features similar to the Dougherty Plain are common. The most prominent of these features is Lake Jackson in Florala (Baker and others, 2005). Flat uplands with shallow ponds, bogs, and marshes occur throughout the district and many of the valleys are saucer-like perpetually wetted by seepage from nearby hills. The abundance of warm summer rains is a major factor in leaching fertility from the soil and favoring the growth of pines in this region. Yellow River drains the Southern Pine Hills in the CPYRW area.

LAND USE

Current land use in the CPYRW is comprised of these main categories: forest (64%), agriculture (22.2%), urban (6.7%), wetlands (6.3%), and water bodies (0.9%) (plate 2). The region is heavily forested with the prominent forest type being evergreen. Other common vegetation classes are deciduous, shrubland, mixed forest, and grassland herbaceous. Agriculture is the second largest land-use category. The majority of agricultural land is comprised of these classes: grassland/pasture/hay, crops, fallow/idle cropland, and aquaculture. Crop classifications in the CPYRW include cotton, corn, peanuts, soybeans, pecans, sorghum, sod/grass seed, herbs, millet, winter wheat, rye, oats, tomatoes, sweet potatoes, blueberries, cucumbers, watermelons, peas, and several varieties of double crops.

There are two distinct areas of intense agriculture observed within the watershed. The boundaries of these areas, designated A and B and shown on figure 4, were derived by assessing the geology, soils, physiography, topography, and land-use patterns. Area A extends from the Pea River in Pike County and eastward to central Barbour County, and area B extends from Andalusia in Covington County to Dothan in Houston County. Clayton, Porters Creek, and Nanafalia Formations, all of which are composed of sand, clay, and limestone, dominate the geology of area A. Area B is underlain primarily by the Gosport Sand, Lisbon Formation, Tallahatta Formation, Jackson Group undifferentiated, and residuum that contains sand, clay, claystone, chert, and limestone. Boundaries of intensive agricultural land use conform closely to geologic contacts. The geology of these regions is the basis for soils, which are conducive to row crop agriculture.

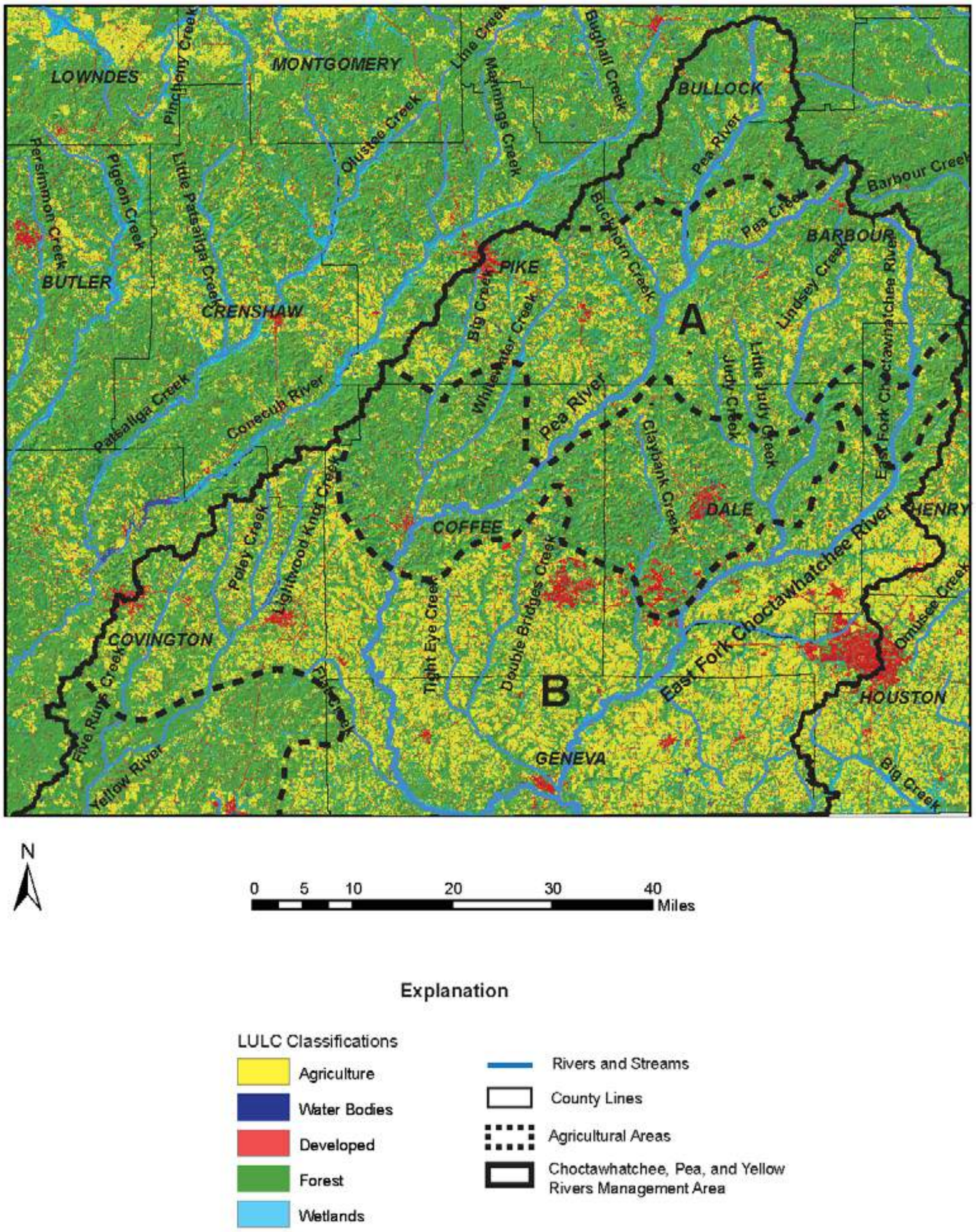

Figure 4.—Land use/land cover for the CPYRW study area (modified from USDA-National Agricultural Statistics Service, 2013).

Urban areas are defined by four categories: developed/open space, developed/low intensity, developed/medium intensity, and developed/high intensity. Wetland classes include woody wetlands and herbaceous wetlands. General land use classifications were derived from the 2011 Multi-Resolution Land Characteristics Consortiums (MRLC) National Land Cover Data (NLCD) and detailed agricultural classes were derived from the U.S. Department of Agriculture (USDA) Cropland Data Layer for Delta States (Jin and others, 2013) (plate 2). All detailed land use classes, areas, and

percentages are displayed in Appendix 2. Land use change is discussed in “Watershed Trends.”

GEOLOGY

Geologic units that crop out in the CPYRW include Quaternary alluvial and terrace deposits, Tertiary clays, sands, and gravels, and Cretaceous clays, sands, and marl (Osborne and others, 1988). With the exception of terrace and alluvial deposits geologic units in the study area dip south-southwestward about 35 to 40 ft/mi. Plate 3 shows the CPYRW geology and table 5 lists area stratigraphy. Much of the stratigraphic information in this watershed management plan was taken from the *Implementation Assessment for Water Resource Availability, Protection, and Utilization for the Choctawhatchee, Pea and Yellow Rivers Watersheds: Hydrogeology* (Smith, 2001). Discussions of individual stratigraphic units follow.

Table 5.—Generalized stratigraphy of the CPYRW (modified from Smith, 2001).

SYSTEM	SERIES	GROUP	GEOLOGIC UNIT	THICKNESS (feet)
Quaternary	Holocene/Pleistocene		Alluvial and Terrace deposits	0-50
	Miocene		Miocene undiff.	20-120
	Oligocene		Chickasawhay Limestone	20-175
	Eocene/Oligocene		Residuum and Crystal River Formation	0-? 100-150
Tertiary	Eocene	Jackson	Yazoo Clay and Moodys Branch Formation.	15-90 10-25
		Claiborne	Lisbon Fm.	75-110
			Tallahatta Fm.	75-100
		Wilcox	Hatchetigbee Fm.	35-100
	Paleocene		Tuscahoma Sand	80-125
			Nanafalia Fm.	100-200
			Salt Mountain Limestone	100-250
		Midway	Porters Creek Fm.	0-35
			Clayton Fm.	70-125
Cretaceous	Upper Cretaceous	Selma	Providence Sand	90-300
			Ripley Fm.	135
			Cusseta Sand	200
			Blufftown Fm.	30-600
		Tuscaloosa	Eutaw Fm.	100-300
			Gordo Fm.	400-550
			middle marine shale	50-150
			Coker Fm.	400-450

CRETACEOUS SYSTEM

UPPER CRETACEOUS SERIES

The Upper Cretaceous Series is composed of the Tuscaloosa Group, Eutaw Formation, Selma Group, and Ripley Formation. The Tuscaloosa Group and Eutaw Formation outcrop north of the management plan area but are included in the following geologic text due to their importance as aquifers in the subsurface of the area (plate 3).

TUSCALOOSA GROUP

The Tuscaloosa Group consists of sand, gravel, and varicolored clay which, in the outcrop belt, ranges from about 900 ft thick in western Alabama and thins to about 300 ft in the eastern part of the state. The Tuscaloosa Group was named from exposures near the city of Tuscaloosa and from river bluffs along the Tuscaloosa (or Black Warrior) River in northwestern Hale County. Sediments assigned to the Tuscaloosa Group are exposed across Alabama in a broad arcuate band extending from the northwestern part of the state southward and southeastward through Tuscaloosa and eastward through northern Macon, northern Russell, and southern Lee Counties to the Chattahoochee River. From Macon County westward, the Tuscaloosa Group in outcrop is subdivided into a lower Coker Formation and an upper Gordo Formation, yet in the eastern Alabama outcrop this subdivision of the Tuscaloosa cannot be recognized and the unit is mapped as the Tuscaloosa Group undifferentiated. However, in the subsurface toward the south from Macon, Lee, and Russell Counties to the Alabama-Florida state line, a three-part subdivision of the Tuscaloosa Group is recognized, consisting of the lower Coker Formation, a middle informal “middle marine shale,” and the upper Gordo Formation (Smith, 2001).

COKER FORMATION

Tuscaloosa sediments exposed within Macon, Lee, and Russell Counties are undifferentiated and are mapped as the Tuscaloosa Group undifferentiated. In outcrop exposures, these sediments consist of white, yellowish-orange, and gray sand and gravel interbedded with gray and varicolored clay and sandy clay containing thin lenses of sandstone. Limited available data suggests that the top of the Coker Formation ranges in depth from about -600 ft MSL in the northern part of Bullock County to perhaps -2,200 to -2,300 ft MSL in southern Pike and Barbour Counties (Smith, 2001).

MIDDLE MARINE SHALE

Within the subsurface of eastern and southeastern Alabama, the Tuscaloosa Group can be divided into three formal and informal formations. The informal “middle marine shale” is a thin yet widespread unit that occurs throughout the subsurface of Alabama. Although not recognized at the surface, its occurrence in the subsurface permits the identification, differentiation, and mapping of the lower Tuscaloosa Coker Formation from the overlying upper Tuscaloosa Gordo Formation. Throughout east-central and southeastern Alabama, the subsurface “middle marine shale” consists of medium-gray to olive-gray, massive-bedded to thinly laminated, finely muscovitic and

lignitic, quartzose silty clay and shale which in part is moderately calcareous and contains common to abundant thin-walled pelecypod shell fragments (Smith, 2001).

GORDO FORMATION

The Gordo Formation represents the upper formal stratigraphic unit within the Tuscaloosa Group. The outcrop extends through Macon County and extends eastward to the Chattahoochee River. In this area, the Gordo Formation in its outcrop is not differentiated from the underlying Coker, and both units are mapped as the Tuscaloosa Group undifferentiated. Within the subsurface of Bullock, Pike, and Barbour Counties, the base of the Gordo Formation is marked by the abrupt change from coarse sands and gravels of the basal Gordo and the massive gray clay of the underlying "middle marine shale" (Smith, 2001).

EUTAW FORMATION

Outcrop exposures of the Eutaw Formation extend through northern Montgomery and northern Russell Counties to the Chattahoochee River. Southward from the outcrop, the Eutaw Formation is recognized throughout the subsurface of southeastern Alabama to the Florida state line. The Eutaw Formation consists predominantly of light-gray to light-greenish-gray, glauconitic, muscovitic, fossiliferous, well-sorted, fine- to medium-grained quartzose sand with subordinate beds of thinly laminated to massive dark-gray, micaceous, lignitic and carbonaceous silty clay and clay (Smith, 2001).

BLUFFTOWN FORMATION

In western and central Alabama, sediments overlying the Eutaw Formation and assignable to the lower Selma Group consist of a lower Mooreville Chalk and an upper Demopolis Chalk. These beds are made up of a series of massive impure chalks and chalky marls with a thin limestone bed, the Arcola Limestone, separating the underlying Mooreville Chalk from the overlying Demopolis Chalk. From Montgomery County eastward, the Mooreville Chalk thins to about 100 ft in southeastern Macon and northeastern Bullock Counties. Further eastward, in western and west-central Russell County, the Mooreville Chalk grades into the lower part of the Blufftown Formation and cannot be mapped. In far eastern Alabama, these chalky marls interfinger with and are eventually replaced entirely by the Blufftown Formation which consists predominantly of marl, calcareous clay, and subordinate thin beds of very fine quartzose sand (Smith, 2001).

CUSSETA SAND MEMBER OF THE RIPLEY FORMATION

The Cusseta crops out near Union Springs in Bullock County in the management plan area. Occurring near the base of the Ripley Formation, the Cusseta is primarily composed of fine- to coarse-grained sand and dark-gray carbonaceous clay (Osborne and others, 1988).

RIPLEY FORMATION

In north-central Barbour, southern Bullock, and far northern Pike Counties, the exposed upper member of the Ripley generally consists of massive-bedded to cross-

bedded, glauconitic fine sands and sandy clay with thin indurated beds of fossiliferous sandstone having a total thickness of about 135 ft (Osborne and others, 1988).

PROVIDENCE SAND

In the outcrop of eastern Alabama, the Providence Sand is subdivided into a lower Perote Member and an upper unnamed member. The lower Perote Member ranges from less than 10 to perhaps 150 ft in thickness and consists of dark-gray, highly micaceous and carbonaceous, laminated to thin-bedded, silty clay and fine quartzose sand. The upper part of the Providence ranges from 80 to 150 ft in thickness and consists of thinly laminated sand and clayey silt that is in part marine and abundantly fossiliferous, overlain by thick-bedded to cross-bedded sand.

From its outcrop in central Barbour and Pike Counties, the Providence Sand extends southward through southern Covington, Geneva, and Houston Counties, to the Alabama-Florida State line, thus underlying the entire study area (Smith, 2001) (plate 3).

TERTIARY SYSTEM

PALEOCENE SERIES

CLAYTON FORMATION

Outcrop exposures of the Clayton Formation extend from the Chattahoochee River area of southeastern Barbour County westward in a narrow arcuate band about 2 to 3 miles in width through central Barbour and Pike Counties into north-central Crenshaw County (plate 3). The presence of Clayton outliers exposed on topographic high ridge crests as much as 10 miles north of its outcrop indicate these updip areas must have had a continuous cover at one time in the past (Baker and Smith, 1997). McWilliams, Newton, and Scott (1968) report that in the subsurface the Clayton generally consists of fossiliferous sandy limestone. Outcrops in many areas have weathered to residual accumulations of chert boulders, moderate-reddish-orange sand, and clay.

PORTERS CREEK FORMATION

Through Pike and Barbour Counties, the Porters Creek Formation is significantly absent. One notable outcrop, however, occurs near the type area of the Clayton Formation (plate 3). This single exposure represents the only known outcrop of the Porters Creek in Barbour County. Gibson (1981) reported 34.4 ft of dark-gray, massive, waxy, fossiliferous, silty clay which he assigned to the Porters Creek Formation on the basis of its lithologic similarity to the Porters Creek in central and western Alabama.

SALT MOUNTAIN LIMESTONE

The Salt Mountain Limestone is the only stratigraphic unit underlying the Choctawhatchee, Pea and Yellow Rivers Watersheds (or, for that matter, the entire south-central and southeastern portions of Alabama) that does not have an equivalent updip, or northward, outcrop exposure. The Salt Mountain Limestone is lithologically distinctive throughout southern Alabama where it overlies the Porters Creek

Formation or, where the Porters Creek is absent, overlies the Clayton Formation, and, in turn, is overlain by the Nanafalia Formation.

The Salt Mountain Limestone consists of white to very light-gray, massive, highly porous and permeable, more rarely dense and indurated, rarely fine to medium quartzose sandy, highly fossiliferous limestone. These limestones vary from highly fossiliferous and porous to massive, dense, very fine grained carbonates (Smith, 2001).

NANAFALIA FORMATION

From central Crenshaw County eastward, the outcrop belt of the Nanafalia Formation increases to as much as 20 miles in width as a direct result of deep dissection and resulting high topographic relief in southeastern Alabama. In southern Barbour and northern Henry Counties, the Nanafalia is highly variable lithologically but generally consists of massive cross-bedded sands, glauconitic and fossiliferous fine sands, and nonfossiliferous clays totaling about 125 ft in thickness (plate 3).

In the CPYRW project study area, the Nanafalia Formation represents one of the most widespread and significant aquifers within the Cretaceous or Tertiary Systems.

TUSCAHOMA SAND

Through northern Dale and Henry Counties to the Chattahoochee River, the Tuscahoma outcrop belt varies from about 15 to 20 miles in width primarily due to the relatively high topographic relief and deeply dissected sediments in the area. In the outcrop of eastern Alabama, the Tuscahoma Sand is about 80 to 125 ft thick and generally consists of a thin basal glauconitic sand overlain by dark-gray to black, thinly laminated, micaceous and carbonaceous, nonfossiliferous clay and silty clay. (Smith, 2001) (plate 3).

EOCENE SERIES

HATCHETIGBEE FORMATION

In outcrop, the Hatchetigbee consists of greenish-gray, very glauconitic, very fine to fine quartzose sand that is abundantly fossiliferous (Smith, 2001). In southern Crenshaw and northern Covington County, the outcropping Hatchetigbee Formation is about 100 ft thick. Further eastward, into Coffee, Dale, and Henry Counties, the Hatchetigbee is reduced to less than 50 ft in thickness. Along the Chattahoochee River in east-central Henry County, Toulmin and LaMoreaux (1963) report only 35 ft in thickness (plate 3).

TALLAHATTA FORMATION

In eastern Alabama, the Tallahatta Formation is 75 to 100 ft thick. Tallahatta sediments in eastern Alabama form the most rugged topography in southeastern Alabama with a deeply dissected outcrop pattern varying from 20 to 30 miles in width.

In the outcrop through northern Covington County, central and southern Coffee and Dale Counties, and extending eastward through the central portions of Henry County, the Tallahatta generally consists of clayey sand, sandy clay, and thin beds of limestone. (Smith, 2001) (plate 3).

LISBON FORMATION

The Lisbon Formation is about 75 ft thick in northern and central Covington County (Toulmin,1967). Further eastward, the Lisbon Formation consists almost entirely of deeply weathered sand. Along the Chattahoochee River in the vicinity of Columbia in northeastern Houston County, the Lisbon Formation consists of about 110 ft of various rock types (Toulmin and LaMoreaux, 1963) (plate 3).

JACKSON GROUP UNDIFFERENTIATED

The Jackson group consists of the Moodys Branch Formation and overlying Yazoo Clay. The only exposures of the Moodys Branch Formation occur along the Conecuh River west of Andalusia in north-central Covington County, along the Yellow River and Lightwood Knot Creek west of Opp in eastern Covington County, along Flat Creek and the Pea River west and northwest of Samson in western Geneva County, and along Double Bridges Creek, the Chattahoochee River and Hurricane Creek in central and east-central Geneva County (Smith, 2001). Only a single exposure of the Moodys Branch Formation is known in Houston County. Toulmin and LaMoreaux (1963) report about 30 ft of Moodys Branch Formation exposed in bluffs along the western bank of the Chattahoochee River about 3 miles north of the U.S. Highway 84 bridge over the Chattahoochee, this bridge being located about 3 miles southeast of Gordon in southeastern Houston County (plate 3).

Within the outcrop of the management plan area, the Yazoo Clay is invariably deeply weathered, cannot be distinguished as a separate formation, and is included with the Tertiary residuum on geological maps. In the shallow subsurface, however, the Yazoo Clay is readily identifiable and has been mapped throughout central and southern Covington County, Geneva County, and western Houston County

EOCENE AND OLIGOCENE SERIES

RESIDUUM AND CRYSTAL RIVER FORMATION

Derived from solution and collapse of limestone in the Jackson Group and Oligocene Series and the slumping of Miocene sediments, the residuum occurs in a wide band across the study area from Covington through Houston Counties (Osborne and others, 1988) (plate 3). It is primarily composed of clay, sandy clay, and layers of gravelly sand and fossiliferous chert. Beds assignable to the Crystal River Formation cannot be identified or mapped in the outcrop in southeastern Alabama but rather are included in the Tertiary residuum. In the shallow subsurface, however, the Crystal River Formation is readily recognizable in Covington County, most of southern Geneva County, and in Houston County. It consists of about 100 to 150 ft of calcareous sands, sandy clays, and marls with thin interbedded limestones (Smith, 2001).

OLIGOCENE SERIES

CHICKASAWHAY LIMESTONE

Within the Choctawhatchee, Pea and Yellow Rivers Watershed area, the Chickasawhay Limestone is exposed only in southern Covington County. In this area, the unit is deeply weathered and oxidized and consists predominantly of reddish-brown sand and clay (plate 3). Fresh unweathered exposures of the Chickasawhay

Limestone are rare and occur only in streams and rivers that have cut through the weathered surficial Chickasawhay residuum (Smith, 2001).

MIOCENE SERIES

MIOCENE SERIES UNDIFFERENTIATED

In the study area the Miocene Series undifferentiated is exposed in southern Covington County (plate 3). It consists principally of poorly sorted sands, sandy clays, and often color mottled clays, with subordinate amounts of gravel (Smith, 2001).

QUATERNARY SYSTEM

PLEISTOCENE AND HOLOCENE SERIES

TERRACE AND ALLUVIAL DEPOSITS

Terrace and alluvial deposits occur throughout the CPYRW and are very similar in lithology, distinguished primarily by their elevations above stream levels. High terrace deposits represent former flood plains when streams were at higher elevations. Low terrace or alluvial deposits occur in stream valleys and along banks of current streams. These sediments consist principally of unconsolidated silt, sand, gravel, and clay, and various admixtures of these sediments (Smith, 2001) (plate 3).

BIOLOGY

The general biologic condition of the CPYRW was evaluated by the Ecosystems Investigations Program at the GSA. General ecosystem conditions, characterization of biological resources, habitat conditions, fish consumption advisories, and aquatic biodiversity are discussed in the Ecosystem Resources section of this report. The biological stream condition of the watershed has been determined by the Index of Biotic Integrity (IBI) method. Based on historical IBI collection data in the GSA database, biological condition was determined for 35 sites within the CPYRW by calculating the IBI using metrics and scoring criteria presented in O'Neil and Shepard (2012). Four sites rated very poor (12%), nine sites rated poor (26%), nine sites rated fair (26%), 11 sites rated good (30%), and two sites rated excellent (6%). Samples taken at these 35 sites represented a range of stream water quality and habitat conditions and were taken for different reasons in the CPYRW. The distribution of these sampling sites is shown in figure 5. Around one-third of the sites had poor to very poor biological condition while two-thirds of the sites were fair or better. The IBI varies seasonally reflecting natural fish community changes due to reproduction cycles, population recruitment and growth, and climate-related flood and drought cycles. As such, several samples should ideally be collected from different seasons to adequately characterize the statistical distribution of IBIs at any one site.

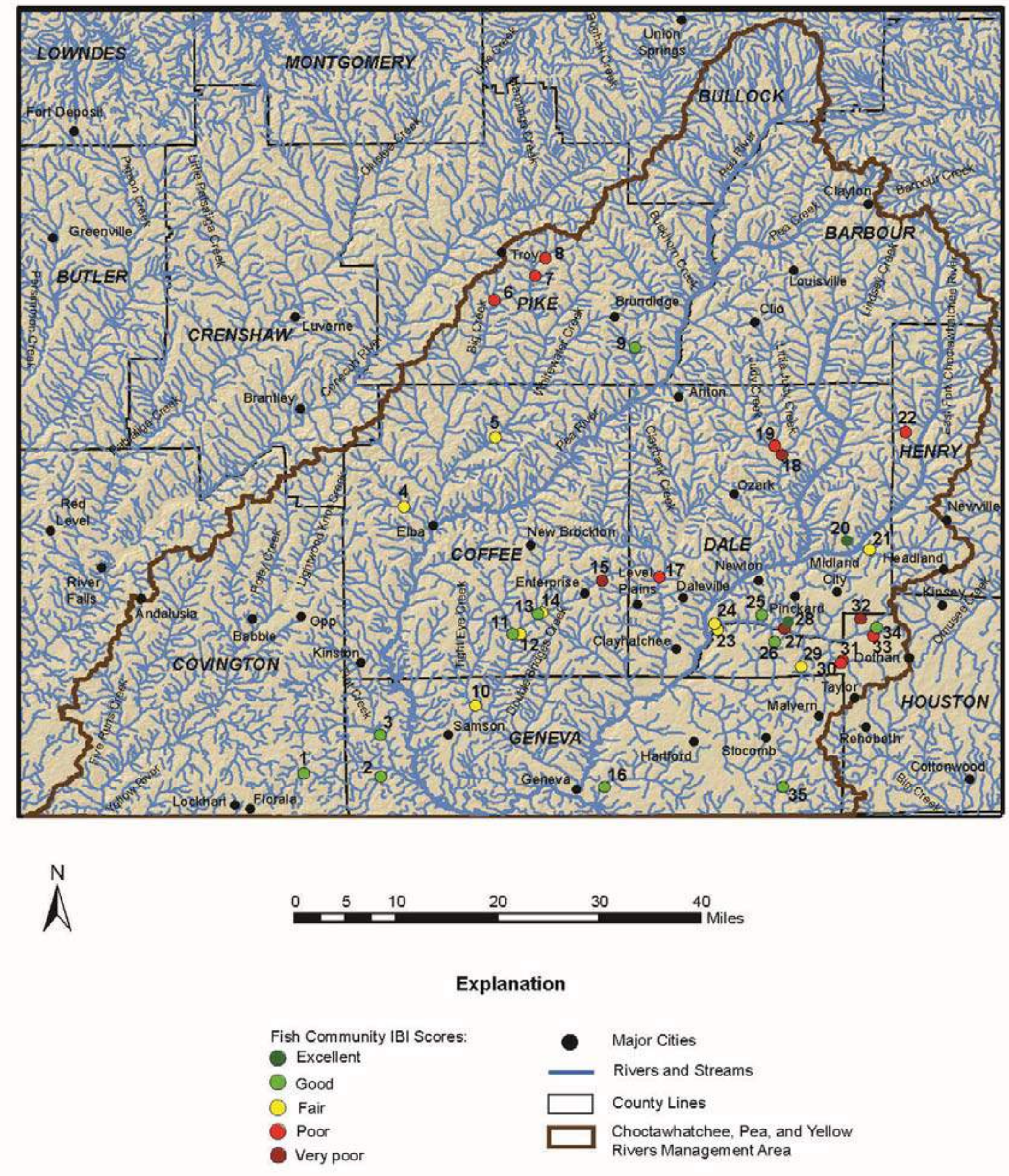

Figure 5.—IBI biological condition assessments in the CPYRW.

SOILS

There are three soil orders in the CPYRW study area: Ultisols, Inceptisols and Histosols (fig. 6). Ultisols account for 90% of soil orders within the study area. Ultisols are intensely weathered soils of warm and humid climates. They are usually formed on older geologic formations in parent material that is already extensively weathered. They are generally low in natural fertility and high in soil acidity, but contain subsurface clay accumulations that give them a high nutrient retention capacity

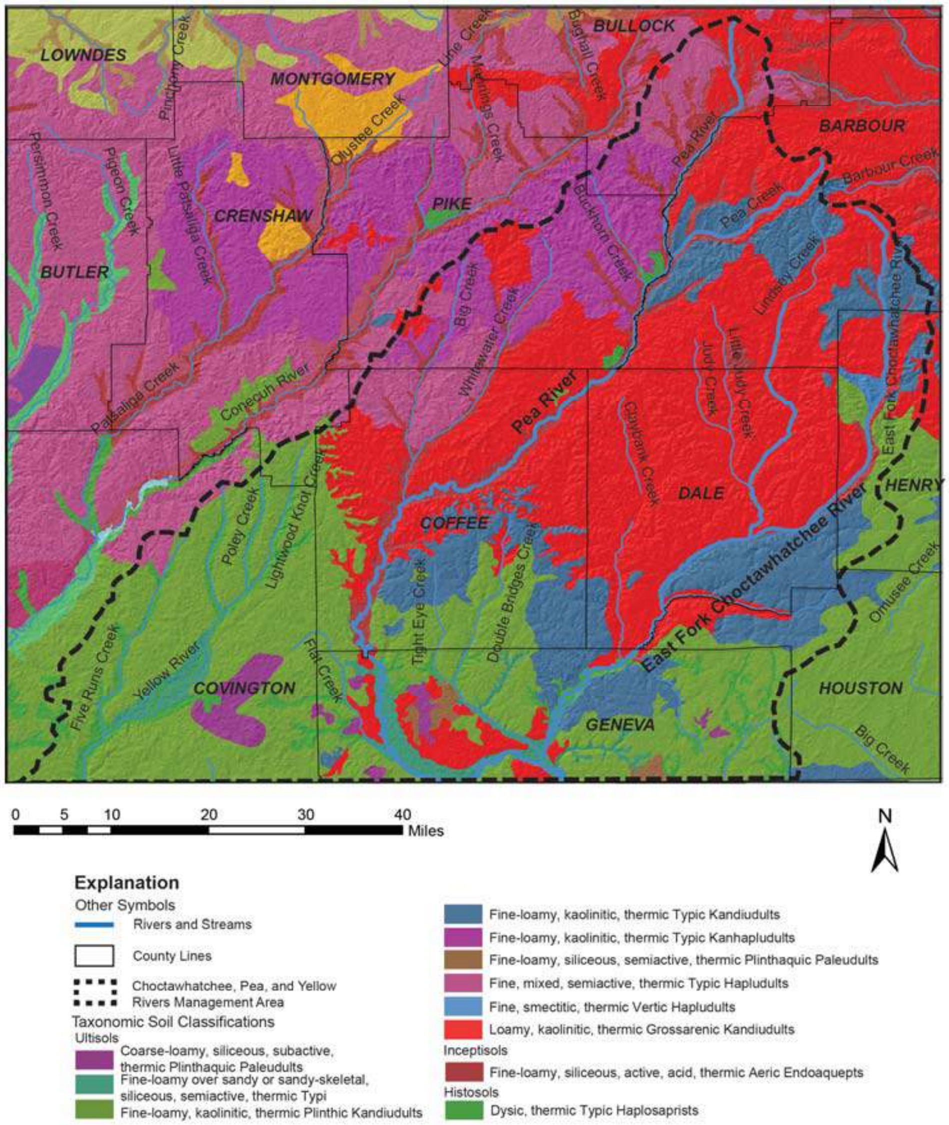

Figure 6.—Taxonomic soil classifications for the CPYRW study area (modified USDA NRCS Web Soil Survey, 2013).

(University of Nebraska and others, 2014). Ultisol soils can be agriculturally productive with the addition of lime and fertilizers. The Ultisol taxonomic soil classifications for the CPYRW include the following: Coarse-loamy, siliceous, subactive, thermic Plinthaquic Paleudults; Fine-loamy over sandy or sandy-skeletal, siliceous, semiactive, thermic Typi; Fine-loamy, kaolinitic, thermic Plinthic Kandiudults; Fine-loamy, kaolinitic, thermic Typic Kandiudults; Fine-loamy, kaolinitic, thermic Typic Kanhapludults; Fine-loamy, siliceous, semiactive, thermic Plinthaquic Paleudults; Fine, mixed, semiactive, thermic Typic Hapludults; Fine, smectitic, thermic Vertic Hapludults; and Loamy, kaolinitic, thermic Grossarenic Kandiudults (USDA, 2009).

Inceptisols account for 6% of soil orders within the CPYRW area and are described as soils in the beginning stages of soil profile development. The differences between horizons are just beginning to appear in the form of color variation due to accumulations of small amounts of clay, salts, and organic material (University of Nebraska Library, 2014). The natural productivity of these soils varies widely and is dependent on clay and organic matter content as well as other plant-related factors. The Inceptisol taxonomic soil classification for this area is fine-loamy, siliceous, active, acid, thermic Aeric Endoaquepts (USDA, 2009).

Histosols account for the remaining 4% of soil orders within the CPYRW. They are described as soils without permafrost predominantly composed of organic material in various stages of decomposition (University of Nebraska Library, 2014). They are usually saturated with water that creates anaerobic conditions and causes faster rates of decomposition, resulting in increased organic matter accumulation. They generally consist of at least half organic materials, which are layered and common in wetlands. The Histosol taxonomic soil classification for this area is Dysic, thermic Typic Haplosaprists (USDA, 2009). The taxonomic soil classification areas for the CPYRW are listed in table 6.

Table 6.—Soil order, suborder, and area for taxonomic classifications in the CPYRW.

Soil Order	**Suborder**	**Taxonomic Classification**	**Square miles**	**Acres**
Ultisols	Udults	Coarse-loamy, siliceous, subactive, thermic Plinthaquic Paleudults	55	34,906
Ultisols	Udults	Fine-loamy over sandy or sandy-skeletal, siliceous, semiactive, thermic Typi	89	56,761
Ultisols	Udults	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	1,002	641,471
Ultisols	Udults	Fine-loamy, kaolinitic, thermic Typic Kandiudults	498	318,583
Ultisols	Udults	Fine-loamy, kaolinitic, thermic Typic Kanhapludults	216	138,494
Ultisols	Udults	Fine-loamy, siliceous, semiactive, thermic Plinthaquic Paleudults	17	11,181
Ultisols	Udults	Fine, mixed, semiactive, thermic Typic Hapludults	158	101,219
Ultisols	Udults	Fine, smectitic, thermic Vertic Hapludults	8	4,856
Ultisols	Udults	Loamy, kaolinitic, thermic Grossarenic Kandiudults	1,244	796,115
Inceptisols	Aquepts	Fine-loamy, siliceous, active, acid, thermic Aeric Endoaquepts	207	132,448
Histosols	Saprists	Dysic, thermic Typic Haplosaprists	143	91,250
Total			3,636	2,327,283

CLIMATE

Climate in Alabama, including the CPYRW area, is classified as humid sub-tropical with hot summers, mild winters, and moderate amounts of precipitation. For the CPYRW, average daily temperatures range from a high of 91˚F to a low of 65˚F in the summer and a high of 60˚F to a low of 39˚F in the winter (National Climatic Data Center normals 1981-2010; National Oceanic and Atmospheric Administration (NOAA), 2011). Table 7 provides a summary of average annual temperatures from selected climate stations in the CPYRW (NOAA, 2011). Average precipitation from 1981 to 2010 ranges from 51 inches in the northeastern section of the CPYRW to 61 inches in the southwest (fig. 7). Average annual and seasonal precipitation values (inches) can be seen for each NOAA precipitation station within the watershed area in table 8. These data are derived from the National Climatic Data Center's 1981-2010 Climate Normals. Climate Normals are defined as the 30-year average of climatological variables, such as precipitation and temperature (NOAA, 2011). The CPYRWMA maintains precipitation gauges, which are described in the Precipitation Monitoring Section of this document.

Table 7.—Average annual temperatures from selected stations in the CPYRW.

Station Name	Average Minimum Temperature (°F)	Average Temperature (°F)	Average Maximum Temperature (°F)
Andalusia	49.8	64	78.1
Andalusia Airport	55.9	67	78
Clayton	50.1	63.2	76.4
Dothan Airport	55.2	66.5	77.9
Enterprise	55.5	66.6	77.7
Geneva	53.1	65.7	78.2
Headland	55.3	66.4	77.6
Troy	53.9	64.8	75.7
Troy 2 W	52.5	64.1	75.7
Troy Airport	52.2	64.3	76.4

Since weather records at multiple stations became available in the 1880s, analyses of these data indicate that, overall, the climate of Alabama has changed little. The temperature of the state has declined slightly since 1883, especially in the climatically sensitive metric of summer daytime maximum temperatures (-0.16 °F per decade). A reconstruction of average daily maximum summertime temperatures near the CPYRW shows year-by-year variability since 1883 and general cooling (fig. 8). As an illustration of this decline, since 1883, at least one station in Alabama reached 100°F or greater in every year to 1964. Since 1965, however, there have been six summers (1965, 1974, 1994, 2001, 2003 and 2013) without any station reaching 100°F despite the presence of many more stations. The downward temperature trend of the past 130

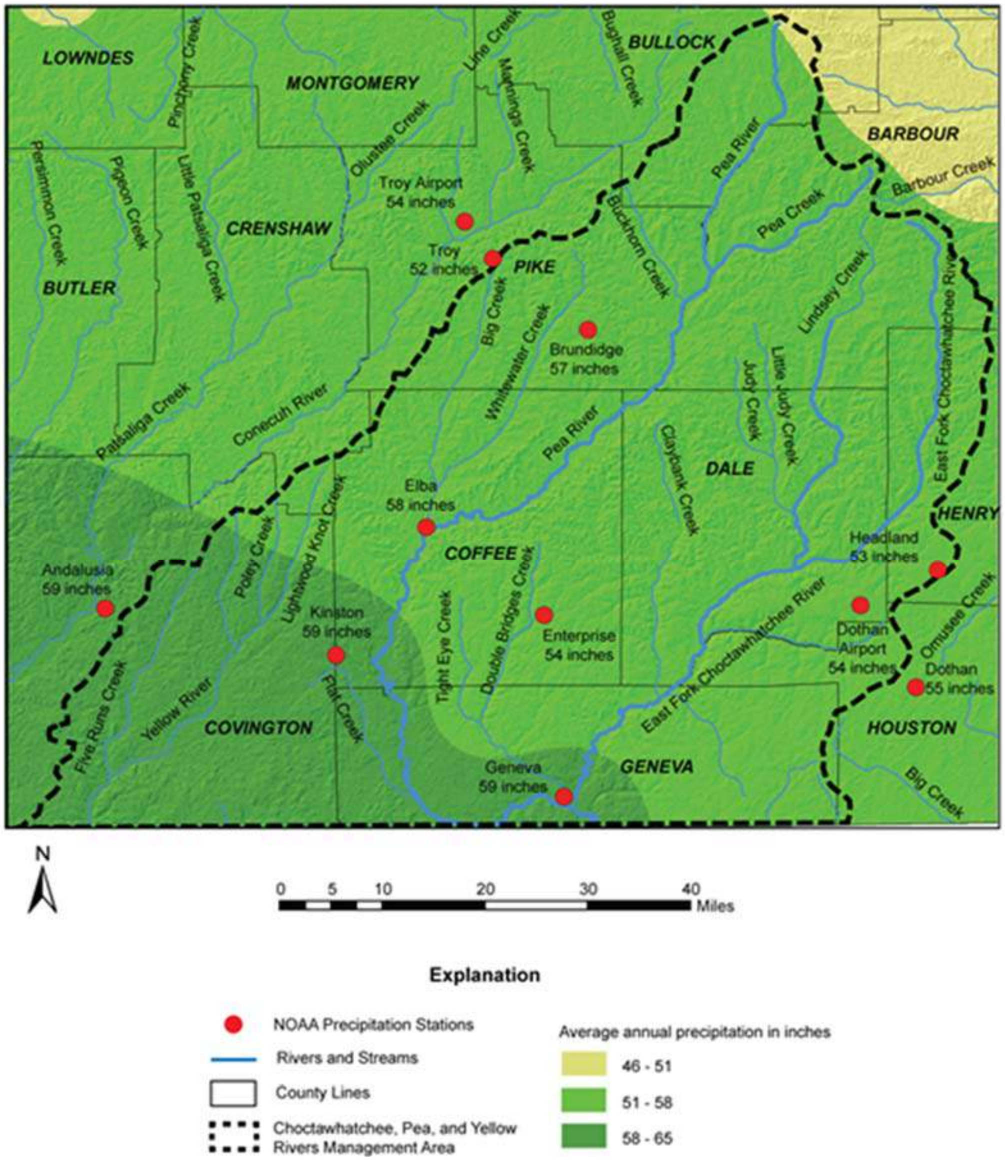

Figure 7.—Average annual precipitation for the CPYRW study area (modified from NOAA National Climatic Data Center (NCDC), 2011, and PRISM Climate Group, 2010).

years cannot be used as a forecasting tool, however, and one would anticipate the very hot summers of the first half of the 20th century are likely to return simply from natural variability as well as from the added influence of extra greenhouse gases in the atmosphere (John Christy, State Climatologist, personal communication, 2014).

Figure 8 shows year by year average of daily maximum temperatures for June-August (1883-2013) for an area centered on Montgomery, Alabama, and extending 50 miles in all directions. Thirty-two climate stations were used in this analysis (John Christy, State Climatologist, personal communication, 2014).

Table 8.—Precipitation values (inches) from selected stations in the CPYRW.

Station Name	Annual	Winter	Spring	Summer	Fall
Abbeville	55.51	15.10	13.39	15.77	11.25
Andalusia	59.97	15.39	14.41	17.11	13.06
Brundidge	57.36	14.01	13.97	16.45	12.93
Dothan	55.91	14.75	13.43	16.32	11.41
Dothan Airport	53.97	13.79	12.96	16.03	11.19
Elba	58.04	14.88	14.73	16.15	12.28
Enterprise	54.31	14.39	13.43	15.51	10.98
Geneva	59.11	15.53	13.95	16.62	13.01
Headland	53.77	14.59	12.39	15.03	11.76
Kinston	59.84	15.34	15.09	16.30	13.11
Troy	52.05	13.11	13.42	14.70	10.82
Troy Airport	54.62	13.97	13.70	15.12	11.83

An analysis of annual precipitation since 1895 (using the water-year of October through the following September) indicates variations around a humid climate. Figure 9 shows the water-year annual precipitation for Climate Division 7 (Alabama Coastal Plain) which includes the CPYRW region. There is no rising or falling trend of any significance in the observations. As with the nation as a whole, the occurrences of very

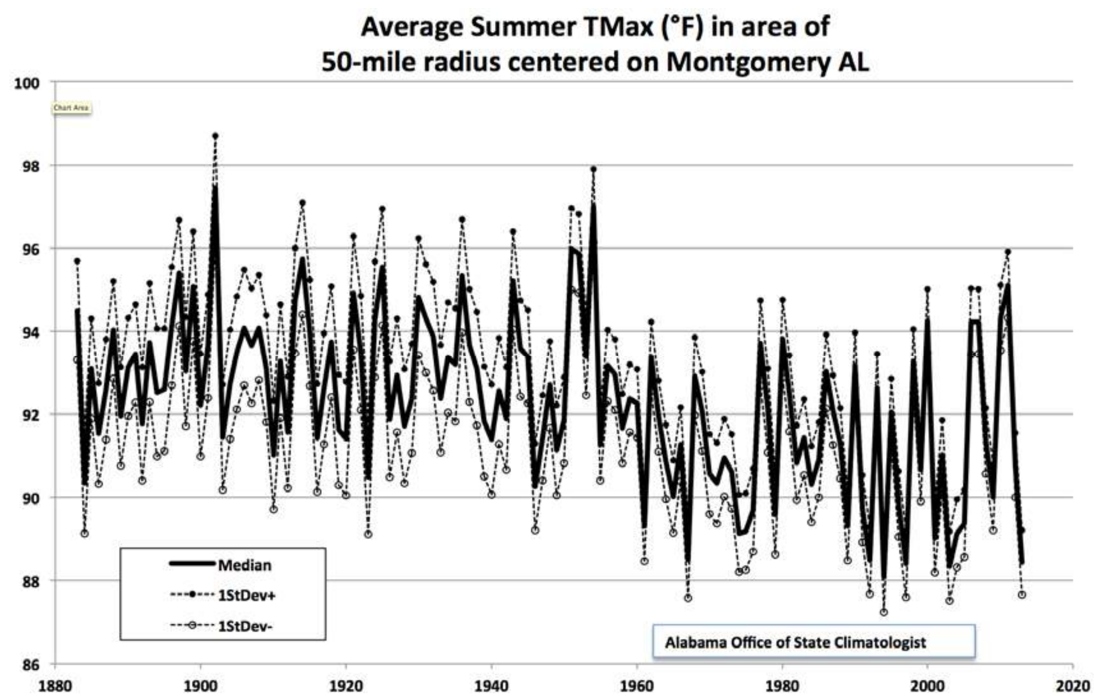

Figure 8.—Average summer temperature (TMax °F) in Montgomery, Alabama (modified from John Christy, State Climatologist, personal communication, 2014).

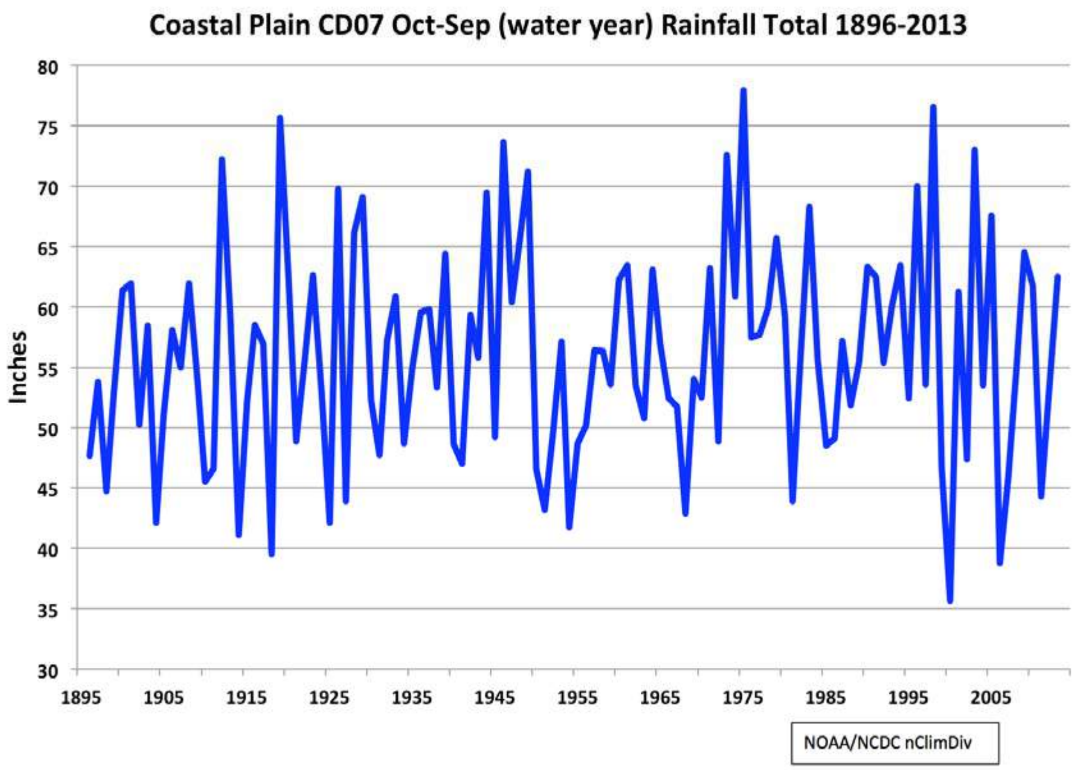

Figure 9.—Annual water-year (October to September) precipitation total for the Coastal Plain climate division in Alabama (modified from NOAA National Climatic Data Center (NCDC) nClimDiv dataset, 2014).

dry and very wet periods have not changed over time (John Christy, State Climatologist, personal communication, 2014).

Because Alabama occupies the land between the warm waters of the Gulf of Mexico and is subject to continental influences to the north and west, extremes in weather events can have a large range, relative to other parts of the country. The extremes of these events, i.e., floods, droughts, heat waves, cold outbreaks, winter storms, severe thunderstorms, tornadoes, and tropical cyclones, often inflict considerable damage on infrastructure as well as nonhuman systems. These events have contributed to more billion-dollar weather disasters in the Southeast than in any other region of the USA during the past three decades, though when normalized for inflation and population growth, there is no long-term trend in these disasters (Pielke, 2013). In other words, the evidence is very strong to demonstrate that extreme events themselves (hurricanes, tornadoes, winter storms, heat waves, cold spells, droughts, floods, etc.) are not increasing in frequency or intensity. However, the infrastructure exposed to such events has expanded significantly both in quantity and value so that damage now is more severe cost-wise than in the past.

PREDICTIONS

The Environmental Protection Agency has estimated key U.S. climate projections based on modeling studies by the Intergovernmental Panel on Climate Change (IPCC)

and the National Research Council. General findings from global and regional climate models suggest that the magnitude and rate of future climate change will depend on the following factors: (1) the rate at which levels of greenhouse gas concentrations in our atmosphere continue to increase, (2) how strongly climate features respond to the expected increase in greenhouse gas concentrations, and (3) natural influences on climate and natural processes within the climate system. Future changes associated with continued emissions of greenhouse gases are expected to include a warmer atmosphere, a warmer and less caustic ocean, and higher sea levels (USEPA, 2014b). However, the sensitivity of the climate models was demonstrated to be much higher than the sensitivity calculated from empirical studies, rendering climate model projections suspect at the outset, especially at the regional scale (IPCC, 2013).

The term “projection” describes how future climate is expected to respond to various scenarios of population growth, greenhouse gas emissions, land development patterns, and other factors that may affect climate change. The latest IPCC AR5 from 2013 uses what is termed “Representative Concentration Pathway” or “RCP” that becomes the input for climate model projections. These RCP scenarios attempt to account for changes in energy systems, population, etc., and are defined as (basically) the maximum radiative forcing that the extra greenhouse gases will exert on the climate system (John Christy, State Climatologist, personal communication, 2014). The values range from 2.6 Wm^{-2} to 8.5 Wm^{-2} (fig. 10). By comparison, the earth, on average, absorbs the sun’s energy at a rate of about 235 Wm^{-2}. The basic idea is that

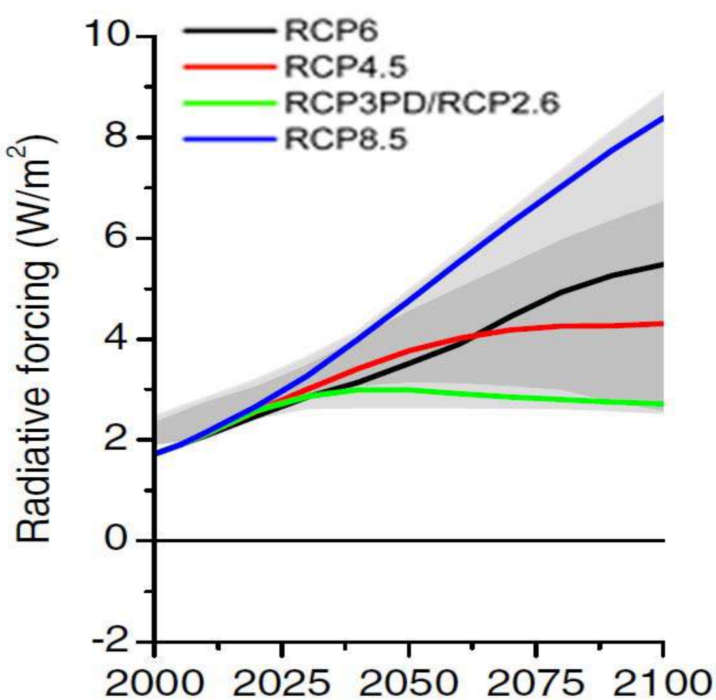

Figure 10.—Additional radiative forcing used as inputs to climate models utilized in the IPCC AR5 (modified from John Christy, State Climatologist, personal communication, 2014).

with greater forcing, greater changes should be observed (John Christy, State Climatologist, personal communication, 2014).

The change we can be most confident of, related to the climate system, will be the continued rise in sea level. Between 15,000 and 7,000 years ago the melting of the major ice sheets on the continents that had formed during the last Ice Age (120,000 to 20,000 years ago) caused sea level to rise at a rate of 5 inches per decade—a total of over 300 ft. The recently revealed submerged "forest" off Mobile Bay, found in 60 ft of water, grew on dry ground 12,000 years ago, before the sea rose to drown it. The previous warm period, or interglacial (130,000 years ago), saw sea levels about 20 ft higher than at present, so the natural direction of sea level is to continue rising as there is still land-bound ice to melt (John Christy, State Climatologist, personal communication, 2014).

Over the past 7,000 years, sea level rose more slowly as the remaining land ice, vulnerable to melting, was limited and resided in mountain glaciers and the ice caps of Greenland and Antarctica. General cooling of the Earth occurred from 5,000 years ago to about 1850 during which glaciers advanced, such as those in the Rocky Mountains, to their largest extent in the past 10,000 years. Since 1850, glaciers have been in general retreat, and along with some melting from Greenland, has added about 0.7 inch per decade of sea level rise. The oceans have warmed since 1850 as well, and this expansion has added another 0.3 to 0.6 inch per decade. The total global average rate of sea level rise in the past century has not accelerated and is currently estimated at 1.2 inches per decade (IPCC, 2013). Estimates of total rise by the end of the 21st century are plagued by considerable uncertainty and depend on such processes as local land motion, and range from 8 to 24 inches (IPCC, 2013). Mean relative sea level rise across the northern Gulf coast is generally consistent with the global trend, except in regions of considerable land subsidence or where land sediments have been prevented from replenishing delta areas (John Christy, State Climatologist, personal communication, 2014).

Other than sea level, very little confidence can be attached to regional projections of climate change in terms of the features of weather and climate that are important. For example, figure 11 displays 76 climate model runs of Alabama summer temperature and precipitation beginning in 1895 and ending in 2013. Summer is the season in which changes are more clearly seen relative to the background variability. (Note that though these projections are labeled "RCP8.5" scenario, there is virtually no difference between the various RCP scenarios, since the time period below is primarily concerned with the known past, or historical forcings which were identical in all RCP scenarios.) In this period, for which we have observations, the models universally and significantly over estimated temperature change (as noted above, it actually declined in Alabama) and were highly inconsistent in terms of precipitation (90% were too dry) (John Christy, State Climatologist, personal communication, 2014).

Regarding the future of Alabama climate, figure 12 shows projections for precipitation from scenario RCP4.5 (a middle scenario) for the southern half of the state that includes the CPYRW during the critical growing season (March through August). No actionable information is provided from these latest model projections.

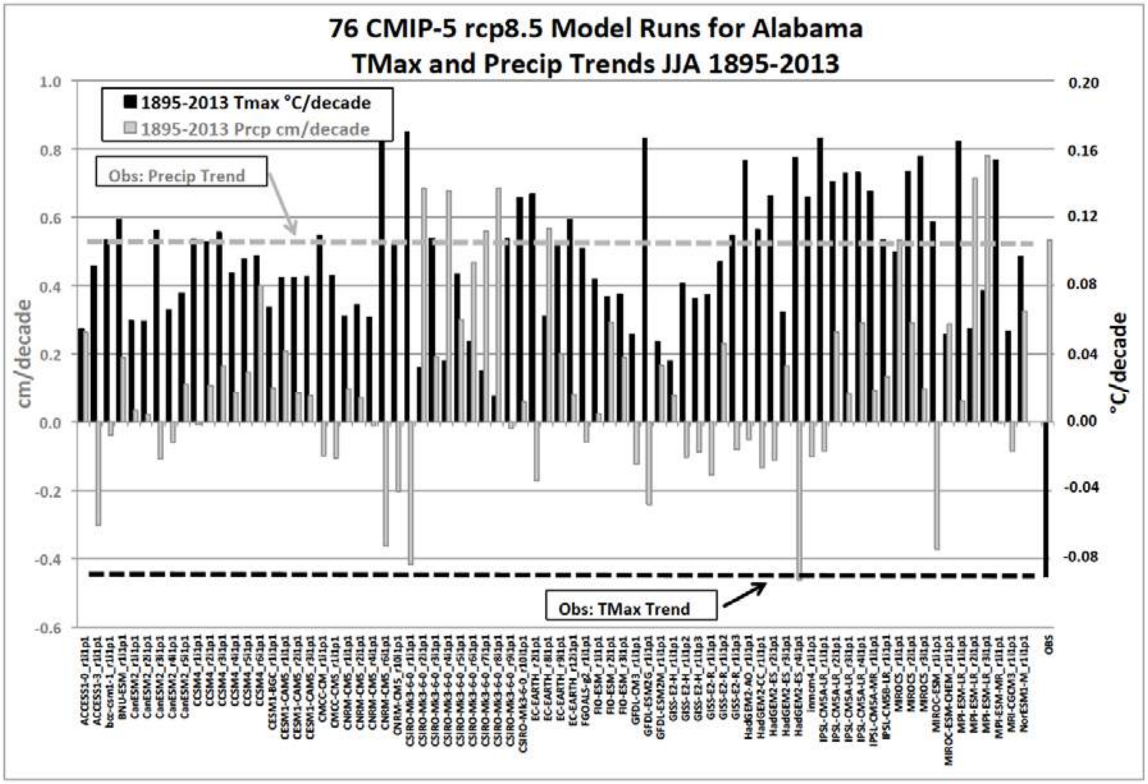

Figure 11.—Decadal trends of precipitation (gray, left axis) and temperature (black, right axis) for Alabama as determined from 76 CMIP-5 climate model simulations using historical forcing from 1895 to 2013 (modified from John Christy, State Climatologist, personal communication, 2014). (Horizontal dashed lines and bars at far right represent the observed values of the trends.)

On average, the models depict no change in growing season rainfall (John Christy, State Climatologist, personal communication, 2014).

In consideration of the evidence above, it is clear that the observational record can provide useful information for the future. Observations indicate that extremely dry/wet and cold/hot periods will continue to occur. Anticipating and adapting to the impacts of these past extremes given today's population, infrastructure and resource needs is a prudent exercise to consider. For example, a heavy rainfall event with today's infrastructure which includes large areas of impervious surfaces, will likely cause greater flood damage than would otherwise be the case. Further, several cold and icy events have occurred in the past 20 years that have exposed Alabamian's inability to cope with such events with the present modern infrastructure (John Christy, State Climatologist, personal communication, 2014).

POTENTIAL IMPACTS

America's health, security, and economic well-being are tied to climate and weather processes. Projected climate impacts in the Southeast United States include higher temperatures, longer periods between rainfall events, strained water

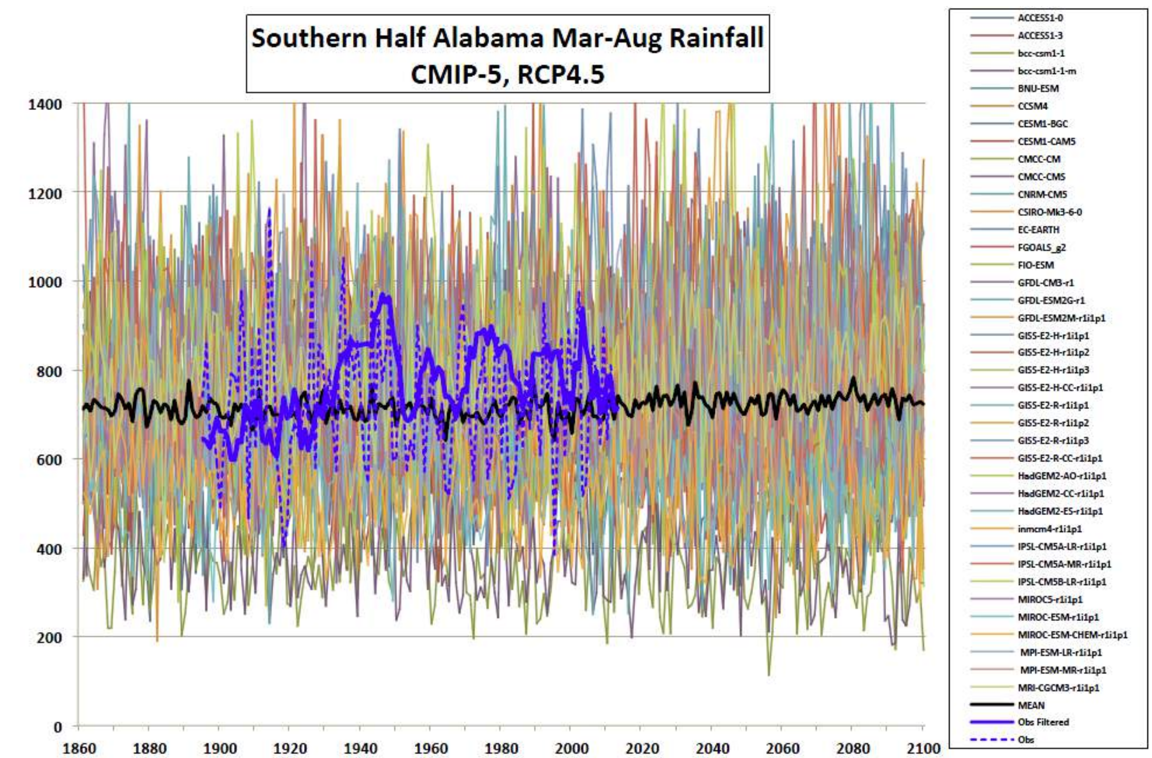

Figure 12.—Climate model predictions for the southern portion of Alabama. The blue curves are observations, solid being 5-year averages and dashed being annual totals (modified from John Christy, State Climatologist, personal communication, 2014).

resources, increased incidences of extreme weather, increased risk to human health, imperiled ecosystems, and impacts on the growth and productivity of crops and forests in the region (USEPA, 2014d). Warmer air and water temperatures, hurricanes, increased storm surges, and sea level rise will likely alter the Southeast's ecosystems and agricultural productivity (USEPA, 2014d).

Projected climate changes will stress human health. Heat waves caused by frequently high temperatures will likely increase heat stress and heat-related deaths. Because high temperatures correlate with poor air quality, there will most likely be an increase in respiratory illnesses (USEPA, 2014d). Impacts from reduced air quality include increases in ozone as well as changes in fine particulate matter and allergens. The spread of certain types of diseases are linked with warmer temperatures, flooding, and increases in geographic range that were limited by temperature.

Climate is an important environmental influence on ecosystems. For many species, climate influences where they live as well as key stages of their life cycle, such as migration, blooming, and mating. Climate impacts on ecosystems include changes in timing of seasonal life-cycle events, range shifts, food web distributions, threshold effects, the spread of pathogens, parasites, and disease, and extinction risks (USEPA, 2014d). Other effects from warmer temperatures include an increase in the occurrence of wildfires as well as pest outbreaks. Climate-related stressors that threaten wildlife

will also affect domestic animals. Livestock may be at risk, both directly from heat stress and indirectly from reduced quality of their food supply. Fisheries will be affected by changes in water temperature that shift species ranges, make waters more hospitable to invasive species, and change life cycle timing (USEPA, 2014d). Agriculture is highly dependent on specific climate conditions. Moderate warming and more carbon dioxide in the atmosphere may help plants to grow faster. However, more severe warming, floods, and drought may reduce yields. Declining soil moisture and water scarcity will likely stress agricultural crops. These climate-induced stressors may ultimately affect human food supply, especially in areas with significant population growth.

RECOMMENDATIONS

Preparation for potential climate change impacts includes monitoring climate conditions (short and long term) and corresponding water resource availability and water use, precipitation and temperature, surface-water discharge, and groundwater levels. CPYRWMA flood warning system and levees at Elba and Geneva must be properly maintained in perpetuity. Coordination and participation with state drought committees, ADECA OWR, Alabama Department of Agriculture and Industries (ADAI), Alabama Emergency Management Agency (AEMA), USDA Natural Resources Conservation Service (NRCS), U.S. Army Corps of Engineers (USACE), and local governments and water supply systems. Close coordination with stakeholders particularly susceptible to climate impacts such as farmers and public water suppliers should be maintained to share information and remedial strategies.

POLICY OPTIONS

Public water suppliers should develop enforceable water conservation policies. A state-implemented water management plan and associated regulations should be developed for equitable water resource distribution and conservation.

DROUGHT

In the past, drought conditions have endangered Alabama's water resources and adversely affected the livelihood of many people. Drought is a natural event, but can be exacerbated by climatic conditions. There are several different indicators of drought: precipitation, soil moisture, forestry fire conditions, stream flows, groundwater levels, and reservoir elevations (Littlepage, 2013). The impacts of drought fall under five main categories: agriculture, industry, domestic supply, recreation, and environment. Each of these drought impact categories have inherent economic risks including crop failure, increased need for irrigation, additional resources to maintain livestock health, timber loss from wildfires, hydroelectric power failure, impaired waterway navigation, and increased food costs (National Drought Mitigation Center (NDMC), 2014).

As water becomes scarce, the environment becomes vulnerable to drought impacts including loss of habitat, lack of water and food sources for wildlife, increased disease, migration of wildlife, additional stress on threatened and endangered species, loss of wetlands, wind and water erosion of soils, poor soil quality, threat of aquifer depletion, and lower water levels in water bodies (NDMC, 2014). Human health and social

wellbeing are reliant upon environmental health. When environments are compromised, social impacts follow. These impacts include health problems related to low water flows, dust, and poor water quality, increased threat to public safety, reduced incomes, fewer recreational activities, and loss of human life (NDMC, 2014). As demonstrated by the potential drought impacts listed above, water resource scarcity compromises the quality of life for present and future generations. It is important to implement mitigation strategies, identify future water sources, and practice water conservation to protect natural resources.

In May 2002, the Alabama Department of Economic Affairs Office of Water Resources was given the initial Executive Order (EO #70) to establish organizations and processes for drought planning. In order to develop a statewide drought management plan and coordinate drought response, ADECA OWR established these organizations: Alabama Drought Assessment and Planning Team (ADAPT) and the Monitoring and Impact Group (MIG). ADAPT coordinates intergovernmental drought response, management, and appropriate media information releases. They also monitor drought-related activities and advise the Governor and ADECA OWR, in coordination with input from the MIG (ADECA OWR, 2012b). The MIG is responsible for monitoring and analyzing all available climate and hydrological data to assess current drought conditions within the state. Based on these analyses, the MIG recommends levels of conservation implementation, which is reported to the ADECA OWR and the ADAPT (ADECA OWR, 2012b).

The Alabama Drought Management Plan was released in 2004 to establish a framework for the assessment of drought conditions, assist stakeholders and water managers in mitigating drought conditions, and encourage water conservation practices (ADECA OWR, 2012b). The plan also establishes an organizational structure to facilitate exchange of data in addition to interagency coordination. In order to accomplish these goals, the plan (1). defines a process to address drought and drought-related activities, such as monitoring, vulnerability assessment, mitigation, and impact assessment and response, (2) identifies long- and short-term activities that can be implemented to reduce and prevent drought impacts, (3) identifies local, state, federal, and private sector entities that are involved with state drought management and defines their responsibilities, and (4) acts as a catalyst for creation and implementation of local drought and response efforts (ADECA OWR, 2012b).

On June 24, 2011, Governor Robert Bentley issued Executive Order 19 on Drought Planning and Management, which enhanced drought planning efforts on a state level and streamlined organizational structure. It formally tasked the ADECA OWR to support Alabama's drought planning and response efforts. The 2007 drought was the first time the Alabama Drought Plan was activated in actual drought conditions. Coordination and communication worked well among government agencies and reservoir systems. A process was developed for Alabama to be entered into the national drought monitor map (U.S. Drought Monitor). Adjustments were made to the drought plan concerning drought regions, drought indicators, and the need for local and timely impact data (Littlepage, 2013). The ADECA OWR periodically revises the Drought Declarations based on current and projected conditions. The latest drought declaration was issued on February 28, 2013, stating that recent rains had continued to improve drought conditions in the state, but emphasizing that public and private

water users should continue to monitor water conditions. The CPYRW is included in regions 6, 7, and 8 of the Alabama Drought Management Plan (fig. 13). Available drought related data are provided by the agencies listed in table 9.

On January 14, 2014, the Alabama Drought Planning and Response Act (No. 2014-400, HB49) was codified by the Alabama Legislature to create the Alabama Drought Assessment and Planning Team (ADAPT) and to provide advice to the Office of Water Resources on development of a statewide drought plan, assess drought conditions in

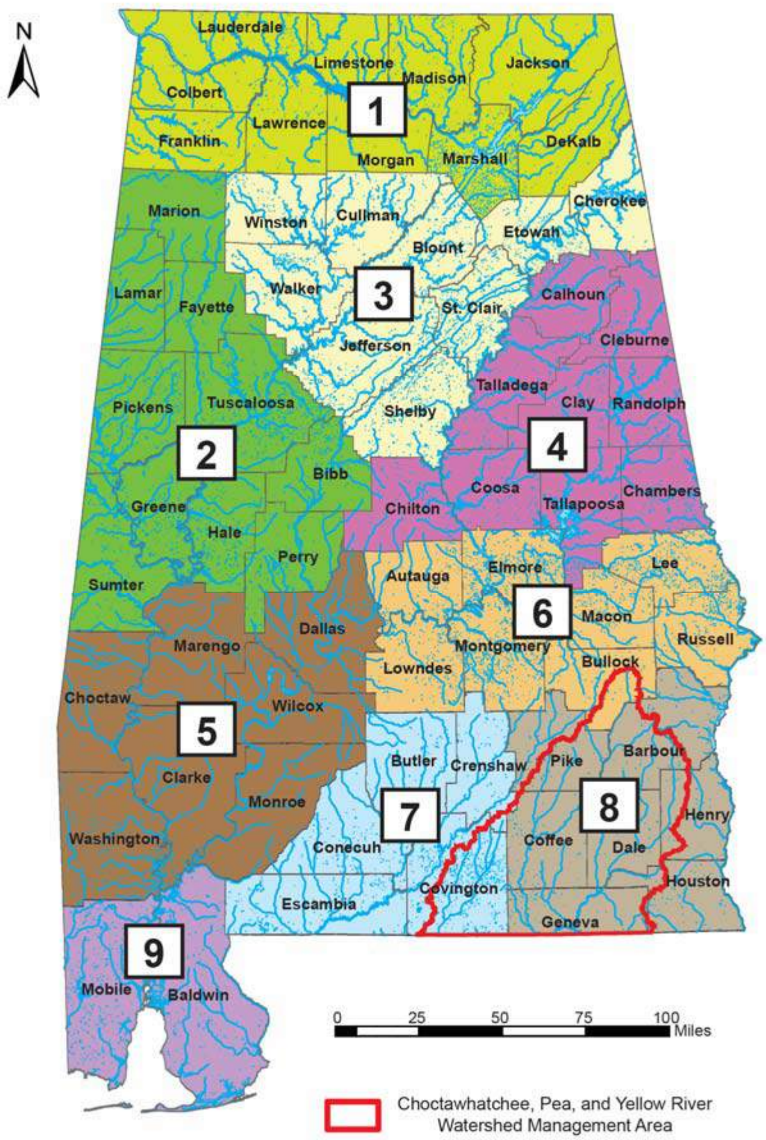

Figure 13.—Alabama drought management regions (modified from ADECA OWR, 2013).

Table 9.—List of agencies that provide drought-related data.

Data Type	Source Agencies
Streamflows	USGS
Reservoir system status	TVA; U.S. Army Corps of Engineers; Alabama Power
Groundwater levels	GSA; USGS
Weather observations and forecasts	National Weather Service
Soil moisture levels	State Climatologist; USDA
Forest fire risk	Alabama Forestry Commission
Public water supply status	ADEM; ADECA OWR
Agricultural drought impacts	USDA; American Geosciences Institute
Impacts on habitat and recreation	ADCNR
Rainfall and river	CPYRWMA

the state, advise the Governor when a drought emergency exists, and recommend mandatory water restrictions to the Governor. The ADAPT consists of various state agencies including the Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority. An amendment was later added which authorizes the Governor to invite representatives of county government to serve on the team in a nonvoting capacity.

There is no way to prevent drought; however, the effects of drought can be reduced or eliminated altogether. The impact of drought can be reduced by improving overall forest health (which reduces the risk of drought induced fires), by improving and maintaining water systems which reduces pumping failures, and by establishing and implementing contingency plans, such as predetermined water conservation measures or by designating alternative emergency water sources (ADECA OWR, 2012b). The Alabama Drought Management Plan includes domestic, agriculture, environmental, industrial, and recreation drought response sectors to be used in coordination with local drought ordinances.

Domestic and residential water suppliers are encouraged to develop local water conservation plans and ordinances to promote reductions in water use during drought conditions or implement more severe restrictions, if necessary (ADECA OWR, 2004). The development of additional water sources may be a viable option to maintain public water supply where there is water scarcity; this is discussed specifically for the CPYRW study area in the Identification of Future Water Sources section. Water conservation and water reuse are discussed in detail in the Water Source Sustainability section. Years of prevalent drought within the CPYRW area during the past decade are mentioned in the Precipitation Monitoring section of Water Monitoring. Research including drought indices and drought impacts, shown on hydrographs, are discussed in detail in the Drought Impact section of Water Quantity.

POPULATION TRENDS

According to the U.S. Census Bureau (2012a), there was an estimated 372,211 people residing within the CPYRW counties during 2012. An increase in population was noted for all counties except Barbour and Bullock, which showed slight declines of 6 and 11%, respectively. Coffee, Houston, and Pike Counties had the largest increases in population, all ranging above 10%. The remaining counties showed less than 5% increases in population. Total housing units numbered 170,107 within the watershed and the average median income was $37,672. Population data, median household income, and housing units for each county in the CPYRW are shown in table 10.

Table 10.—County population profile data for CPYRW counties (U.S. Census Bureau, Population Estimates, 2012a).

County	Estimated total population, 2000	Estimated total population, 2012	Percent change since 2000	Median household income, 2008-2012	Housing units, 2012
Barbour	29,038	27,201	-6	$31,889	11,845
Bullock	11,714	10,474	-11	$34,500	4,479
Coffee	43,615	51,252	18	$44,626	22,740
Covington	37,631	37,955	1	$35,321	18,801
Crenshaw	13,665	14,083	3	$37,309	6,724
Dale	49,129	50,444	3	$45,247	22,800
Geneva	25,764	26,931	5	$33,618	12,674
Henry	16,310	17,287	6	$40,680	8,954
Houston	88,787	103,402	16	$41,828	45,707
Pike	29,605	33,182	12	$31,702	15,383
Total	345,258	372,211	8 (avg.%)	$376,720	170,107

Selected economic characteristics for the region show that industry is composed of the following classes: agriculture, forestry, fishing and hunting, and mining; construction; manufacturing; wholesale and retail trade; transportation and warehousing, and utilities; information services; finance, insurance, and real estate; professional, scientific, management, and administrative and waste management services; educational services, and health care and social assistance, arts, entertainment, recreation, and accommodation and food services; and public administration (U.S. Census Bureau, 2012a). Table 11 shows the percentages of each general occupation class for combined counties in the watershed. These data were derived from the Selected Economic Characteristics (DP03) portion of the U.S. Census Bureau 2008-2012 (5-year estimates) American Community Survey.

ECONOMIC IMPACTS

Water resource management plays an integral role in economic development. Sufficient amounts of water must be available to support population growth and promote an expanding economic infrastructure. Availability of water is critical for industry, agriculture, transportation, recreation, power generation, and tourism,

Table 11.—Occupational categories for CPYRW counties
(U.S. Census Bureau, Selected Economic Characteristics, 2012b).

County	Management, business, science, and arts occupations	Service occupations	Sales and office occupations	Natural resources, construction, and maintenance occupations	Production, transportation, and material moving occupations	Total civilian employed population, 16 years and older
Barbour	2,575	1,529	2,181	981	1,911	9,177
Bullock	826	523	763	723	1,246	4,081
Coffee	6,291	3,015	4,923	2,485	2,618	19,332
Covington	3,562	2,341	3,649	2,636	2,899	15,087
Crenshaw	1,647	827	1,406	938	1,081	5,899
Dale	5,150	3,748	4,679	3,393	2,889	19,859
Geneva	2,704	1,606	2,803	2,030	1,918	11,061
Henry	1,871	1,142	1,560	822	1,148	6,543
Houston	13,052	7,974	11,949	4,870	6,474	44,319
Pike	3,786	2,913	3,437	1,723	2,385	14,244
Total	**41,464**	**25,618**	**37,350**	**20,601**	**24,569**	**149,602**

which drive economic health and growth and job creation in Alabama (Alabama Water Agencies Working Group (AWAWG), 2012). Regions where plentiful water resources are available to be utilized for economic growth could be targeted for industrial recruitment. In addition to potential consumptive water needs, efforts must be made for the continuation of waterborne transportation. Although not specifically in the CPYRW, navigable waterways remain a viable component for the state's intermodal transportation infrastructure. Water navigation provides a cost effective alternative to rail and trucking transport methods and provides incentive for certain industries and locations (AWAWG, 2012). Some infrastructure investments, such as water and wastewater treatment plants, can provide long-term investments for local and state economies. There are several state and federal funding programs that help meet water and wastewater infrastructure needs. Federal programs include the USDA Rural Development Program and the U.S. Army Corps of Engineers' Planning Assistance to the States Program. Another program provided under state law is the Water Supply Assistance Fund (*Code of Alabama, §22-23A*).

Water resource programs impact economic development in all sectors, including industry, agriculture, transportation, and recreation. In some cases, these uses are conflicting, which makes proper water resource management practices critical for resolution. Industries use water in manufacturing processes, cooling purposes, and product transportation. Water for industrial use may be self-supplied or purchased from a public-water supplier. Farmers are highly dependent on natural rainfall and only a small percentage of farming operations in the CPYRW irrigate. Additional funding and the development of low-interest loans or tax credits (mentioned in the Agricultural Issues section) may encourage investments in irrigation infrastructure. Recreational activities such as fishing, paddling, and wildlife viewing account for a significant and quickly growing tourism industry in Alabama, especially in the CPYRW. As part of the overall efforts to support recreational activities, it is important to ensure adequate public access to maximize development and promote participation. It is critical that water resource management and water source development be used

as tools for economic growth and job creation opportunities, while minimizing the need for interbasin transfers as well as optimizing surface-water and groundwater withdrawals.

RECOMMENDATIONS

The CPYRWMA should develop future options for water source development and protection to ensure the availability of water for economic development. An economic development program should be developed for the CPYRW and made available to the Alabama Department of Commerce and other economic development agencies and industrial recruiters. The CPYRWMA should coordinate with the Southeast Alabama Regional Planning Commission, Alabama Department of Commerce, and the Alabama Department of Economic and Community Affairs to ensure that water supply and other economic development information for the CPYRW is available and considered, relative to economic development and impacts.

POLICY OPTIONS

In the future, a comprehensive statewide management plan should be implemented to promote prudent water source development, equitable water distribution, and conservative water use.

WATERSHED TRENDS

LAND USE

Over time watershed trends tend to change, specifically in the areas of land use and water use. Current land use was discussed previously in the Land Use section of this document. Historical and current land uses are compared to provide a framework for estimated future land uses within the watersheds. Previous land-use/land-cover investigations employed datasets compiled from the MRLC's NLCD, based on Landsat satellite Thematic Mapper imagery (circa 1992) with a spatial resolution of 30 meters (CWP and GSA, 2005). Based on the 1992 NLCD dataset, the predominant land use was forests (58.1%) followed by agriculture (30.5%), wetlands (6.1%), urban uses (4.7%), and lakes and water bodies (0.6%) (Vogelmann and others, 2001). As discussed previously, 2011 land uses in the CPYRW included forests (64%), agriculture (22.2%), urban uses (6.7%), wetlands (6.3%), and water bodies (0.9%) (fig. 14). By comparing historic and current land uses, it is apparent that urbanized areas are increasing, specifically at 42.55% from 1992 through 2011, with the only percentage decline of 27.21% observed in agriculture (fig. 15). Increases in urbanized areas are indicative of population increases, resulting in a higher demand for urban and residential areas.

RECOMMENDATIONS

Regional planning strategies for land use should be developed that protect water resources and identify options for future water source development. This includes but is not limited to the following: development of enforceable land use options that limit construction and impervious surfaces in critical recharge areas, controls sediment from construction activities, protects and preserves critical wetlands, and protects designated source water protection areas and critical habitat areas.

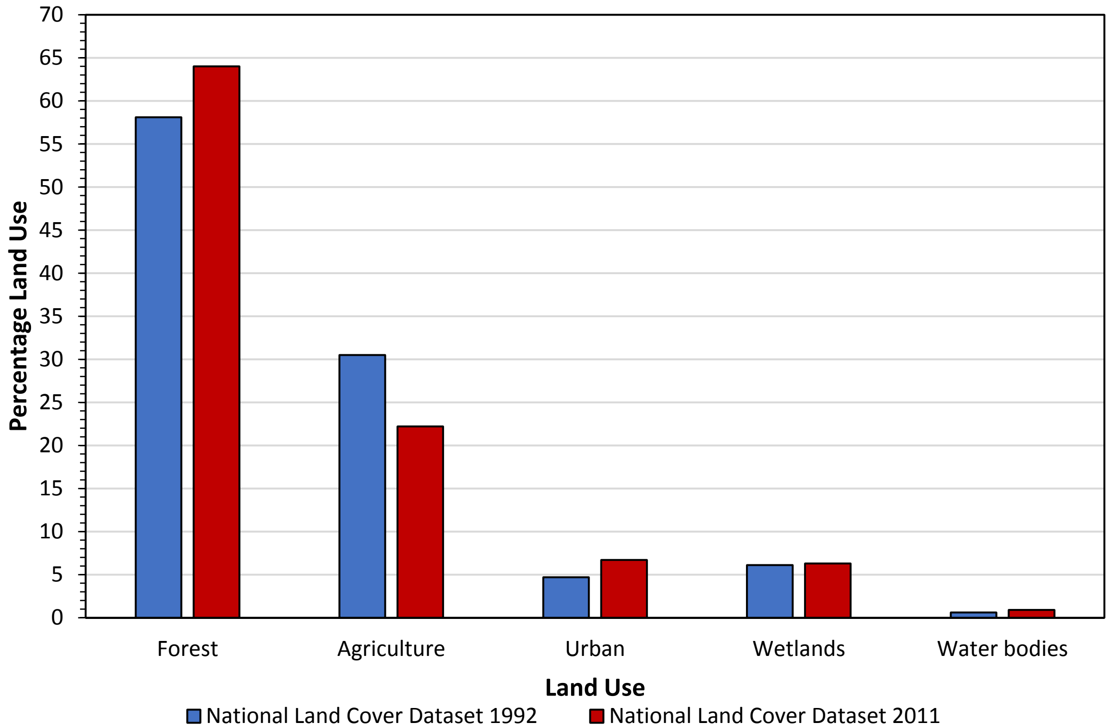

Figure 14.—Land use/land cover trends from 1992 and 2011.

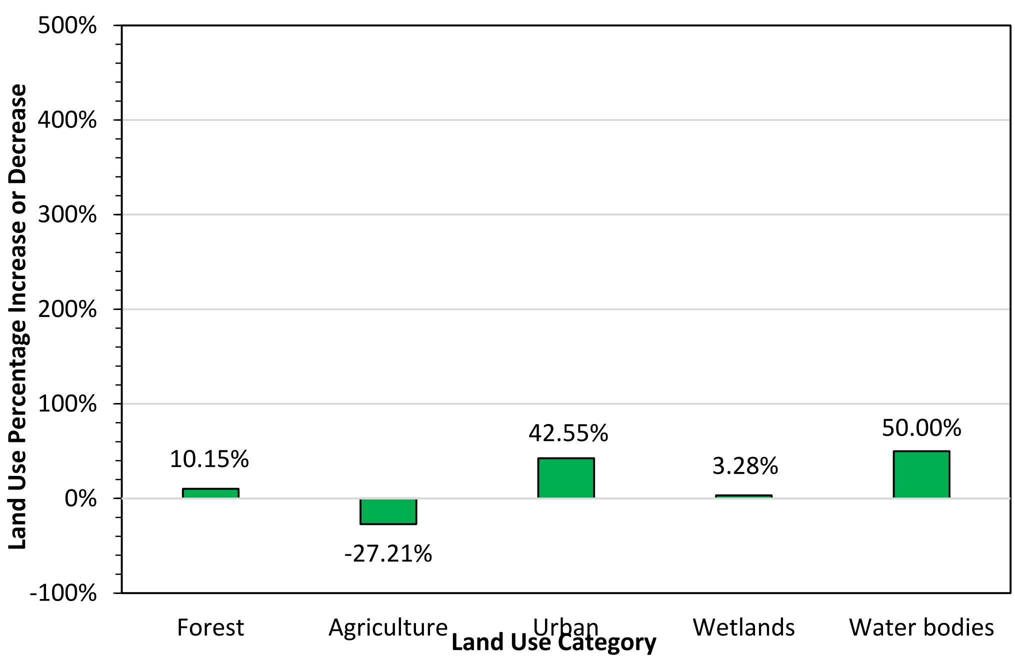

Figure 15.—Percentage increase/decrease in land use categories from 1992 through 2011.

POLICY OPTIONS

Water policy options should be developed that will complement land-use regulations, such as county-wide zoning and habitat and species protection, which will result in comprehensive protection of water and biological resources.

WATER USE

The sole source of drinking water in the Choctawhatchee, Pea and Yellow Rivers watersheds is from groundwater with surface water mainly used for agricultural purposes (CWP and GSA, 2005). Significant water use categories in the watersheds can be divided into residential, nonresidential, agricultural, and power generation. Within the 10-county area, there are a total of 359 wells throughout the ten counties. Appendix 3 provides a list of the public water suppliers within the 10-county area.

Multiple sources of data for this Water Management Plan (WMP) were used to determine historic and future estimated water use within the watersheds. The following publications were used for determining historic, current, and estimated future water uses in the CPYRW:

- the GSA's *Use of Water in Alabama*, published every five years from 1970-1990,
- the U.S. Geological Survey (USGS) publication *Water Use in Alabama*,1995,
- the *2002 Municipal and Industrial Water Demand Forecasts* report prepared for the CPYRWMA by the USACE,
- the *2008 Agricultural Water Demand* report prepared by the USDA NRCS, and
- the *2009 Estimated Use of Water in Alabama in 2005*, published by the USGS and ADECA OWR.

Since 1993, ADECA OWR has been tasked with collecting and reporting estimated water use within the state of Alabama, with the most current published estimated water use data for the year 2005; however, preliminary data for 2010 has been obtained from ADECA OWR. Therefore, estimates are provided for 2015 and beyond, based on estimated water use as taken from the USACE and NRCS reports. Inaccuracies may occur within these estimates due to limited local input and reporting of water use to the state water management authority. Agricultural water use estimates by NRCS, USACE, and ADECA OWR are somewhat contradictory, due to the nature of the relationship with the agricultural industry in Alabama. NRCS estimates are considered the most reliable agricultural water use within the watershed (CWP and GSA, 2005).

Table 12 shows the estimated water use for 1970 through 2005. Estimated total water use, not including water consumed for power generation, within the ten-county area for 1970 was 36.84 million gallons per day (mgd), with groundwater and surface-water uses accounting for 27.29 mgd and 9.55 mgd, respectively. In 2005, estimated water use, not including water for power generation was 154.63 mgd, with groundwater and surface-water uses accounting for 84.24 mgd and 70.40 mgd, respectively (fig. 16). Increased estimated water use was 86.43% for surface-water and 67.60% for groundwater from 1970 through 2005) (fig. 17).

Since 1970, Houston County has shown the largest water usage in the watershed, while Bullock County has shown the smallest water usage since 1980 (table 13). In

Table 12.—Estimated water use for the 10 counties in the CPYRW, 1970 through 2005. Measurements in million gallons per day (mgd).

Groundwater							
Estimated Water Usage							
1970	1975	1980	1985	1990	1995	2000	2005
27.29[1]	34.30[2]	52.52[1]	54.77[2]	60.19[1]	74.58[2]	79.58[1]	84.24[3]
Surface-Water							
Estimated Water Usage							
9.55[1]	14.17[2]	22.83[1]	36.33[2]	30.66[1]	43.20[2]	56.10[1]	70.40[3]
Total Estimated Water Usage							
36.84[1]	48.47[2]	75.35[1]	91.09[2]	90.85[1]	117.78[2]	135.68[1]	154.63[3]

[1]From USDA NRCS (2002)
[2]From Mooty and Richardson (1998) and USDA NRCS (2002)
[3]From Hutson and others (2009) and NRCS (2002)

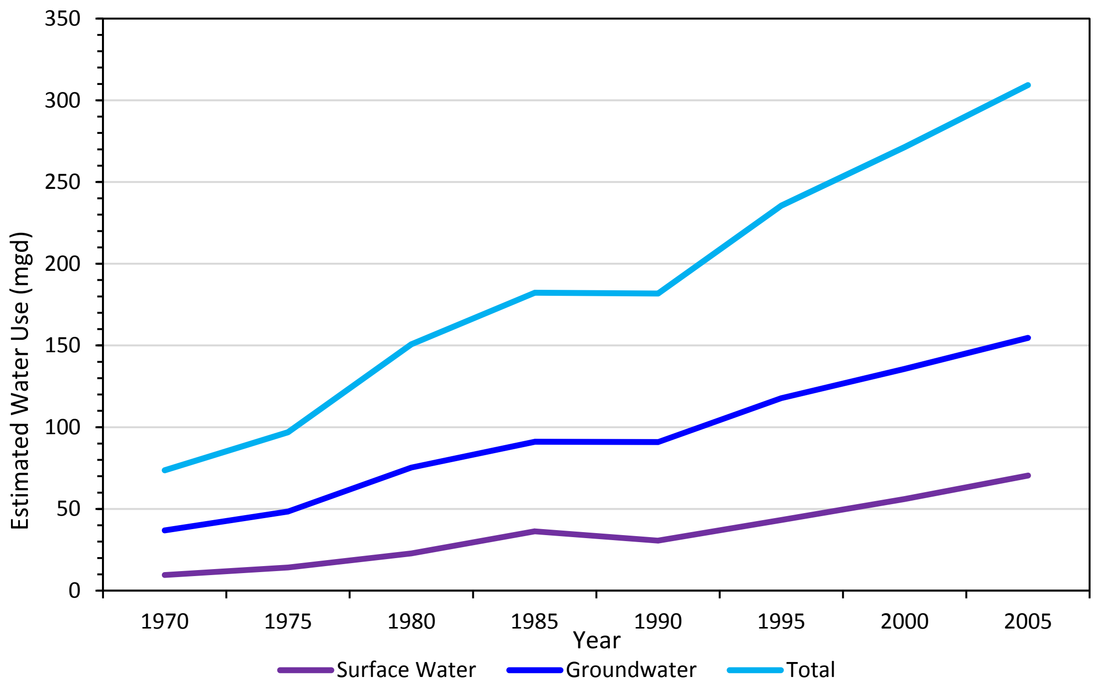

Figure 16.—Estimated surface-water and groundwater use for counties in the CPYRW, 1970 through 2005.

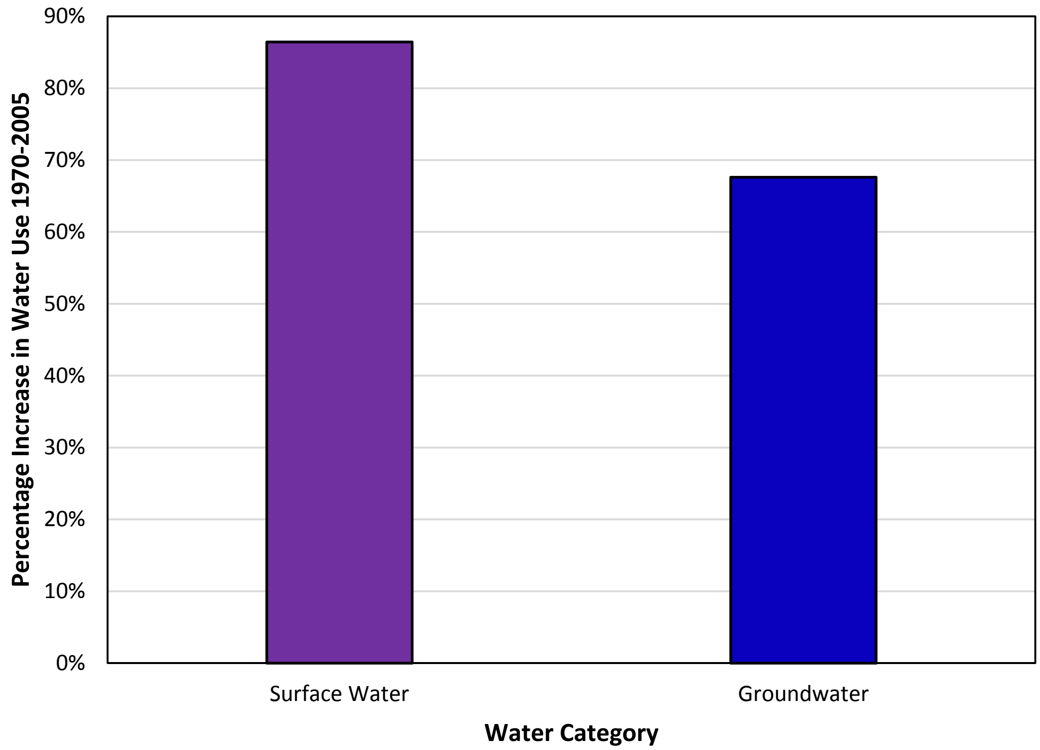

Figure 17.—Estimated percentage increase of water use for counties in the CPYRW, 1970 through 2005.

2005, Houston County had the largest estimated water use at 37.24 mgd, with groundwater and surface-water uses accounting for 22.32 mgd and 14.93 mgd, respectively, whereas Bullock County had the smallest estimated water use at 3.96 mgd, with groundwater and surface-water uses accounting for 2.59 mgd and 1.37 mgd, respectively (table 13).

Water use for the CPYRW can also be analyzed according to watersheds and water use categories for 2005 data and 2010 preliminary data (table 14). Table 14 shows the groundwater and surface water withdrawals by watershed for use categories including public supply, irrigation, livestock, and industrial. As compared to 2005 water use data, two watersheds (Pea and Lower Choctawhatchee) showed increases in groundwater use, whereas the other two watersheds (Yellow and Upper Choctawhatchee) showed decreases in groundwater use (table 14).

Water use is divided into four categories for the CPYRW: residential, nonresidential, agricultural, and power generation. Residential water usage includes both publically supplied and self-supplied sources for household use (USACE, 2002). Public-supply water use includes all water delivered to household customers via municipal, county, and water authority water systems (USACE, 2002), with groundwater being the sole source of water supply for all residential water in the watersheds (CWP and GSA, 2005). Nonresidential water use includes all commercial, industrial, government, and nonhousehold public water usage (USACE, 2002).

Table 13.—Estimated groundwater and surface-water use for counties in the CPYRW, 1970 through 2005. Measurements in million gallons per day (mgd).

	1970[1]		1975[2]		1980[3]		1985[4]	
County	Ground-water	Surface Water	Ground-water	Surface Water	Ground-water	Surface Water	Ground-water	Surface Water
Barbour	2.16	1.85	3.30	2.89	3.66	2.22	4.00	2.97
Bullock	1.77	0.83	1.73	0.83	1.29	0.63	1.69	0.60
Coffee	3.68	0.45	6.34	0.75	7.84	2.78	8.53	4.28
Covington	2.78	0.53	3.43	0.68	5.12	0.91	4.11	1.29
Crenshaw	1.11	1.87	1.21	1.87	2.15	2.41	2.12	2.79
Dale	4.06	0.38	3.97	1.20	6.84	1.58	7.11	1.74
Geneva	1.81	0.69	3.22	1.89	3.55	3.76	4.15	6.84
Henry	1.19	0.45	1.18	0.84	2.81	3.23	4.22	8.19
Houston	6.15	1.05	7.03	2.08	14.81	3.23	13.60	6.90
Pike	2.61	1.48	2.93	0.68	4.48	2.11	5.27	3.76

	1990[5]		1985[6]		2000[7]		2005[9]	
County	Ground-water	Surface Water	Ground-water	Surface Water	Ground-water	Surface Water	Ground-water	Surface Water
Barbour	4.00	3.08	8.15	7.80	1.53	4.58	8.01	5.63
Bullock	2.05	1.20	2.39	1.73	0.43	1.28	2.59	1.37
Coffee	7.80	4.65	9.02	6.68	2.00	6.00	10.70	8.33
Covington	5.37	1.36	5.55	1.43	1.78	5.33	8.05	6.60
Crenshaw	2.19	2.94	1.89	0.60	0.50	1.50	2.85	1.73
Dale	9.12	2.19	11.36	1.95	1.28	3.83	10.95	4.80
Geneva	4.40	5.86	3.07	1.80	3.35	10.05	6.70	12.54
Henry	2.52	1.21	3.96	5.40	2.80	8.40	5.66	10.51
Houston	16.81	6.23	22.79	10.95	3.98	11.93	22.32	14.93
Pike	5.95	1.96	6.42	4.88	1.08	3.23	6.43	3.98

[1]From USDA NRCS (2002)
[2]From Mettee, Moser and Dean (1978) and USDA NRCS (2002)
[3]From Baker, Gillett and Meng (1982) and USDA NRCS (2002)
[4]From Baker and Mooty (1987) and USDA NRCS (2002)
[5]From Baker and Mooty (1993) and USDA NRCS (2002)
[6]From Mooty and Richardson (1998) and USDA NRCS (2002)
[7]From USACE (2002) and USDA NRCS (2002)
[8]From Hutson and others (2009) and USDA NRCS (2002)

Agricultural water use includes self-supplied water for crops, orchards, cultivated sod, nursery, livestock, poultry, and aquaculture (USDA NRCS, 2002). Power uses include water used to generate power, which includes cooling water and hydropower.

Estimated residential water use increased 13% from 23.43 mgd in 1970 to 26.93 mgd in 2005 (fig. 18). Estimated nonresidential groundwater use increased by 95%, from 1.71 mgd in 1970 to 33.98 mgd in 2005, with data for year 2000 taken from USACE estimates. Estimated surface water decreased by 86%, from 3.09 mgd in 1970 to 0.42 mgd in 2005, with a substantial decrease of 90% from 1975 to 1980, which could be attributed to the closure of industrial facilities, such as textile mills (fig. 19).

Groundwater and surface water are both sources for agricultural water uses. However, 75% of the water used for agricultural purposes is from surface water

Table 14.—Estimated water use for the CPYRW for 2005 and 2010 by watershed and category.

Watershed	Category	Groundwater withdrawals (mgd) 2005[1]	Surface-water withdrawals (mgd) 2005[1]	Groundwater withdrawals (mgd) 2010[2]	Surface-water withdrawals (mgd) 2010[2]
Pea – 03140202	Public Supply	6.30	0.00	6.66	0.00
	Irrigation	2.01	4.04	1.49	3.72
	Livestock	0.55	0.74	0.53	0.73
	Industrial	0.86	0.00	1.14	0.00
Total Pea – 03140202		9.72	4.78	9.82	4.45
Yellow – 03140103	Public Supply	1.06	0.00	1.43	0.00
	Irrigation	0.99	0.26	0.37	0.56
	Livestock	0.14	0.19	0.13	0.19
	Industrial	0.43	0.00	0.05	0.00
Total Yellow – 03140103		2.62	0.45	1.98	0.74
Upper Choctawhatchee - 03140201	Public Supply	23.42	0.00	20.93	0.00
	Irrigation	3.08	5.47	3.54	4.49
	Livestock	0.51	0.70	0.54	0.73
	Industrial	0.22	0.00	0.27	0.00
Total Upper Choctawhatchee – 03140201		27.23	6.17	25.28	5.62
Lower Choctawhatchee - 03140203	Public Supply	0.52	0.00	0.58	0.00
	Irrigation	0.41	0.50	0.42	0.43
	Livestock	0.08	0.11	0.08	0.10
Total Lower Choctawhatchee – 03140203		1.01	0.61	1.08	0.53

[1]From Hutson and others (2009) and USDA NRCS (2002)
[2]From ADECA OWR, unpublished preliminary data (2014)

sources (USDA NRCS, 2002). Estimated water used for agricultural purposes has increased significantly (91%) since 1970. In 1970, an estimated 8.6 mgd were used for agricultural purposes, with groundwater and surface water accounting for 2.15 mgd and 6.45 mgd, respectively. In 2005 total estimated use increased to 93.31 mgd, with groundwater and surface water accounting for 23.33 mgd and 69.98 mgd, respectively (fig. 20). The bulk of the estimated agricultural water use in the CPYRW is historically and currently used for irrigation (fig. 20). From 1970 to 2005, the estimated water use for irrigation increased 98% from 1.7 mgd in 1970 to 83.2 mgd in 2005. In 2005, Houston County had the largest estimated water usage for irrigation (19.4 mgd), whereas Bullock County had the smallest (1.6 mgd) (fig. 21). In 1970, estimated water use was 4.8 mgd and 2.1 mgd for livestock and aquaculture, respectively. By 2005, estimated use increased by 21 and 48% to 6.1 mgd and 4.0 mgd. In 2005, Coffee County had the largest estimated water use for livestock (1.0 mgd) and Barbour County had the highest estimated water use for aquaculture (2.1 mgd).

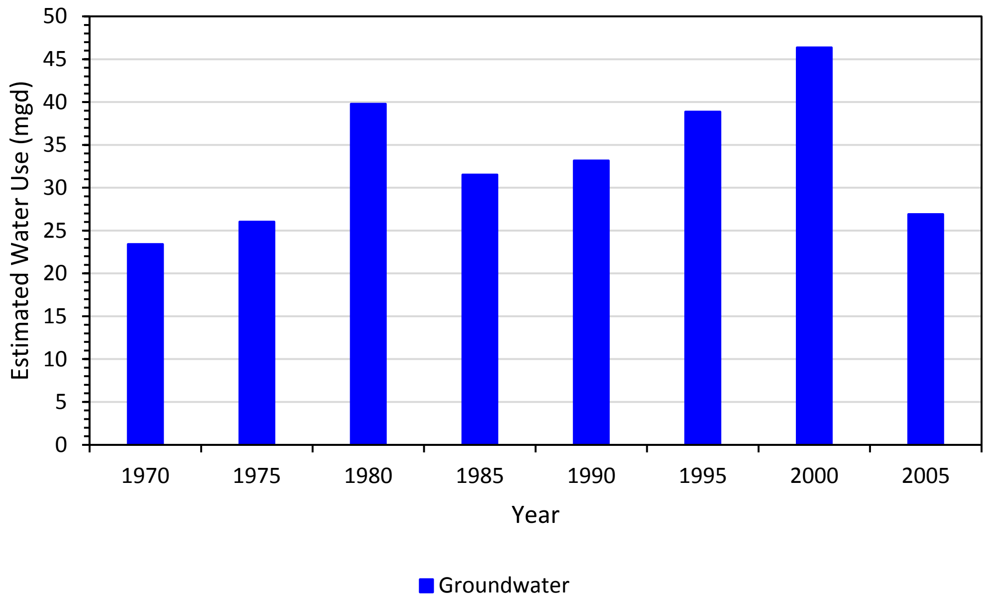

Figure 18.—Estimated residential groundwater use for counties in the CPYRW for the years 1970 through 2005.

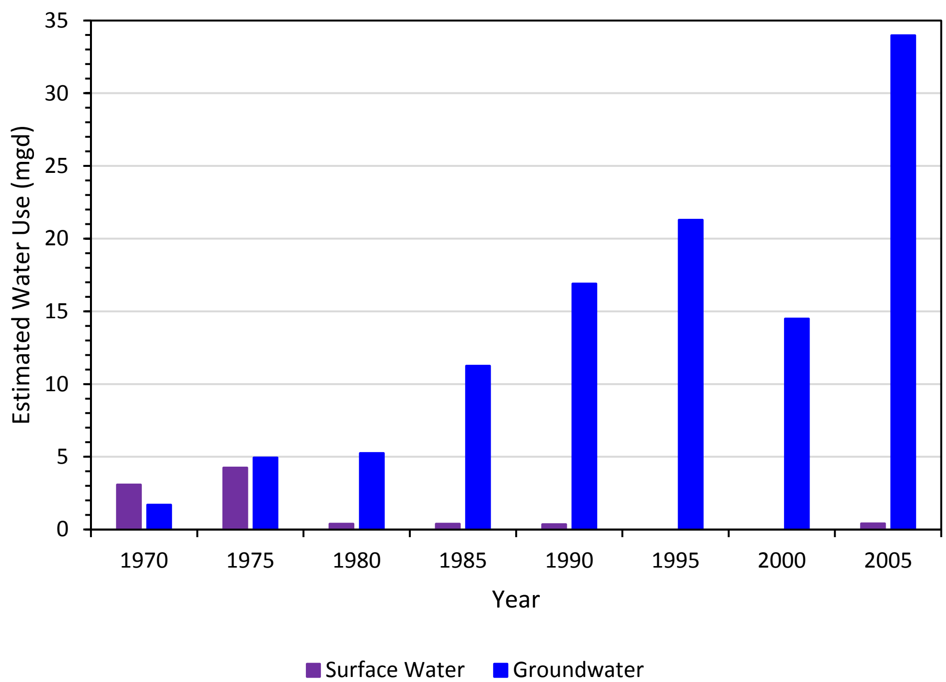

Figure 19.—Estimated non-residential groundwater and surface water use for counties in the CPYRW for the years 1970 through 2005.

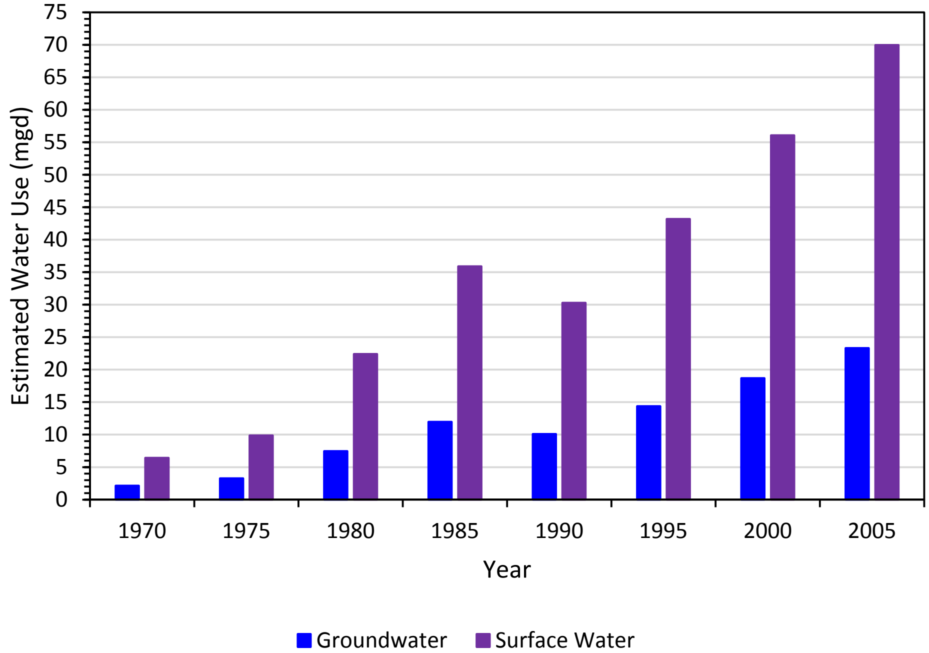

Figure 20.—Estimated agricultural groundwater and surface-water use for counties in the CPYRW, 1970 through 2005.

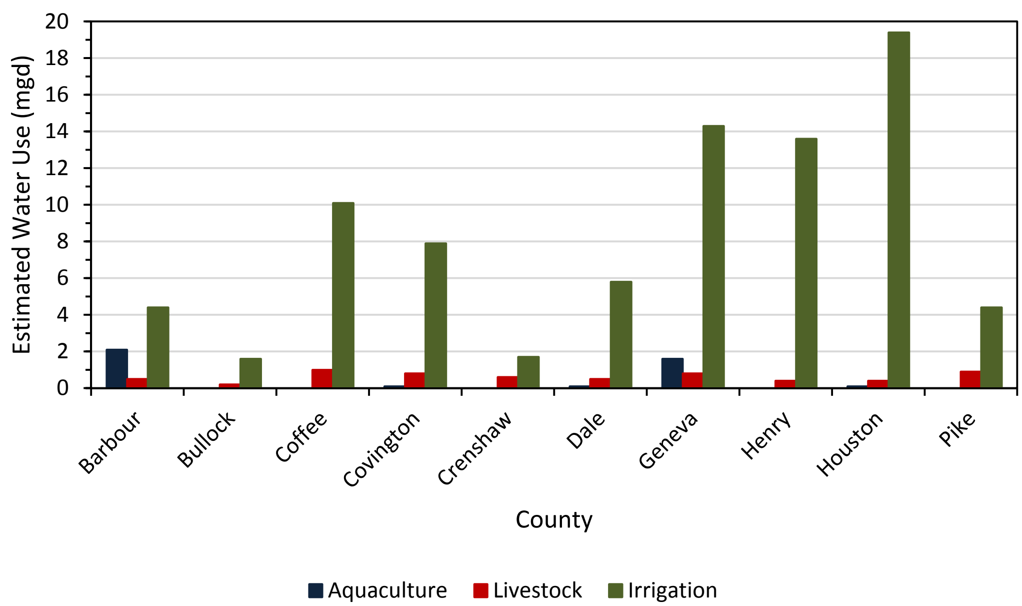

Figure 21.—Estimated agricultural water use for CPYRW for 2005 by county and category.

Information regarding water usage for power generation was obtained from publications of the GSA, including *Use of Water in Alabama*, Information Series (IS) 42 (Peirce, 1972), IS 48 (Mettee, Moser and Dean, 1978), IS 59 (Baker, Gillett and Meng, 1982), IS 59D (Baker and Mooty, 1987), and IS 59E (Baker and Mooty, 1993) for 5-year intervals from 1970 to 1990; from a publication by the USGS, *Water Use in Alabama, 1995* (Mooty and Richardson, 1995), and from a publication by ADECA OWR *Estimated Use of Water in Alabama in 2005* (Hutson and others, 2009). Water usage for power generation was not included in the USACE's *Municipal and Industrial Water Demand Forecasts* (USACE, 2002); therefore, no projections are provided for future water consumption from power generation.

Three power plants are located within the ten-county area: a hydroelectric plant in Covington County, a thermoelectric (nuclear) plant in Houston County, and a thermoelectric (fossil fuel) plant in Covington County. Estimated water demand has increased since 1980 for the Farley Nuclear Plant in Houston County, from 71.74 mgd in 1980 to 105.36 mgd in 2005, or an increase of 32%. Similarly, estimated water demand has increased since 1970 for the McWilliams Plant (fossil fuel) in Covington County, from 0.25 mgd in 1970 to 4.30 mgd in 2005, or an increase of 94% (fig. 22). Hydroelectric plants consume almost no water during hydroelectric-power generation and this water use is considered in-stream water use because the majority of the water is returned to the source (Mooty and Richardson, 1998). Covington County has two hydroelectric facilities that are considered in-stream water users. Estimated in-stream water use has decreased from 1,480 mgd in 1970 to 954.73 mgd in 1995, a decrease of less than 1% (fig. 23).

With available historic and current estimated water usage data, water demand forecasts are prepared to provide estimates for future water usage. Water demand forecasts prepared by the USACE are dependent upon changes in population, housing units, and employment, with forecasts projected for three growth scenarios (low, moderate, and high) for residential and nonresidential use only (USACE, 2002). The USDA NRCS agricultural water use study also included forecasts for future water demand. Therefore, these two data sets were combined to obtain a comprehensive water demand forecast for the CPYRW.

Table 15 lists the forecasted estimated water use for low, moderate, and high growth scenarios. Residential water demand for the low growth scenario is expected to increase from 48.82 mgd in 2010 to 55.64 mgd in 2050 (12%). The moderate growth scenario predicts the water demand to increase from 49.96 mgd in 2010 to 61.40 mgd in 2050 (19%), and the high growth scenario predicts an increase from 50.71 mgd in 2010 to 72.31 mgd in 2050 (30%). Nonresidential water demand, excluding water used for power generation, is predicted to increase from 15.72 mgd in 2010 to 17.91 mgd in 2050 (12%) for the low growth scenario, 16.09 mgd in 2010 to 19.78 mgd in 2050 for the moderate growth scenario (19%), and 16.33 mgd in 2010 to 23.29 mgd in 2050 (30%) for the high growth scenario. Agricultural water demand is expected to increase from 111.60 mgd in 2010 to 200.7 mgd in 2050, a 44% increase. The majority of this increase is expected to come from expanded irrigation (USDA NRCS, 2002). The low growth forecasted water demand indicates an increase from 176.14 mgd in 2010 to 274.25 mgd in 2050 (36%), the moderate growth forecasted an water demand should increase from 177.65 in 2010 to 281.88 mgd in 2050 (37%), and high growth forecasted

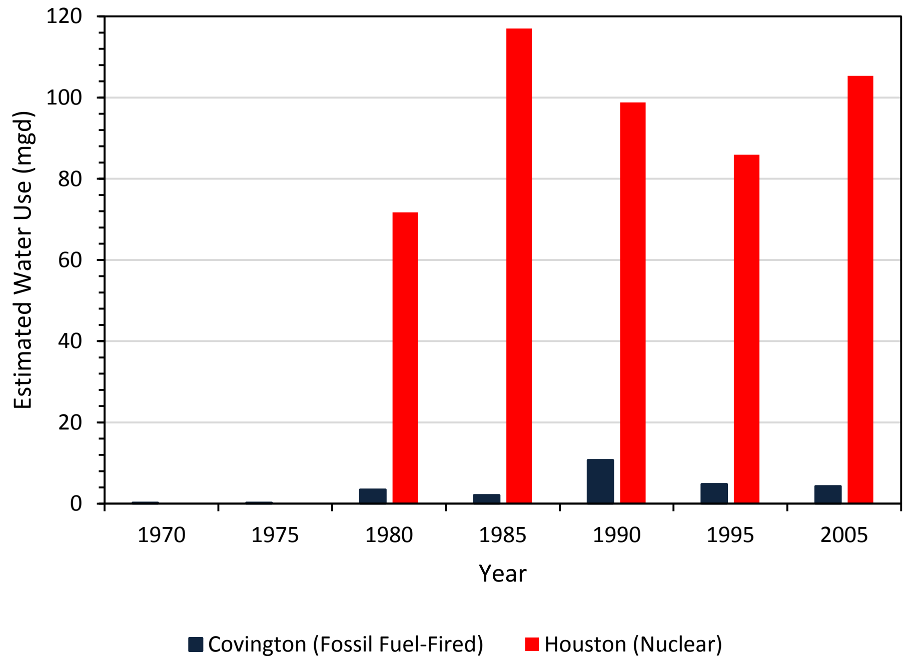

Figure 22.—Estimated water used to generate thermoelectric power in the CPYRW by county and category.

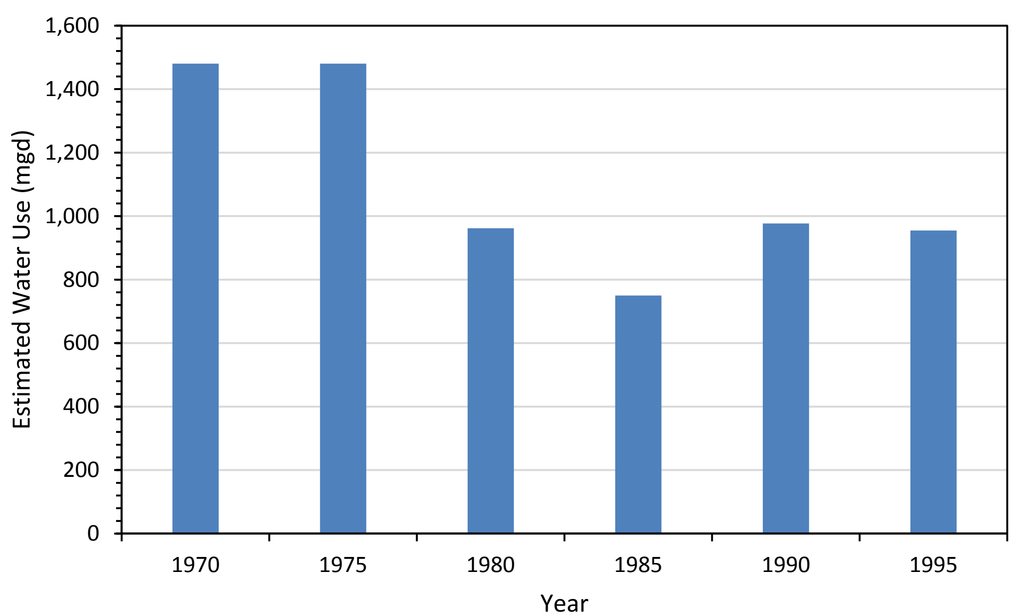

Figure 23.—Estimated water use (non-consumptive) to generate hydroelectric power in Covington County.

Table 15.—Water demand forecasts for counties in the CPYRW from 2010 to 2050 using three growth scenarios (low, moderate, high). Measurements in million gallons per day (mgd).

Water Use Category	2010	2015	2020	2025	2030	2035	2040	2045	2050
Estimated Water Use—Low[1]									
Agriculture[2]	111.60	122.60	133.70	145.20	156.10	167.30	178.80	189.70	200.70
Residential[2]	48.82	49.86	50.78	51.55	52.33	53.14	53.95	54.79	55.84
Non-Residential[2]	15.72	16.06	16.36	16.61	16.86	17.11	17.37	17.64	17.91
Total	176.14	188.52	200.84	213.36	225.29	237.55	250.12	262.13	274.25
Estimated Water Use—Moderate[1]									
Agriculture[2]	111.60	122.60	133.70	145.20	156.10	167.30	178.80	189.70	200.70
Residential[2]	49.96	51.63	53.02	54.42	55.82	57.21	58.61	60.00	61.40
Non-Residential[2]	16.09	16.64	17.08	17.53	17.98	18.43	18.88	19.33	19.78
Total	177.65	190.87	203.80	217.15	229.90	242.94	256.29	269.03	281.88
Estimated Water Use—High[1]									
Agriculture[2]	111.60	122.60	133.70	145.20	156.10	167.30	178.80	189.70	200.70
Residential[2]	50.71	52.98	55.39	57.90	60.54	63.29	66.16	69.17	72.31
Non-Residential[2]	16.33	17.07	17.85	18.66	19.50	20.39	21.31	22.28	23.29
Total	178.64	192.65	206.94	221.76	236.14	250.98	266.27	281.15	296.30

[1]From USDA NRCS (2002)
[2]From USACE (2002)

water demand indicates that water demand should increase from 178.64 mgd in 2010 to 296.30 mgd in 2050 (40%) (fig. 24).

RECOMMENDATIONS

The CPYRWMA in coordination with the ADECA OWR, Alabama Rural Water Association (ARWA), Alabama Farmers Federation (ALFA), and other water related agencies should develop methodologies for collection of water use data from local water users.

POLICY OPTION

Accurate and timely water use information is critical for future water source planning and water policy development. A coordinated water use data collection program will require the establishment of enforceable state law or ordinances requiring all applicable water users to submit water use data to the state water management authority as part of a comprehensive water management plan.

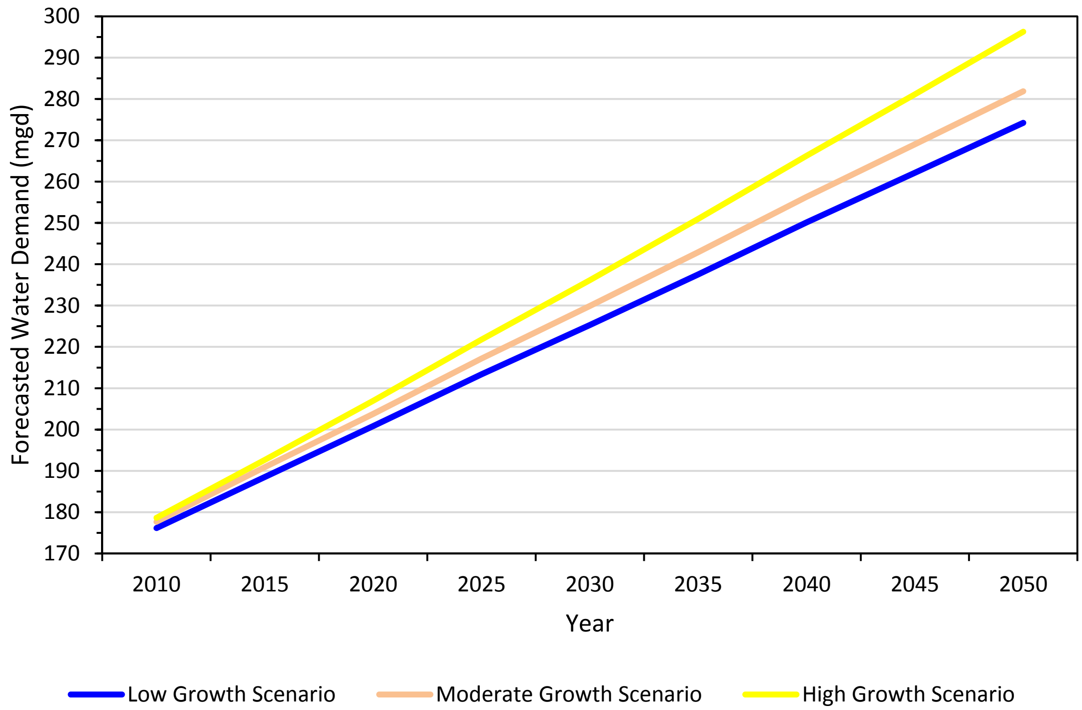

Figure 24.—Total forecasted water demands based on low, moderate, and high growth scenarios in the CPYRW.

INTERSTATE ISSUES

Five interstate issues currently affect or have the potential to affect the CPYRW and Alabama, Georgia, and Florida are Tri-State Water Wars, Floridan aquifer, downstream water quality, Florida nutrient criteria, and Florida Coastal Zone Impacts.

TRI-STATE WATER WARS

The Tri-State Water Wars involves the states of Alabama, Florida, and Georgia, and the following basins: Alabama, Coosa, and Tallapoosa Rivers (ACT), and Apalachicola, Chattahoochee, and Flint Rivers (ACF). The ACT basin flows from northwest Georgia and empties into Alabama's Mobile Bay, and the ACF basin flows from northwest Georgia south along the border of Alabama and empties into Florida's Apalachicola Bay (Southern Environmental Law Center (SELC), 2013) (fig. 25).

A brief summary of events that occurred leading up to the current situation are presented as follows. In 1957, the USACE built Buford Dam on the Chattahoochee River, thereby creating Lake Lanier for the purpose of providing flood control,

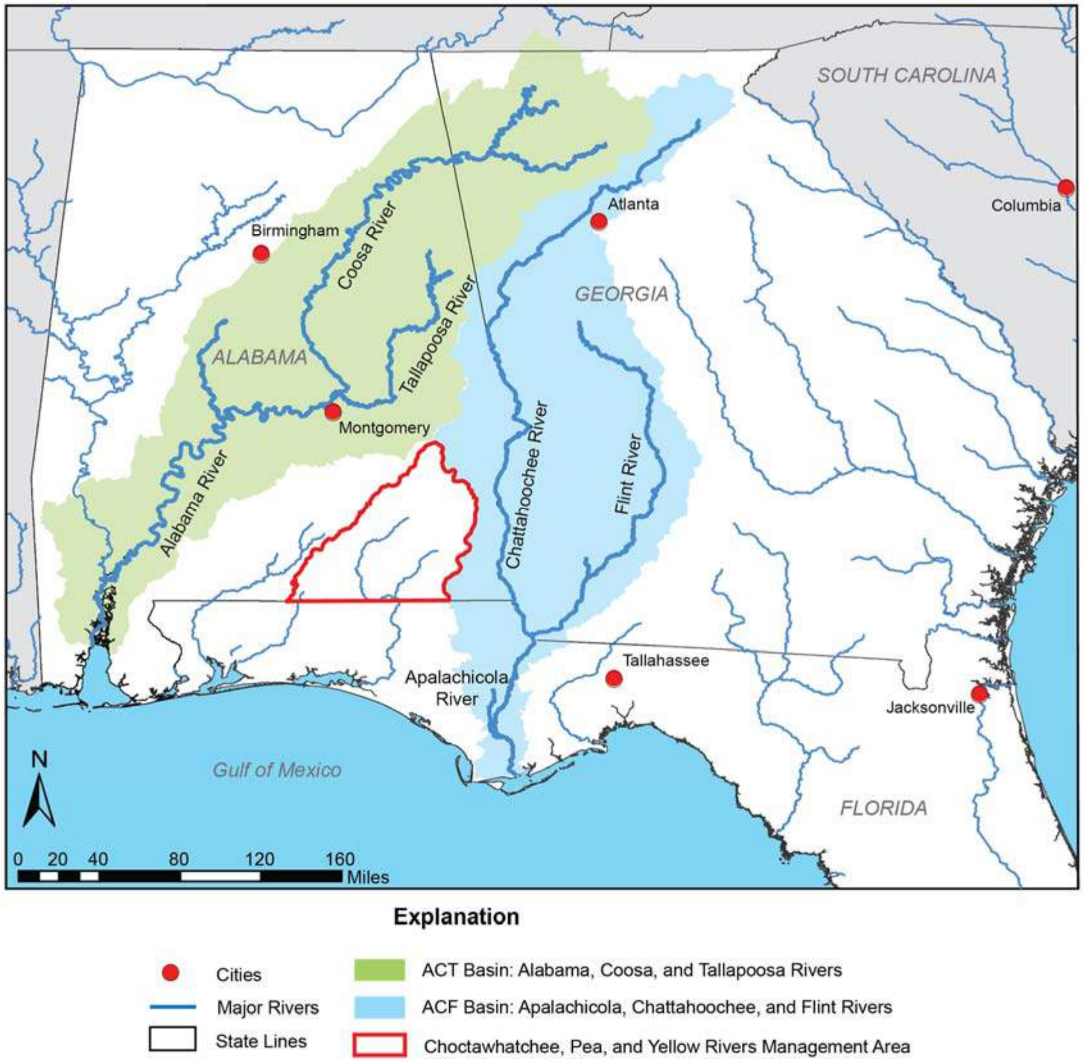

Figure 25.—Tri-State Water Wars river basins in Alabama, Florida, and Georgia.

hydropower, and navigation. However, following the construction of Lake Lanier, the metro population of Atlanta began to increase, which necessitated the need for a greater supply of water (SELC, 2013). As a result of this increased water demand, Atlanta began to use Lake Lanier as a water supply, with the USACE issuing contracts to municipal water suppliers, in effect bypassing the National Environmental Policy Acts (SELC, 2013). The water demand for Atlanta continued to increase over the years, resulting in the USACE recommending that 20% of the lake water be reallocated for water supply in the Atlanta region, which prompted a lawsuit filed by the state of Alabama claiming that this reallocation favored Georgia's interests and that the USACE had ignored the environmental impacts to the downstream states (SELC, 2013). In 1992, negotiations between the states and the

USACE began, but by 2003, with no compromises reached by interested parties, negotiations stalled. This was followed by a court ruling in 2009 that Lake Lanier was not properly authorized to provide water supplies to metro Atlanta, which was reversed two years later by the 11th Circuit Court of Appeals and gave Atlanta lawful access to Lake Lanier for its drinking water needs (SELC, 2013). In 2012, the Supreme Court refused to hear Alabama and Florida appeals of this decision (SELC, 2013). Since this last court proceeding, the USACE published the draft Water Control Manual.

It should be noted that this issue would only affect the CPYRWMA if the Chattahoochee Watershed in Barbour, Bullock, and Houston Counties were brought under the management of the CPYRWMA. However, with the location of the CPYRW, these watersheds could be subject to issues with bordering states.

FLORIDAN AQUIFER

The Floridan aquifer recharge area (fig. 26) underlies roughly 100,000 mi^2 in southern Alabama, southern Georgia, southeastern Mississippi, southern South Carolina, and all of Florida (Berndt and Crandall, 2009). This highly productive aquifer is the primary source of drinking water for the state of Florida, while also providing water to the states of Alabama, Georgia, and South Carolina (Berndt and Crandall, 2009). In Alabama, the counties of Baldwin, Clarke, Conecuh, Covington, Escambia, Geneva, Houston, Mobile, Monroe, and Washington are underlain by the Floridan aquifer recharge area.

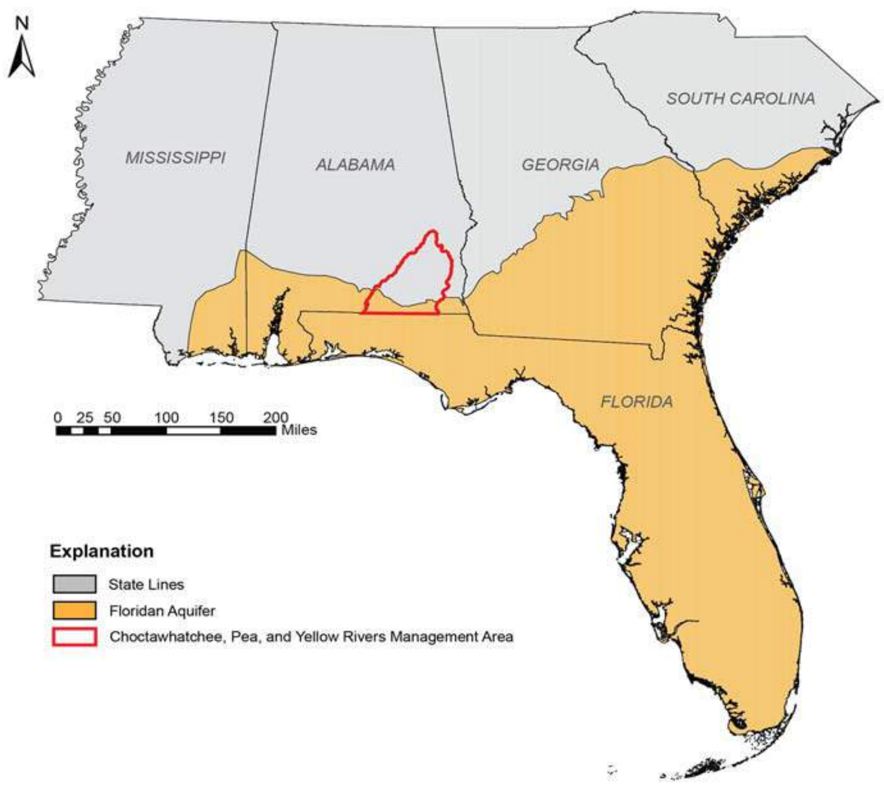

Figure 26.—Floridan aquifer recharge areas in Alabama, Florida, Georgia, Mississippi, and South Carolina.

Interstate issues related to this aquifer recharge area include over pumpage and contamination (Berndt and Crandall, 2009). In 2000, the total estimated amount of water withdrawn from the aquifer was 4,020 mgd distributed between Alabama (7 mgd), Florida (3,125 mgd), Georgia (825 mgd), and South Carolina (63 mgd) (Berndt and Crandall, 2009). Regional water level declines have been observed in the Florida panhandle, northeast Florida, west-central Florida, coastal Georgia, and South Carolina (Bush and Johnson, 1988), and long-term groundwater level declines could be attributed to the withdrawal of groundwater exceeding the recharge rates, which could also result in salt water intrusion, especially in coastal areas (Southwest Florida Water Management District (SWFWMD), 2009). A possible side effect of declining water levels is decreased discharges to surface water bodies, which can result in lower lake levels, slower river currents, and decreasing wetlands, and which could conversely impact animal habitats (SWFWMD, 2009).

Due to relative shallowness of this aquifer, it is also highly susceptible to contamination, especially in areas of high aquifer recharge (SWFWMD, 2009). Sources of contamination include excessive and improper use of fertilizers and pesticides, pet and livestock waste near water bodies, leaking underground storage tanks, and septic tanks (SWFWMD, 2009).

RECOMMENDATIONS

The CPYRWMA should establish a dialogue with the state of Florida to discuss groundwater quality and quantity data availability and Alabama impacts on the Floridan aquifer. These impacts could include quantities of recharge, water production, and future water source development.

POLICY OPTIONS

The aforementioned recommendation would be enhanced and facilitated by development of a comprehensive state water management plan that addresses water quality and quantity policy options.

DOWNSTREAM WATER QUALITY

Downstream water quality is a major concern for downstream water users due to impacts of upstream contamination. In southeast Alabama, the Choctawhatchee, Pea and Yellow Rivers originate in Alabama and drain into Florida. The primary constituents that affect water quality for these rivers originate from nonpoint sources, which consist of sediment, nutrients, bacteria, and metals (Cook and Murgulet, 2010). Water quality data has been collected by the GSA at three sites on both the Choctawhatchee and Pea Rivers and at one site on the Yellow River (fig. 27). Two sites, CR1 and PR3, are downstream monitoring sites for the Choctawhatchee River and the Pea River, respectively, immediately upstream from the Florida state line. CR1 is the southernmost downstream site, located at the confluence of the Choctawhatchee River with Double Bridges Creek, about 1 mile from the confluence of the Choctawhatchee River with the Pea River; and PR3 is the southernmost site for the Pea River, located in Geneva County near the confluence of the Pea and Choctawhatchee Rivers (Cook and Murgulet, 2010). The Yellow River monitoring site

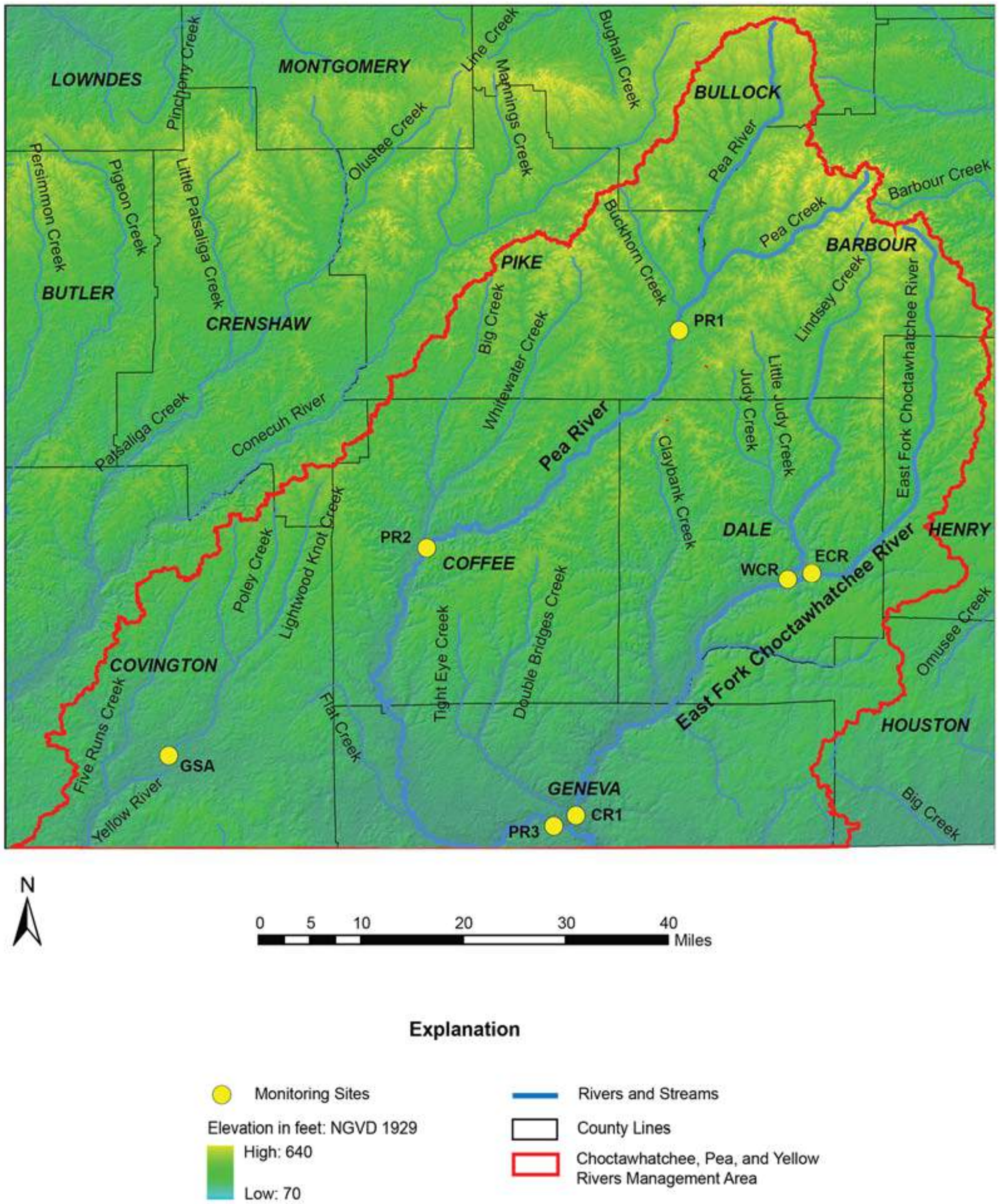

Figure 27.—Geological Survey of Alabama monitoring sites on the Choctawhatchee, Pea and Yellow Rivers.

is located at the State Highway 55 crossing, approximately 7 miles north of the Florida state boundary (Cook, and others, 2002).

Estimated loadings were calculated for the Choctawhatchee, Pea and Yellow Rivers from concentrations of constituents and stream discharges (table 16). The total estimated total suspended solids (TSS) loading from the Choctawhatchee, Pea and Yellow Rivers to Florida is 56,184 tons/year. The total estimated nitrate loading to

Table 16.—Estimated loadings at select monitoring sites in the CPYRW.

River	Loadings (tons/year)		
	TSS	Nitrate	Phosphorus
Choctawhatchee[1]	15,033	561	56.5
Pea[1]	30,631	1,376	120
Yellow[2]	10,520	31	5.6

[1]From Cook and Murgulet (2010)
[2]From Cook, O'Neil, Moss, and DeJarnette (2002)

Florida from the three rivers is 1,968 tons/year. The total estimated phosphorus loading to Florida from the rivers is 182.1 tons/year.

For all three constituents, the Pea River (GSA site PR3) has the highest loadings, followed by the Choctawhatchee and Yellow Rivers. The results of these studies are indicative of impacts from agricultural practices and developed land in surrounding areas (Cook and Murgulet, 2010). Water quality is discussed in more detail in the Water Quality section of the WMP.

RECOMMENDATIONS

The CPYRWMA should establish a program to monitor surface-water quantity and regularly update existing water quality data for streams discharging into Florida. The CPYRWMA should also establish a dialog with the Alabama Department of Environmental Management (ADEM) and the State of Florida regarding discharge entering Florida.

FLORIDA COASTAL ZONE IMPACTS

The Coastal Zone Management Act (CZMA) was enacted by Congress in 1972 to address measures intended to preserve, protect, develop, restore, and enhance the resources of the nation's coastal zones by encouraging the coastal states to develop and implement their own federally approved coastal management programs (Florida Department of Environmental Protection (FDEP), 2012a). The Florida Coastal Management Program (CMP) was created as a result of the CZMA and allows Florida to promote the effective protection and use of the land and water resources in the coastal zone (FDEP, 2013). The CZMA requires the state Coastal Management Plan (CMP) to define boundaries of the state's coastal zone, coastal land or water uses and natural resources that have a direct and significant impact on coastal waters, geographic areas of concern, authorities and enforceable policies of the CMP, guidelines on priorities of uses, organizational structure for implementing the CMP, shorefront access and protection planning, new energy facility planning, and shoreline erosion/mitigation planning (FDEP, 2013).

The Florida CMP defined seaward boundaries extending 3 miles into the Atlantic Ocean and 3 marine leagues (approximately 9 nautical miles) into the Gulf of Mexico (FDEP, 2013). Interstate boundaries are defined as the adjudicated boundary between

Florida and Alabama to the west, and the northern lateral boundary as the adjudicated boundary between Florida and Alabama and Florida and Georgia (FDEP, 2013). For purposes related to planning and development projects related to the Florida CMP, only the geographical area encompassed by the 35 Florida coastal counties (counties that border either the Gulf of Mexico or the Atlantic Ocean) and the adjoining territorial sea is utilized (FDEP, 2013). No counties in Alabama are subject to Florida's CMP.

RECOMMENDATION

The CPYRWMA should monitor conditions related to the Florida CMP and report updated information to the Alabama Governor's Office, ADEM, and the Alabama Department of Conservation and Natural Resources (ADCNR). The CPYRWMA should also open a dialog with Florida officials to preemptively address proposed changes to coastal impact zones.

FLORIDA NUTRIENT CRITERIA

In 2009, the USEPA determined that new or revised water quality standards in the form of numeric water quality criteria for nitrogen and phosphorus are necessary for the state of Florida to meet the requirements of the Clean Water Act, which resulted in a consent decree between the Sierra Club, Florida Wildlife Federation, Conservatory of Southwest Florida, Environmental Confederation of Southwest Florida, and St. Johns Riverkeeper, in order to establish a schedule to propose and implement numeric nutrient criteria to meet Clean Water Act regulations (USEPA, 2013d). In June 2013, the USEPA approved proposed water quality standards in Florida's Numeric Nutrient Standards Implementation Document for lakes, streams, spring vents, and southwest/south Florida estuaries (USEPA, 2013d). As part of this plan, the FDEP published information related to nutrient criteria for Choctawhatchee Bay, which is fed primarily by the Choctawhatchee River, with other inflows from nearby bayous (FDEP, 2012b).

SOUTHEAST ALABAMA ISSUES

Issues of concern in southeast Alabama include de-nitrification of alternate and supplemental water sources, competition between irrigation and public water supply systems, climate change and drought impacts, surface-water discharge and quality, aging infrastructure, possible implementation of a state water policy, population growth and economic development, and energy production and water resource impacts (water/energy nexus). The issues mentioned above, with the exception of the energy and water nexus, are discussed in other sections of this plan in detail, including recommendations for the CPYRWMA.

WATER / ENERGY NEXUS

Water and energy are interdependent, with energy required for water transportation, treatment, and distribution, and water required for such energy processes as thermoelectric cooling, fuel production, hydropower generation, and biofuel feedstock (Murkowski, 2014). Water is crucial for supporting the expansion of natural gas production, ethanol production for transportation, electricity generation, and oil production (Murkowski, 2014).

In southeast Alabama, biofuels and hydropower are important components of the water/energy nexus. Biofuels, such as ethanol, are produced from corn, which requires irrigation, which is a consumptive use, thus no water is assumed to percolate into the subsurface. Limited hydropower generation in southeast Alabama is currently limited to two facilities in Covington County, as discussed previously.

RECOMMENDATION

The CPYRWMA should cooperate with the ADECA OWR to develop estimates of water usage in the CPYRW related to energy production (ethanol and electrical power generation). The CPYRWMA should also monitor hydropower generation and potential water resource impacts and consult with the ADAI to determine acres of corn grown in the CPYRW that are earmarked for ethanol production. Water use data discussed previously should be evaluated by the CPYRWMA to determine impacts to water resources from irrigation.

POLICY OPTIONS

Data and actions mentioned above should be part of a state water management plan.

WATER USE REPORTING PROGRAM

Alabama's water resources support a myriad of activities including residential and public water supply, industrial use, power generation, and agricultural pursuits. The Alabama Water Resources Act establishes the Alabama Water Resources Commission and mandates it to adopt rules and regulations governing the development and use of water in the State (CWP and GSA, 2005). The Office of Water Resources, which is a division of the Alabama Department of Economic and Community Affairs (ADECA OWR), is charged in Section 9-10B-1 of the Alabama Water Resources Act to assess the State's water resources. In order to administer these provisions, the ADECA OWR created the Alabama Water Use Reporting Program.

Within the program, all public water systems and those other individuals and organizations who have a capacity to withdraw 100,000 gallons per day or more are required to register with ADECA OWR and obtain a Certificate of Use (ADECA OWR, 2012a). The process begins with the submittal of an application form, called the "Declaration of Beneficial Use." When the form has been completed and reviewed, ADECA OWR will issue a "Certificate of Use," which lists the individual or organization's name as well as any information concerning all registered surface and/or groundwater withdrawal points and respective withdrawal information (ADECA OWR, 2012a). The certificate owner will then submit water usage information to ADECA OWR on an annual basis. The number of Certificates of Use per county within the CPYRW area are shown in table 17. The percentage of certificate category use within the watershed is shown in figure 28.

Table 17.—Certificates of Use issued by county in the CPYRW in 2014.

County	Surface Water	Groundwater	County Total
Barbour	11	11	22
Bullock	1	3	4
Coffee	11	13	24
Covington	1	10	11
Crenshaw	0	3	3
Dale	5	11	16
Geneva	7	12	19
Henry	9	10	19
Houston	15	26	41
Pike	12	8	20
Total	72	107	179

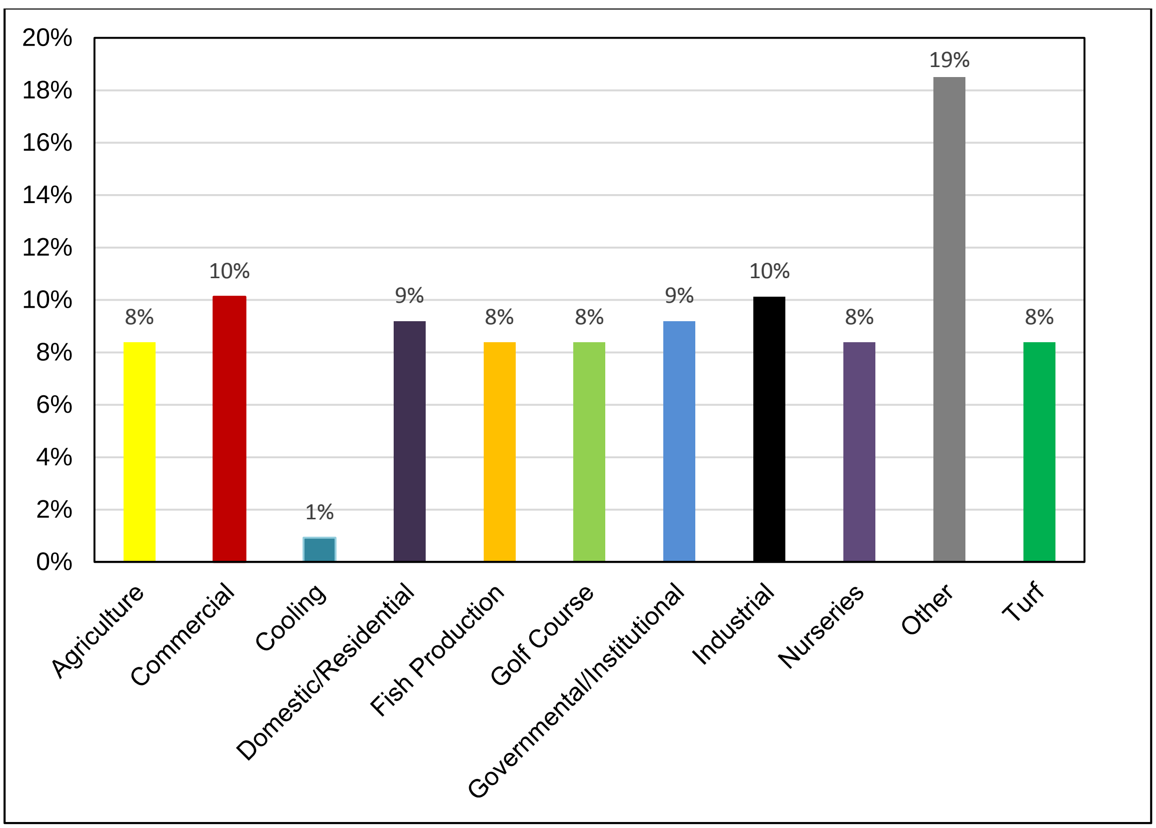

Figure 28.—Percentage of certificate category use within the CPYRW in 2014.

WATER RESOURCES

SURFACE WATER

Hydrologic unit boundaries are defined by hydrographic and topographic criteria that delineate an area of land upstream from a specific point on a river, stream or similar surface waters (USDA NRCS, 2004a). There are six levels, each with progressively smaller area sizes: regions, subregions, basins, subbasins, watersheds, and subwatersheds (USGS and USDA, 2012). Table 18 lists these six hydrologic unit boundaries and their corresponding national average sizes.

The CPYRW lies in the South Atlantic-Guild hydrologic region (03) and in the Choctawhatchee-Escambia subregion (0314). The Choctawhatchee River (031402) is further divided into the Upper Choctawhatchee subbasin (03140201) and the Lower Choctawhatchee Subbasin (03140203). The Pea River subbasin (03140202) is also located within the Choctawhatchee Basin. The Yellow River subbasin (03140103) is located within the Florida Panhandle Coastal Basin (031401).

Table 18.—Hydrologic unit levels and corresponding average sizes.

Hydrologic Unit Level[1]	Name	Digits	Average Size (mi^2)
1	Region	2	177,560
2	Subregion	4	16,800
3	Basin	6	10,596
4	Subbasin	8	700
5	Watershed	10	227
6	Subwatershed	12	40

[1]From USGS and USDA NRCS (2013)

MAIN STEMS AND TRIBUTARIES

UPPER CHOCTAWHATCHEE RIVER (03140201)

The Upper Choctawhatchee River subbasin comprises approximately 1,526 mi^2 of the CPYRW, lies in the eastern portion of the CPYRW study area, and is situated in six counties in the CPYRW (plate 1). This subbasin includes the Choctawhatchee River from its headwaters near Clayton in Barbour County southwestward to the confluence of the Pea River at Geneva in southern Geneva County (CWP and GSA, 2005). The Upper Choctawhatchee River subbasin is the largest of the subbasins in the CPYRW, with 12 watersheds (10-digit) and 54 subwatersheds (12-digit) within this subbasin (table 19).

Table 19.—Watershed and subwatersheds in the Upper Choctawhatchee River Subbasin.

Subbasin (8-digit)	Watershed (10 digit)	Watershed Name	Subwatershed (12 digit)	Subwatershed Name	Acres	Square Miles
03140201	0314020101	Upper East Choctawhatchee River	031402010101	Headwaters Upper East Fork Choctawhatchee	19,917	31.12
03140201	0314020101	Upper East Choctawhatchee River	031402010102	Little Piney Woods Creek-Piney Woods Creek	1,778	2.78
03140201	0314020101	Upper East Choctawhatchee River	031402010103	Beaver Creek-Hamm Creek	20,988	32.79
03140201	0314020101	Upper East Choctawhatchee River	031402010104	Indian Creek-Cowpens Creek	17,316	27.06
03140201	0314020102	Lower East Fork Choctawhatchee River	031402010201	Jack Creek	22,476	35.12
03140201	0314020102	Lower East Fork Choctawhatchee River	031402010202	Poor Creek	13,279	20.75
03140201	0314020102	Lower East Fork Choctawhatchee River	031402010203	Pebbles Mill Creek-Panther Creek	11,985	18.73
03140201	0314020102	Lower East Fork Choctawhatchee River	031402010204	Riley Creek	19,318	30.18
03140201	0314020102	Lower East Fork Choctawhatchee River	031402010205	Little Blackwood Creek	17,520	27.38
03140201	0314020102	Lower East Fork Choctawhatchee River	031402010206	Dunham Creek	10,820	16.91
03140201	0314020102	Lower East Fork Choctawhatchee River	031402010207	Turkey Creek-Choctawhatchee River	14,268	22.29
03140201	0314020102	Lower East Fork Choctawhatchee River	031402010208	Outlet East Fork Choctawhatchee River	21,615	33.77
03140201	0314020103	Judy Creek	031402010301	Upper Judy Creek	14,305	22.35
03140201	0314020103	Judy Creek	031402010302	Little Judy Creek	19,346	30.23
03140201	0314020103	Judy Creek	031402010303	Middle Judy Creek	18,634	29.12
03140201	0314020103	Judy Creek	031402010304	Lower Judy Creek	22,564	35.26
03140201	0314020104	West Fork Choctawhatchee River	031402010401	Mill Branch-Lindsey Creek	25,793	40.30
03140201	0314020104	West Fork Choctawhatchee River	031402010402	Headwaters West Fork Choctawhatchee River	21,301	33.28

Table 19.—Watershed and subwatersheds in the Upper Choctawhatchee River Subbasin—continued.

Subbasin (8-digit)	Watershed (10 digit)	Watershed Name	Subwatershed (12 digit)	Subwatershed Name	Acres	Square Miles
03140201	0314020104	West Fork Choctawhatchee River	031402010403	Sikes Creek	23,207	36.26
03140201	0314020104	West Fork Choctawhatchee River	031402010404	Upper West Fork Choctawhatchee River	13,944	21.79
03140201	0314020104	West Fork Choctawhatchee River	031402010405	Hopn Branch-Bear Creek	22,465	35.10
03140201	0314020104	West Fork Choctawhatchee River	031402010406	Middle West Fork Choctawhatchee River	29,587	46.23
03140201	0314020104	West Fork Choctawhatchee River	031402010407	Lower West Fork Choctawhatchee River	15,984	24.98
03140201	0314020105	Little Choctawhatchee River	031402010501	Newton Creek	25,501	39.85
03140201	0314020105	Little Choctawhatchee River	031402010502	Sasser Branch-Bear Creek	16,054	25.08
03140201	0314020105	Little Choctawhatchee River	031402010503	Murphy Mill Branch-Little Choctawhatchee River	26,423	41.29
03140201	0314020105	Little Choctawhatchee River	031402010504	Panther Creek-Little Choctawhatchee River	35,059	54.78
03140201	0314020106	Klondike Creek-Choctawhatchee River	031402010601	Klondike Creek-Hurricane Creek	17,346	27.10
03140201	0314020106	Klondike Creek-Choctawhatchee River	031402010602	Killebrew Factory Creek	10,431	16.30
03140201	0314020106	Klondike Creek-Choctawhatchee River	031402010603	Brooking Mill Creek	16,682	26.07
03140201	0314020106	Klondike Creek-Choctawhatchee River	031402010604	Middle Choctawhatchee River	7,237	11.31
03140201	0314020107	Upper Claybank Creek	031402010701	Little Claybank Creek-Bear Creek	23,115	36.12
03140201	0314020107	Upper Claybank Creek	031402010702	Headwaters Claybank Creek	23,155	36.18
03140201	0314020107	Upper Claybank Creek	031402010703	Upper Claybank Creek	7,211	11.27
03140201	0314020108	Steephead Creek	031402010801	Bowles Creek	18,942	29.60
03140201	0314020108	Steephead Creek	031402010802	Steep Head Creek	8,557	13.37

Table 19.—Watershed and subwatersheds in the Upper Choctawhatchee River Subbasin—continued.

Subbasin (8-digit)	Watershed (10 digit)	Watershed Name	Subwatershed (12 digit)	Subwatershed Name	Acres	Square Miles
03140201	0314020108	Steephead Creek	031402010803	Blacks Mill Creek	13,682	21.38
03140201	0314020109	Lower Claybank Creek	031402010901	Harrand Creek	13,145	20.54
03140201	0314020109	Lower Claybank Creek	031402010902	Little Cowpen Creek-Cowpen Creek	9,051	14.14
03140201	0314020109	Lower Claybank Creek	031402010903	Middle Claybank Creek	10,230	15.98
03140201	0314020109	Lower Claybank Creek	031402010904	Lower Claybank Creek	23,072	36.05
03140201	0314020110	Hurricane Creek	031402011001	Pine Log Branch	19,571	30.58
03140201	0314020110	Hurricane Creek	031402011002	Pates Creek	12,097	18.90
03140201	0314020110	Hurricane Creek	031402011003	Sconyers Branch	10,049	15.70
03140201	0314020110	Hurricane Creek	031402011004	Cox Mill Creek-Hurricane Creek	15,712	24.55
03140201	0314020111	Double Bridges Creek	031402011101	Little Double Bridges Creek	13,657	21.34
03140201	0314020111	Double Bridges Creek	031402011102	Blanket Creek-Double Bridges Creek	26,996	42.18
03140201	0314020111	Double Bridges Creek	031402011103	Tight Eye Creek	27,704	43.29
03140201	0314020111	Double Bridges Creek	031402011104	Beargrass Creek	20,257	31.65
03140201	0314020111	Double Bridges Creek	031402011105	Bushy Branch-Beaverdam Creek	16,514	25.80
03140201	0314020111	Double Bridges Creek	031402011106	Long Branch-Double Bridges Creek	19,655	30.71
03140201	0314020112	Choctawhatchee River	031402011201	Wilkerson Creek	23,196	36.24
03140201	0314020112	Choctawhatchee River	031402011202	Campbell Mill Creek	28,876	45.12
03140201	0314020112	Choctawhatchee River	031402011203	Rocky Creek-Adams Creek	19,335	30.21
Total					976,922	1,526

Upper East Choctawhatchee River watershed (0314020101) covers approximately 94 mi^2 of the study area and is mainly situated within Barbour County, southeast of Clayton, but also extends into the northern portion of Henry County. Four subwatersheds (12-digit) are located within this watershed: Headwaters Upper East Fork Choctawhatchee River, Little Piney Woods Creek-Piney Woods Creek, Beaver Creek-Hamm Creek, and Indian Creek-Cowpens Creek (fig. 29).

Lower East Fork Choctawhatchee River watershed (0314020102) covers approximately 205 mi^2 and is located directly downstream of the Upper East Choctawhatchee River watershed, with the majority of the watershed located in western Henry County and extending into eastern Dale County. Eight subwatersheds

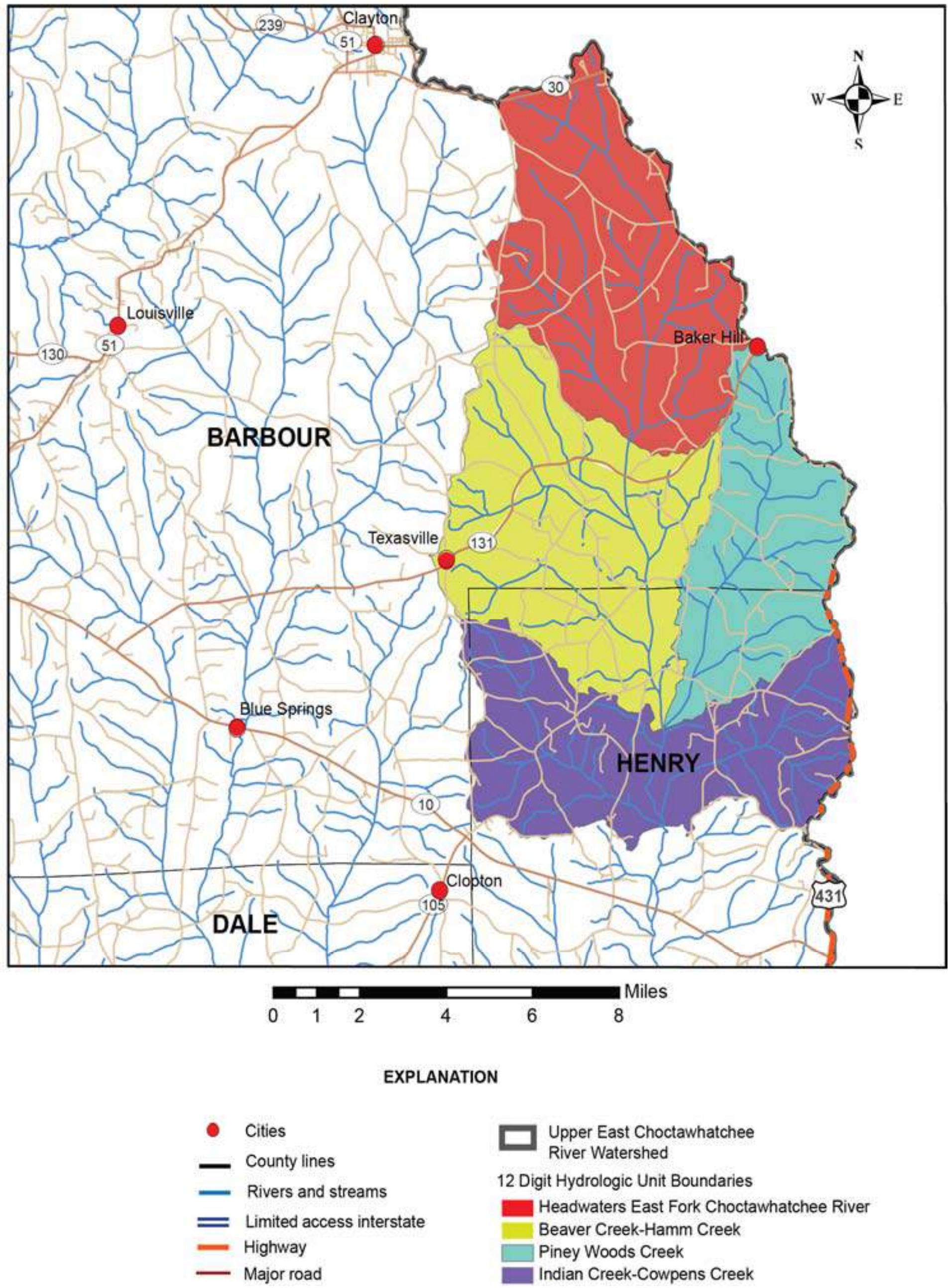

Figure 29.—Upper East Choctawhatchee River watershed (0314020101).

are located within this watershed: Jack Creek, Poor Creek, Pebbles Mill Creek-Panther Creek, Riley Creek, Little Blackwood Creek, Dunham Creek, Turkey Creek-Choctawhatchee River, and Outlet East Fork Choctawhatchee River (fig. 30).

Judy Creek watershed (0314020103) covers approximately 117 mi^2 and is located near Clio in Barbour County and extends southward into Dale County. Four

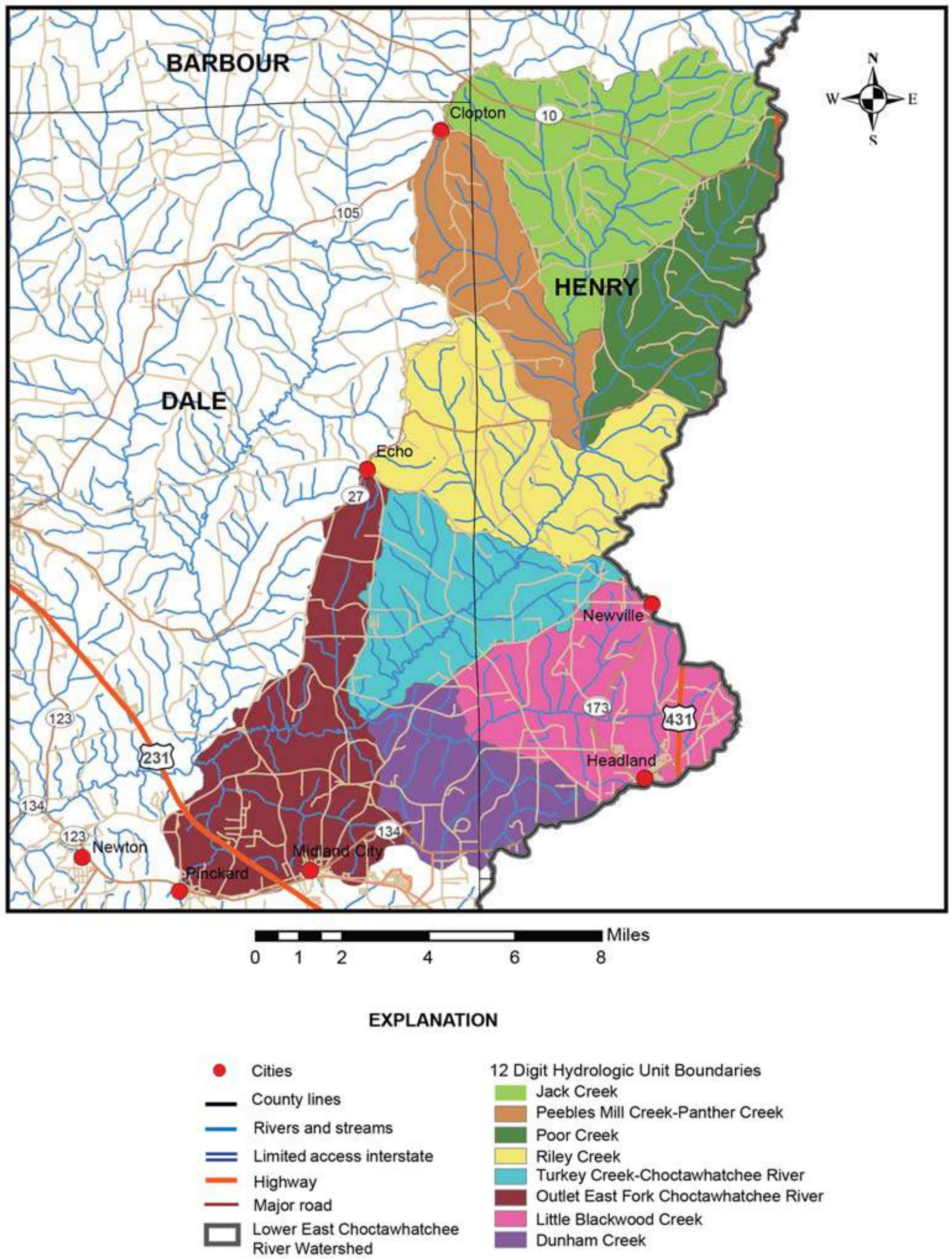

Figure 30.—Lower East Fork Choctawhatchee River watershed (0314020102).

subwatersheds are located within this watershed: Upper Judy Creek, Little Judy Creek, Middle Judy Creek, and Lower Judy Creek (fig. 31).

West Fork Choctawhatchee River watershed (0314020104) covers approximately 238 mi^2 and is located in central Barbour County, extending southward into Dale County, east of Ozark. Seven subwatersheds are located within this watershed: Mill

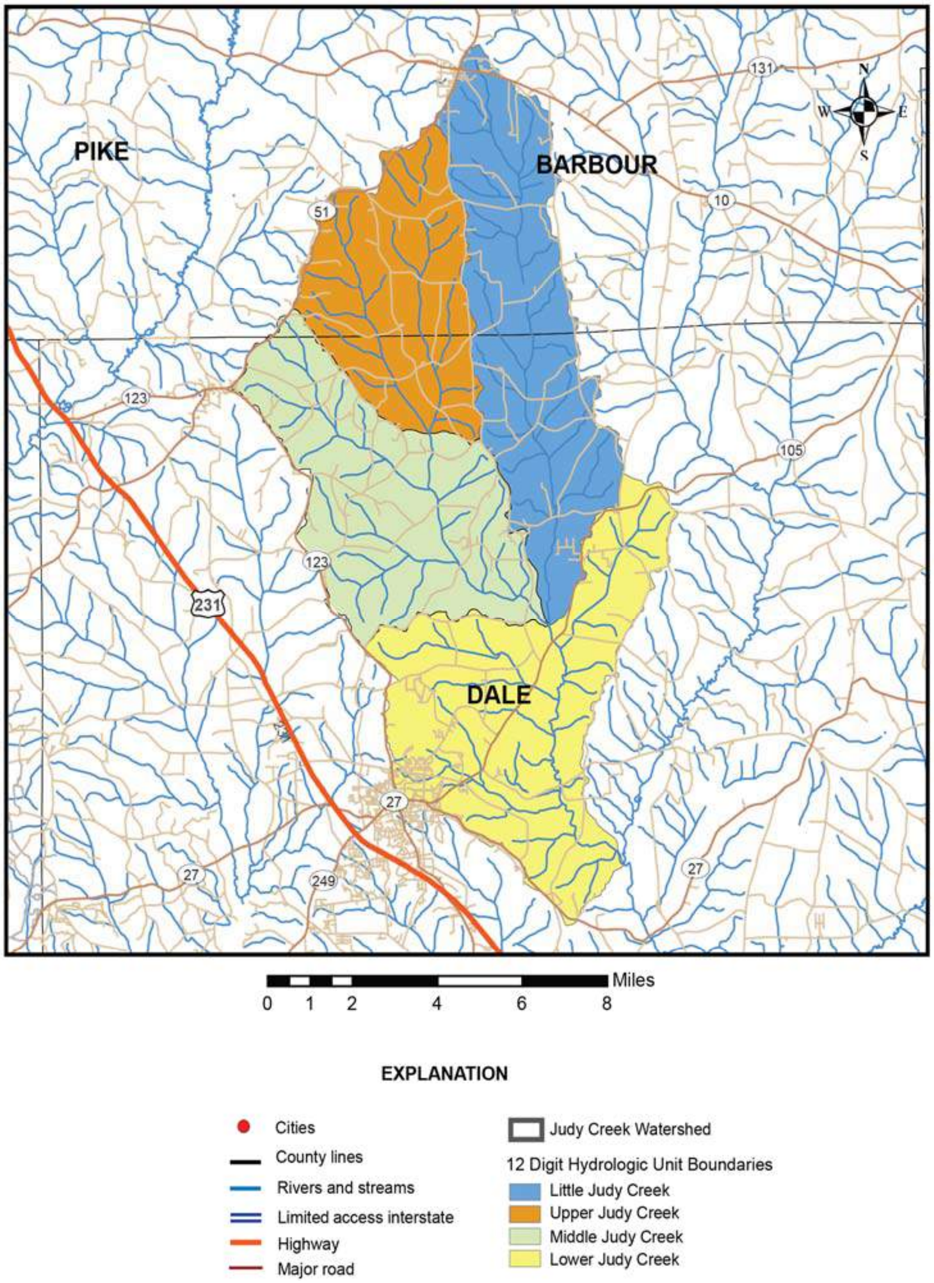

Figure 31.—Judy Creek Watershed (0314020103).

Branch-Lindsey Creek, Headwaters West Fork Choctawhatchee River, Sikes Creek, Upper West Fork Choctawhatchee River, Hopn Branch-Bear Creek, Middle West Fork Choctawhatchee River, and Lower West Fork Choctawhatchee River (fig. 32).

Little Choctawhatchee River watershed (0314020105) covers approximately 161 mi^2 and is located in portions of Dale County, Geneva County, and Houston County. Four subwatersheds are located within this watershed: Newton Creek, Sasser Branch-Bear Creek, Murphy Mill Branch-Little Choctawhatchee River, and Panther

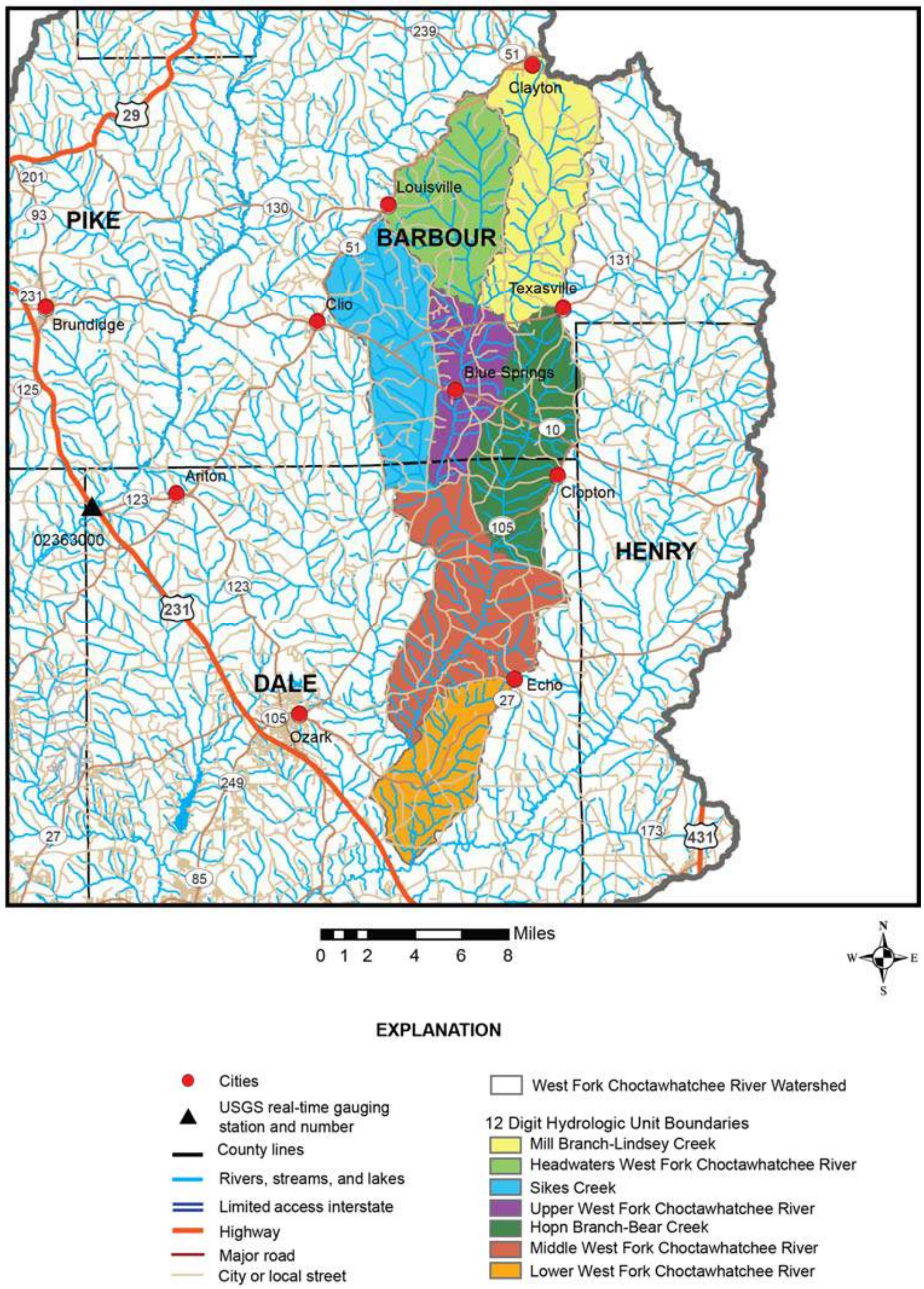

Figure 32.—West Fork Choctawhatchee River watershed (0314020104).

Creek-Little Choctawhatchee River (fig. 33). Klondike Creek-Choctawhatchee River watershed (0314020106) covers approximately 81 mi^2 and is contained entirely within Dale County. Four subwatersheds are located within this watershed: Klondike Creek-Hurricane Creek, Killebrew Factory Creek, Brooking Mill Creek, and Middle Choctawhatchee River (fig. 34).

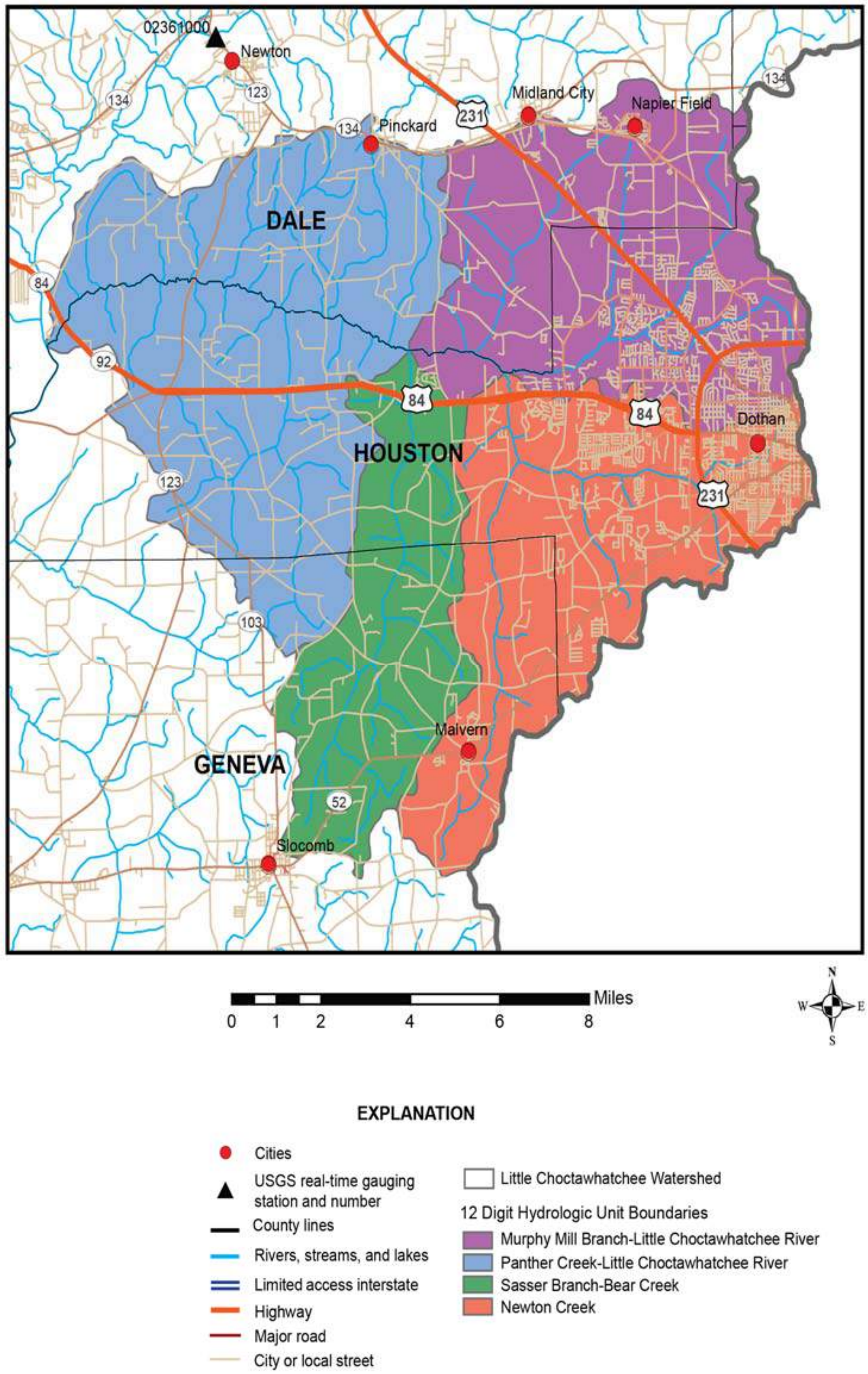

Figure 33.—Little Choctawhatchee River watershed (0314020105).

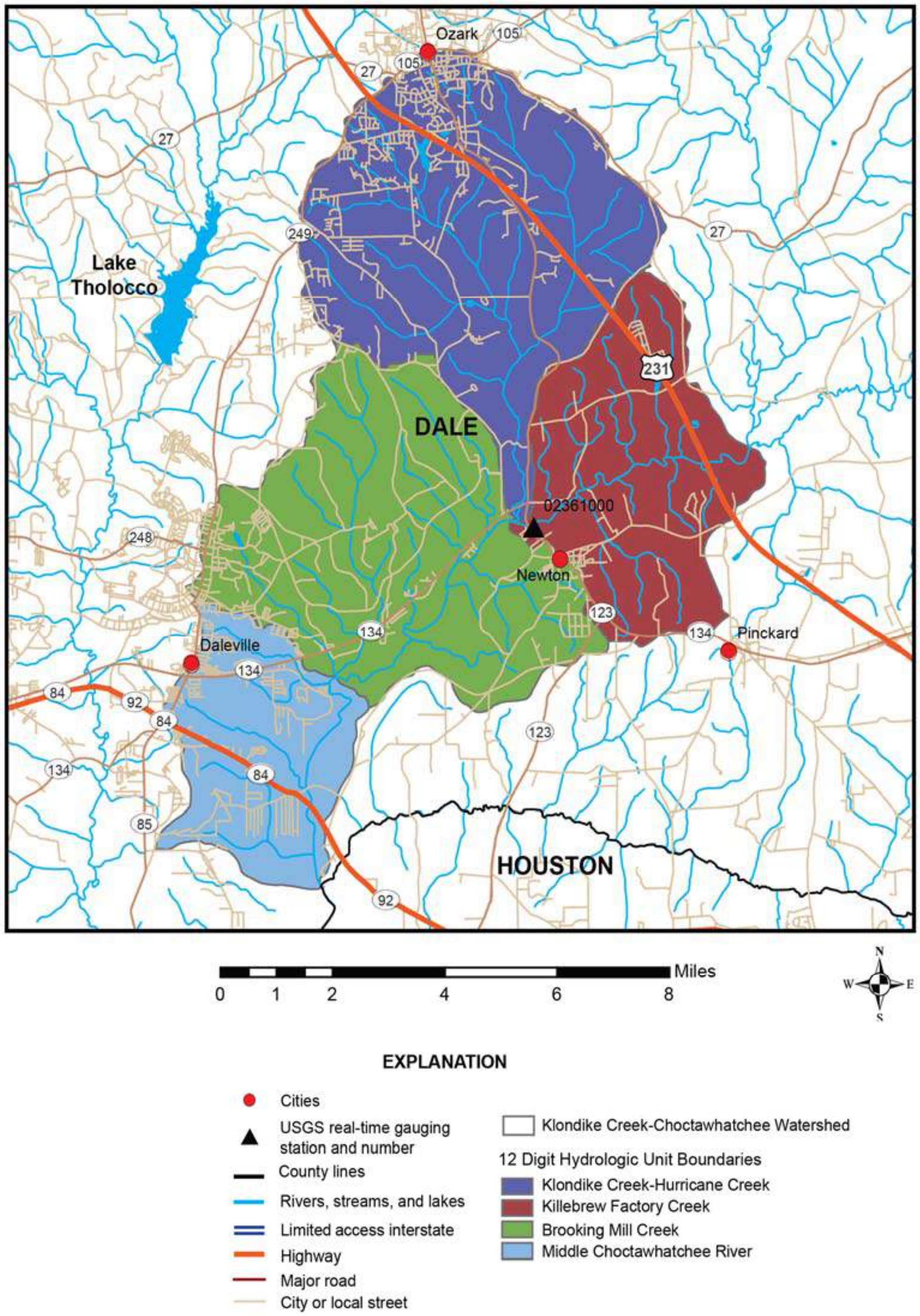

Figure 34.—Klondike Creek-Choctawhatchee River watershed (0314020106).

Upper Claybank Creek (0314020107) covers approximately 84 mi^2 and is located within Coffee County and Dale County, with the northern boundary of the watershed originating in northwest Dale County near Ariton and extending southward to Ozark and Lake Tholocco. Three subwatersheds are located within this watershed: Little Claybank Creek-Bear Creek, Headwaters Claybank Creek, and Upper Claybank Creek (fig. 35).

Steep Head Creek watershed (0314020108) covers approximately 64 mi^2 in west-central Dale County and east-central Coffee County. Three subwatersheds are located within this watershed: Bowles Creek, Steep Head Creek, and Blacks Mill Creek (fig. 36).

Lower Claybank Creek watershed (0314020109) covers approximately 87 mi^2, with the northeastern portion of this watershed originating around Lake Tholocco dam in Dale County and extending southward to Daleville and westward to Enterprise in Coffee County, with the southernmost portions continuing into southwest Dale County and a small portion of north-central Geneva County. Four subwatersheds are located within this watershed: Harrand Creek, Little Cowpen Creek-Cowpen Creek, Middle Claybank Creek, and Lower Claybank Creek (fig. 37).

Hurricane Creek watershed (0314020110) covers approximately 90 mi^2, originates in southwest Dale County and in the southwest portion of the panhandle of Houston County, and continues southward into Geneva County. Four subwatersheds are located within this watershed: Pine Log Branch, Pates Creek, Sconyers Branch, and Cox Mill Creek-Hurricane Creek (fig. 38).

Double Bridges Creek watershed (0314020111) covers approximately 195 mi^2, with the northern boundary of the watershed originating in Coffee County near New Brockton and extending to Enterprise, continuing southward into Samson in Geneva County, and terminating in the town of Geneva in south-central Geneva County. Six subwatersheds are located within this watershed: Little Double Bridges Creek, Blanket Creek-Double Bridges Creek, Tight Eye Creek, Beargrass Creek, Bushy Branch-Beaverdam Creek, and Long Branch-Double Bridges Creek (fig. 39).

The Choctawhatchee River Watershed (0314020112) covers approximately 112 mi^2 from southeastern Coffee County and southwestern Dale County southeasterly to Hartford and southwestward to the town of Geneva in south-central Geneva County. Three subwatersheds are located within this watershed: Wilkerson Creek, Campbell Mill Creek, and Rocky Creek-Adams Creek (fig. 40).

LOWER CHOCTAWHATCHEE RIVER (03140203)

The Lower Choctawhatchee River Subbasin comprises approximately 134 mi^2 of the CPYRW (plate 1) and lies in the extreme southeastern portion of the CPYRW. This subbasin includes tributaries to the Choctawhatchee River from the southeast border of Geneva County northwestward to Hartford and southwestward to Geneva, with the majority in Geneva County and a small portion in the extreme southwest corner of Houston County. The 3 watersheds (10-digit) and 8 sub-watersheds (12-digit) within this subbasin are listed in table 20.

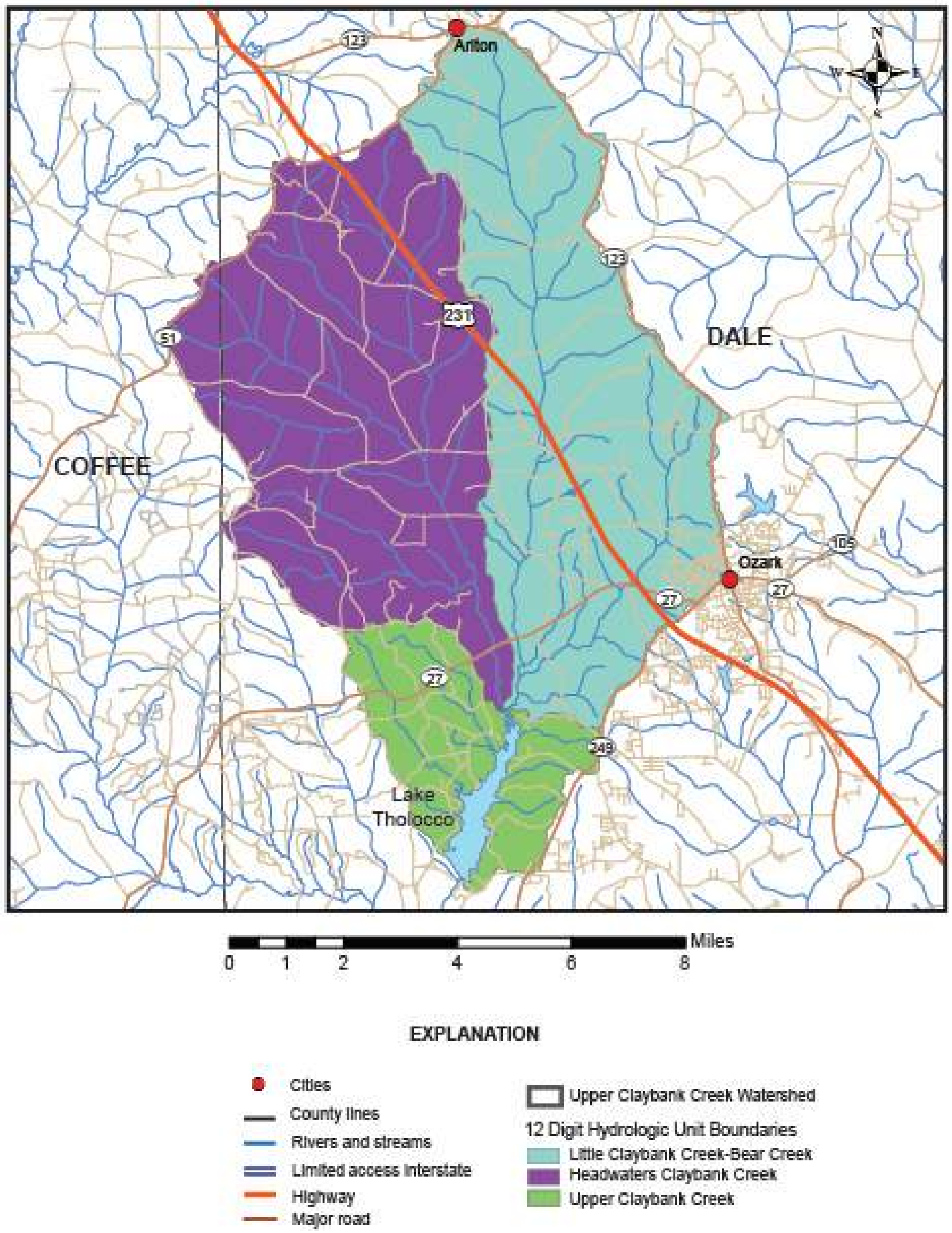

Figure 35.—Upper Claybank Creek watershed (0314020107).

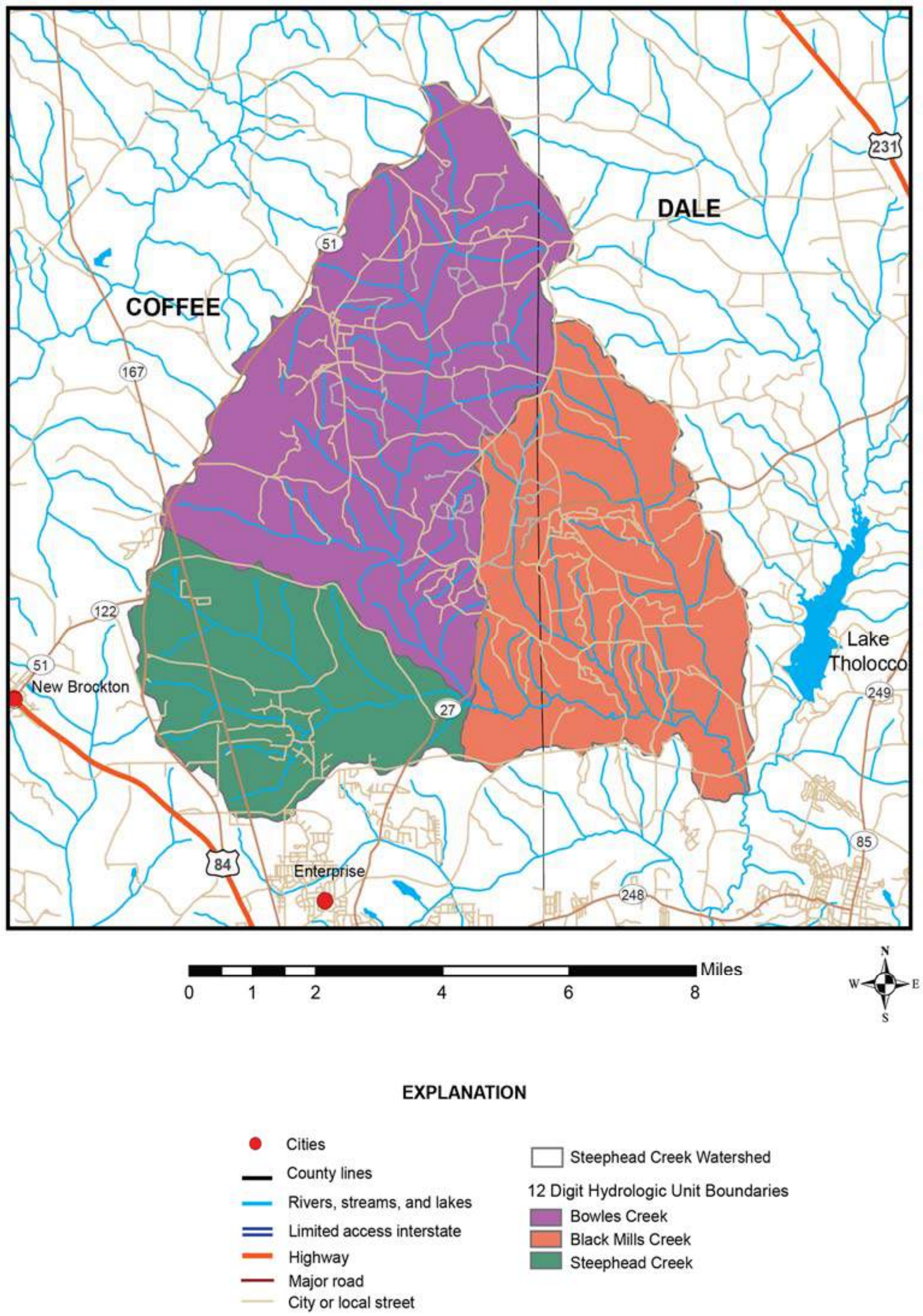

Figure 36.—Steep Head Creek watershed (0314020108).

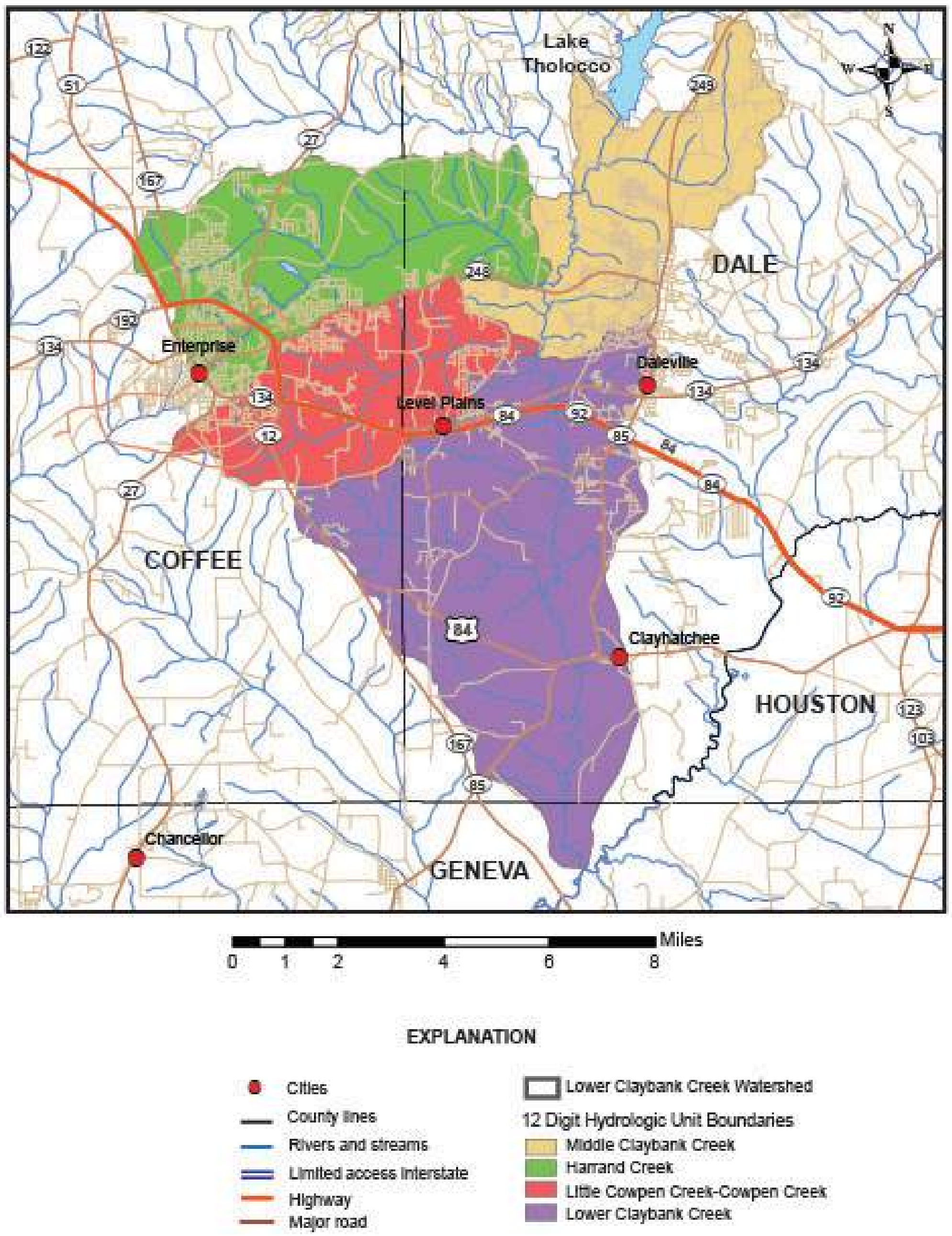

Figure 37.—Lower Claybank Creek watershed (0314020109).

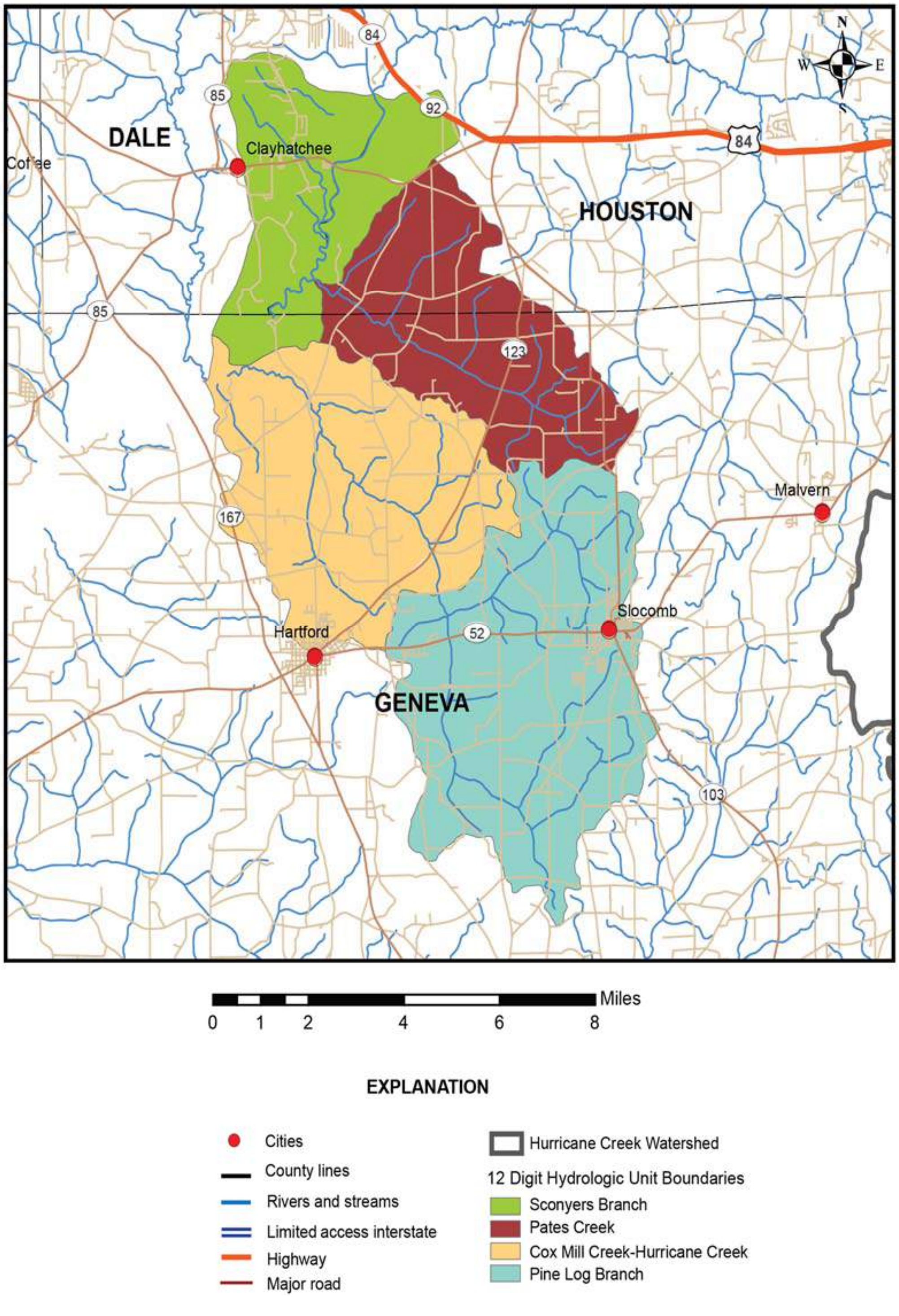

Figure 38.—Hurricane Creek watershed (0314020110).

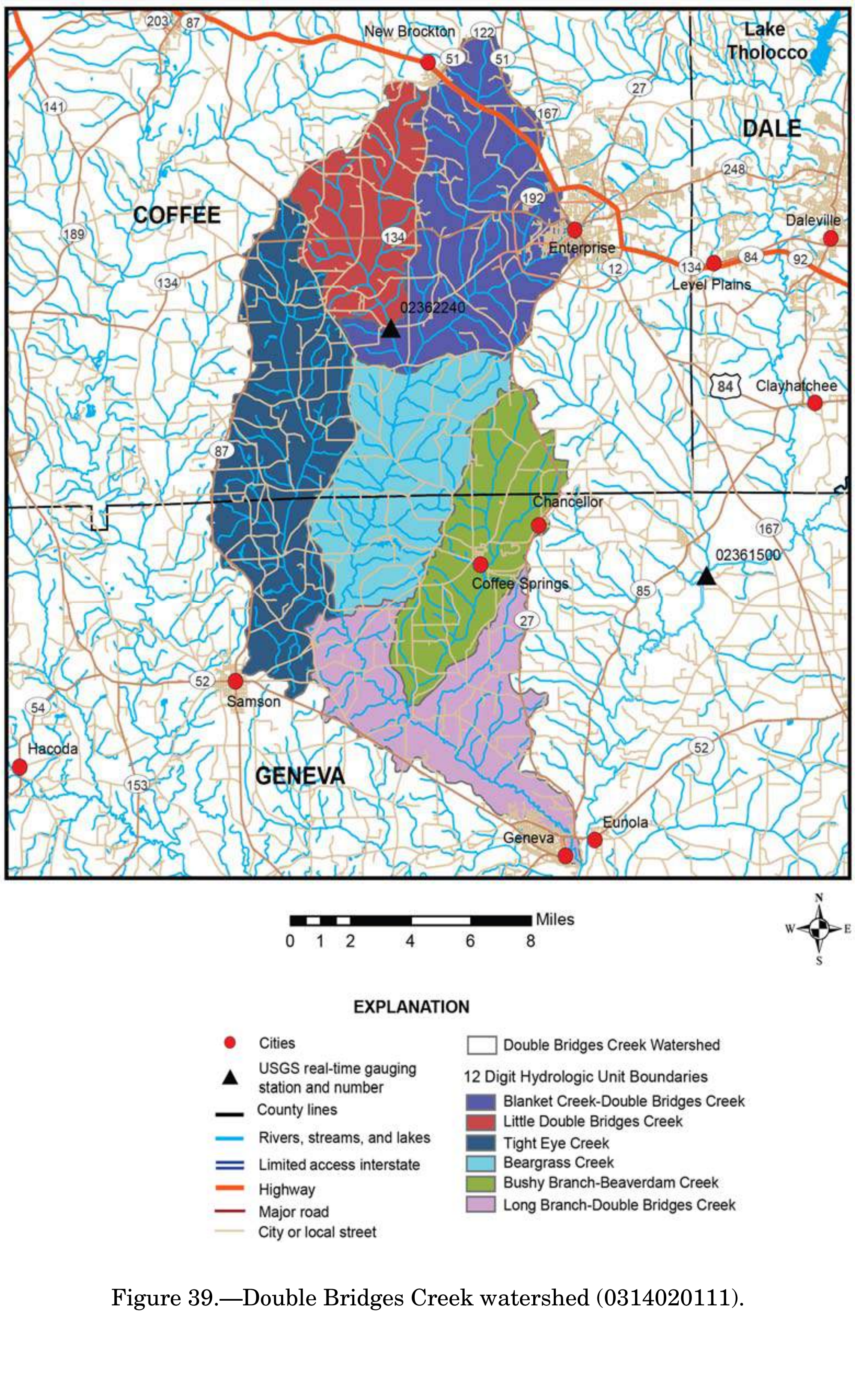

Figure 39.—Double Bridges Creek watershed (0314020111).

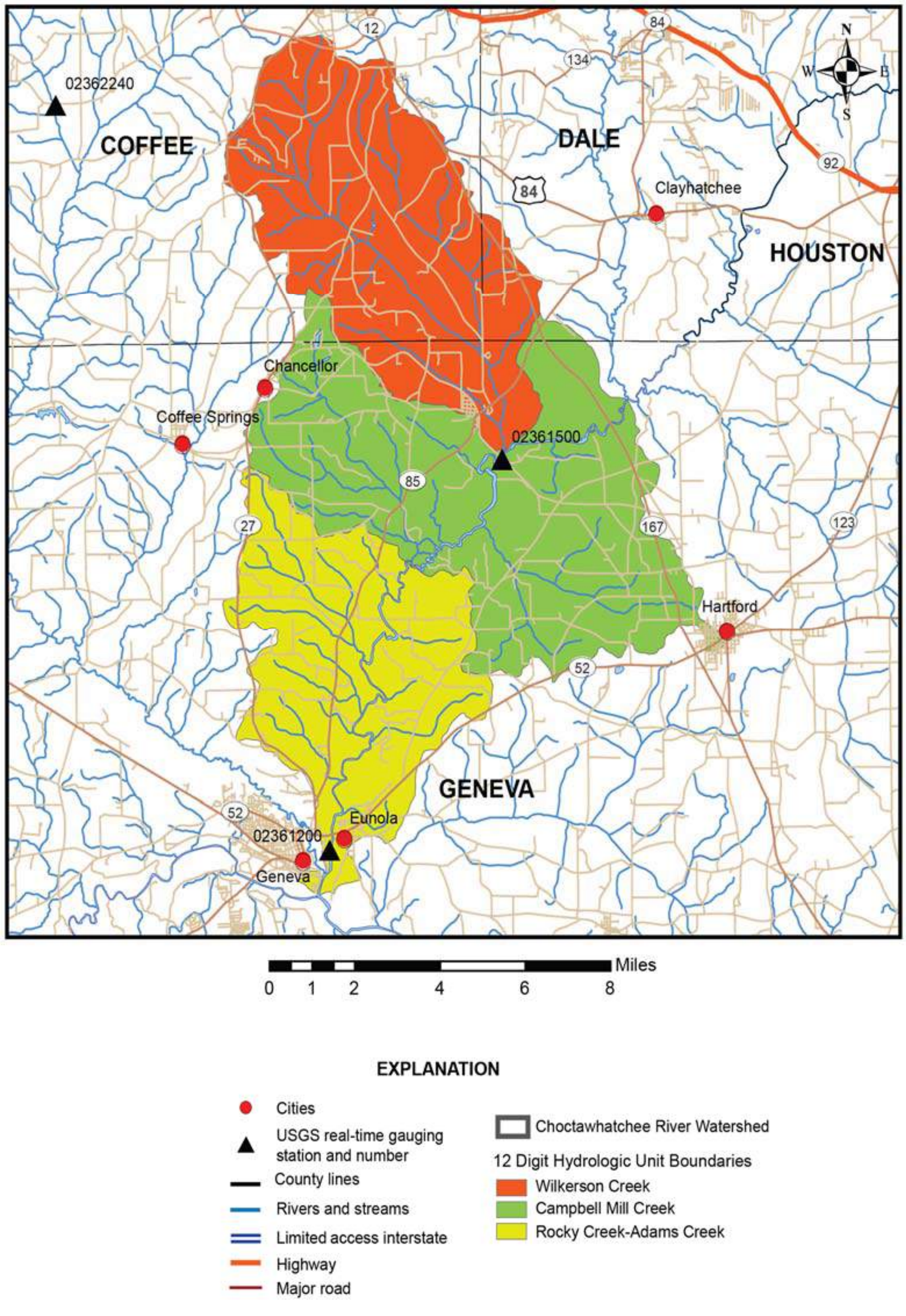

Figure 40.—Choctawhatchee River watershed (0314020112).

Table 20.—Watershed and subwatersheds in the Lower Choctawhatchee River Subbasin.

Subbasin (8-digit)	Watershed (10 digit)	Watershed Name	Subwatershed (12 digit)	Subwatershed Name	Acres	Square Miles
03140203	0314020301	East Pittman Creek-Choctawhatchee River	031402030101	Justice Mill Creek	9,168	14.33
03140203	0314020301	East Pittman Creek-Choctawhatchee River	031402030102	Upper Spring Creek	10,848	16.95
03140203	0314020301	East Pittman Creek-Choctawhatchee River	031402030103	Spring Creek-Choctawhatchee River	14,216	22.21
03140203	0314020301	East Pittman Creek-Choctawhatchee River	031402030104	Parrot Creek	1,669	2.61
03140203	0314020301	East Pittman Creek-Choctawhatchee River	031402030105	East Pittman Creek-Choctawhatchee River	7,283	11.38
03140203	0314020302	Wrights Creek	031402030201	Upper Wrights Creek	23,282	36.38
03140203	0314020302	Wrights Creek	031402030302	Ten Mile Creek	8,161	12.75
03140203	0314020307	Upper Holmes Creek	031402030701	Big Branch-Holmes Creek	11,220	17.53
Total					85,847	134

East Pittman Creek-Choctawhatchee River Watershed (0314020301) covers approximately 67 mi^2, and originates near Hartford in Geneva County and extends southward to the Alabama-Florida state line, southwest of the town of Geneva in south-central Geneva County. Five subwatersheds are located in this watershed: Justice Mill Creek, Upper Spring Creek, Spring Creek-Choctawhatchee River, East Pittman Creek-Choctawhatchee River, and Parrot Creek (fig. 41).

Wrights Creek Watershed (0314020302) covers approximately 50 mi^2 from just east of Slocomb in Geneva County and continues southwestward to the Alabama-Florida state line. Two subwatersheds are located within this watershed: Upper Wrights Creek and Ten Mile Creek (fig. 42).

Upper Holmes Creek Watershed (0314020307) covers approximately 18 mi^2 in the extreme southeast Geneva and southwest Houston Counties, terminating at the Alabama-Florida state line. One subwatershed is located within this watershed: Big Branch-Holmes Creek (fig. 43).

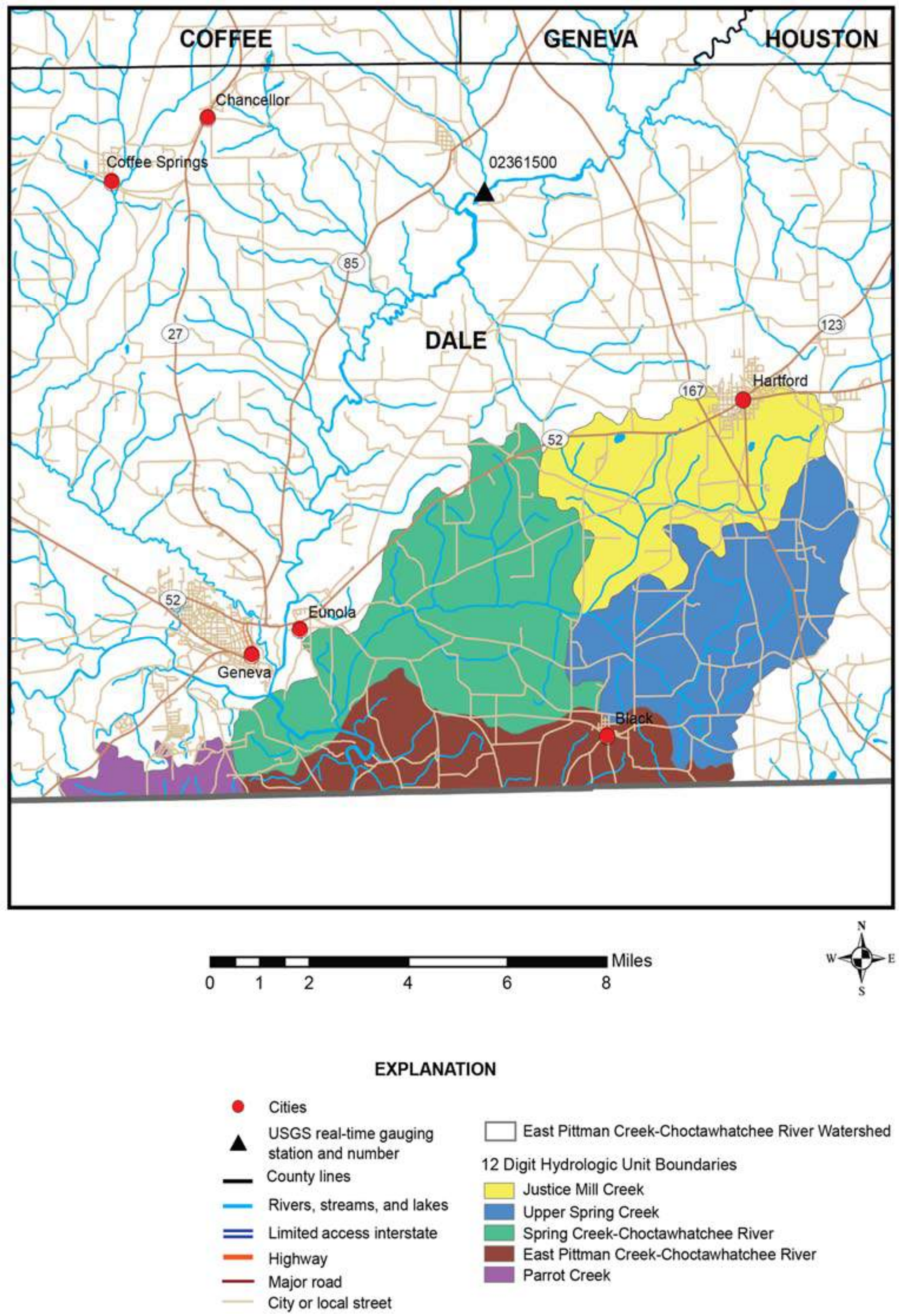

Figure 41.—East Pittman-Choctawhatchee River watershed (0314020301).

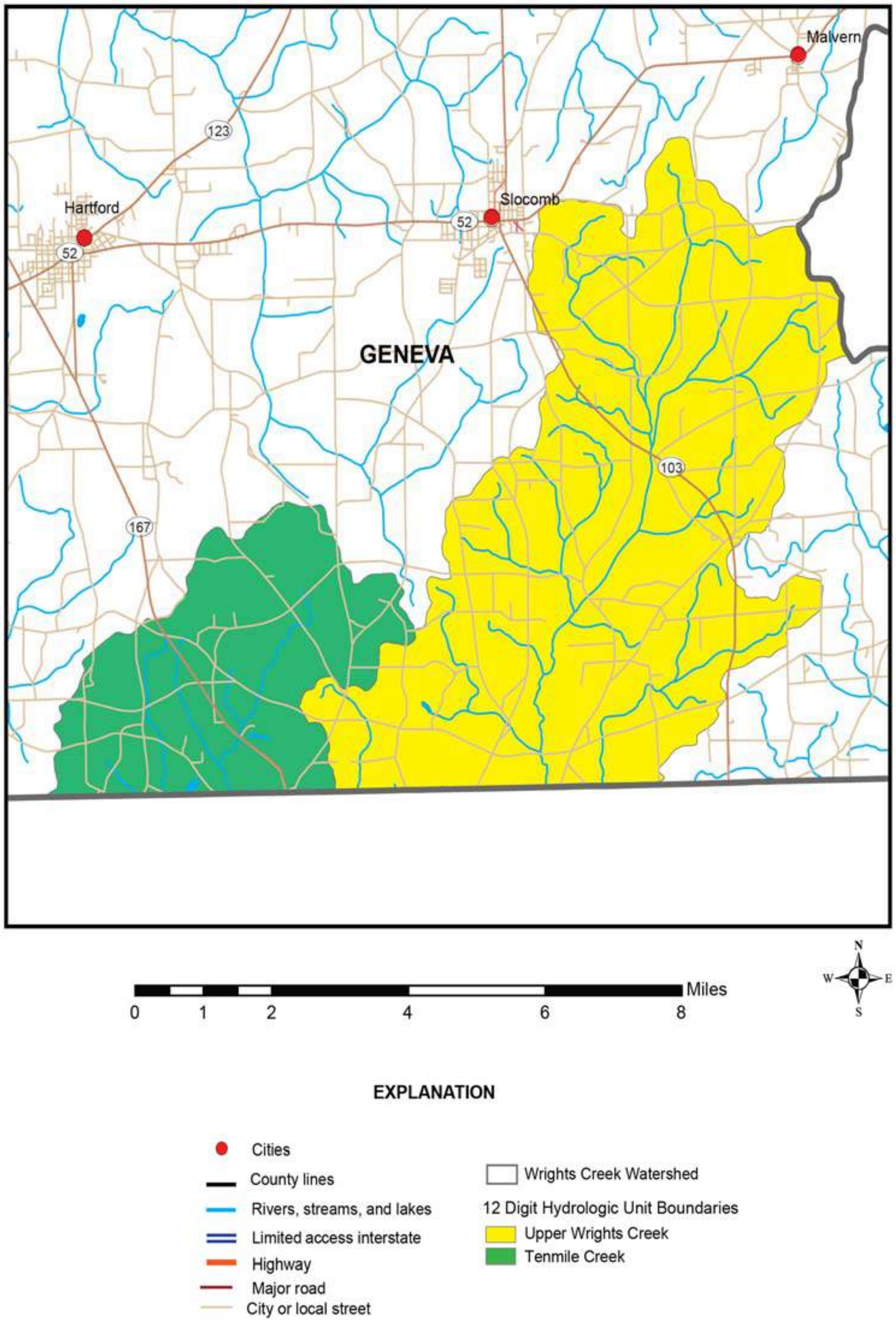

Figure 42.—Wrights Creek Watershed (0314020302).

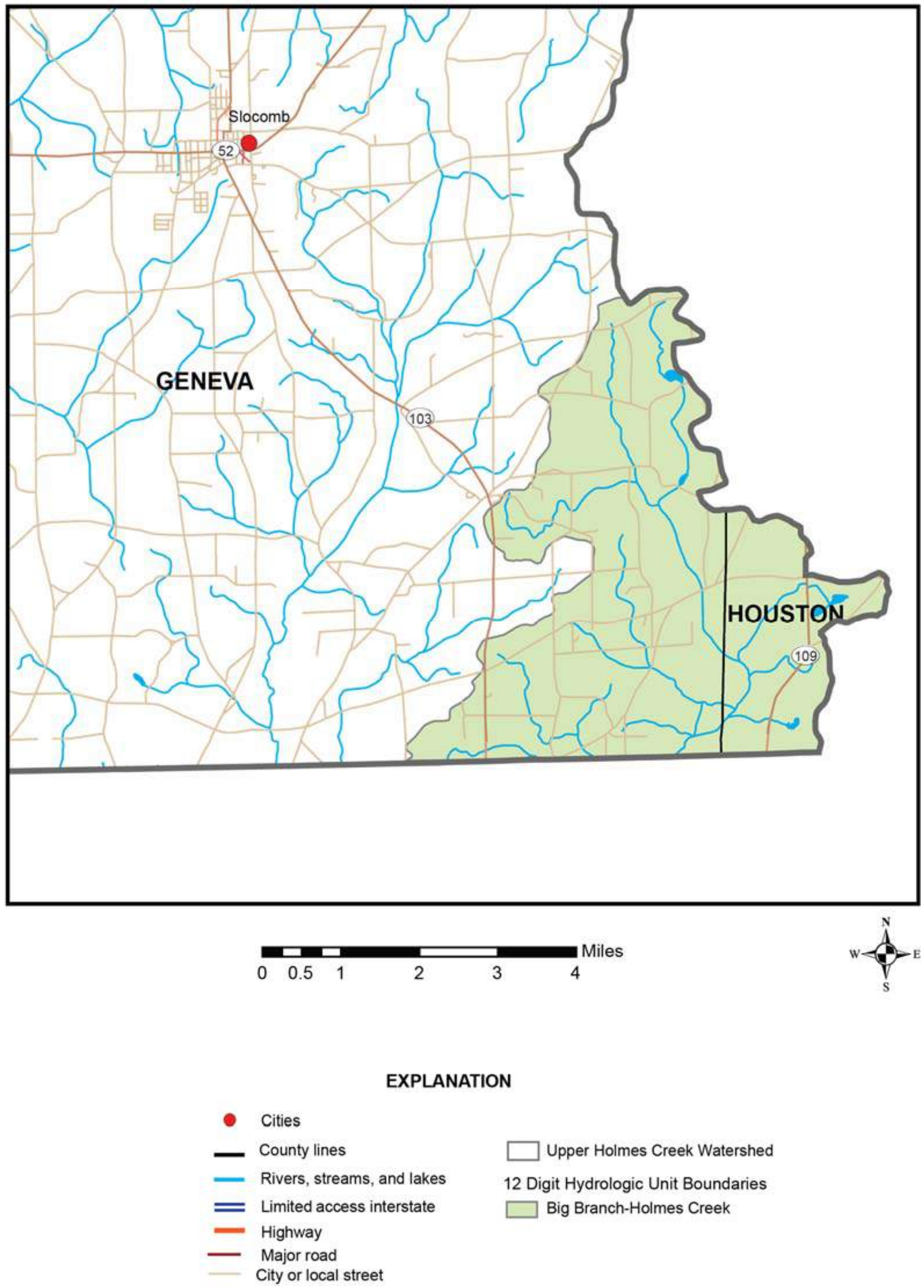

Figure 43.—Upper Holmes Creek watershed (0314020307).

PEA RIVER (03140202)

The Pea River subbasin covers approximately 1,445 mi^2 of the CPYRW (plate 1) and is in the central portion of the CPYRW. This watershed includes the Pea River from its headwaters at Midway in Bullock County, southwestward to the confluence of the Pea River with the Choctawhatchee at Geneva in south-central Geneva County. The Pea River subbasin is the longest subbasin in length, covering eight counties, and it is the second largest subbasin of the CPYRW (CWP and GSA, 2005). Nine watershed (10-digit) and 49 subwatersheds (12-digit) are located within this subbasin. The watersheds and subwatersheds are listed in table 21.

Pea Creek watershed (0314020201) covers approximately 105 mi^2 and is within Barbour County, originating in the central Barbour County, near Clayton, and extending southwestward to its confluence with the Pea River at the Barbour and Pike County line. Four subwatersheds are located within this watershed: Stinking Creek, Williams Mill Branch, Hurricane Creek-Pea Creek, and Pea Creek (fig. 44).

Headwaters Pea River watershed (0314020202) covers approximately 193 mi^2 and originates in southern Bullock County, extending southward into extreme northeastern Pike County and northwest Barbour County, along the Pea River. Seven subwatersheds are contained within this watershed: Johnson Creek-Headwaters Pea River, Fishers Lake-Spring Creek, Little Indian Creek, Bib Sandy Creek, Dry Creek-Pea River, Double Creek, and Conners Creek (fig. 45).

Buckhorn Creek watershed (0314020203) covers approximately 144 mi^2 with the northern portion in the southwest corner of Bullock County, extending southward to Brundidge in Pike County and eastward to Clio in Barbour County. Three subwatersheds are located within this watershed: Buckhorn Creek, Richland Creek, and Sand Creeks (fig. 46).

Whitewater Creek watershed (0314020201) covers approximately 317 mi^2, and extends from the cities of Bank and Brundidge in Pike County, southwestward to Elba in Coffee County. Nine subwatersheds are located within this watershed: Persimmon Branch-Walnut Creek, Beaver Pond Branch, Mims Creek, Silers Mill Creek, Smart Branch-Big Creek, Stinking Creek-Big Creek, Sweetwater Creek-Big Creek, Jump Creek, and Pea Creek-Whitewater Creek (fig. 47).

Upper Pea River watershed (0314020205) covers approximately 199 mi^2, originates in southeast of Brundidge in Pike County, and the extreme southwest corner of Barbour County, and extends southwestward through the extreme northwestern corner of Dale County, southwestward to Elba in Coffee County. Eight subwatersheds are located within this watershed: Bowden Mill Creek, Danner Creek Clearwater Creek, Huckleberry Creek, Turner Creek-Halls Creek, Cardwell Creek, and Harpers Mill Creek (fig. 48).

Middle Pea River watershed (0314020206) covers approximately 236 mi^2 and originates in the west central portion of Coffee County, northwest of Elba, and extends southward to Samson in Geneva County and westward to Opp in Covington County. Ten subwatersheds are located within this watershed: Beaver Dam Creek, Bucks Mill Creek, Helms Mill Creek, Hays Creek, Kimmy Creek, Pages Creek, Caney Branch-Cripple Creek, Holley Mill Creek, Bear Branch, and Samson Branch (fig. 49).

Table 21.—Watershed and subwatersheds in the Pea River Subbasin.

Subbasin (8-digit)	Watershed (10 digit)	Watershed Name	Subwatershed (12 digit)	Subwatershed Name	Acres	Square Miles
03140202	0314020201	Pea Creek	031402020101	Stinking Creek	12,812	20.02
03140202	0314020201	Pea Creek	031402020102	Williams Mill Branch	18,653	29.15
03140202	0314020201	Pea Creek	031402020103	Hurricane Creek-Pea Creek	13,014	20.33
03140202	0314020201	Pea Creek	031402020104	Pea Creek	22,833	35.68
03140202	0314020202	Headwaters Pea River	031402020201	Johnson Creek-Headwaters Pea River	27,377	42.78
03140202	0314020202	Headwaters Pea River	031402020202	Fishers Lake-Spring Creek	7,097	11.09
03140202	0314020202	Headwaters Pea River	031402020203	Little Indian Creek	14,422	22.53
03140202	0314020202	Headwaters Pea River	031402020204	Big Sandy Creek	11,581	18.10
03140202	0314020202	Headwaters Pea River	031402020205	Dry Creek-Pea River	27,529	43.01
03140202	0314020202	Headwaters Pea River	031402020206	Double Creek	16,059	25.09
03140202	0314020202	Headwaters Pea River	031402020207	Conners Creek	19,709	30.80
03140202	0314020203	Buckhorn Creek	031402020301	Buckhorn Creek	37,900	59.22
03140202	0314020203	Buckhorn Creek	031402020302	Sand Creek	19,703	30.79
03140202	0314020203	Buckhorn Creek	031402020303	Richland Creek	34,586	54.04
03140202	0314020204	Whitewater Creek	031402020401	Persimmon Branch-Walnut Creek	28,111	43.92
03140202	0314020204	Whitewater Creek	031402020402	Beaver Pond Branch	20,618	32.22
03140202	0314020204	Whitewater Creek	031402020403	Mims Creek	32,522	50.82
03140202	0314020204	Whitewater Creek	031402020404	Silers Mill Creek	7,024	10.98
03140202	0314020204	Whitewater Creek	031402020405	Smart Branch-Big Creek	25,718	40.18
03140202	0314020204	Whitewater Creek	031402020406	Stinking Creek-Big Creek	14,379	22.47
03140202	0314020204	Whitewater Creek	031402020407	Sweetwater Creek-Big Creek	25,172	39.33
03140202	0314020204	Whitewater Creek	031402020408	Jump Creek	28,353	44.30
03140202	0314020204	Whitewater Creek	031402020409	Pea Creek-Whitewater Creek	20,680	32.31
03140202	0314020205	Upper Pea River	031402020501	Bowden Mill Creek	11,891	18.58
03140202	0314020205	Upper Pea River	031402020502	Danner Creek	23,671	36.99
03140202	0314020205	Upper Pea River	031402020503	Clearwater Creek	14,231	22.24

Table 21.—Watershed and subwatersheds in the Pea River Subbasin—continued.

Subbasin (8-digit)	Watershed (10 digit)	Watershed Name	Subwatershed (12 digit)	Subwatershed Name	Acres	Square Miles
03140202	0314020205	Upper Pea River	031402020504	Huckleberry Creek	13,051	20.39
03140202	0314020205	Upper Pea River	031402020505	Turner Creek-Halls Creek	15,435	24.12
03140202	0314020205	Upper Pea River	031402020506	Cardwell Creek	25,940	40.53
03140202	0314020206	Middle Pea River	031402020609	Bear Branch	14,398	22.50
03140202	0314020205	Upper Pea River	031402020507	Harpers Mill Creek	23,219	36.28
03140202	0314020206	Middle Pea River	031402020601	Beaver Dam Creek	19,246	30.07
03140202	0314020206	Middle Pea River	031402020602	Bucks Mill Creek	19,950	31.17
03140202	0314020206	Middle Pea River	031402020603	Helms Mill Creek	17,342	27.10
03140202	0314020206	Middle Pea River	031402020604	Hays Creek	10,857	16.96
03140202	0314020206	Middle Pea River	031402020605	Kimmy Creek	8,349	13.05
03140202	0314020206	Middle Pea River	031402020606	Pages Creek	9,484	14.82
03140202	0314020206	Middle Pea River	031402020607	Caney Branch-Cripple Creek	12,529	19.58
03140202	0314020206	Middle Pea River	031402020608	Holley Mill Creek	14,423	22.54
03140202	0314020206	Middle Pea River	031402020610	Samson Branch	24,568	38.39
03140202	0314020207	Flat Creek	031402020701	Cowhead Creek-Panther Creek	20,162	31.50
03140202	0314020207	Flat Creek	031402020702	Shotbag Creek-Flat Creek	37,426	58.48
03140202	0314020208	Corner Creek	031402020802	Corner Creek	33,430	52.23
03140202	0314020208	Corner Creek	031402020803	Lower Eightmile Creek	18,577	29.03
03140202	0314020209	Lower Pea River	031402020901	Gin Creek-Pea River	11,074	17.30
03140202	0314020209	Lower Pea River	031402020903	Limestone Branch	2,397	3.75
03140202	0314020209	Lower Pea River	031402020904	Hurricane Creek-Pea River	5,672	8.86
03140202	0314020209	Lower Pea River	031402020905	Sandy Creek	19,584	30.60
03140202	0314020209	Lower Pea River	031402020906	Limestone Branch-Pea River	12,077	18.87
Total					924,835	1,445

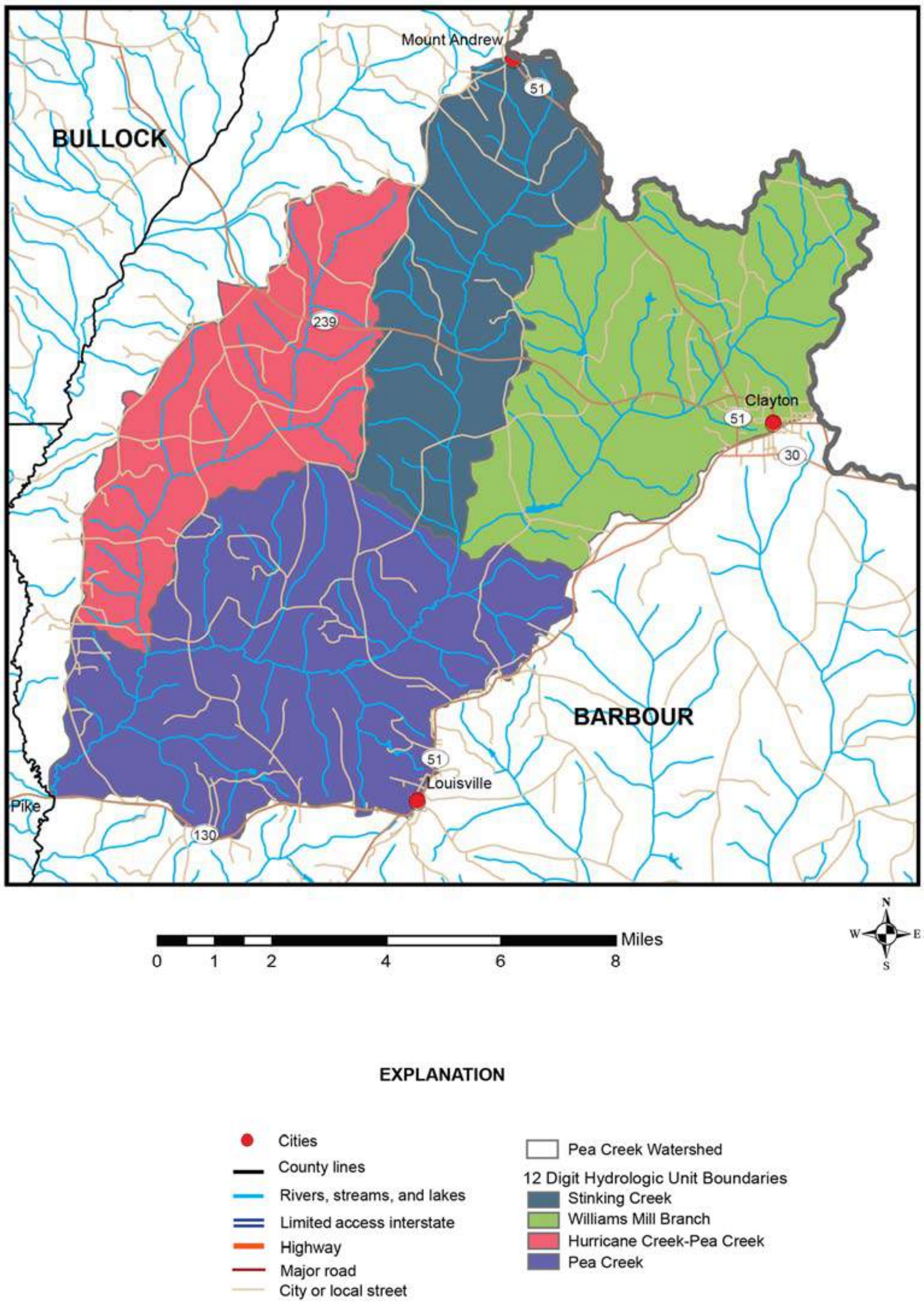

Figure 44.—Pea Creek watershed (0314020201).

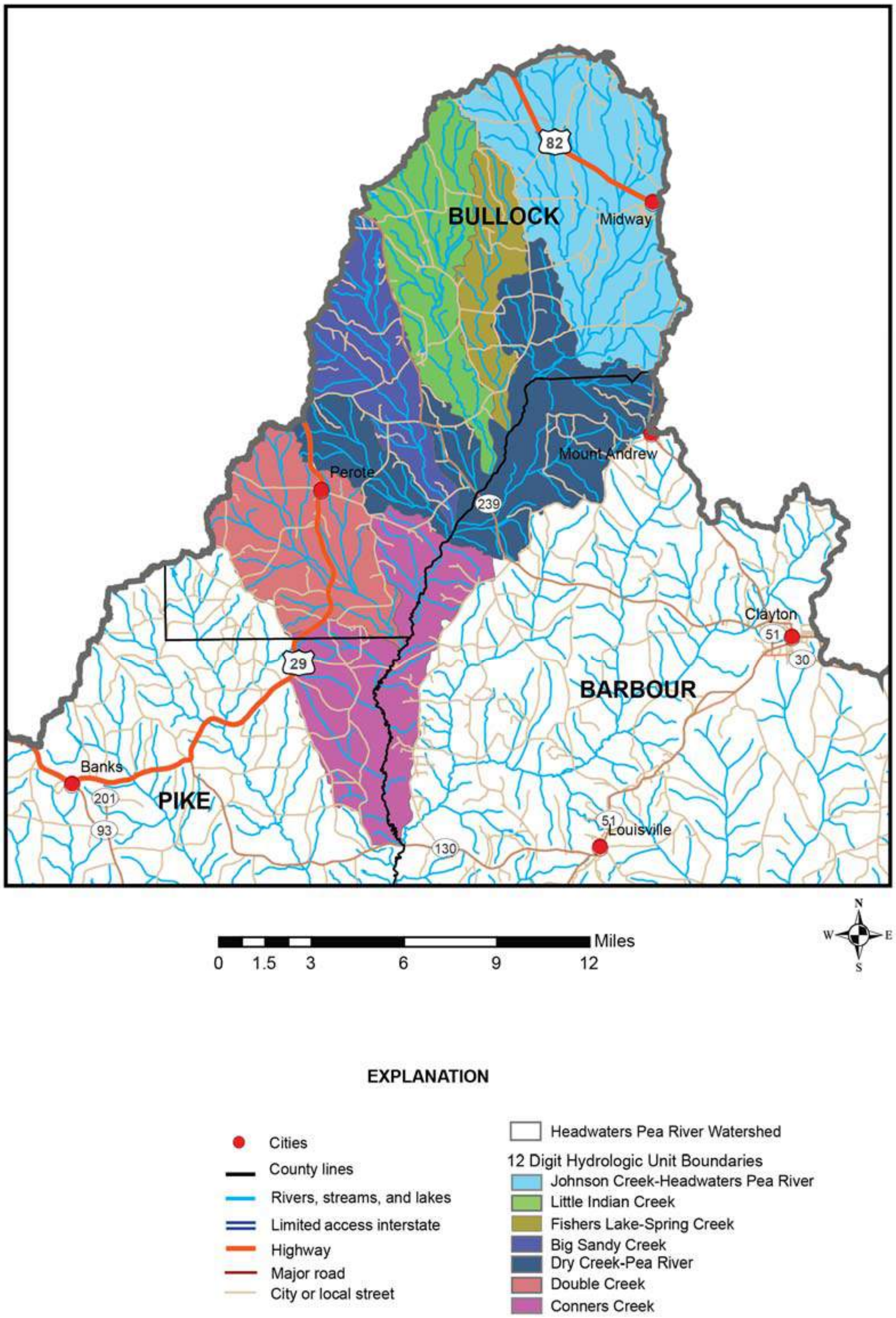

Figure 45.—Headwaters Pea River watershed (0314020202).

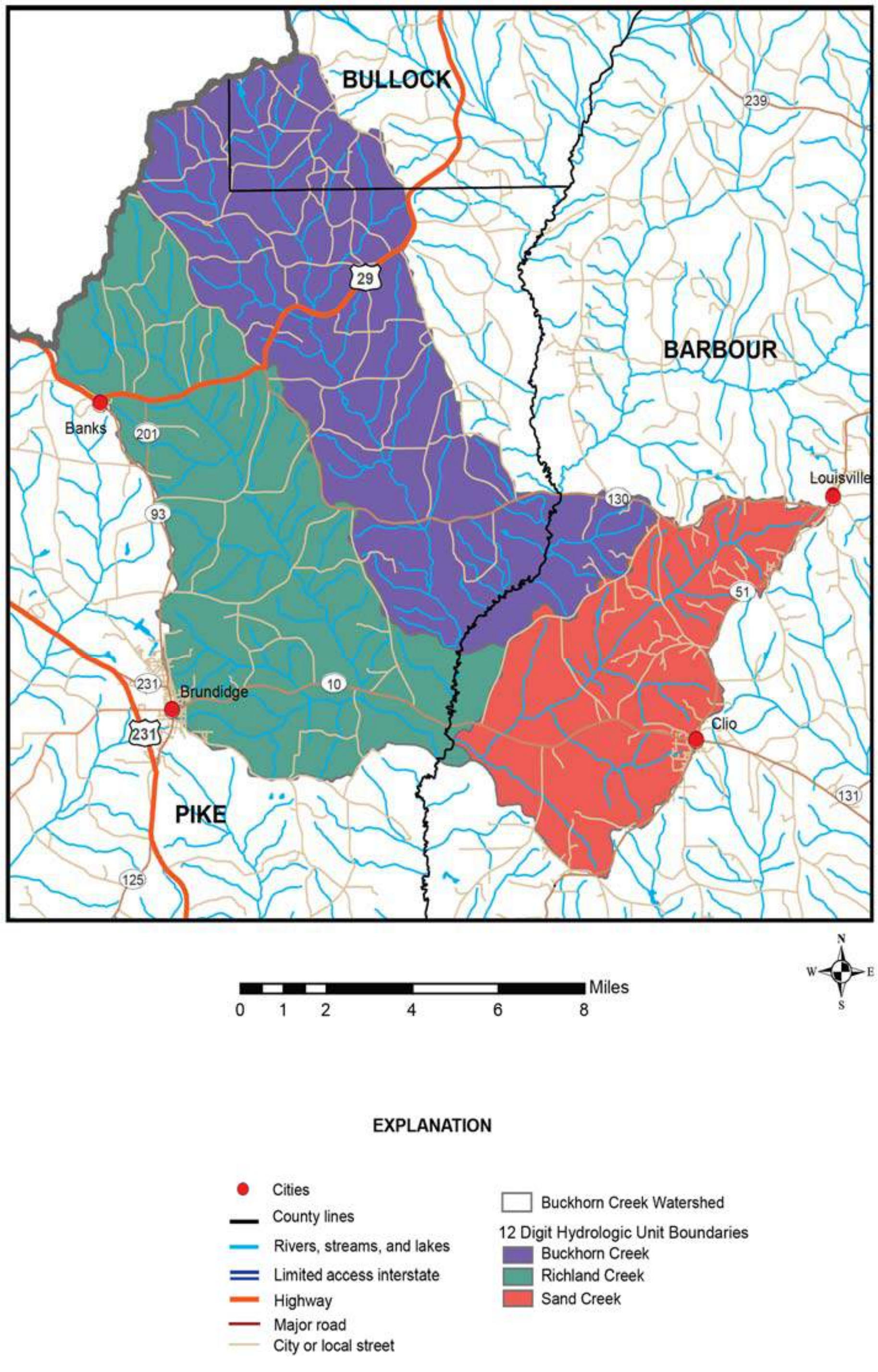

Figure 46.—Buckhorn Creek watershed (0314020203).

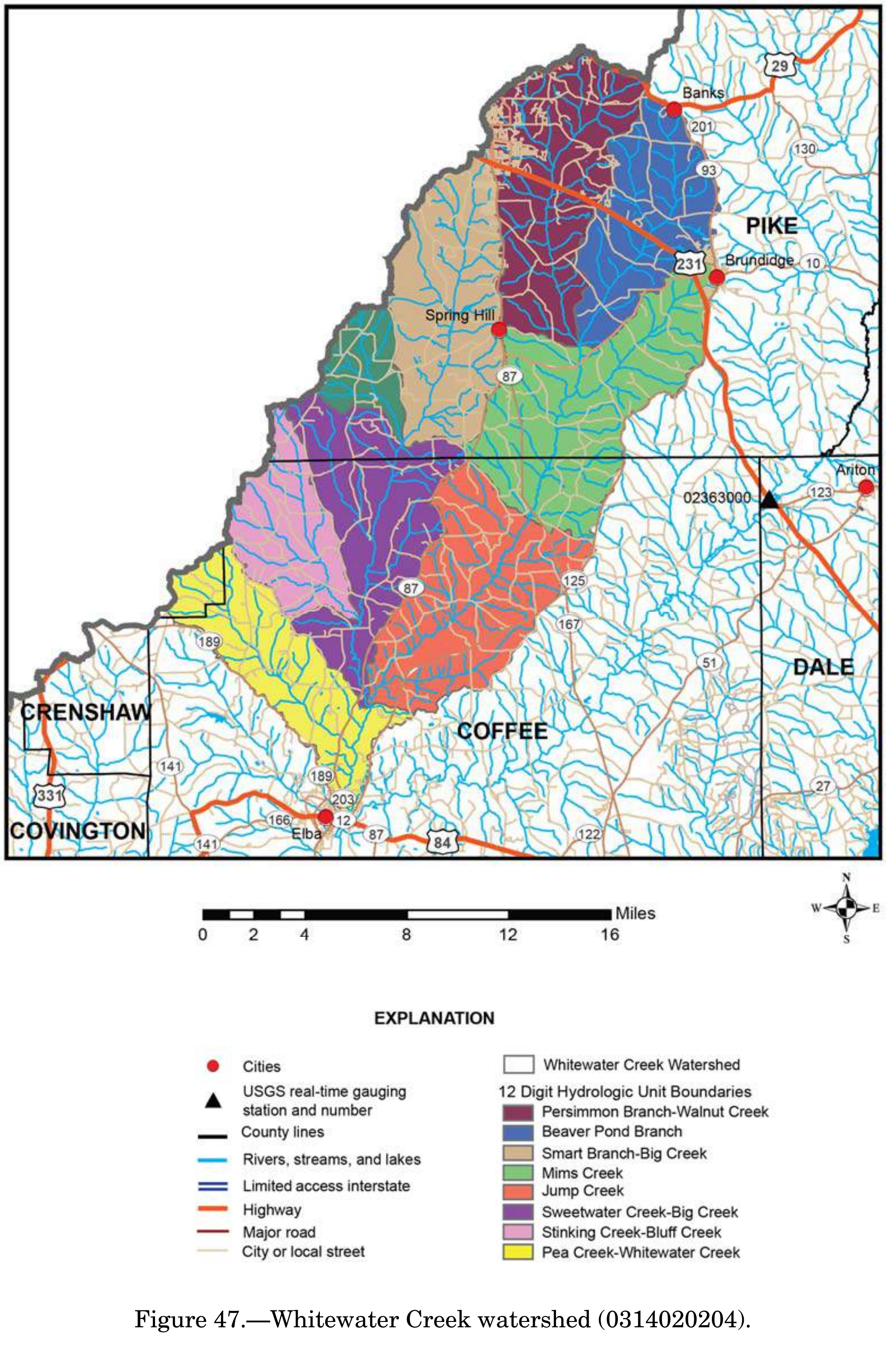

Figure 47.—Whitewater Creek watershed (0314020204).

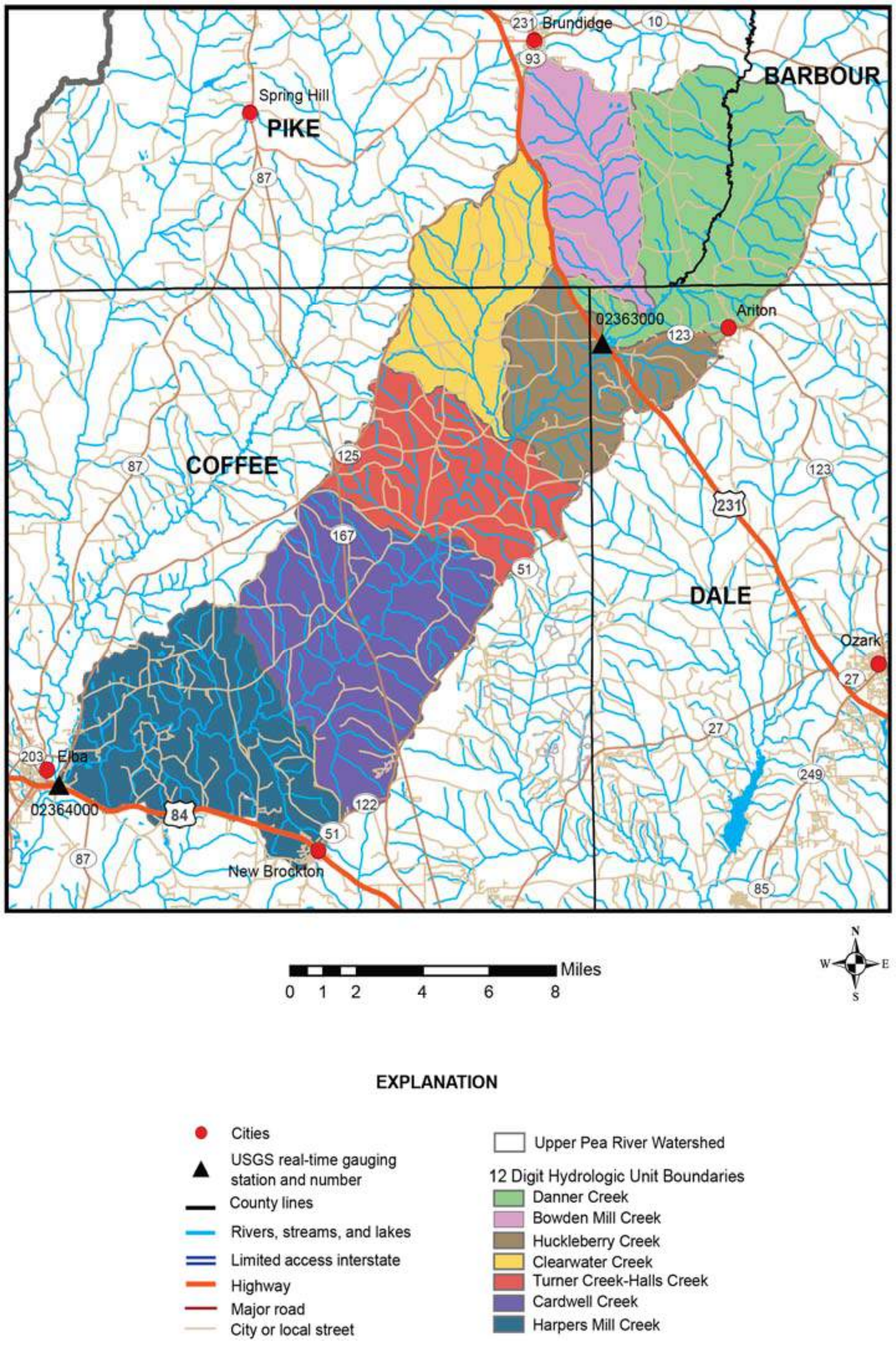

Figure 48.—Upper Pea River watershed (0314020205).

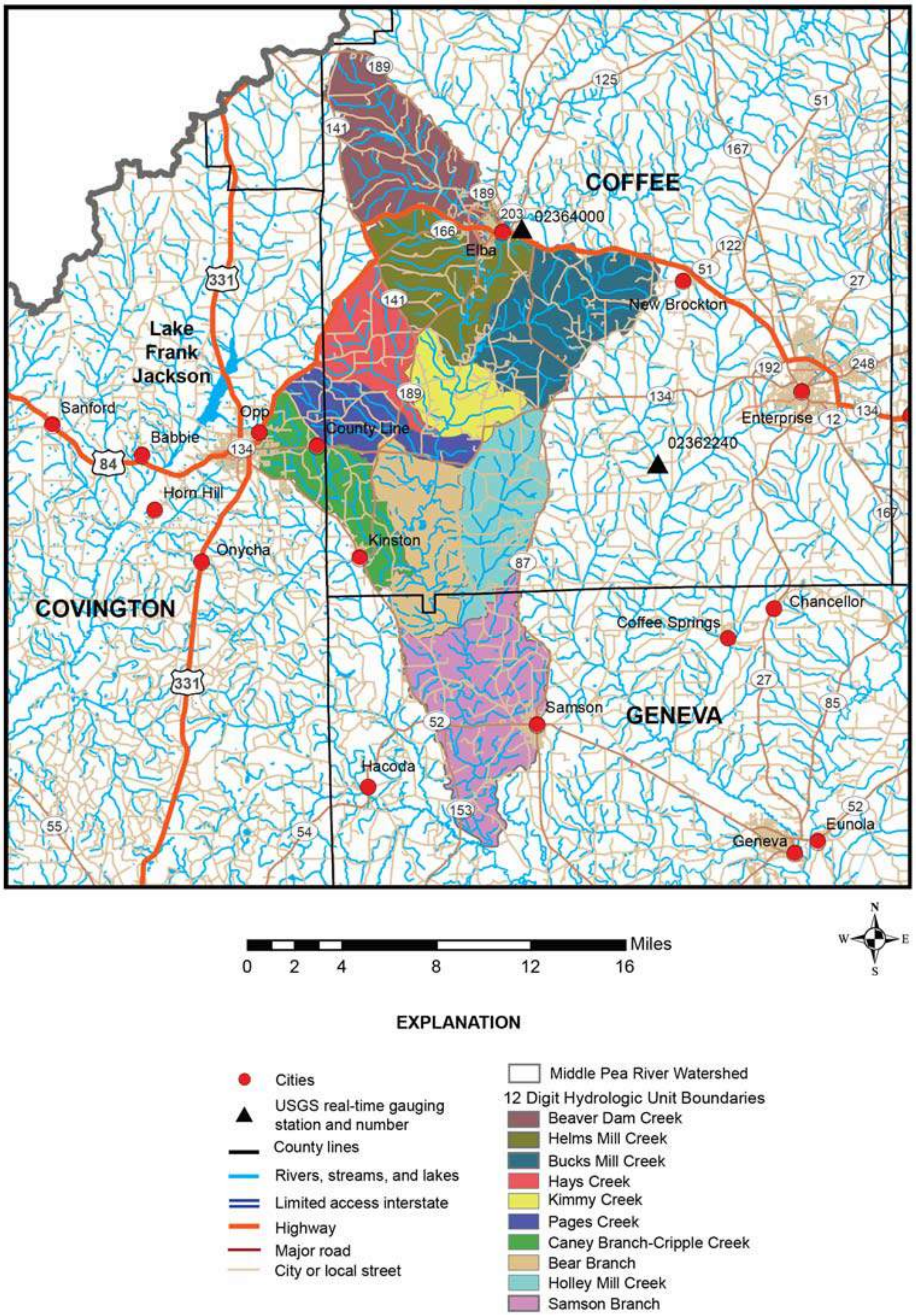

Figure 49.—Middle Pea River watershed (0314020206).

Flat Creek Watershed (0314020207) covers 90 mi^2 and begins in Covington County, just south of Opp, and extends southward along U.S. Highway 331 within 2 miles of the Alabama-Florida state line, and also extends southeastward from Opp through Kinston in Coffee County to within 1 mile of the Alabama Florida state line. Two subwatersheds are located within this watershed: Cowhead Creek-Panther Creek and Shotbag Creek-Flat Creek (fig. 50).

Corner Creek watershed (0314020208) covers approximately 81 mi^2 along the Alabama-Florida state line, extending from Florala in Covington County northeastward into Geneva County. Two subwatersheds are located within this watershed: Corner Creek and Lower Eightmile Creek (fig. 51).

Lower Pea River watershed (0314020209) covers approximately 79 mi^2 and originates in Samson and Geneva County, extending southward to the Alabama-Florida state line. Five subwatersheds are located within this watershed: Gin Creek-Pea River, Limestone Creek-Pea River, Hurricane Creek-Pea River, Sandy Creek, and Limestone Branch-Pea River (fig. 52).

YELLOW RIVER (03140103)

The Yellow River Subbasin comprises approximately 556 mi^2 of the southwestern part of the CPYRW (plate 1), including the Yellow River from its headwaters in the southeast corner of Crenshaw County through the majority of Covington County to the Alabama Florida state line. Yellow River is the only subbasin in the Florida Panhandle Coastal Basin (031401) of the CPYRW. There are five watersheds (10-digit) and 17subwatersheds (12-digits) within this subbasin (table 22).

Headwaters Yellow River watershed (0314010301) covers approximately 159 mi^2 and originates in the southeast corner of Crenshaw County, continuing southward into extreme northwest Coffee County and into the cities of Opp and Horn Bill in Covington County, and includes Lake Frank Jackson in Covington County. Four subwatersheds are located within this watershed: Pond Creek, Lightwood Knot Creek, Poley Creek-Lightwood Knot Creek, and Yellow River (fig. 53).

Five Runs Creek Watershed (0314010302) covers approximately 123 mi^2, entirely within Covington County. Three subwatersheds are located within this watershed: Bay Branch Creek, Hog Foot Creek, and Five Runs Creek (fig. 54).

Upper Yellow River watershed (0314010303) covers approximately 162 mi^2 in Covington County, with northern boundaries at Sanford and Opp, and extending east along U.S. Highway 331 to within 1 mile of the Alabama-Florida state line. Five subwatersheds are located within this watershed: Mulberry Fork-Indian Creek, Taylor Mill Creek-Yellow River, Dry Creek-Clear Creek, Poplar Creek-Yellow River, and North Creek (fig. 55).

Middle Yellow River watershed (0314010304) covers approximately 95 mi^2, entirely within Covington County, adjacent to the Alabama-Florida state line, west of Florala in the south-central portion of Covington County. Three subwatersheds are located within this watershed: Larkin Creek-Yellow River, Big Creek-Yellow River, and Big Horse Creek-Yellow River (fig. 56).

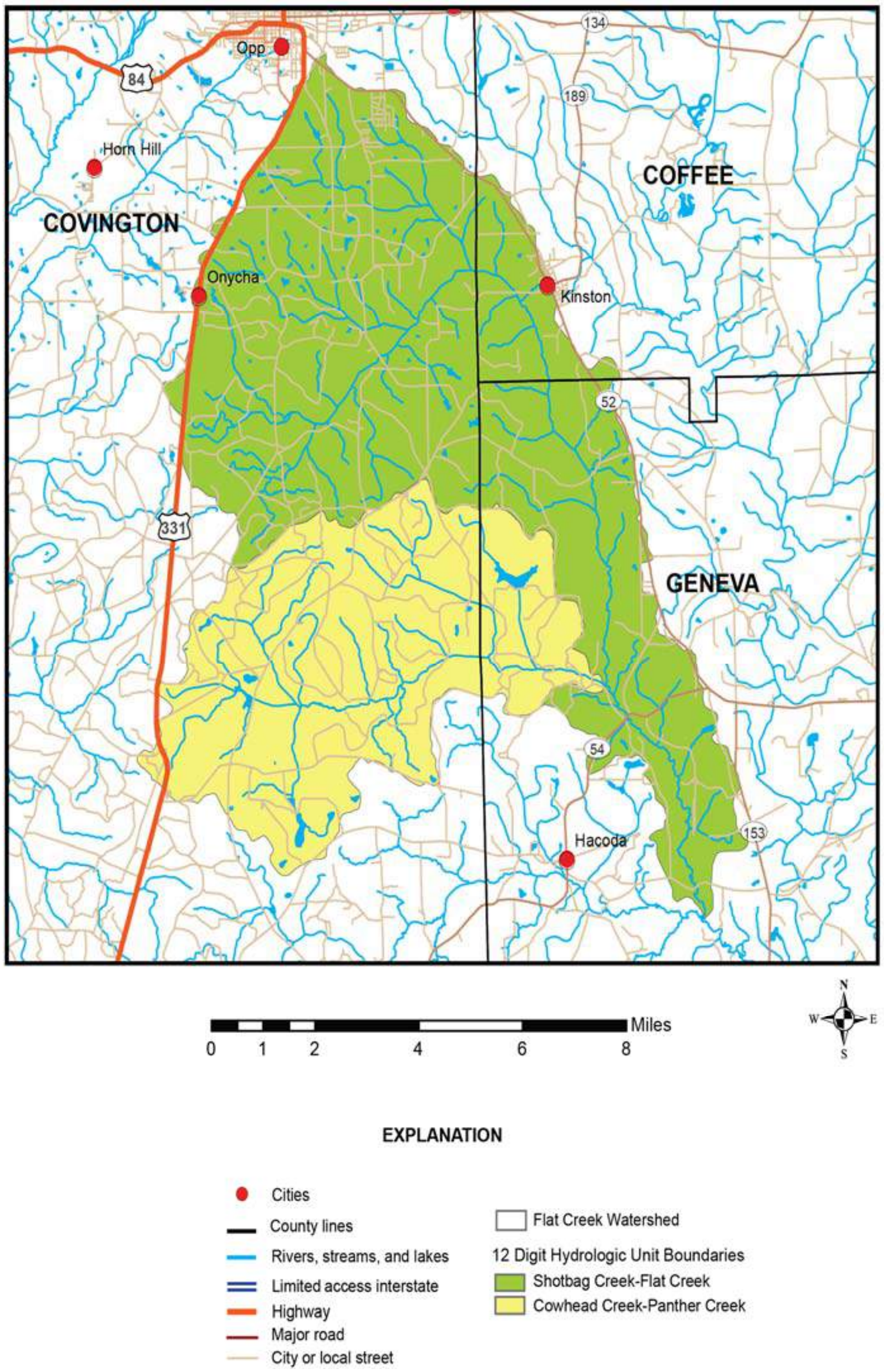

Figure 50.—Flat Creek watershed (0314020207).

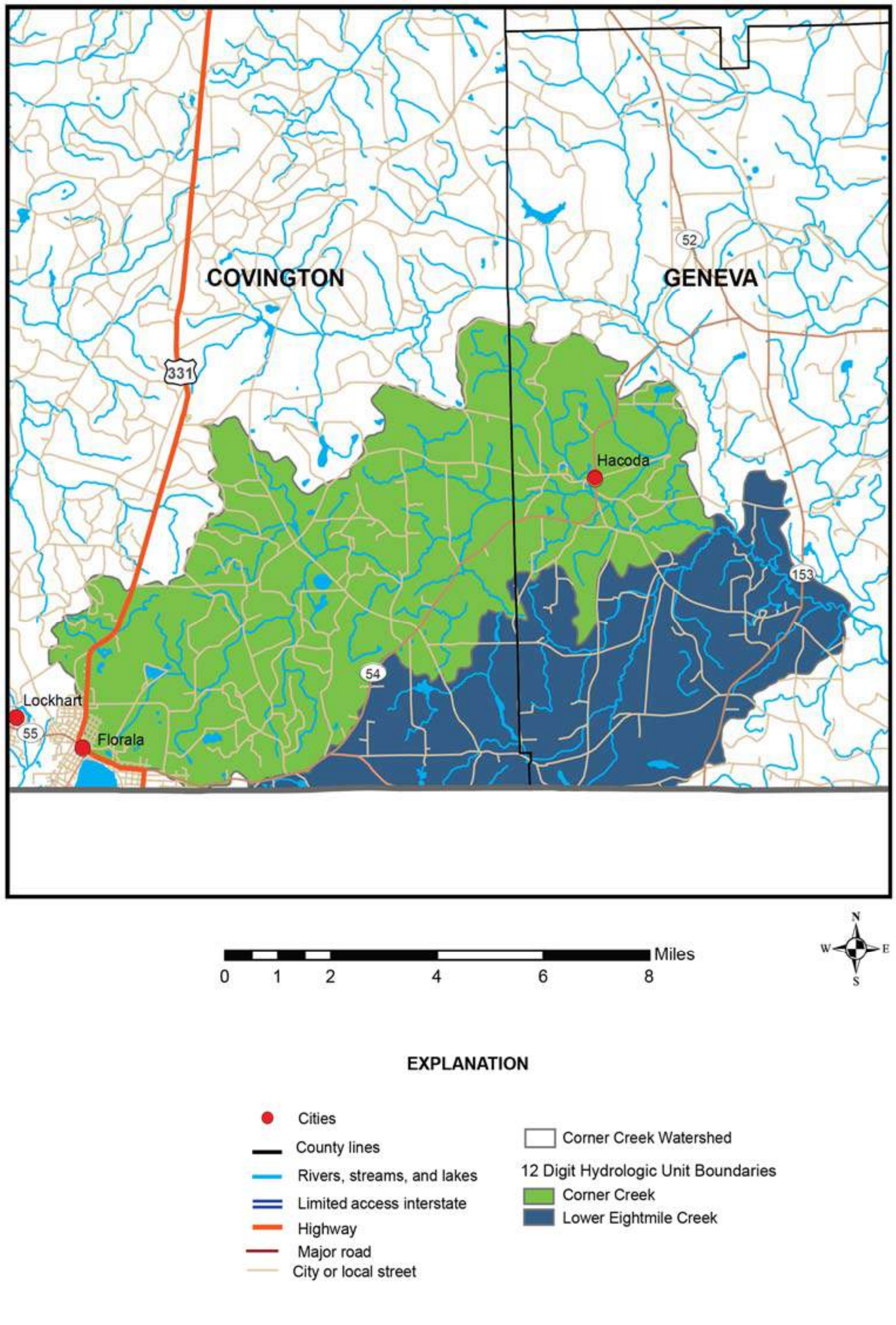

Figure 51.—Corner Creek watershed (0314020208).

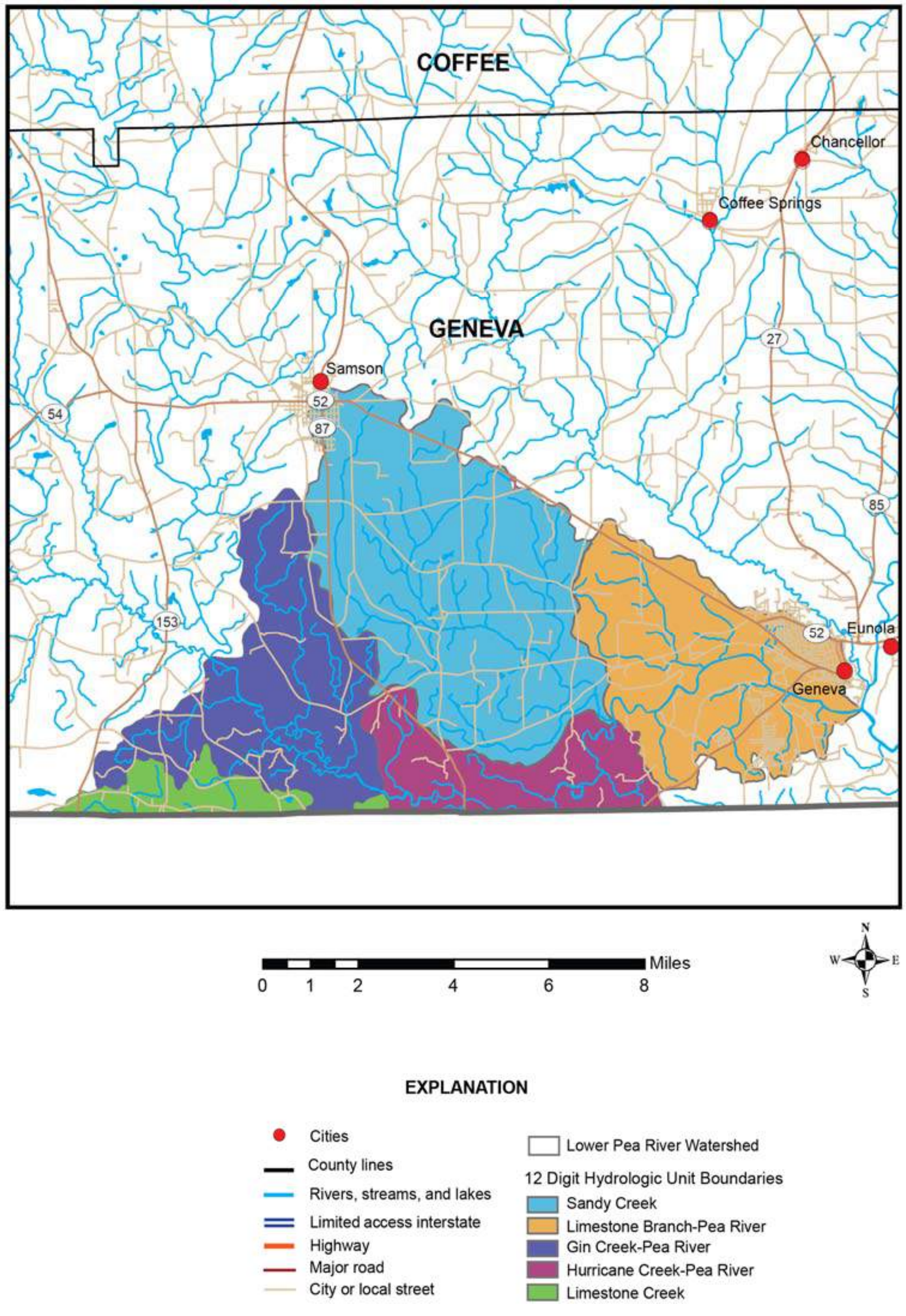

Figure 52.—Lower Pea River watershed (0314020209).

Table 22.—Watershed and subwatersheds in the Yellow River Subbasin.

Subbasin (8-digit)	Watershed (10 digit)	Watershed Name	Subwatershed (12 digit)	Subwatershed Name	Acres	Square Miles
03140103	0314010301	Headwaters Yellow River	031401030101	Pond Creek	12,663	19.79
03140103	0314010301	Headwaters Yellow River	031401030102	Lightwood Knot Creek	37,030	57.86
03140103	0314010301	Headwaters Yellow River	031401030103	Poley Creek-Lightwood Knot Creek	26,011	40.64
03140103	0314010301	Headwaters Yellow River	031401030104	Yellow River	25,800	40.31
03140103	0314010302	Five Runs Creek	031401030201	Bay Branch Creek	34,025	53.16
03140103	0314010302	Five Runs Creek	031401030202	Hog Foot Creek	16,357	25.56
03140103	0314010302	Five Runs Creek	031401030203	Five Runs Creek	28,112	43.93
03140103	0314010303	Upper Yellow River	031401030301	Mulberry Fork-Indian Creek	14,443	22.57
03140103	0314010303	Upper Yellow River	031401030302	Taylor Mill Creek-Yellow River	15,354	23.99
03140103	0314010303	Upper Yellow River	031401030303	Dry Creek-Clear Creek	32,378	50.59
03140103	0314010303	Upper Yellow River	031401030304	Poplar Creek-Yellow River	22,221	34.72
03140103	0314010303	Upper Yellow River	031401030305	North Creek	19,160	29.94
03140103	0314010304	Middle Yellow River	031401030401	Larkin Creek-Yellow River	21,103	32.97
03140103	0314010304	Middle Yellow River	031401030402	Big Creek-Yellow River	11,328	17.70
03140103	0314010304	Middle Yellow River	031401030403	Big Horse Creek-Yellow River	28,343	44.29
03140103	0314010306	Pond Creek-Shoal River	031401030601	Fleming Creek-Pond Creek	5,440	8.50
03140103	0314010306	Pond Creek-Shoal River	031401030602	Horsehead Creek	6,189	9.67
Total					355,957	556

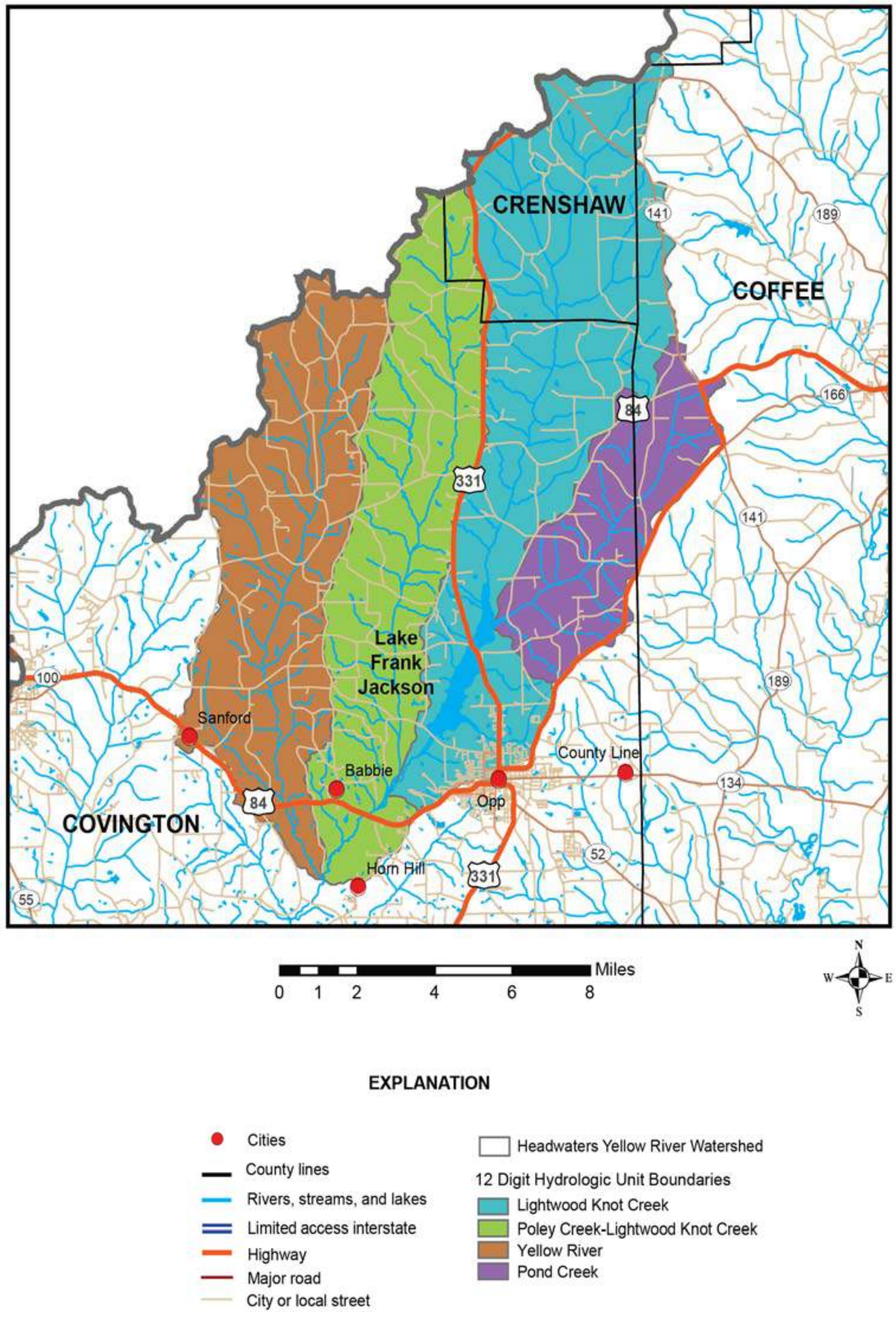

Figure 53.—Headwaters Yellow River watershed (0314010301).

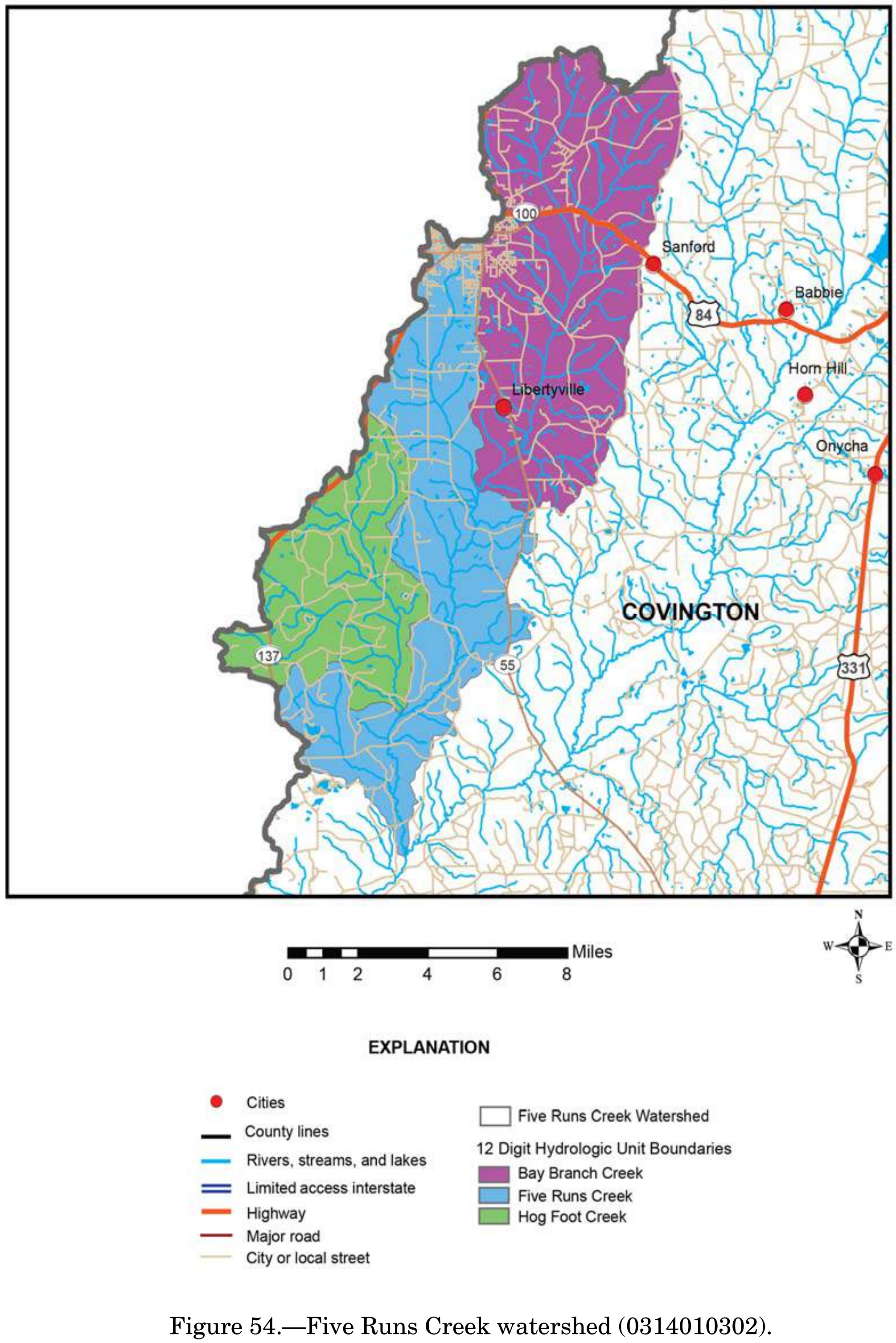

Figure 54.—Five Runs Creek watershed (0314010302).

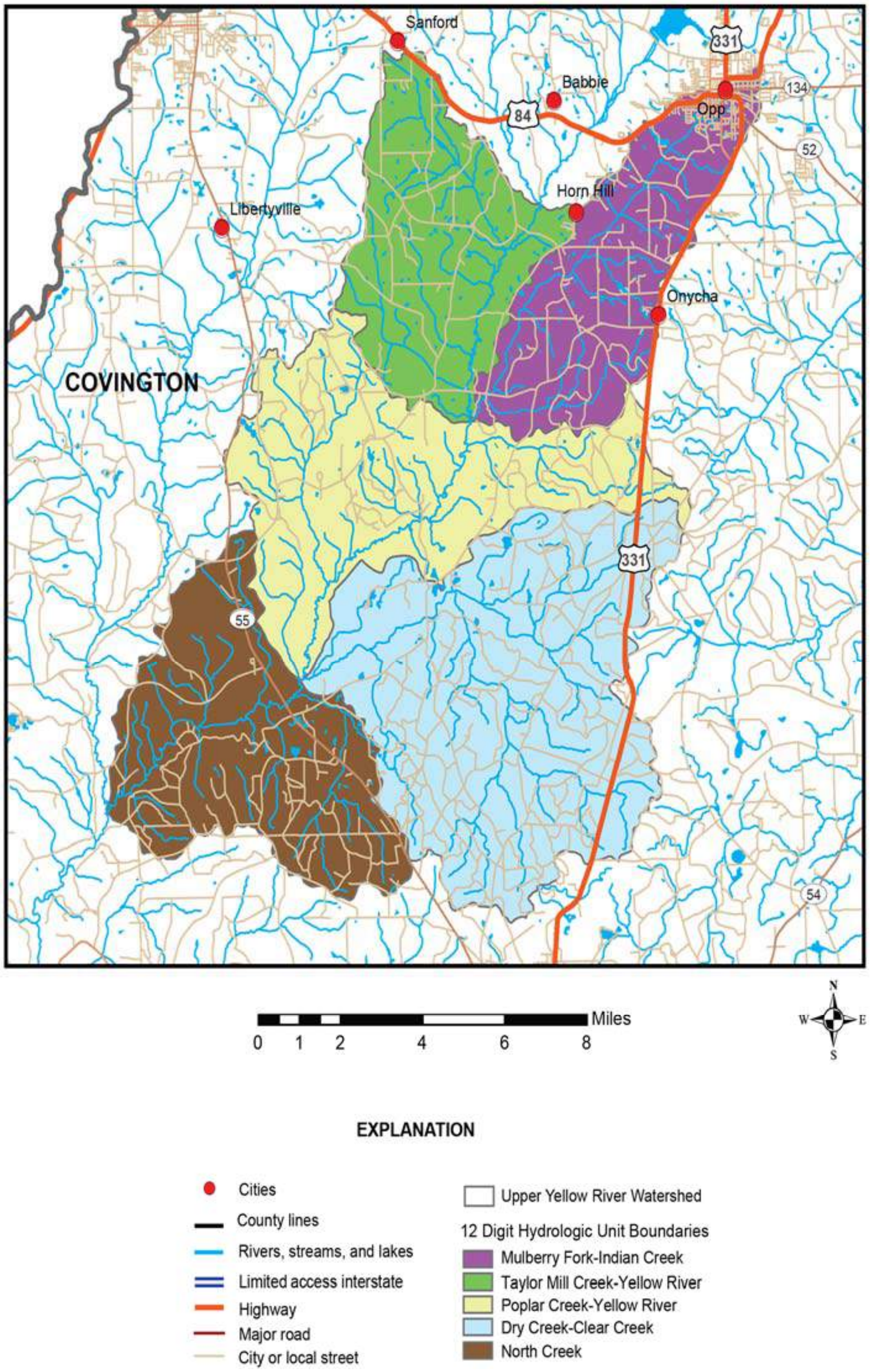

Figure 55.—Upper Yellow River watershed (0314010303).

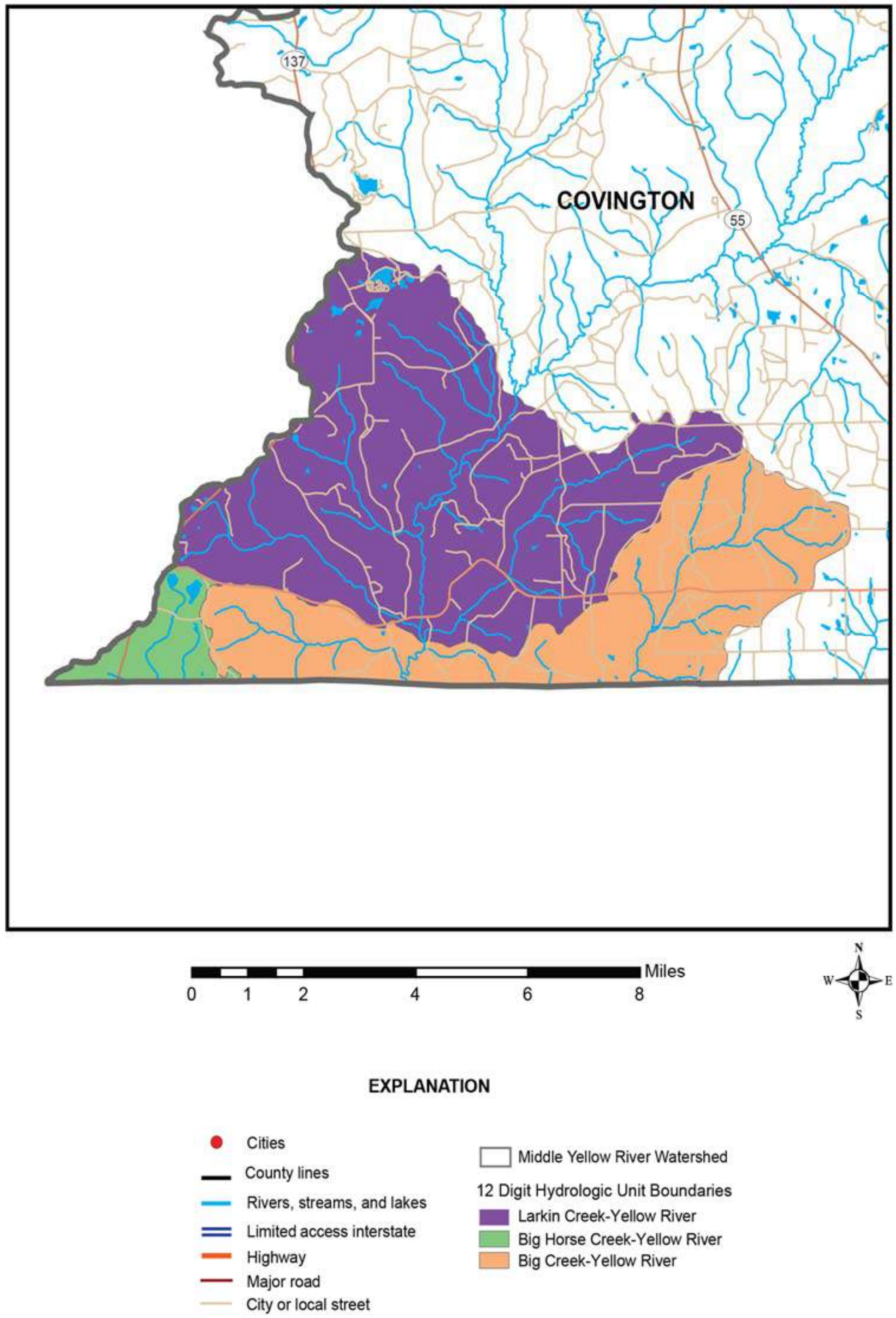

Figure 56.—Middle Yellow River watershed (0314010304).

Pond Creek-Shoal River Watershed (0314010306) covers approximately 18 mi² in Covington County, adjacent to the Alabama Florida state line, and also includes a portion of Lake Jackson. Two subwatersheds are within this watershed: Fleming Creek-Pond Creek and Horsehead Creek (fig. 57).

GROUNDWATER RESOURCES

Groundwater in the CPYRW occurs in porous sand, gravel, clay, and limestone under water table and artesian conditions. Precipitation, primarily in the form of rainfall, infiltrates the ground surface in a geologic unit's area of outcrop and percolates downward until coming into contact with a confining unit (mainly clay) and moving laterally or downdip. Plate 3 depicts the geologic units in the study area.

Geologic units composed of lithologies with adequate porosity and permeability to transmit economic quantities of water are classified as aquifers. The CPYRW has 10 primary aquifers named in older to younger geologic age as: Coker and Gordo Formations of the Tuscaloosa Group, Eutaw Formation, Providence Sand, Ripley Formation Cusseta Sand member, Nanafalia Formation, Salt Mountain Limestone, Clayton Formation, Lisbon Formation, and Eocene-Pleistocene undifferentiated. Although not currently an aquifer in Alabama, recent research by the GSA has identified the Lower Cretaceous undifferentiated as a potential major aquifer for the northern part of the CPYRW (Cook and others, 2013). Plate 3 shows the aquifers and their recharge areas in the CPYRW.

TUSCALOOSA GROUP AQUIFER

The Tuscaloosa Group aquifer is composed of the Gordo and Coker aquifers, with the recharge area extending through Macon County eastward to the Chattahoochee River (USGS, 1993). The Tuscaloosa Group aquifers are differentiated in the subsurface, but are described as undifferentiated in the recharge area (Osborne and others, 1989).

COKER AQUIFER

The Coker aquifer provides the deepest water production in south Alabama. In the CPYRW, the Coker yields water to a limited number of wells in the northern portion of the watershed, however, few wells have penetrated the zone in the central portions of the watershed, where excessive chloride concentrations may be a limiting factor with future development of the aquifer (Smith, 2001).

GORDO AQUIFER

The Gordo aquifer is composed of alternating gravel, sand, and clay, with the best water bearing zones consisting of fine to coarse-grained sand and gravel. It is a major water source for much of the northern portion of the CPYRW and although only sparsely developed, the aquifer in the central portion of the watershed may yield more than 2,000 gallons per minute (gpm) at depths from 1,500 to 2,700 ft (Cook, 2002). The most productive areas for the Gordo aquifer extend from northern Henry County, northwestward through southern Barbour, northern Dale, southern Pike, northern Coffee, and central Crenshaw Counties and northwestward from southwestern Barbour, through northeastern Pike, and central Bullock Counties (Cook and others,

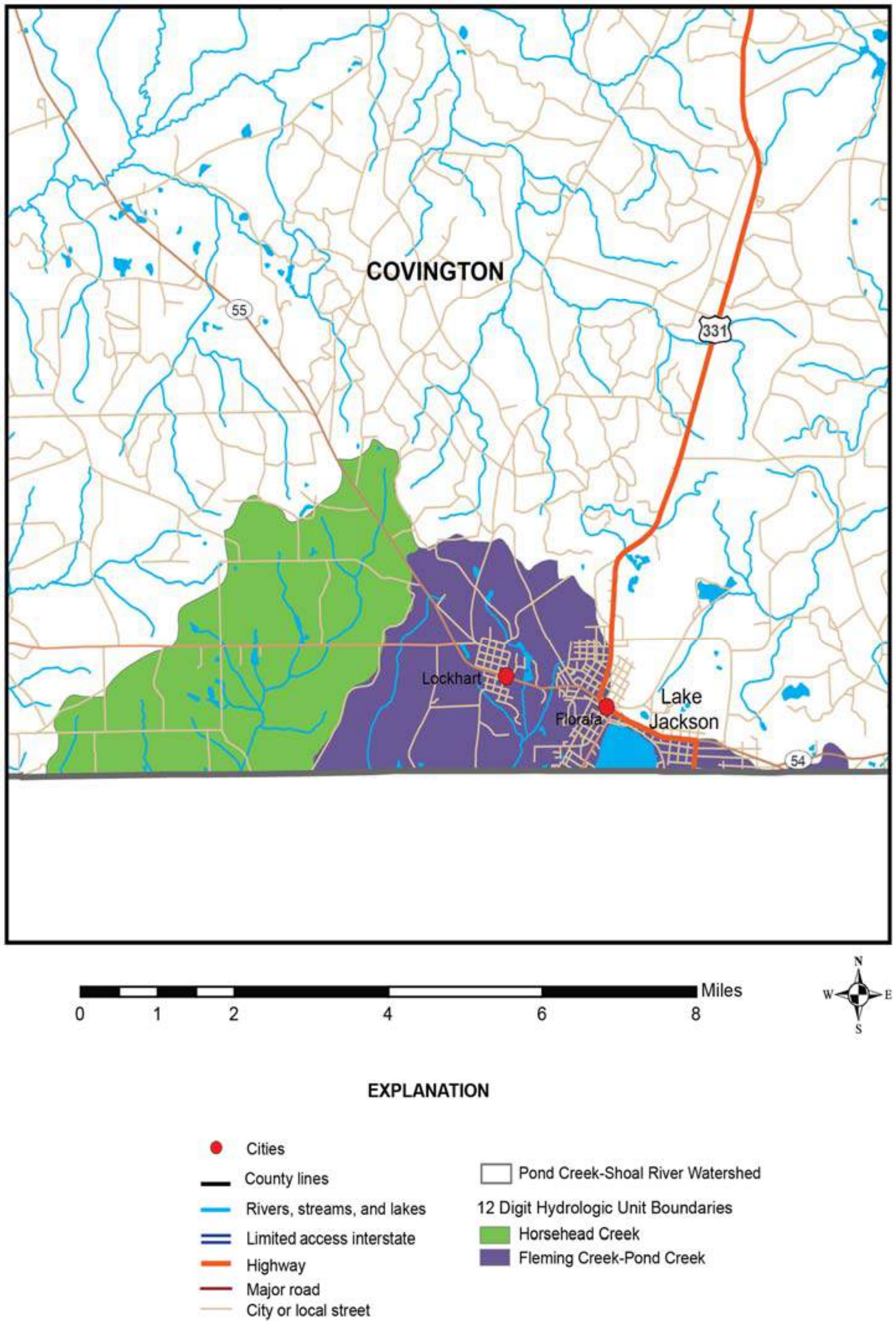

Figure 57.—Pond Creek-Shoal River watershed (0314010306).

2007; Cook and others, 2013). Water with chloride concentrations in excess of drinking water standards (250 milligrams per liter (mg/L)) is likely from central Coffee, Dale, and Henry Counties, southward (Cook, 2002).

EUTAW AQUIFER

The Eutaw aquifer is a major water source for much of west and central Alabama; however, water production decreases in the east-central and southeastern portions of the state due to dominant fine-grained stratigraphic facies (CWP and GSA, 2005). The recharge area of the Eutaw Formation extends through northern Montgomery and northern Russell Counties to the Chattahoochee River. The aquifer most likely contains water with relatively high chloride content from southern Coffee, Dale, and Henry Counties southward (Cook, 2002).

RIPLEY AQUIFER

CUSETTA SAND MEMBER

The recharge area for the Cusseta Sand Member of the Ripley Formation in the CPYRW extends from the Chattahoochee River in northeastern Barbour County and southeastern Russell County, westward through Central Bullock County, into southern Montgomery County (Smith, 2001). The aquifer was described by Smith (2001) as clear to very light-gray, ferruginous-stained, quartzose, moderately well sorted, medium to very coarse sand with black, heavy minerals.

The Cusseta Sand is historically a major water producer in northern Dale and southern Pike Counties where yields from individual public supply wells may be more than 700 gpm (Cook and others, 2014). The most productive area for the Cusseta Sand aquifer extends northwestward from central Henry County through northern Dale, southern Pike, and central Crenshaw Counties (Cook and others, 2007). Numerous private wells are constructed in the Cusseta Sand in south Bullock County.

PROVIDENCE SAND AQUIFER

The Providence Sand aquifer recharge area extends from the Georgia state line through northern Barbour, southern Bullock and Montgomery Counties, before terminating in south-central Lowndes County (Szabo and others, 1988). The Providence Sand is a minor aquifer in the CPYRW with yields generally less than 20 gpm, primarily to domestic wells.

CLAYTON AQUIFER

The recharge area for the Clayton aquifer extends from the Chattahoochee River in southeastern Barbour County, westward in a narrow band 2 to 3 miles wide through central Barbour and Pike Counties, into north-central Crenshaw County (Smith, 2001) (plate 3). The aquifer is lithologically highly variable and consists of silty to medium-grained quartzose sandy limestone, often very porous, with interbedded sand layers. The Clayton aquifer may yield more than 1,000 gpm to properly constructed wells, with the most productive area about 15 miles wide, extending from northwestern Houston County westward across southern Dale, northeastern Geneva, southern Coffee, and northeastern Covington Counties (Cook and others, 2007; Cook and others, 2014).

SALT MOUNTAIN AQUIFER

The Salt Mountain aquifer is composed of porous and permeable limestone that is hydraulically connected to the Clayton aquifer and is only observed in the subsurface across the central and southern parts of the CPYRW. This aquifer is capable of yielding more than 750 gpm from properly constructed wells (Cook and others, 2014). The most productive area of the Salt Mountain aquifer is about 15 miles wide extending from southwestern Dale County through north-central Geneva, southern Coffee, and northern Covington Counties (Cook and others, 2007).

NANAFALIA AQUIFER

The recharge area for the Nanafalia aquifer is about 20 miles wide and extends from the Chattahoochee River in northern Henry and southeastern Barbour Counties, westward across southern Barbour and Pike Counties and central Crenshaw County (plate 3). The aquifer is described as massive cross-bedded sands, glauconitic and fossiliferous fine sands, and clays (Smith, 2001).

The most productive area of the Nanafalia aquifer is about 20 miles wide and extends from central Houston County across northeastern Geneva, southern Dale and Coffee Counties, and northern Covington County (Cook and others, 2007). The aquifer yields more than 500 gpm in many wells across the most productive area (Cook and others, 2014).

LISBON AQUIFER

The Lisbon aquifer, composed mostly of coarse sand, sandy clay, and clayey sand beds (Smith, 2001). The recharge area extends across central Henry and Dale, southern Coffee, and northern Covington Counties (plate 3). Depending on construction, individual wells generally yield more than 300 gpm (Cook and others, 2014).

CRYSTAL RIVER AQUIFER

The Crystal River Formation is the southern-most aquifer in the CPYRW with a recharge area that extends through Houston, Geneva, and southern Covington Counties (plate 3). It is described as fossiliferous highly porous and permeable limestone, chalky limestone, and chalky sand (Smith, 2001). Yields of water to individual wells are highly variable, based on construction, but the largest production rates are from irrigation wells in southern Houston County and public water supply wells in southern Covington County that produce more than 800 gpm (Cook and others, 2014).

WATER QUANTITY

GROUNDWATER OCCURRENCE

Groundwater occurs in the CPYRW in aquifers, characterized by sand and limestone formations with sufficient porosity and permeability to store and transmit economic quantities of water. Delineation of these sand and limestone beds and determination of their thicknesses is critical to evaluating the vertical and spatial occurrence of groundwater sources. Accurate determinations of groundwater occurrence rely upon the use of geophysical well logs with the aid of drillers' logs and sample descriptions. Continuous recordings of measurements of the natural gamma radiation (gamma ray logs) in subsurface sediments, coupled with resistivity and spontaneous potential (SP) logs, are the principal means of determining the likely presence and thicknesses of quartz sand and limestone intervals in formations penetrated by boreholes (Cook and others, 2007).

This study presents results of a commonly used method whereby each gamma ray log is calibrated as a measure of the percent sand and/or limestone (sand and/or limestone denoted hereafter as "sand/limestone"). A summation of sand/limestone thickness, recorded as "net feet of sand/limestone" was determined for each well that penetrated and logged each of the major aquifers. Net feet of sand/limestone was plotted on a map and the values contoured. Net thickness of sand/limestone used for this assessment is greater than 75% for the logged interval (Cook and others, 2007). Limiting the net thicknesses to this high percentage of "clean" (less than 25% clay or silt-sized materials) sand/lime sediments provide indications of intervals of potential optimum aquifer quality, which are designated "net potential productive intervals" (NPPIs) (Cook and others, 2013).

It should be noted that maps depicting NPPIs do not always coincide with thicknesses of the geologic formations. For example, it is not uncommon for a geologic formation to thicken southward in the study area, while the NPPI thins. Depositional environments, sediment supply, and post-depositional geologic events determine thickness of the geologic units and affect other characteristics such as porosity and permeability. It should also be stressed that locating areas of thick NPPI increases the probability of finding usable aquifers, but does not guarantee that desired quantities of groundwater of desired quality can be obtained (Cook and others, 2007).

Resistivity and SP logs complement NPPI determinations, and though less definitive, can be used to evaluate wells in which gamma ray logs were not acquired, to give a general estimate of net sand/limestone thickness (Cook and others, 2007). Data presented on NPPI maps (plates 4-9) in this report suggest that downdip limits of water production in aquifers are commonly a combination of NPPI thickness and water-quality (salinity) estimation from geophysical logs and limited water-quality analyses.

Net potential production intervals mapping for the Gordo aquifer in southeast Alabama indicates the thickest NPPI (about 200 ft) occurs across southern Barbour,

northern Henry, Dale and Coffee, southwestern Pike, and central Crenshaw Counties. A secondary thick NPPI trend extends south to north from northeastern Pike County (about 150 ft), through Union Springs to Fort Davis in south-central Macon County (about 100 ft) (plate 4) (Cook and others, 2014).

Sand beds of the Cretaceous Ripley Formation and its locally present Cusseta Sand Member comprise a significant aquifer across a portion of the study area. The thickest NPPI (100-175 ft) area of the Ripley/Cusseta aquifer extends from southeastern Crenshaw County across southern Pike County and connects to a thick (175 ft) area in south-central Henry County (plate 5). Another thick NPPI area is in southern Dale County, but the sands there likely contain brackish water (plate 5). The downdip limit of freshwater occurrence extends from southernmost Crenshaw County, southeastward through Coffee County, and in an easterly direction across southern Dale and Henry Counties (plate 5) (Cook and others, 2014).

The Tertiary Clayton Formation is composed of limestone and sand beds that comprise one of the most important aquifers in southeastern Alabama. As shown in plate 6, a thick NPPI area extends from the Dothan area of northwestern Houston County, where the NPPI is more than 250 ft thick, across southern Dale County and south-central Coffee County, where the NPPI varies from 125 to 175 ft. The Clayton appears to thin away from this thick "fairway," though the thinning is poorly defined, due to more sparse well control (plate 6). The probable downdip limit of water production in the Clayton aquifer extends across central Covington County to Geneva County and continues eastward across the southern part of the study area. This limit is due to both thinning of the NPPI and an increase in groundwater salinity (plate 6) (Cook and others, 2014).

Smith (2001) noted the presence of visible porosity in well cuttings of some wells that penetrated the Salt Mountain Limestone, the presence in some wells of sand interbeds, and the general absence of clay. The thickest portion of the net "clean" portion of the limestone and sand extends from northern Covington County, southeastward across southwestern Coffee County, and into north-central Geneva County, where the NPPI is more than 250 ft thick. The Salt Mountain NPPI thins north and south away from this thick "fairway," and to the east into Houston County. The Salt Mountain is not present (or not distinguishable on logs from the Clayton) north of a line across northern Coffee and Dale Counties (plate 6). The downdip limit of fresh water probably extends across south-central Covington and southwestern Geneva Counties (plate 7) (Cook and others, 2014).

The Nanafalia Formation contains thick sand intervals along with some limestone beds. The thickest net "clean" sand and limestone occurs in a "fairway" from northern Covington County across southern Coffee and Dale Counties into western Houston County where the thickest NPPIs vary from 75 to 125 ft (plate 8). The thickest NPPIs occur in two main areas: one centered in the northwestern Houston County "panhandle" and southern Dale County and the other centered in Coffee County west of Enterprise (plate 8). Like other aquifers in this study, thinning of the formation and its NPPIs is evident in the updip direction (plate 8). The interpreted downdip limit of Nanafalia aquifer water production extends in a general northwest to southeast line across southern Covington County and southwestern Geneva County.

This limit is the result of a general decrease in the net sand/limestone content and greater salinity to the southwest (plate 8) (Cook and others, 2014).

The thickest NPPIs for the Tallahatta aquifer vary from 75 to more than 125 ft and occur in a linear trend across north-central Geneva County and northwestern Houston County. Elsewhere, NPPI thicknesses vary from 20 to 70 ft, with thinning in the updip (northerly) direction. Sands in the Tallahatta aquifer contain fresh water, except in the southwestern part of the project area where the water is increasingly saline (plate 9) (Cook and others, 2014). Across much of the area Tallahatta sands appear to be overlain directly by sands of the Lisbon aquifer, indicating likely hydraulic interconnection of the two aquifers.

GROUNDWATER AVAILABILITY

Groundwater availability may be generally defined as the total amount of groundwater of adequate quality stored in the subsurface. However, groundwater availability is more complex than this simple definition. Unlike oil and gas, which is trapped in isolated subsurface accumulations with no generation of additional resource, water moves relatively freely, sometimes for great distances and in most cases, is constantly replenished from the land surface. In order to adequately determine availability, we must understand processes involved in recharge, storage, and sustainable production of groundwater (Cook and others, 2014).

Groundwater recharge involves infiltration of precipitation into the subsurface and down gradient flow under water table conditions through the unconfined recharge area. Some of this water continues down gradient as confined flow where it exists under artesian conditions. Water in the unconfined aquifer zone is situated in the pore spaces of granular formations and in open fractures of less permeable rocks (pore water). The total volume of pore water is determined by multiplying the saturated thickness of an aquifer by the area by its average total porosity. Water stored in the confined aquifer zone (total storage volume) is under pressure and can be determined by the volume of water discharged from an aquifer due to a specified change in hydraulic head (Fetter, 1994).

GROUNDWATER RECHARGE

Volumes of groundwater recharge and distances of groundwater movement in Alabama coastal plain aquifers are highly variable and are influenced by a number of factors including precipitation, permeability of recharge areas, hydraulic connection and exchange of groundwater between aquifers, and aquifer confinement and hydraulic gradient. On average, the coastal plain of Alabama receives from 55 to 60 inches of precipitation each year. However, precipitation may be substantially less during periods of drought. Permeability of Alabama coastal plain aquifer recharge area is highly variable. However, on average, most aquifers receive adequate recharge to maintain long-term sustainability. Although few studies have been performed to determine the hydraulic connection of coastal plain aquifers in Alabama, knowledge of the stratigraphy of aquifers leads to the assumption that most aquifers that are in close vertical proximity have some degree of hydraulic connection. In southeast Alabama, pump tests and potentiometric surface mapping have shown that the Salt Mountain aquifer is hydraulically connected to the overlying Nanafalia and

underlying Clayton aquifers (Cook and others, 2007). It is also known that the Eutaw aquifer is hydraulically connected to the underlying Gordo aquifer in Bullock, Barbour and Pike Counties in southeast Alabama (Cook and others, 2013). The down gradient parts of all aquifers in southeast Alabama are highly confined although exchange of water between adjoining aquifers is likely. The direction of groundwater flow and the hydraulic gradient of aquifers in the coastal plain are controlled by the position of a particular locale relative to the Gulf of Mexico basin. Groundwater in southeast Alabama generally flow south-southeast and hydraulic gradients vary from 20 to 50 ft/mi (Cook and others, 2013).

Subsurface water movement occurs in two primary environments. The first is in and near the recharge area, where aquifers are unconfined or partially confined, groundwater movement is under water table conditions, and groundwater/surface-water interaction is common. In this environment, precipitation infiltrates into the subsurface, moves down gradient and laterally to areas of low topography where the water discharges into streams or as seeps and springs. Groundwater/surface-water interaction is driven by hydraulic head (head) and serves to sustain streams during periods of drought when runoff is absent (groundwater head is higher than surface-water head) and contributes aquifer recharge when stream levels are high (surface-water head is higher than groundwater head). Groundwater discharge to streams forms the base flow component of stream discharge, forms the sustainable flow of contact springs and wetlands and supports habitat and biota. Subsurface water movement in this environment is generally less than 15 miles and occurs from the updip limit of an aquifer down gradient to the point where the aquifer is sufficiently covered by relatively impermeable sediments and becomes confined in the subsurface (Cook and others, 2014).

The second environment is characterized by subsurface water that underflows streams and areas of low topography down gradient to deeper parts of the aquifer. Groundwater in this environment is separated from the land surface by relatively impermeable sediments that form confining layers. Groundwater in the coastal plain can move relatively long distances from recharge areas in aquifers that contain fresh water at depths that exceed 2,500 ft (Cook, 2002). With increasing depth, groundwater becomes highly pressurized and moves slowly down gradient or vertically and laterally along preferential paths of highest permeability. As it moves, minerals are dissolved from the surrounding sediments and accumulate to transform fresh water to saline water. This deep, highly mineralized groundwater eventually discharges into the deep oceans (Alberta Water Portal, 2014).

UNCONFINED OR PARTIALLY CONFINED AQUIFER RECHARGE

Estimates of recharge can be useful in determining available groundwater, impacts of disturbances in recharge areas, and water budgets for water-resource development and protection. Numerous methods have been developed for estimating recharge, including development of water budgets, measurement of seasonal changes in groundwater levels and flow velocities. However, equating average annual base flow of streams to groundwater recharge is the most widely accepted method (Risser and others, 2005) for estimating groundwater flow in and near aquifer recharge areas. Although it is desirable to assess recharge in watersheds with unregulated streams

that are not subject to surface-water withdrawals, or discharges from wastewater treatment plants or industries, it is unrealistic to expect that no human impacts occur in any of the assessed watersheds.

Average precipitation in southeast Alabama is 52 inches per year (Southeast Regional Climate Center, 2012). Precipitation is distributed as runoff, evapotranspiration, and groundwater recharge. Sellinger (1996) described the various pathways of precipitation movement that compose stream discharge and determine the shape of a stream hydrograph (fig. 58). However, for the purposes of this report, the pathways of precipitation movement shown in figure 58 are combined into two primary components: runoff and base flow. Runoff is defined as the part of total stream discharge that enters the stream from the land surface. Kopaska-Merkel and Moore (2000) reported that average annual runoff in southeast Alabama varies from 18 to 22 in/year, depending on the location of the subject watershed with respect to topography and geology. Base flow is the part of stream flow supplied by groundwater, an essential component that sustains stream discharge during periods of drought and is equated to groundwater recharge.

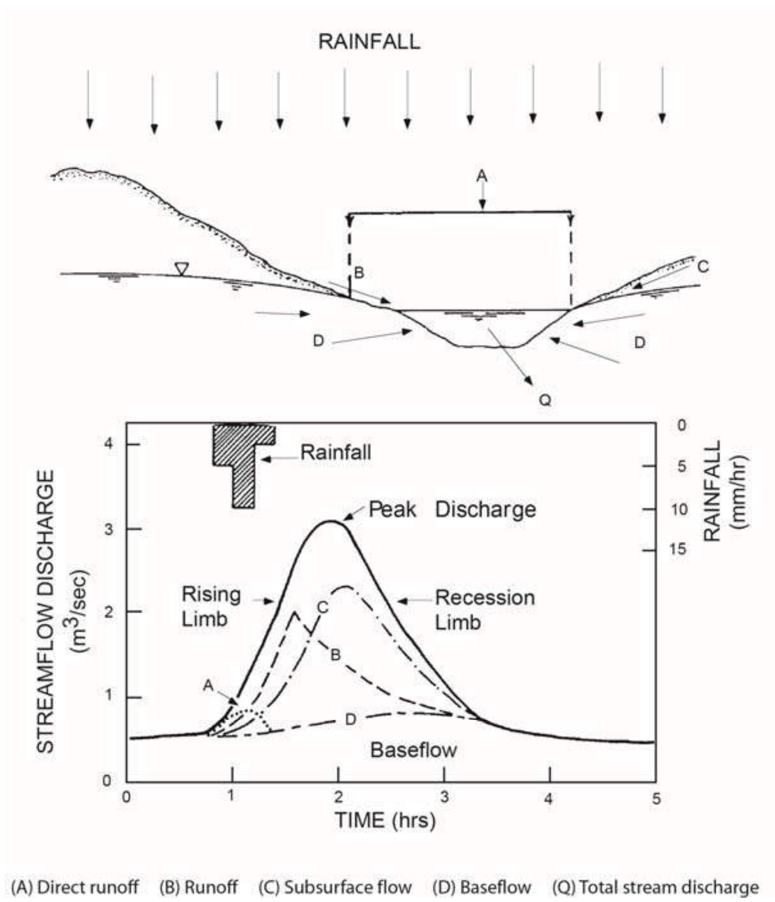

Figure 58.—Diagram and stormflow hydrograph illustrating pathways of movement of rainfall into stream. (modified from Sellinger, 1996).

Separating runoff and base flow from total stream discharge can be accomplished by several methods (Sellinger, 1996; Risser and others, 2005) including (1) recession analysis (Nathan and McMayhon, 1990), (2) graphical hydrograph separation (Meyboom,1961), and (3) partitioning of stream flow using daily rainfall and stream flow (Shirmohammadi and others, 1984). More recently, a number of computer models have automated hydrograph separation techniques (Risser and others, 2005; Lim and others, 2005). The Meyboom method requires stream hydrograph data over two or more consecutive years. Base flow is assumed to be entirely groundwater, discharged from unconfined aquifers. An annual recession is interpreted as the long-term decline during the dry season following the phase of rising stream flow during the wet season. The total potential groundwater discharge (V_{tp}) to the stream during this complete recession phase is derived as:

$$V_{tp} = \frac{Q_0 K}{2.3}$$

Where Q_0 is the baseflow at the start of the recession and K is the recession index, the time for baseflow to decline from Q_0 to $0.1Q_0$.

Discharge data for 12 ungauged stream sites (nodes) in the southeast Alabama pilot project area were used in the recharge evaluation (fig. 59). Selected sites were on main stems or tributaries of the Choctawhatchee, Pea, Yellow, and Conecuh Rivers. Nodes were selected in strategic locations relative to critical aquifer recharge area boundaries. Estimates of discharge from ungauged sites were obtained from the ADECA OWR. Raw discharge values were estimated by the USGS using the Precipitation Runoff Modeling System with measured discharge from the USGS Choctawhatchee River near the Newton, Alabama, gauge (USGS site 02361000). The period of record for estimated discharge for each node is October 1, 1980, to September 30, 2008.

Previous comparisons of automated hydrograph separation programs with the Meyboom graphical method indicated that the Web-based Hydrograph Analysis Tool (WHAT) automated hydrograph separation program (Lim and others, 2005; Purdue University, 2004) produced the most equitable results. Based on the general agreement between the Meyboom method and the WHAT program, input values were determined and base flow was estimated by the WHAT program. Baseflow output from the WHAT program was used to calculate recharge rates and volumes of groundwater recharge for unconfined and partially confined aquifers. Discharge node information and recharge rates and volumes for individual nodes are shown in table 23.

Estimates of base flow contributions of individual aquifers or related aquifer groups (unconfined and partially confined aquifer recharge) indicate that the largest recharge rate occurs in the Crystal River aquifer (408.4 mgd) (table 24). This was expected, due to the size of the recharge area, stratigraphic composition of the formation (sandy residuum and karst limestone) that maximizes infiltration of precipitation into the subsurface, and relatively low topographic relief that minimizes runoff. Recharge for the Lisbon and Tallahatta aquifers were estimated together due to the proximity of the recharge areas and had the second largest recharge rate (269.9 mgd). The Nanafalia aquifer had the third largest rate (133.9 mgd) When recharge data were normalized relative to recharge area size, the Eutaw aquifer had the largest

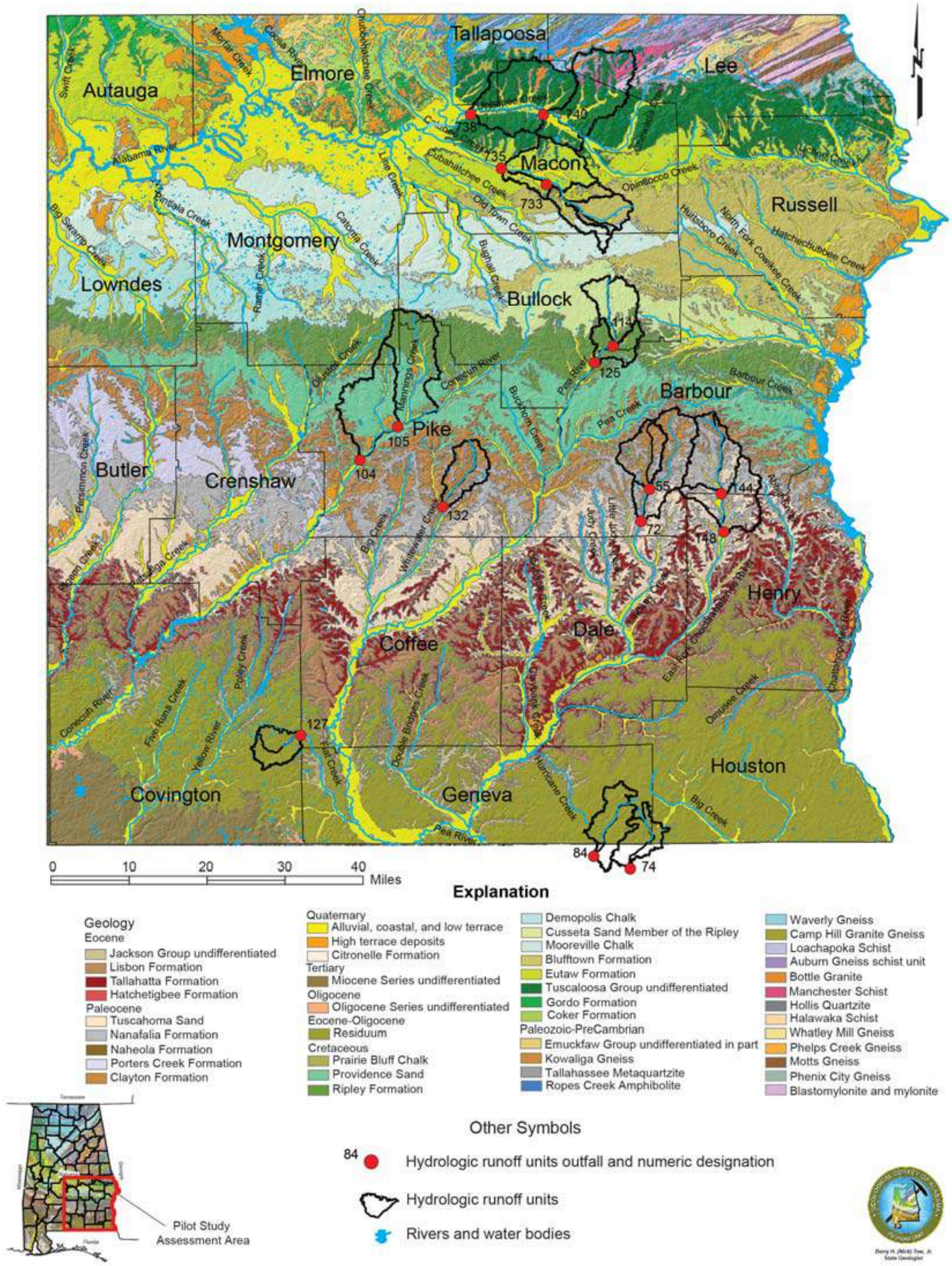

Figure 59.—Ungauged stream sites in the southeast Alabama pilot project area used for recharge evaluation.

Table 23.—Discharge node information, recharge rates, and volumes for individual nodes in the southeast Alabama pilot project area.

Discharge node	Stream	Node area (mi^2)	Aquifer	Base flow (percentage of total discharge)	Recharge (inches per year)	Recharge (gal/day/mi^2)
738	Uphapee Creek	86	Tuscaloosa Group	26	4.4	209,511
735	Calebee Creek	53	Eutaw Formation	28	5.8	276,173
114	Pea River	37	Cusseta Member Ripley Formation	16	2.6	111,803
125	Pea River	59	Ripley Formation	18	2.9	136,352
105	Conecuh River	244	Ripley/Providence Formations	25	4.0	189,078
104	Conecuh River	325	Providence Formation	26	4.3	51,041
132	Pea River	32	Clayton Formation	18	2.6	124,380
55	Choctawhatchee River	33	Clayton/Nanafalia Formations	28	4.6	217,412
72	Choctawhatchee River	54	Nanafalia/Clayton Formations	32	4.8	229,827
144	Choctawhatchee River	51	Nanafalia/Clayton Formations	28	4.7	220,522
148	Choctawhatchee River	47	Nanafalia Formation	28	4.7	220,591
142	Claybank Creek	76	Lisbon and Tallahatta Formations	24	5.0	239,050
74	Choctawhatchee River	29	Crystal River Formation	25	5.4	256,019
84	Choctawhatchee River	41	Crystal River Formation	19	3.2	152,634
127	Pea River	25	Crystal River Formation	30	6.7	319,272

rate (273,900 gallons per day per square mile (gal/d/mi^2)), followed by the Crystal River (242,700 gal/d/mi^2), Lisbon and Tallahatta (239,100 gal/d/mi^2), and Nanafalia (237,800 gal/d/mi^2) aquifers. Table 25 shows recharge rates for unconfined and partially confined aquifer recharge areas in the southeast Alabama pilot project area.

CONFINED AQUIFER RECHARGE

Aquifers in the southeast Alabama pilot project area generally dip to the south-southeast into the subsurface at rates of 20 to 40 ft/mi. As the distance from the recharge area (outcrop) increases, aquifers are overlain by an increasing thickness of sediments, some of which are relatively impermeable. At some point, down gradient aquifers become fully confined and have no hydraulic connection with the land

Table 24.—Unconfined or partially confined recharge for aquifers in the southeast Alabama pilot project area.

Aquifer	Recharge			
	Area (mi^2)	Million gallons per day	Gallons per day per square mile	Inches per year
Tuscaloosa Group	643	106.3	165,300	4.4
Eutaw Formation	445	121.9	273,900	5.8
Cusseta Member Ripley Formation	267	32.9	123,200	2.6
Ripley Formation	453	61.8	136,400	2.9
Providence Formation	569	29.0	51,000	1.1
Clayton Formation	461	78.3	169,800	3.7
Nanafalia Formation	563	133.9	237,800	5.0
Lisbon and Tallahatta Formations	1,129	269.9	239,100	5.0
Crystal River Formation	1,683	408.4	242,700	5.1

Table 25.—Confined recharge for selected aquifers in the southeast Alabama pilot project area.

Aquifer	Transmissivity (ft^2/d)	Thickness (ft)	Hydraulic Gradient (ft/mi)	Recharge (mgd)
Gordo Formation	3,000	175	3.3	6.5
Ripley Formation	7,500	100	11.4	37.8
Clayton Formation	10,000	150	7.5	48.1
Nanafalia Formation	4,470	50	8.3	24.6

surface. Groundwater flow can be estimated using Darcy's law, which states that discharge is related to the nature of a porous medium (hydraulic conductivity), multiplied by the cross-sectional area of the medium, multiplied by the hydraulic gradient (Fetter, 1994),

$$Q = -KA\ (dh/dl)$$

Darcy's law can be modified to estimate the total volume of flow in a confined aquifer by adding terms to account for aquifer thickness and aquifer area (Fetter, 1994). Darcy's law then becomes

$$Q = -Kb\ (dh/dl) \times \text{width}$$

where b is aquifer thickness and width is the lateral length of the aquifer. Aquifer thickness was taken from average net potential productive interval thicknesses previously discussed. Volumes of groundwater flow were determined for confined areas of major aquifers in the pilot project area using recently measured water levels, aquifer thicknesses, and hydraulic gradients, and published estimates of transmissivity (Smith and others, 1996, Baker and Smith, 1997, Smith and others, 1997, Cook and others, 1997, Kuniansky and Bellino, 2012) from wells in the project area (table 23). Note that the recharge area (unconfined area) for the Tuscaloosa

Group in southeast Alabama is designated as Tuscaloosa Group undifferentiated; however, in the subsurface (confined area), the Tuscaloosa Group is differentiated into the Gordo and Coker Formations. Therefore, recharge rates for unconfined and confined zones are designated in like manner in tables 24 and 25. Confined aquifer recharge for the Eutaw, Cusseta Member, Providence, and Lisbon and Tallahatta aquifers was not determined due to a lack of adequate transmissivity data. Also, the Crystal River aquifer is not included due to the fact that this aquifer is unconfined or partially confined throughout the project area. Figure 60 shows unconfined and confined recharge for evaluated aquifers in the project area. Comparisons of estimated recharge rates reveal that confined rates are about 6% of unconfined or partially confined rates for the Gordo aquifer, 61% for the Ripley and Clayton aquifers, and 18% for the Nanafalia aquifer, illustrating the importance of subsurface groundwater storage for future groundwater supplies.

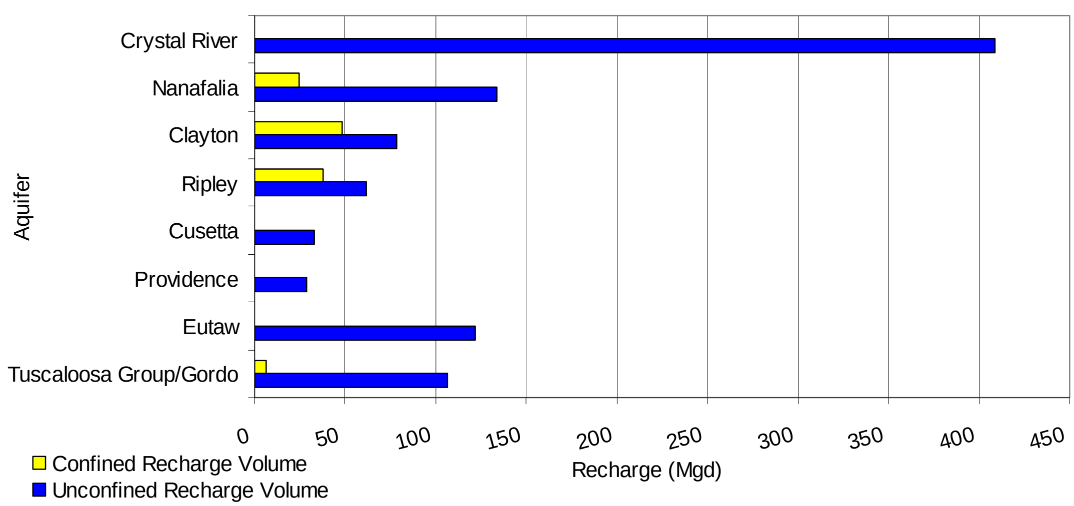

Figure 60.—Recharge volumes for unconfined and confined zones of major aquifers in the southeast Alabama project area.

SUBSURFACE GROUNDWATER STORAGE

As previously defined, available groundwater is the total amount of groundwater of adequate quality stored in the subsurface. However, this simple definition is not adequate to describe the complexities of groundwater occurrence and use, particularly in Alabama where complex geologic/hydrologic relationships are common. Alley and others (1999) defined groundwater sustainability as the development and use of groundwater in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social consequences. The definition of "unacceptable" is largely subjective, depending on the individual situation. The term safe yield should be used with respect to specific effects of pumping, such as water level declines or reduced stream flow. Thus, safe yield is the maximum pumpage for which the consequences are considered acceptable (Ponce, 2007).

Groundwater sustainability is based on the rate of water removal, volume of water available (water in storage and rate of replenishment), and the ability of an aquifer to yield water (effective porosity). The hydraulic impact of water production is observed in declining hydraulic head and aquifer water levels. In confined aquifers with acceptable rates of groundwater production, water is removed and head declines, yet aquifers remain fully saturated and potentiometric surfaces remain above the stratigraphic tops of geologic units. Therefore, useable aquifer storage is the volume of water that can be removed while maintaining head above the stratigraphic top of the aquifer.

Specific storage (S_s) is the amount of water per unit volume of a saturated formation that is expelled from storage due to compressibility of the mineral skeleton and the pore water per unit change in head (Fetter, 1994). Accurate determination of specific storage requires a number of terms including density of water, gravitational acceleration, compressibility of the aquifer skeleton, compressibility of water, and average effective porosity. All terms are generally known except effective porosity. Effective porosity is that portion of the total void space of a porous material that is capable of transmitting water (Barcelona, 1984). One of the most accurate determinations of porosity is obtained from neutron/density geophysical logs. Two neutron/density logs were available from oil and gas test wells in the project area in Henry and Bullock Counties. However, only the Eutaw Formation, Tuscaloosa Group, and Lower Cretaceous were logged in the fresh-water section. Values were recorded for coarse-grained units with effective porosities identified by GSA Net Potential Productive Interval mapping.

The storage coefficient, or storativity (S), is the volume of water that a permeable unit will absorb or expel from storage per unit surface area per unit change in head (fig. 61). Therefore, storativity of a confined aquifer is the product of the specific storage and the aquifer thickness (b) (Fetter, 1994):

$$S = bS_s$$

When storativity is multiplied by the surface area overlying an aquifer and the average hydraulic head above the stratigraphic top of a confined aquifer, the product is the volume of available groundwater in storage in a confined aquifer (Fetter, 1994):

$$V_w = SA\ h$$

Table 26 shows measured and estimated effective porosity, aquifer thickness, storativity, and the volume of available groundwater in storage for major confined aquifers in the project area. Groundwater in storage for the Lower Cretaceous undifferentiated is included in table 26. Currently, Lower Cretaceous sediments are not developed as water sources in Alabama. However, evaluations of electric and geophysical logs and drill cutting descriptions in oil and gas test wells in the project area indicate that Lower Cretaceous sediments may have future potential as sources of fresh water. Total fresh groundwater in storage for the project area is given in table 26.

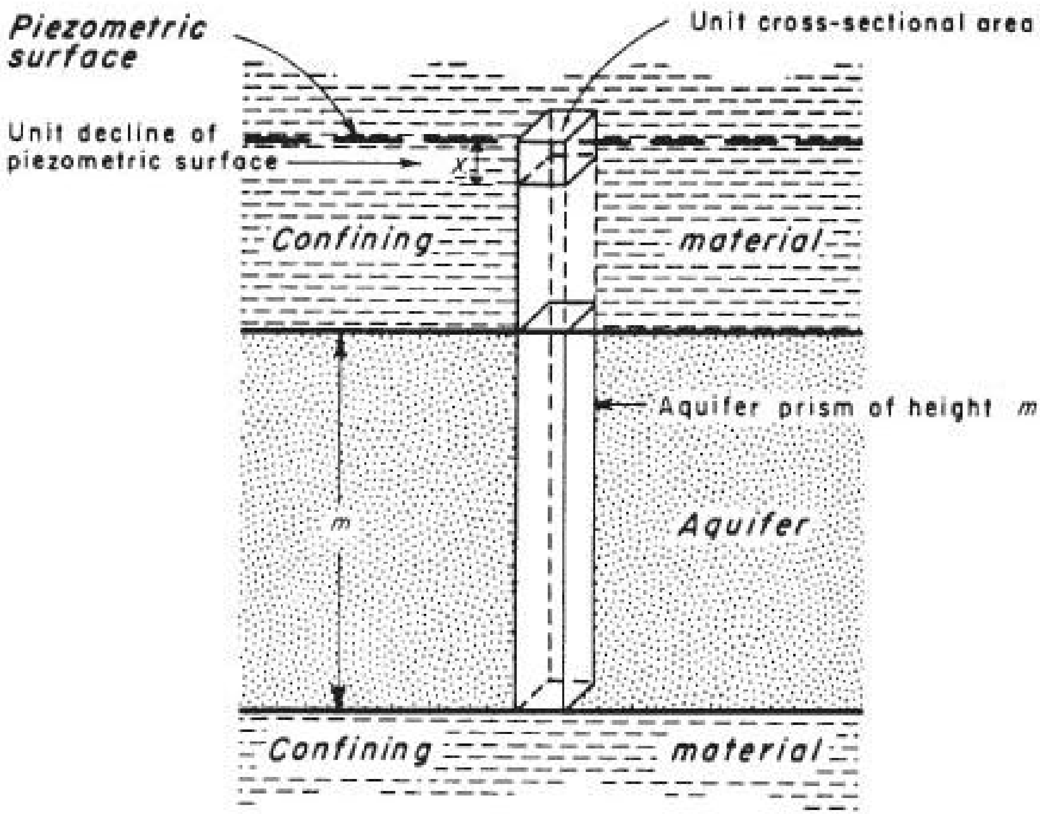

Figure 61.—Storativity of a confined aquifer (modified from Ferris and others, 1962).

Table 26.—Storativity, related aquifer characteristics, and available groundwater in storage for major confined aquifers in the project area.

Aquifer	Average effective porosity (percent)	Confined aquifer area (fresh water) (mi^2)	Aquifer potential productive interval thickness (ft)	Storativity	Available groundwater in storage (million ft^3)	(million gallons)
Lower Cretaceous	28	2,400	350	0.0000044	294.4	2,202.4
Coker Formation	32	4,500	210	0.0000026	293.6	2,196.1
Eutaw and Gordo Formations	36	4,000	175	0.0000030	281.0	2,102.3
Ripley Formation	30*	4,600	100	0.0000013	58.4	436.5
Clayton Formation and Salt Mountain Limestone	40*	1,980	325	0.0000019	124.5	931.2
Nanafalia Formation	30*	2,900	50	0.00000062	15.6	116.5

*Estimated effective porosity

RECOMMENDATION

The CPYRWMA should cooperate with the ADECA OWR, GSA, ADAI, and the ARWA to establish dialogs with groundwater users to provide information concerning sustainable yields for each aquifer in the CPYRW, based on groundwater availability, consumptive use, and current geographic distribution of groundwater production.

POLICY OPTIONS

Water management and policy strategies should include development guidelines for sustainable groundwater production as part of a statewide water management plan.

SURFACE-WATER AVAILABILITY

The CPYRW has an abundance of small and medium-sized lakes and streams that flow south and southwestward into northwest Florida and the Gulf of Mexico. Although a relatively small quantity of surface water is used from these water bodies, this water resource plays an important role for biological habitat and may provide sources of water for many uses in the future. For the purposes of the WMP, surface-water availability was evaluated, using statistical data from USGS gauged discharge sites and from estimated discharge from ungauged streams obtained from ADECA OWR.

In preparation for a statewide surface-water availibility assessment, the ADECA OWR, in partnership with the USGS developed a large data set of ungauged stream discharge estimates. ADECA OWR performed statistical analyses on the raw discharge data to provide flow-duration and low-flow characteristics and average daily monthly and annual flows.

Flow statistics were calculated in the Choctawhatchee River watershed for the mouth of the East and West Forks of the Choctawhatchee River, Choctawhatchee River at Newton (USGS gage site), the mouth of Claybank Creek, Choctawhatchee River at Bellwood (USGS gage site), the mouth of Double Bridges Creek, and Choctawhatchee River at the confluence with the Pea River near the Florida state line. Drainage areas and average annual daily discharge and volumes for the above sites are shown in table 27.

RECOMMENDATION

The CPYRWMA should cooperate with the ADECA OWR, GSA, ADAI, and ADEM, to establish dialogs with current and potential future surface-water users, and entities that impact surface-water quality to provide information concerning surface-water production and protection. A dialog should also be established with the state of Florida concerning surface-water development and protection.

POLICY OPTIONS

Water management and policy strategies should include development of a statewide water management plan and establishment of policies to protect the quantity and quality of streams and impoundments.

Table 27.—Drainage areas, discharge, and flow volumes for the Choctawhatchee, Pea and Yellow Rivers and tributaries.

Stream and location	Drainage area (mi^2)	Average annual daily discharge (cfs)	Average annual daily volume (mgd)
East Fork Choctawhatchee River (mouth)	316	367	237.2
West Fork Choctawhatchee River (mouth)	355	438	283.1
Double Bridges Creek (mouth)	194	304	196.5
Choctawhatchee River at Pea River confluence	1,541	2,067	1,336.0
Pea River at confluence with Choctawhatchee River	299	325	210.1
Whitewater Creek (mouth)	317	449	290.2
Yellow River at Florida state line	461	768	496.4

INSTREAM FLOW

Instream flow, the amount of water flowing in a stream channel, is a key factor in sustaining aquatic habitat, supporting fish and wildlife populations, promoting aquifer recharge, and maintaining acceptable water quality conditions (AWAWG, 2013). All of these factors are reliant upon seasonal fluctuation of stream levels as well as anthropogenic effects. Natural stream flow regimes vary during seasonal flood events, low flows in summer, and high flows in late winter and spring (fig. 62). Stress from population growth and susceptibility to extreme drought conditions could potentially threaten surface water and groundwater supplies to the point of altering instream flows. Reduction in instream flow could threaten fish and wildlife populations and significantly degrade wetland and riparian ecosystems.

The AWAWG defines instream flow as the amount of water required for instream uses including maintaining water quality standards; protection of freshwater and estuarine fish and wildlife habitat, migration, and propagation; outdoor recreation activities; downstream uses; navigation; power generation; waste assimilation; future needs; and ecosystem maintenance, which includes recruitment of freshwater to estuaries, riparian areas, floodplain wetlands, and maintenance of channel geomorphology (fig. 63). Each of these uses can be assigned various economic, social, and ecological benefits that should be balanced when uses compete against one another. The instream flow use referred to as environmental, ecological, or conservation flow is that amount of flow in a stream or river channel that adequately supports the full suite of ecological functions (biodiversity, channel maintenance, floodplain inundation). It is defined in respect to the seasonal timing, frequency,

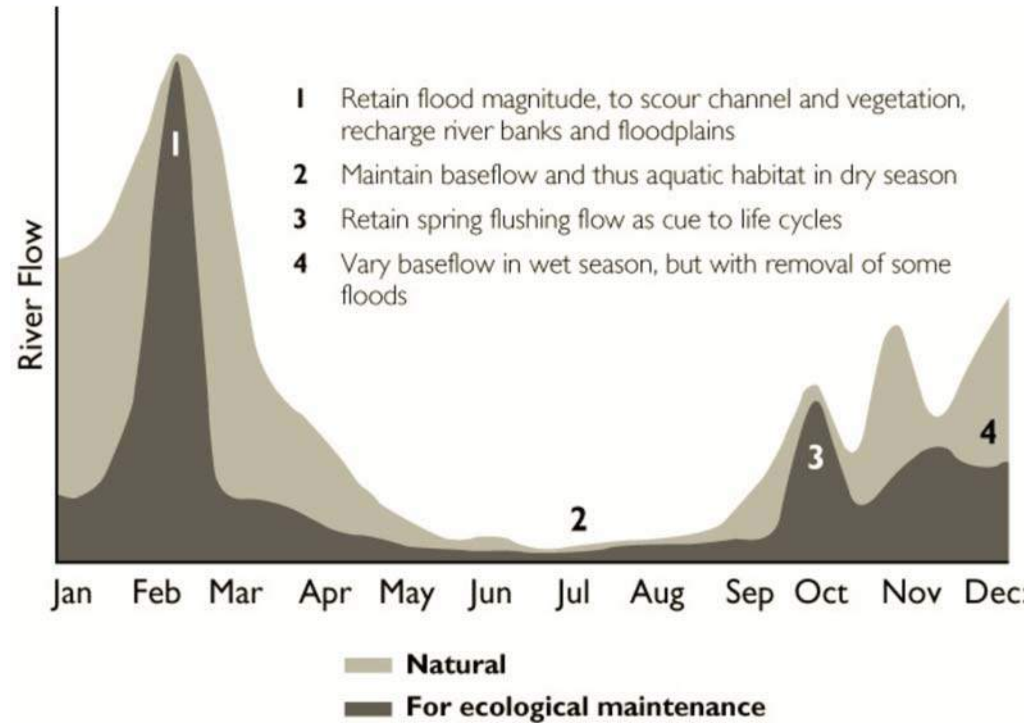

Figure 62.—Depiction of annual flow regime with instream requirement for ecological maintenance (modified from Postel and Richter, 2003).

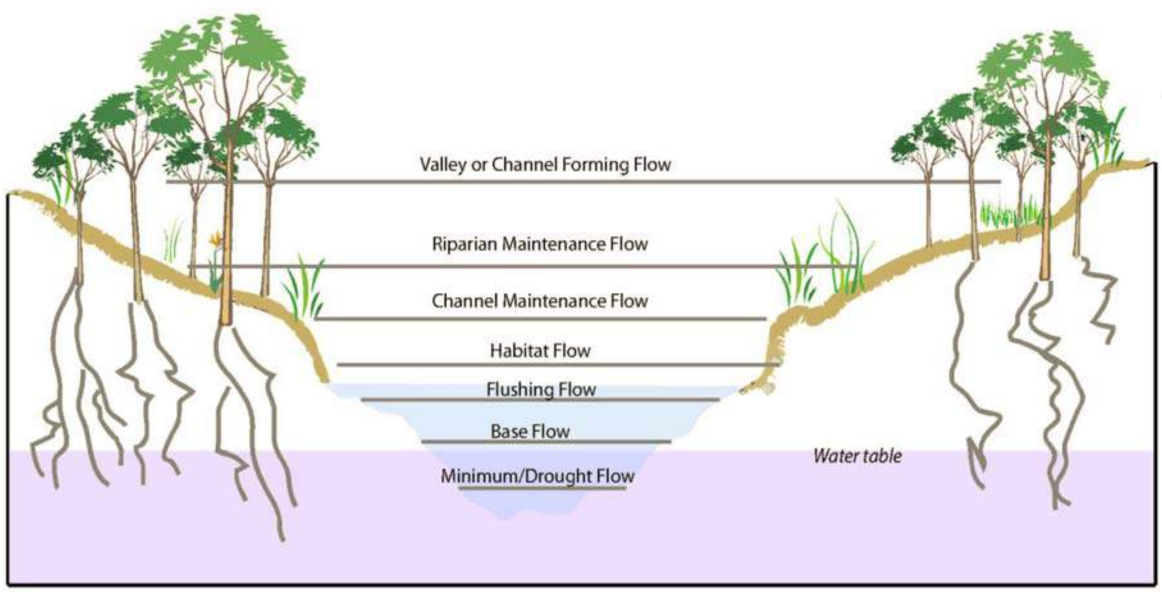

Figure 63.—Classification of instream flows relative to ecological functions (modified from Annear and others, 2004).

magnitude (size of flood or drought event), rate of change (how quickly water is delivered during flood event), and duration (length of flood or drought) to ensure ecosystem functionality. Conceptually, conservation flow includes high (flood) events, flows during dry periods of the year including droughts, as well as average flows (AWAWG, 2013).

Instream flows are often thought of as “minimum flows”. This is a misconception because minimum flows may not fully protect instream uses and values. Minimum flow regimes have led to the depletion and degradation of many rivers and streams. Minimum flow standards impair hydrological and ecosystem function because the natural flow variability component has been removed. In some cases, minimum flows actually become maximum flows in highly used, hydrologically altered systems because managed flows are rarely allowed to exceed the “minimum” limit (AWAWG, 2013).

Instream flow water rights have been established in other states to legally protect water levels for the conservation of aquatic habitat and biota. Through the implementation of instream flows, water resource managers can strive to achieve a flow regime that maintains natural processes necessary to support ecosystems while also balancing human use. In order to make appropriate management decisions regarding instream flow for the state of Alabama, several questions will need to be addressed: (1) how can this hydrologic regime be implemented within water resource management policies to provide for protected ecological functions and uses while also allowing development of water resources for human needs and economic activities for off-stream uses, and (2) how much ecological degradation are we willing to socially accept given a certain level of water resource development? Answers to these questions may be provided through the implementation of practical research to produce solutions to flow-related ecological issues (AWAWG, 2013).

Successful management of an instream flow regime requires that science-based procedures are applied not only in the initial planning stages of water resource management, but also in the research and application phases as well. The USGS is conducting research to update low-flow statistics at USGS stream gauges and regionalize selected low-flow characteristics for Alabama streams. The project is a joint effort between the USGS, the USDA NRCS, and Alabama state agencies. Historically, low-flow statistics, such as the annual minimum 7-day average flow that likely will occur, on average, once every 10 years (7Q10), have been used by water-resource managers as a threshold criterion for applying the chronic aquatic life criteria for determining waste-load allocations for point sources, total maximum daily loads (TMDL) for streams, and the quantity of water that can be safely withdrawn from a particular stream. It is critical to effectively measure and document base-flow data for use in updating low-flow frequency relations on a regular basis, preferably every 10 years, and especially after periods of extreme low flow, such as have occurred in the Southeast in recent years.

For some states, the regulated riparian regime of permits and licenses is standard and requires adaptive elements for effective management of water use and supply across watersheds. Water legislation and implementation vary widely from state to state and few methods link flow regimes to maintaining functional stream ecology while also considering local water requirements. Federal environmental legislation

such as the Clean Water Act and Endangered Species Act play a role in protecting instream flows in rivers, but only in an indirect manner. Certain state agencies in the southeastern U.S., including Alabama, have utilized the Public Trust Doctrine through state conservation agencies to protect instream flows, but the full extent of inter and intra-annual flow variability is not considered in these requirements.

The state of Alabama has no law prescribing instream flow standards. However, the ADCNR adopted an instream flow policy in 2012 under the Public Trust Doctrine for all flowing waters of the state. This policy was the first state agency step toward managing instream flow in a more comprehensive, ecologically protective manner in Alabama and will require further work on specific implementation details. It is partly based on the percentage-of-flow approach used in several states which serves as guidance in all negotiations with industries and other agencies with regard to protecting aquatic habitat, fish, and wildlife. Instream (conservation) flow regimes have been prescribed for some main river channels in Alabama by ADCNR through Federal Energy Regulatory Commission (FERC) negotiated site-specific flow requirements for large utility projects. The ADCNR is charged with the duty to protect, conserve, and increase the wildlife of the state (*Code of Alabama*, 1975, §9-2-2). Maintaining ecologically significant instream flows is fundamental to fulfilling the trustee resource conservation requirements of the ADCNR. The Public Trust Doctrine provides an indirect means of protecting flow-dependent fish and wildlife resources held in trust for the people of the State. But, while the public trust doctrine regarding water appears to be a legislative duty, other policies and laws involving water ownership need to be addressed to achieve balanced, natural flow variability in order to provide a holistic water management framework for the state (AWAWG, 2013).

RECOMMENDATION

The CPYRWMA should cooperate with the AWAWG, ADCNR, and GSA for stream discharge monitoring and instream flow assessments for streams in the CPYRW and future establishment of instream flow guidelines. State agencies, including the CPYRWMA should continue to cooperate with the USGS in low-flow assessments. The CPYRWMA should establish discharge rating for all flood warning sites to provide discharge data for instream flow monitoring and assessments.

POLICY OPTIONS

Development of a statewide water management plan with provisions for establishing instream flow guidelines.

SUSTAINABLE YIELD

Sustainable groundwater yield may be defined as: “The groundwater extraction regime, measured over a specified planning timeframe, that allows acceptable levels of stress and protects dependent economic, social, and environmental values” (Australia Department of the Environment, 2013). The groundwater extraction regime consists of wells in a specified area, producing at specified rates, for specified periods of time, in a specified aquifer or group of aquifers, and the impacts of these wells on groundwater levels, and/or surface water bodies. Sustainable yields may include groundwater extraction rates greater than recharge rates, depending on

groundwater levels, rates of groundwater level drawdown, available groundwater in storage, impacts of groundwater extraction from unconfined or partially confined aquifers on surface-water levels or flows, and an extraction period that allows for reduced pumping or down time that provides time for aquifers to replenish (Cook and others, 2014). Levels of acceptable stress must be determined that provide balance between economic, social, and environmental needs.

Generally, groundwater extraction regimes characterized by wells with adequate spacing, wells constructed in multiple aquifers, if available, and extraction rates that prevent excessive water level drawdown, will acquire acceptable levels of aquifer stress and will be sustainable for the long term (Cook and others, 2014). Aquifer stress areas in southeast Alabama are generally in and near population centers where water demand is high and where relatively large numbers of high capacity wells are extracting groundwater in close proximity (Cook and others, 2014). Evaluations of groundwater levels, drawdown, well spacing, and extraction rates for groundwater extraction regimes in 13 counties in southeast Alabama were evaluated during the southeast Alabama component of the GSA statewide groundwater assessment (Cook and others, 2014). Based on this evaluation, a number of areas in southeast Alabama have readily identifiable aquifer stress, yet no well or group of wells currently has an unacceptable level of stress (Cook and others, 2014).

In order to ascertain the sustainability of groundwater resources in a specified area, available volumes of groundwater of adequate quality must be compared to current groundwater use. As mentioned previously, current water use values are not available. Therefore, total volumes of available groundwater in subsurface storage and confined aquifer recharge were compared to 2005 water use values for the southeast region of the GSA statewide groundwater assessment (Cook and others, 2014). An exact comparison is not possible, since groundwater use data are compiled for geographic areas and are not available for specific aquifers. However, improved insights into groundwater availability and current groundwater production impacts can be developed by comparing available information. Unconfined or partially confined recharge was not included in the comparison, since water use from unconfined aquifers in southeast Alabama is relatively minimal. Also, groundwater use data includes all aquifers, which are compared to groundwater availability values for selected aquifers.

Total available groundwater in subsurface storage for all assessed confined aquifers (Lower Cretaceous, Coker, Eutaw/Gordo, Ripley, Clayton/Salt Mountain, and Nanafalia) is about 8.0 billion gallons and the Gordo, Ripley, Clayton, and Nanafalia aquifers are being replenished at a rate of 117.0 mgd. This is compared with total 2005 groundwater use for 13 counties in the assessment area, which is about 123 mgd. Therefore, when confined recharge rates for minor aquifers are considered, 2005 groundwater use is equivalent to confined recharge (Cook and others, 2014). Although the groundwater use and availability comparison from the southeast region of the GSA statewide groundwater assessment was for the entire southeast region, these data are applicable to the CPYRW.

DROUGHT IMPACTS

Since the 1930s, southeast Alabama has experienced 19 severe droughts and 5 extreme droughts, which have adversely impacted people, industries, agriculture, and recreation. Alabama's drought response mechanisms are spread across several different state programs including public health, water supply, agriculture, water quality, habitat protection, and forestry. As previously mentioned in the climate section, the state's primary drought coordination mechanism is housed in the ADECA OWR.

The Palmer Drought Severity Index (PDSI) was used to determine periods of drought in Southeast Alabama from 1929-2013. The PDSI is a tool developed by the NOAA to identify prolonged and abnormal moisture deficiency or excess. The PDSI is an important climatological tool for evaluating the scope, severity, and frequency of prolonged periods of abnormally dry or wet weather. It can be used to help delineate disaster areas and indicate the availability of water supplies for irrigation, reservoir levels, range conditions, adequacy of stock water, and potential intensity of forest fires. The PDSI calculations include the weekly precipitation totals, average temperature, division constants (water capacity of the soil), and previous history of indices. PDSI indices indicate general conditions; they do not indicate local variations caused by isolated rain. The equation for the PDSI index was empirically derived from the monthly temperature and precipitation scenarios of 13 instances of extreme drought in western Kansas and central Iowa by assigning an index value of -4 for these cases. Conversely, a +4 represents extremely wet conditions (NOAA, 2005). From these values, 7 categories of wet and dry conditions are defined (table 28).

Table 28.—Palmer Drought Severity Index (PDSI) conditions and corresponding values (NOAA, 2005).

Condition	PDSI Value
Extreme drought	-4.0 or less
Severe drought	-3.0 to -3.9
Moderate drought	-2.0 to -2.9
Near normal	-1.9 to +1.9
Unusual moist spell	+2.0 to +2.9
Very moist spell	+3.0 to +3.9
Extremely moist	+4.0 and above

Drought conditions were examined for the CPYRW, utilizing PDSI data from the contiguous United States (CONUS) Alabama climate division 7 to estimate the total number of months of drought from 1930-2013 (fig. 64). Since 1930, there have been 36 occurrences of moderate drought; 19 occurrences of severe drought; and 5 occurrences of extreme drought in the CPYRW. Each period of drought varied from less than one year to more than seven years. Instances of sustained drought caused severe impacts on local agriculture and the general economy. The first instance of sustained drought (moderate and severe) occurred from 1930-1934. One of the worst sustained droughts

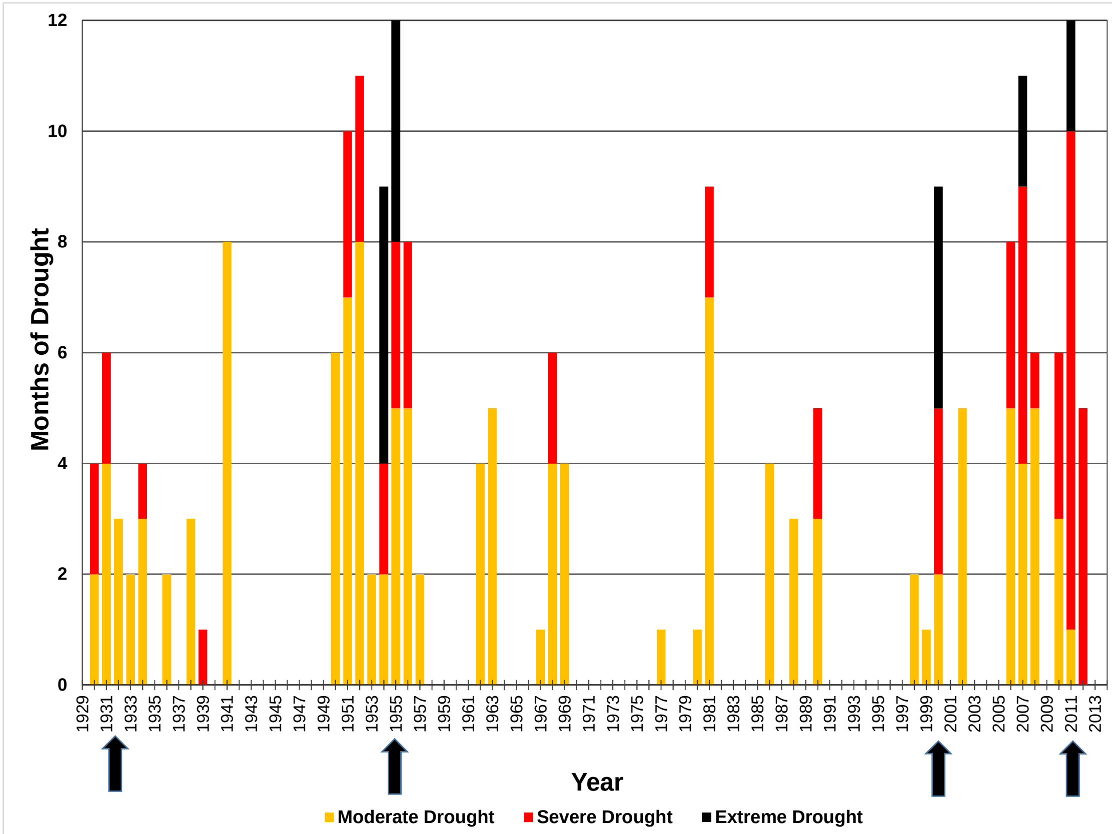

Figure 64.—Occurrences of drought in southeast Alabama from 1930-2013.

ever recorded within the state of Alabama spanned from 1950-1963 statewide, and from 1950-1957 in the CPYRW (fig. 64). The drought of record occurred in 1954 with 2 months of moderate drought, 2 months of severe drought, and 5 months of extreme drought; and 1955 with 5 months of moderate drought, 3 months of severe drought, and 4 months of extreme drought (fig. 64). In 2000, the CPYRW experienced 4 months of extreme drought, 3 months of severe drought, and 2 months of moderate drought. A period of extended drought occurred from 2006 to 2012, excluding 2009, in which most of the drought months were severe. The worst conditions during this period occurred in 2011, with 1 month of moderate drought, 9 months of severe drought, and 2 months of extreme drought (fig. 64).

The GSA has a periodic monitoring well system that tracks groundwater levels in 369 wells and 49 spring discharges throughout the state (fig. 65). Some of the water sources in this program have been monitored for decades and reflect changing climatic conditions and water use patterns. There are 63 periodic monitoring wells within the CPYRW area. Recorded water levels in each well have been used to construct hydrographs (graph showing depth to water level relative to time) to assess climatic and water use impacts for most aquifers in the CPYRW.

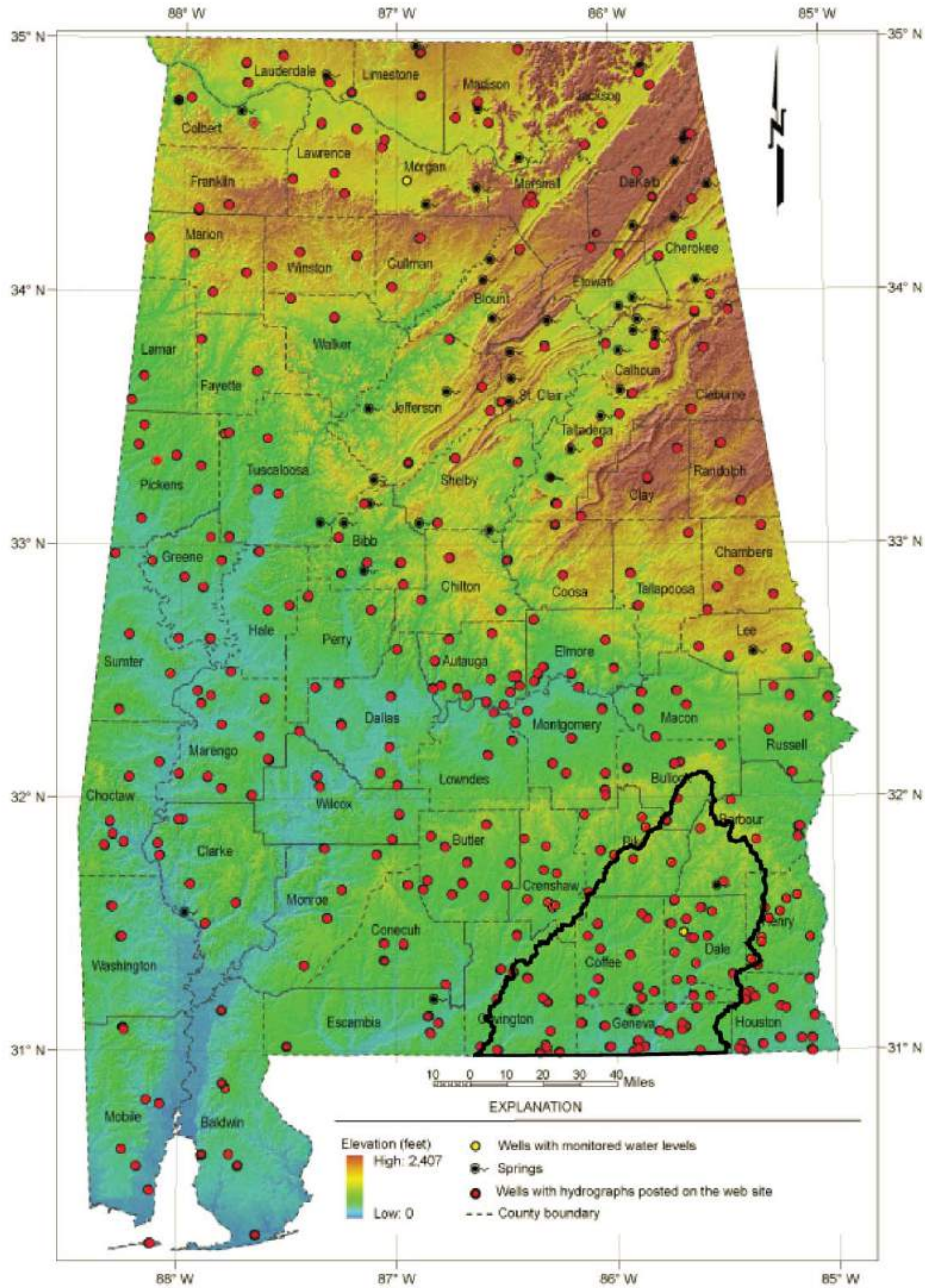

Figure 65.—Location of periodic monitoring wells (modified from GSA, 2014b).

The hydrograph for well A-9 in Coffee County shows declining water levels during the drought of 1990, when the water level dropped 10 ft (fig. 66). This well is 242 ft deep and is constructed in sand and limestone of the Clayton Formation of Paleocene Age.

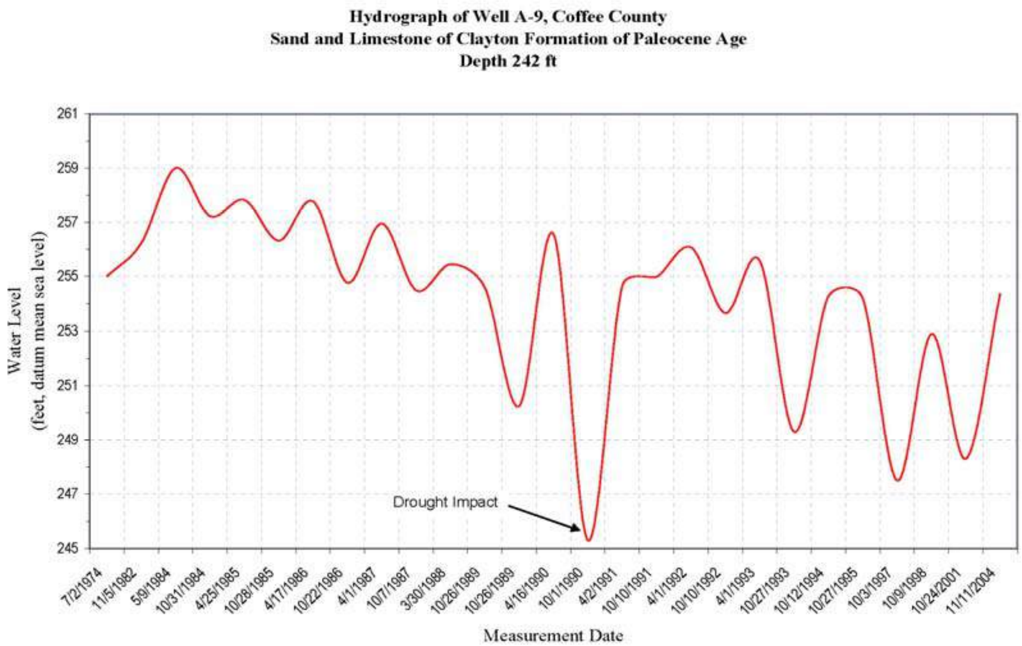

Figure 66.—Hydrograph of well A-9 displaying drought impact.

The hydrograph for well M-5 in Covington County shows declining water levels during the drought of 2006-2007, when the water level dropped about 11 ft. Well M-5 is 170 ft deep, supplies water for an industrial plant, and is constructed in the Lisbon Formation of the middle Eocene age (fig. 67). Well B-8 in Dale County is an institutional supply well, 270 ft deep, and is constructed in the Tuscahoma Sand of the Paleocene age. The hydrograph shows drought impact during 1990, where the water level dropped about 10 ft and did not recover until 1991-1992 (fig. 68). Additional declines occurred during the 2007 drought, when the water level dropped about 10 ft and did not replenish until 2009 and declined again during the 2010 drought.

Well L-7 in Geneva County is an unused well, 322 ft deep, and is constructed in the Tallahatta and Lisbon Formations of Early and Middle Eocene Age. Since this well is not impacted by water production, water levels reflect climatic variation. Severe water level impacts occurred during the 2000 drought, when water levels dropped 11 ft (fig. 69).

Drought impacts are most severe in surface water bodies and shallow aquifers. The magnitude of groundwater declines caused by drought varies locally due to differences in groundwater conditions, water requirements for humans and the

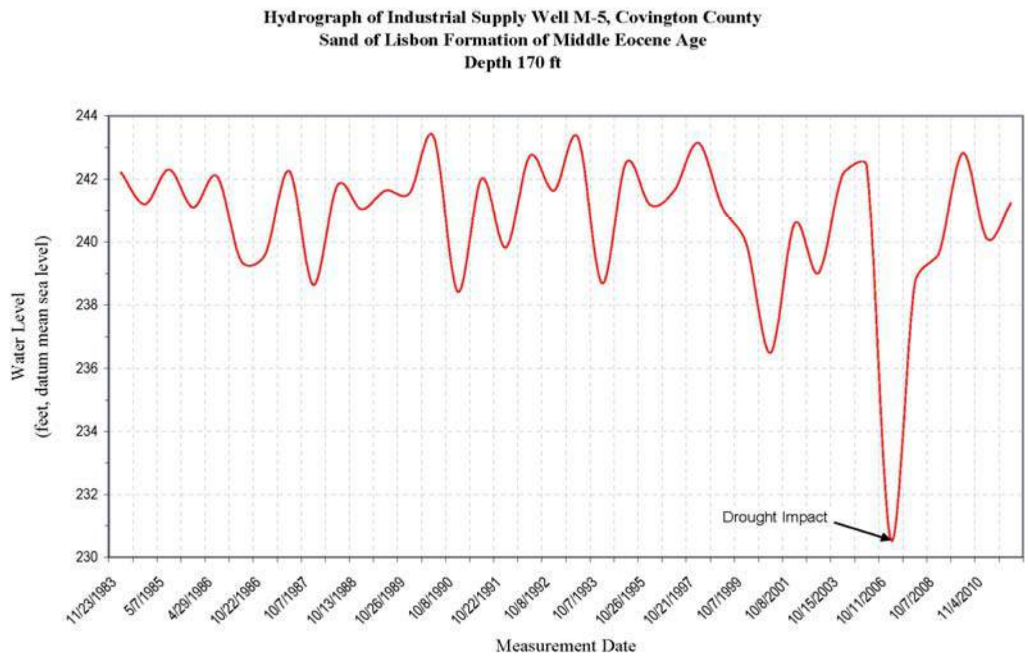

Figure 67.—Hydrograph of well M-5 displaying drought impact.

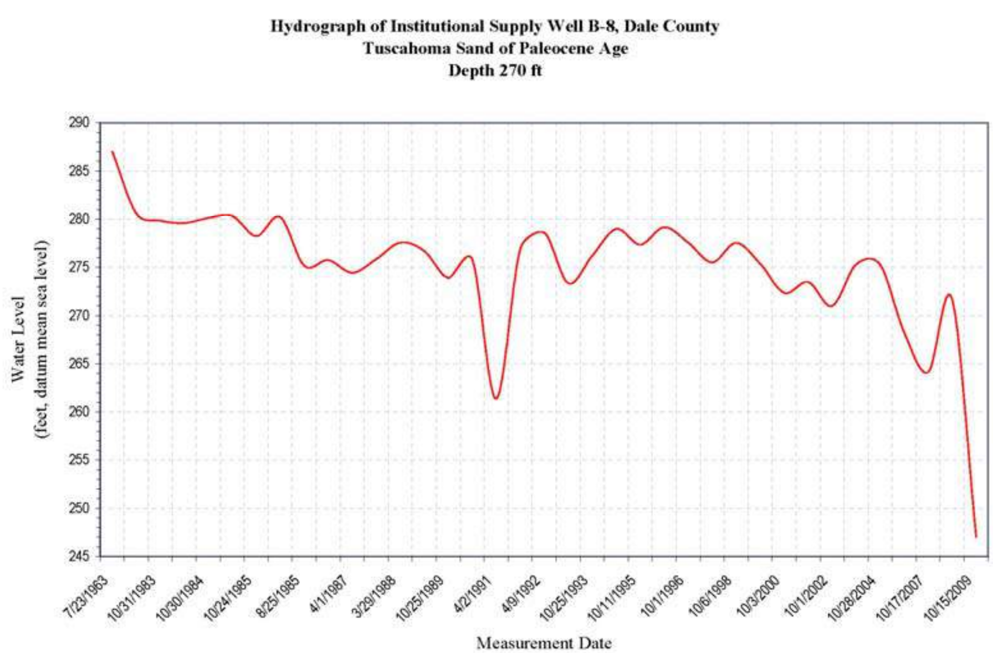

Figure 68.—Hydrograph of well B-8 displaying drought impact.

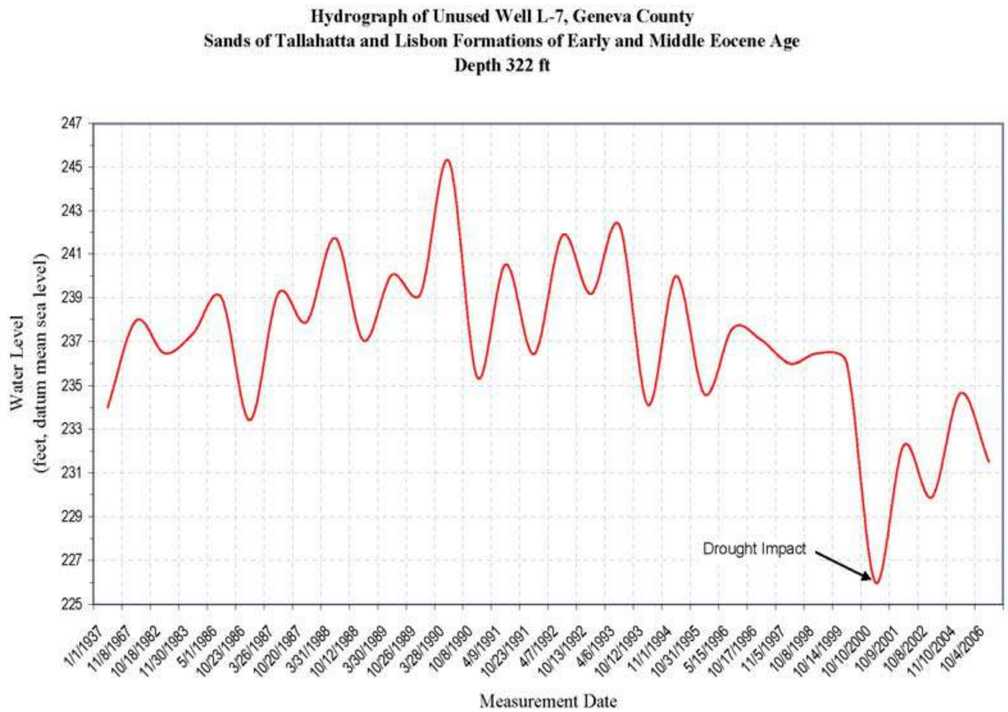

Figure 69.—Hydrograph of well L-7 displaying drought impact.

environment, and depth and hydraulic properties of aquifers. Wells in deeper, confined aquifers generally show minimal response to drought. The hydrographs shown above are from wells in relatively shallow aquifers where variation in water level caused by drought impacts are readily observed. Figure 70 shows an example of a deep, confined well with no significant effects from drought. This is a real-time well from Marion County that shows continuous water level measurements from 1952. The well is 520 ft deep and is constructed in the Pottsville Formation. Water levels in the well exhibit regular, seasonal fluctuations and minimal declines during periods of drought (fig. 70).

RECOMMENDATION

The CPYRWMA, as a member of the state drought mitigation team should take the lead role in southeast Alabama in assisting ADECA OWR with monitoring drought conditions, notification and dialog with key local stakeholders, and implementation of local drought mitigation initiatives.

POLICY OPTIONS

Drought mitigation should be part of a comprehensive statewide water management plan that includes current state drought classification methodology, drought monitoring, water availability, and impact mitigation.

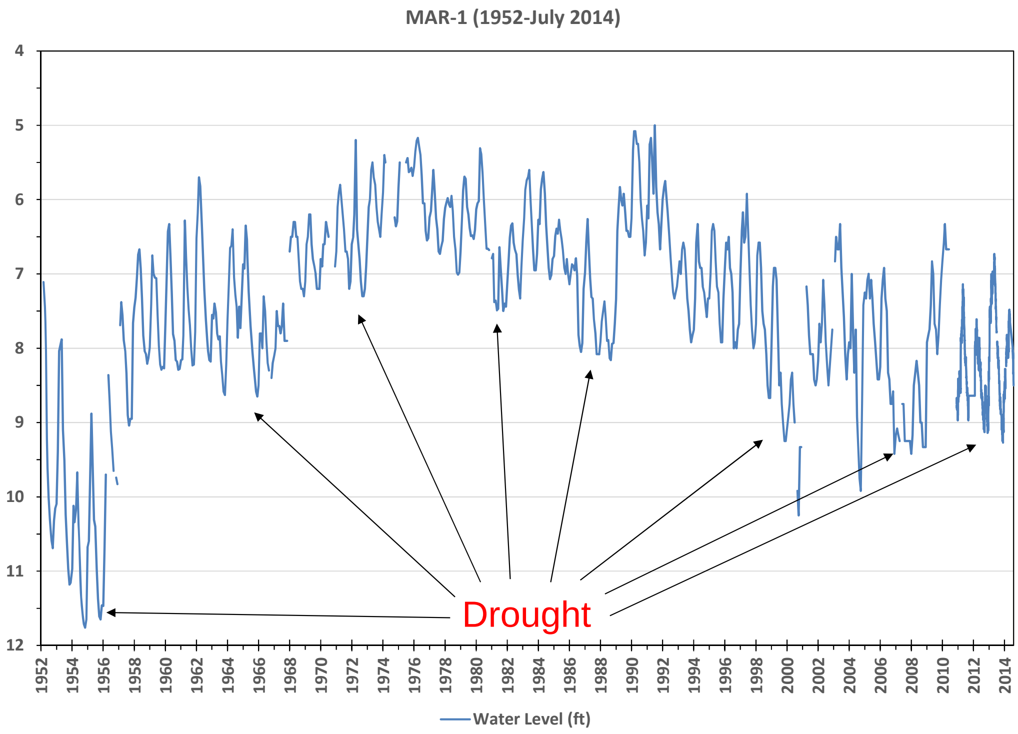

Figure 70.—Hydrograph of Marion County real-time well.

ESTIMATION OF WATER USE AND DEMAND

SURFACE WATER AND GROUNDWATER INTERACTION

Subsurface water movement occurs in two primary environments. The first is in and near the recharge area where aquifers are unconfined or partially confined, groundwater movement is under water table conditions, and groundwater/surface-water interaction is common. In this environment, precipitation infiltrates into the subsurface and moves down gradient and laterally to areas of low topography where the shallow groundwater discharges into streams or as seeps and springs. Groundwater/surface-water interaction is driven by hydraulic head (head) and serves to sustain streams during periods of drought when runoff is absent (groundwater head is higher than surface-water head) and contributes aquifer recharge when stream levels are high (surface-water head is higher than groundwater head). Groundwater discharge to streams forms the base flow component of stream discharge, forms the sustainable flow of contact springs and wetlands, and supports habitat and biota. Subsurface water movement in this environment is generally less than 15 miles and occurs from the updip limit of an aquifer, down gradient to the point where the aquifer is sufficiently covered by relatively impermeable sediments and becomes confined in the subsurface (Cook and others, 2014).

The second environment is characterized by subsurface water that underflows streams and areas of low topography and moves down gradient to deeper parts of the aquifer. Groundwater in this environment is separated from the land surface by relatively impermeable sediments that form confining layers. Groundwater in the coastal plain can move relatively long distances from recharge areas in aquifers that contain fresh water at depths that exceed 2,500 ft (Cook, 2002). With increasing depth, groundwater becomes highly pressurized and moves slowly down gradient or vertically and laterally along preferential paths of highest permeability. As it moves, minerals are dissolved from the surrounding sediments and accumulate to transform fresh water to saline water. This deep, highly mineralized groundwater eventually discharges into the deep oceans.

RECOMMENDATION

Develop strategies to promote groundwater recharge to maintain historic rates of base flow, including limitations on shallow groundwater production and protection of recharge areas.

POLICY OPTIONS

Develop a statewide water management plan that addresses groundwater/surface-water interaction with guidelines for protection of aquifer recharge areas and historic base flows.

WATER MONITORING

STREAM DISCHARGE GAUGES

The CPYRWMA operates and maintains a Flood Warning System (FWS) in southeast Alabama. Currently, 16 electronic stream/precipitation gauge stations and 5 precipitation gauge stations are operated and maintained by the CPYRWMA (fig. 71). The FWS was installed in 1993 by the USACE and is a joint effort of the USACE Mobile District, and the CPYRWMA (CPYRWMA, 2013a). River levels for FWS stations are recorded for the prior 72 hours and can be obtained from the CPYRWMA's website.

Table 29 lists the CPYRWMA stream/precipitation gauge stations, along with corresponding subbasins and watersheds. Stream/precipitation gauges are located in Barbour, Coffee, Covington, Dale, Geneva, Henry, and Houston Counties. Currently, Bullock, Crenshaw, and Pike Counties have no stream gauges, primarily due to the relatively small part of each county included in the CPYRWMA.

RECOMMENDATIONS

Further studies should be conducted to rate stream discharge for CPYRWMA flood warning system gauges. Discharge rating would provide discharge volumes for corresponding stage measurements for each stream that could be used for future water resource research and water policy development. The current flood warning system should be expanded with additional stream/precipitation gauges. Some possible locations for expansion include installing a stream gauge on the Yellow River near the confluence of Poley Creek and Lightwood Knot Creek, an upstream gauge at the Shiloh rainfall gauge, the upstream portion of Lightwood Knot Creek in Crenshaw County, and the headwaters of the Pea River in Bullock County. A final recommendation would include downloadable historical rainfall/gauge height data from the CPYRWMA website.

REAL-TIME GROUNDWATER MONITORING SYSTEM

The GSA Groundwater Assessment Program (GAP) currently operates and maintains 23 real-time groundwater monitoring systems, monitoring water levels and discharge in various aquifers in wells (21) and springs (2) throughout Alabama. Groundwater levels from wells and discharge for springs are recorded every 30 minutes and transmitted daily to the GSA GAP office (GSA, 2014b). Hydrographs, based on mean daily water levels are automatically generated, updated daily, and uploaded to the GSA GAP page on the GSA website, which can be accessed at www.gsa.state.al.us/.

The GSA GAP currently has three real-time wells installed in the CPYRW (fig. 72). DLE-1, which is located in Dale County, was the first real-time well installed in the CPYRW and is constructed in the Clayton aquifer to a depth of 453 ft below land surface (bls). The GSA GAP maintains a period of record for this well from 1980 to

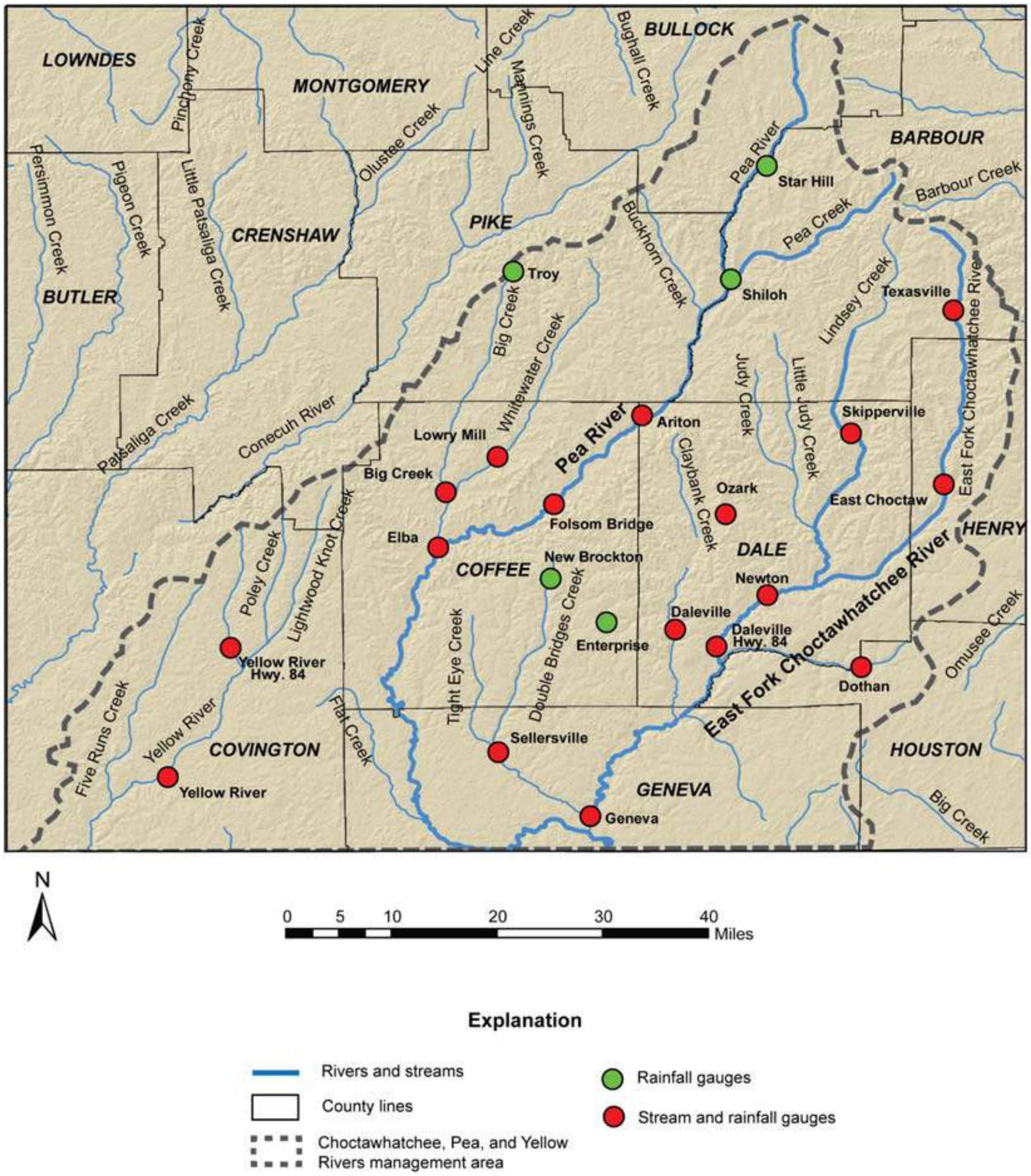

Figure 71.—CPYRWMA Flood Warning System stream and rainfall gauges.

present (fig. 73), although the real-time hydrograph depicts water levels since August 2012, when the real-time system was installed (fig. 74). The hydrograph for DLE-1 also depicts percentile lines based on data from 2000 through 2010 to allow comparison with previous water levels.

The real-time monitoring system in the CPYRW was recently expanded with the addition of two new monitoring stations. These two wells were installed in Geneva and Dale Counties, as a cooperative effort between the CPYRWMA and GSA. Well Geneva-1 (real-time system installed in October 2013), in north-central Geneva

Table 29.—Stream gauges operated and maintained by the CPYRWMA.

County	Gauge	Location	Subbasin	Watershed	Waterbody
Barbour	Texasville	Highway 131	Upper Choctawhatchee River	Upper East Fork Choctawhatchee River	East Fork Choctawhatchee River
Coffee	Big Creek	Highway 87 North	Pea River	Whitewater Creek	Big Creek
Coffee	Elba	Highway 84 West	Pea River	Middle Pea River	Pea River
Coffee	Folsom Bridge	Highway 167 North	Pea River	Upper Pea River	Pea River
Coffee	Lowry Mill	County Road 214	Pea River	Whitewater Creek	Whitewater Creek
Covington	Yellow River	Highway 55 North	Yellow River	Upper Yellow River	Yellow River
Covington	Yellow River 84	Highway 84	Yellow River	Headwaters Yellow River	Yellow River
Dale	Ariton	US Highway 231 North	Pea River	Upper Pea River	Pea River
Dale	Daleville	Highway 84 West	Upper Choctawhatchee River	Lower Claybank Creek	Claybank Creek
Dale	Newton	Highway 123 North	Upper Choctawhatchee River	Klondike Creek-Choctawhatchee River	Choctawhatchee River
Dale	Daleville 84	Highway 84	Upper Choctawhatchee River	Klondike Creek-Choctawhatchee River	Choctawhatchee River
Dale	Ozark	US Highway 231	Upper Choctawhatchee River	Upper Claybank Creek	Little Claybank Creek
Dale	Skipperville	Highway 105	Upper Choctawhatchee River	West Fork Choctawhatchee River	West Fork Choctawhatchee River
Geneva	Geneva	Highway 52 East	Lower Choctawhatchee River	Choctawhatchee River	Choctawhatchee River
Geneva	Sellersville	County Road 40	Upper Choctawhatchee River	Double Bridges Creek	Double Bridges Creek
Henry	East Choctaw	Highway 27 East	Upper Choctawhatchee River	Lower East Choctawhatchee River	East Fork Choctawhatchee River
Houston	Dothan	Highway 27 East	Upper Choctawhatchee River	Little Choctawhatchee River	Little Choctawhatchee River

County, is constructed in the Nanafalia aquifer to a depth of 790 ft bls. Geneva-1 was previously a GSA continuous monitored well with a period of record from 1967 through 1971 and from 1974 through 2012 (fig. 75). Figure 76 shows the hydrograph depicting water levels in Geneva-1 since October 2013. Well DLE-2, located in Dale County, is constructed in the Nanafalia aquifer to a depth of 240 ft bls. The GSA GAP maintains

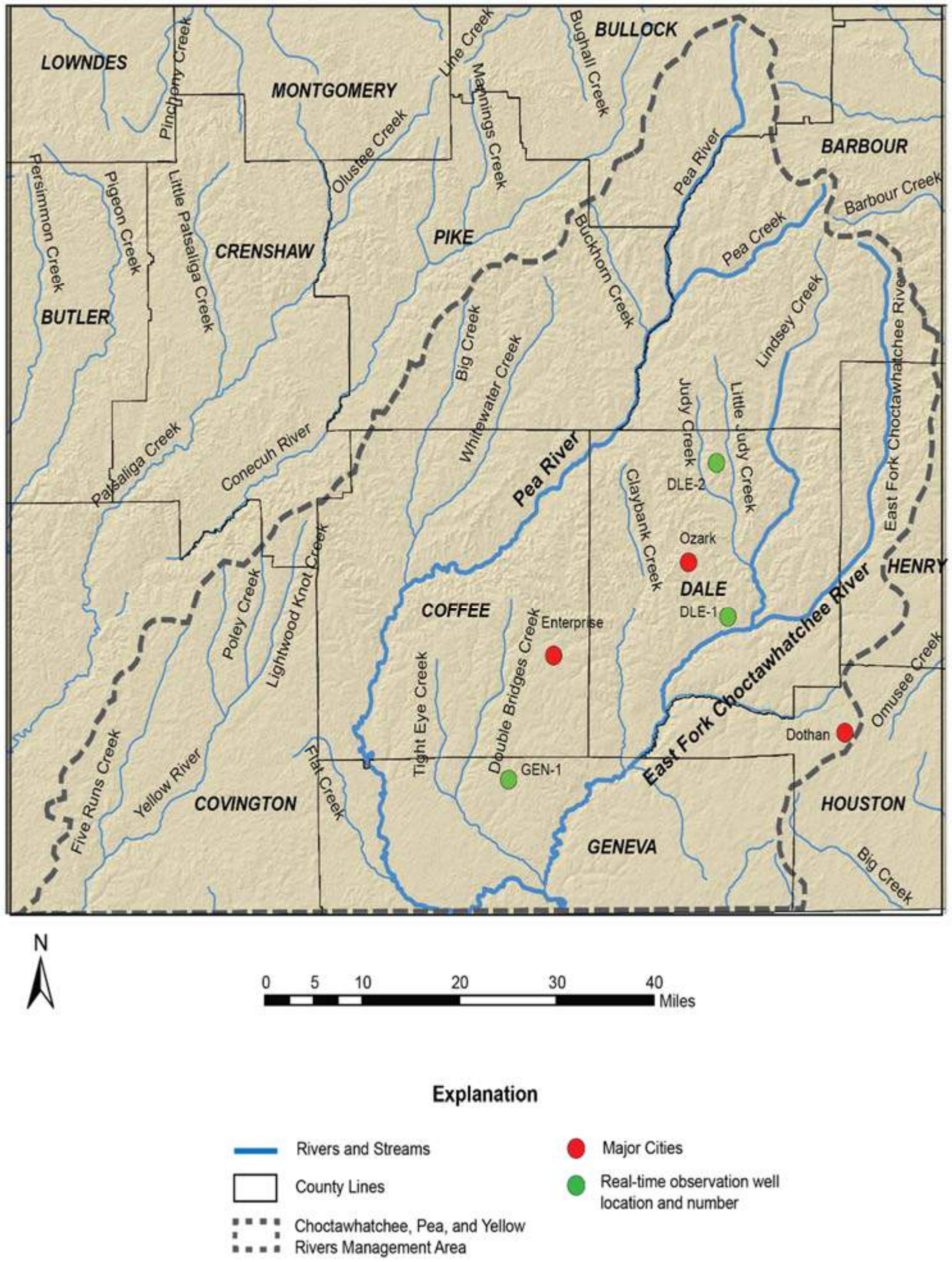

Figure 72.—Real-time monitoring wells in the CPYRW.

a period of record for this well for 1965, and from 1967 through 1971, and from 1974 to present (fig. 77). Figure 78 is a hydrograph for well DLE-2, which was fitted with a real-time monitoring system in November 2013. Wells Geneva-1 and DLE-2 were selected to demonstrate groundwater-level trends in the relatively deep, highly confined and relatively shallow, partially confined Nanafalia aquifer (figs. 76, 78).

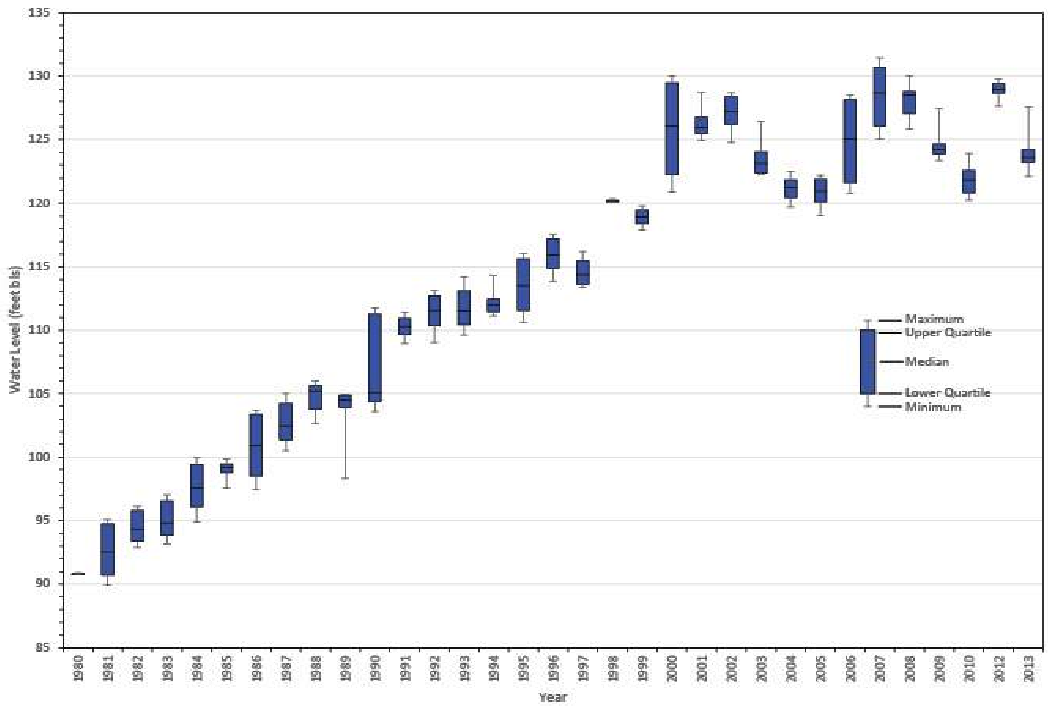

Figure 73.—Statistics and period of record for DLE-1 water levels.

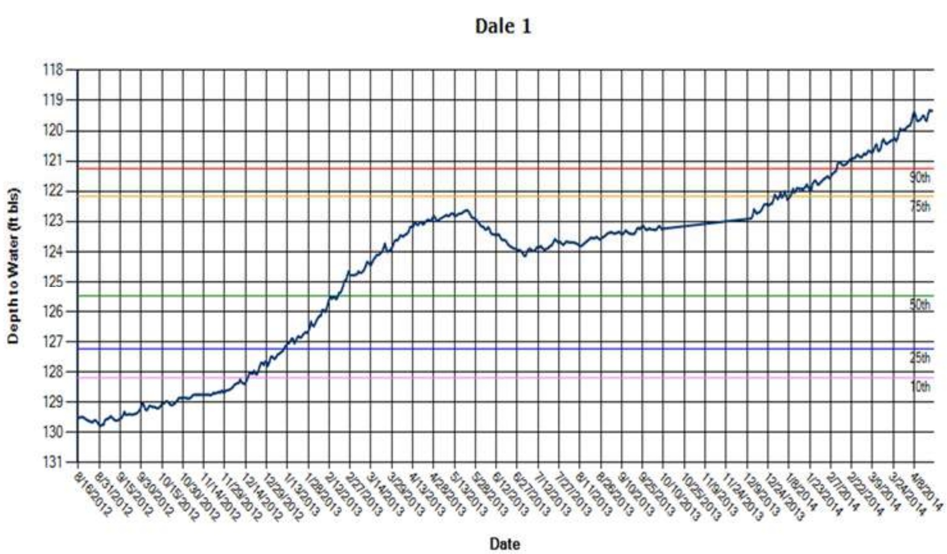

Figure 74.—Real-time hydrograph for monitoring well DLE-1.

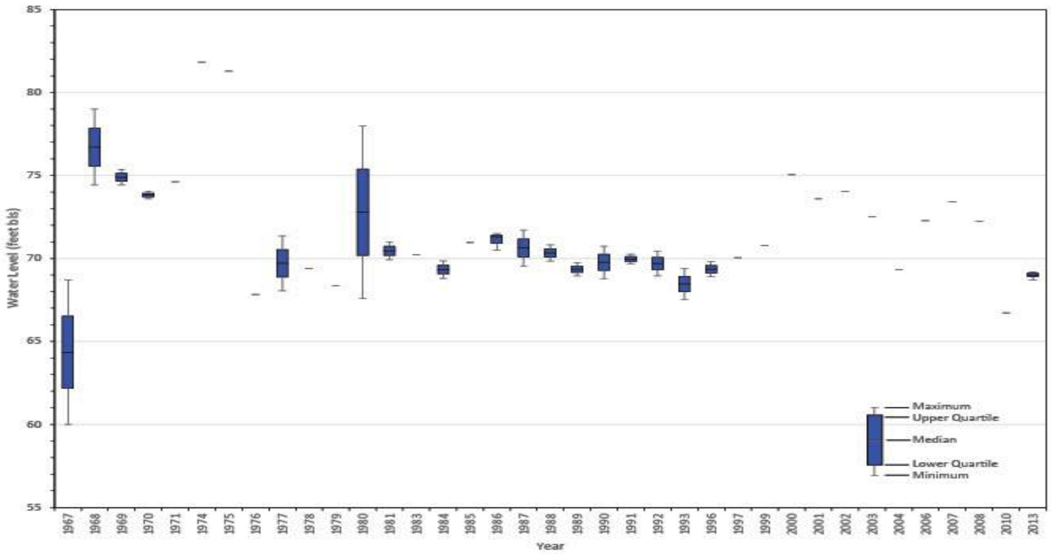

Figure 75.—Statistics and period of record for GEN-1 water levels.

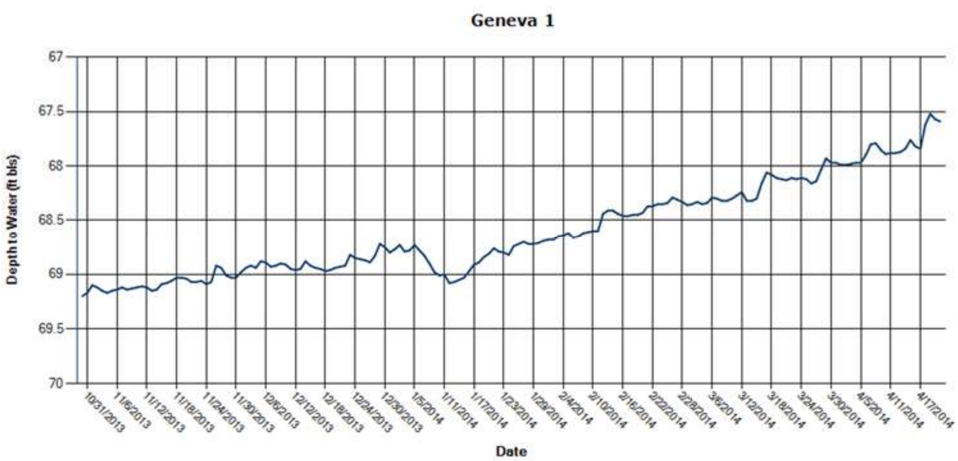

Figure 76.—GSA real-time hydrograph for monitoring well GEN-1.

RECOMMENDATION

The CPYRWMA should cooperate with the GSA to expand the GSA real-time monitoring program in southeast Alabama to aid in determining long-term fluctuations in groundwater levels in response to groundwater withdrawals, land use, and climatic changes. Other monitoring systems should be installed in the CPYRW including climate (temperature and precipitation) and soil moisture. The CPYRWMA should also provide educational outreach in conjunction with GSA to provide information on the GSA's real-time system.

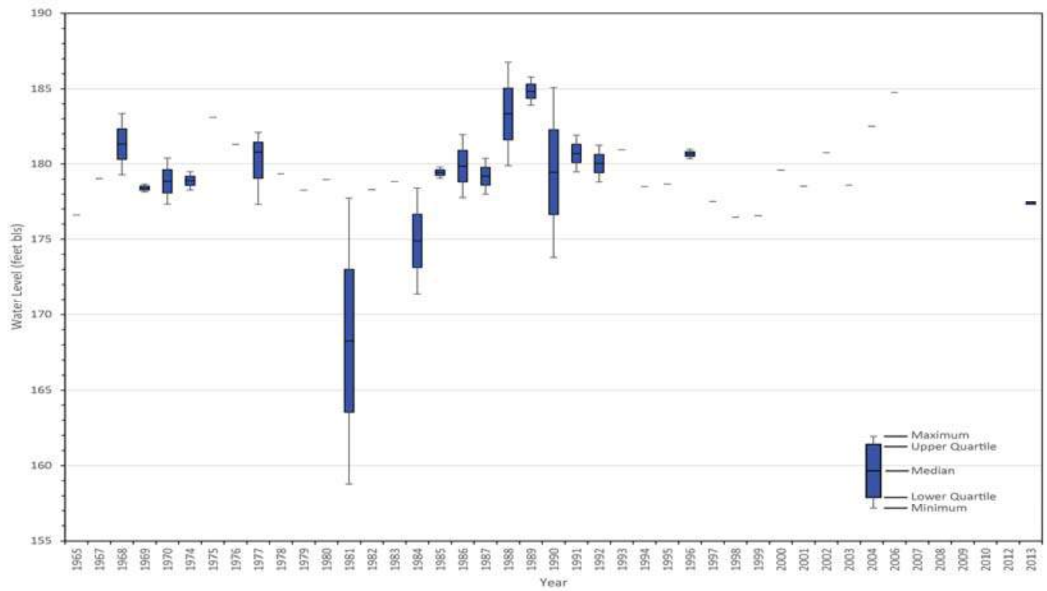

Figure 77.—Statistics and period of record for DLE-2 water levels.

Figure 78.—GSA real-time hydrograph for monitoring well DLE-2.

POLICY OPTION

Real-time groundwater monitoring should be part of the overall monitoring program included in a state water management plan.

PRECIPITATION MONITORING

Alabama's climate is classified as humid sub-tropical with mild winters and hot summers (CWP and GSA, 2005). Average annual temperature in Alabama is about 63 degrees Fahrenheit (°F) (Southeast Regional Climate Center, 2012). Mean rainfall in the CPYRW is 53.4 inches for the time-period 2000 through 2013, based on rainfall

data obtained from the CPYRWMA. Rainfall data was tabulated for the years 2000 through 2013 from 21 precipitation gauges maintained and operated by the CPYRWMA (table 30).

Rainfall in the watershed is generally well distributed throughout the year, with the driest portion of the year, on average, in September and October; however, drought and years of excessive precipitation periodically occurs (CWP and GSA, 2005). Using the overall mean rainfall of 53.38 inches from 2000 through 2013, drought conditions prevailed in the CPYRW in 2000, 2001, 2002, 2003, 2006, 2007, 2010, and 2011. Excessive precipitation occurred in 2009 with mean rainfall of 77.43 inches. The minimum average annual rainfall of 20.30 inches was recorded in Coffee County at Folsom Bridge Station in 2000. The maximum average annual rainfall of 89.48 inches was recorded in Geneva County at Geneva Station in 2013.

RECOMMENDATION

Current FWS precipitation gauges should be expanded. These data should be maintained and combined with supplemental data from other precipitation monitoring stations in the CPYRW. These data should be made available to key stakeholders in near real time on the CPYRWMA website.

POLICY OPTION

A comprehensive statewide water management plan should be developed to include groundwater, surface water, climate (temperature and precipitation), and soil moisture monitoring systems.

NATIONAL SOIL MOISTURE DATA

The USDA NRCS maintains 21 stations in Alabama (fig. 79) to monitor soil moisture, among other parameters, as part of a pilot project for establishing a national soil-climate monitoring program (USDA NRCS, 2004b). This pilot project, Soil Climate Analysis Network, currently has 191 stations in 40 states (USDA NRCS, 2014). A data logger records soil moisture at depths of 2, 4, 8, 20, and 40 inches and reports the data to the National Water and Climate Center in Portland, Oregon (USDA NRCS, 2004b). Currently, there are no soil monitoring stations installed within the CPYRW management area; however, the CPYRWMA can request that stations be installed by contacting the USDA NRCS.

RECOMMENDATION

The CPYRWMA should submit a request to the USDA NRCS for the installation of soil monitoring stations within the CPYRW.

INTERSTATE SURFACE WATER AND CONTAMINATION TRANSPORT

Interstate surface-water and contamination transport studies have been previously conducted and published by the GSA) (fig. 80). In 2002, the GSA published its assessment of the Yellow River and in 2010 published its assessment of the Choctawhatchee and Pea Rivers. Together, these assessments depict discharge and

Table 30.—Annual rainfall in CPYRW (2000-2013).

County	Station Name	Annual Rainfall													
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Barbour	Star Hill	32.83	51.26	42.01	48.37	41.46	52.75	44.60	39.48	60.04	73.68	44.60	38.28	50.28	60.88
Barbour	Texasville	29.29	40.89	45.60	42.81	46.31	58.31	39.09	50.32	58.68	72.04	40.80	35.04	50.40	65.40
Coffee	Big Creek	29.55	42.03	44.49	44.25	59.04	62.38	40.60	55.40	56.36	82.92	40.64	45.84	48.88	60.12
Coffee	Elba	29.94	40.30	57.16	52.93	62.67	59.32	37.52	48.16	54.80	75.52	34.64	35.04	49.24	62.44
Coffee	Enterprise[1]	-	-	-	-	-	-	-	-	-	-	-	-	-	67.84
Coffee	Folsom Bridge	20.30	41.68	53.10	57.53	58.62	58.84	45.07	54.12	59.48	85.64	46.16	36.28	54.76	66.64
Coffee	Lowry Mill	24.59	47.52	57.86	47.33	61.36	56.14	43.84	58.80	61.28	82.60	38.40	42.08	52.80	56.68
Coffee	New Brockton[2]	-	-	36.74	48.06	50.91	65.54	43.20	54.76	64.80	86.68	42.20	35.52	55.68	61.64
Covington	Yellow River[3]	-	-	49.84	48.11	55.04	57.28	48.80	55.20	49.60	83.36	45.64	43.80	54.36	65.12
Dale	Ariton	34.75	44.44	47.46	55.63	55.72	59.96	49.36	53.68	65.80	83.94	42.72	40.88	42.92	67.76
Dale	Daleville	33.28	43.93	56.85	54.76	59.20	62.32	45.60	50.64	53.92	81.80	42.96	40.28	59.76	73.32
Dale	Newton	31.98	45.96	55.41	52.83	52.96	52.46	38.38	45.32	51.08	75.24	41.76	41.00	54.12	74.00
Dale	Ozark[4]	-	-	-	-	-	-	-	-	-	-	-	33.24	57.28	68.40
Dale	Skipperville	30.22	42.98	45.18	52.16	48.16	64.56	37.24	42.28	62.48	75.48	43.44	40.48	50.56	70.72
Geneva	Geneva	30.28	42.20	59.42	48.33	64.96	49.56	45.88	64.68	51.02	78.08	39.24	43.36	62.12	89.48
Geneva	Sellersville	26.05	35.65	49.04	52.14	65.80	50.44	40.64	49.76	47.28	88.88	40.12	38.48	63.48	70.96
Henry	East Choctaw[5]	-	-	46.68	40.69	47.40	55.87	40.57	45.76	50.92	64.40	43.24	35.84	41.68	64.72
Houston	Dothan[6]	-	-	-	-	-	-	-	-	-	-	-	-	-	79.60
Pike	Troy	20.33	47.90	55.32	52.72	51.00	42.16	33.68	36.76	51.92	63.16	49.20	36.32	45.88	55.56
Pike	Shiloh	31.58	44.64	49.26	48.56	46.94	51.86	42.52	44.52	55.92	62.88	42.68	36.60	44.40	57.52

[1]Installed October 2012 [2]Installed July 2001 [3]Installed May 2001
[4]Installed September 2010 [5]Installed December 2011 [6]Installed July 2012
-Indicates only partial data or no data available

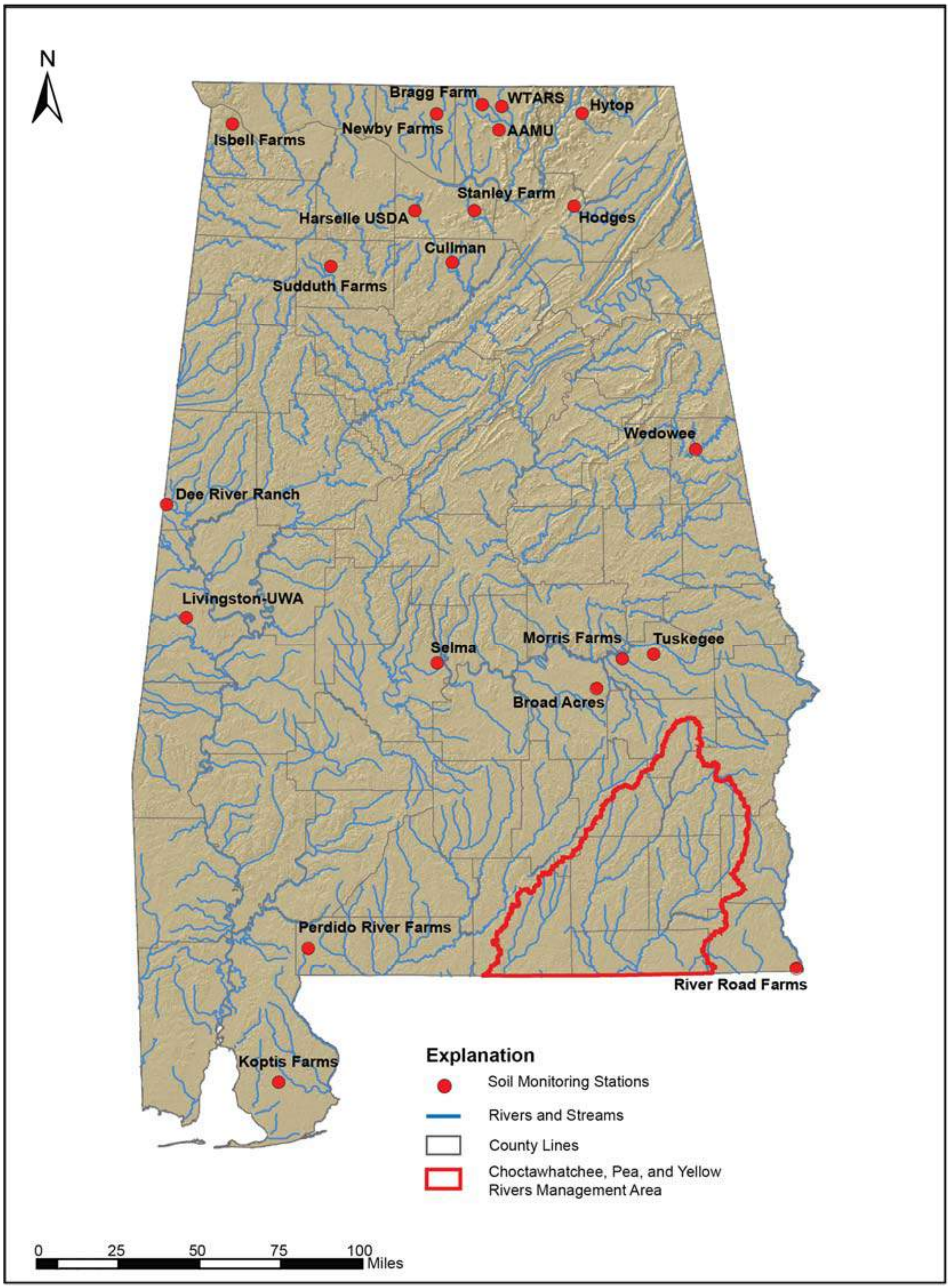

Figure 79.—Soil monitoring stations in Alabama operated by the USDA NRCS.

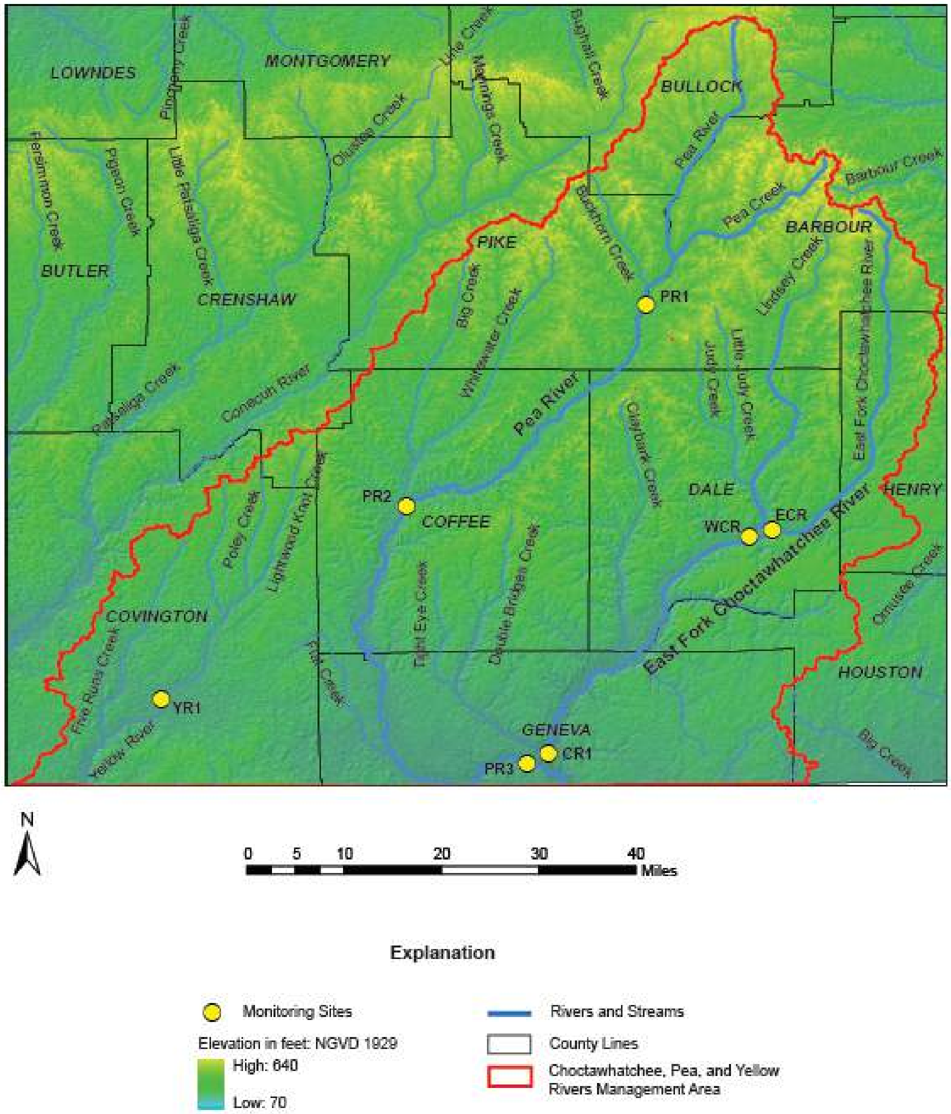

Figure 80.—Previous GSA monitoring sites along the Choctawhatchee, Pea and Yellow Rivers.

water quality conditions in the Choctawhatchee, Pea and Yellow Rivers. Table 31 lists the GSA monitoring sites on the three rivers. Constituents analyzed during the monitoring events included the following:

- stream discharge,
- field parameters (stream temperature, turbidity, specific conductance, pH, and dissolved oxygen (DO)),
- laboratory analyses (nutrients, biochemical oxygen demand (BOD),

- total dissolved solids (TDS),
- turbidity,
- total suspended solids (TSS),
- inorganic nonmetallic constituents, metals, and
- bacteria (Cook and others, 2002; Cook and Murgulet, 2010).

Table 31.—Location of previous GSA monitoring sites along the Choctawhatchee, Pea and Yellow Rivers.

Site	River	Monitoring Site Location
YR1	Yellow River	State Highway 55 crossing, 7 miles north of Florida state boundary, Covington County
PR1	Pea River	Alabama Highway 10 crossing, Pike County
PR2	Pea River	U.S. Highway 84 crossing, Coffee County
PR3	Pea River	Alabama Highway 27 crossing, Geneva County
ECR	East Fork Choctawhatchee	County Road 59 crossing, Dale County
WCR	West Fork Choctawhatchee	County Road 20 crossing, Dale County
CR1	Choctawhatchee River	Alabama Highway 52 crossing, Geneva County

The USEPA has published standards for primary and secondary drinking water regulations. Primary drinking water standards are enforceable, whereas secondary standards are recommendations only. Primary standards are protective of human health, while secondary standards deal mainly with aesthetic conditions, such as taste, odor, and color (USEPA, 2009).

Of the 25 constituents analyzed by the GSA for these prior studies, only five constituents (pH, aluminum, iron, lead, and manganese) exceeded primary/secondary drinking water standards (table 32). The upstream monitoring site (PR1) on the Pea River had an average pH value of 5.9, which is outside the range for secondary drinking water standards (6.5-8.5). The downstream site (CR1) on the Choctawhatchee River had an average pH value of 6.4, which is also outside the range for secondary drinking water standards. Although naturally occurring, aluminum concentrations for all five sites on the Choctawhatchee and Pea Rivers were above secondary drinking water standards (50-200 micrograms per liter (µg/L)), with the highest average concentration at site WCR on the West Fork Choctawhatchee River at 950 µg/L, and the lowest average concentration (212 µg/L) at site CR1 on the downstream segment of the Choctawhatchee River. All six sites on the Choctawhatchee, Pea and Yellow Rivers had average concentrations that exceeded the secondary drinking water standards for iron (300 µg/L), which is also naturally occurring, with the highest average concentration (744 µg/L) at site WCR and the lowest average concentration (440 µg/L) at site PR3 on the downstream segment of the Pea River. Two sites, PR1 and PR3, had average lead concentrations above

Table 32.—Constituents concentrations as determined at GSA monitoring sites in the Choctawhatchee, Pea and Yellow Rivers.

Constituent	Primary Drinking Water Standards	Secondary Drinking Water Standards	Average concentration of constituents monitored at selected sites						
			YR1	PR1	PR2	PR3	ECR	WCR	CR1
Stream Discharge (cfs)	-	-	268	678	1,687	2,419	1,001	1,118	7,759
Stream Temperature (°C)	-	-	20	15.6	15.5	16.2	15.8	16.6	16.7
Specific Conductance (µS/cm)	-	-	86.0	53.0	72.6	73.1	67.0	61.6	59.3
pH	-	6.5-8.5	6.8	**5.9**[a]	6.5	6.5	6.6	6.6	**6.4**
Dissolved Oxygen (mg/L)	-	-	8.0	8.4	9.0	8.3	9.7	9.7	8.3
Biochemical Oxygen Demand (mg/L)	-	-	0.7	1.2	1.5	1.2	1.2	0.8	0.9
Total Dissolved Solids (mg/L)	-	500	44	-	-	-	-	-	-
Turbidity (NTU)	-	-	11	22	48	64	38	24	66
Total Suspended Solids (mg/L)	-	-	19	13	25	28	26	19	29
Ammonia, NH_3 as N (mg/L)	-	-	0.017	0.04	0.05	0.04	0.03	0.08	0.04
Nitrate, NO_2 as N (mg/L)	10	-	0.092	0.16	0.25	0.23	0.21	0.13	0.38
Chloride (mg/L)	-	250	-	5.7	5.8	4.9	5.6	4.5	5.2
Phosphorus (mg/L)	-	-	0.014	0.09	0.08	0.07	0.09	0.08	0.09
Fecal Coliform (col/100 mL)	-	-	575	-	-	-	-	-	-
Fecal Streptococci (col/100 mL)	-	-	900	-	-	-	-	-	-
Aluminum (µg/L)	-	50-200	79	**247**	**244**	**220**	**252**	**950**	**212**
Arsenic (µg/L)	10	-	-	BDL[b]	BDL	BDL	BDL	BDL	BDL
Barium (µg/L)	2,000	-	24	65	55	56	51	49	45
Beryllium (µg/L)	4	-	-	BDL	BDL	BDL	BDL	BDL	BDL
Cadmium (µg/L)	5	-	-	BDL	BDL	BDL	BDL	BDL	BDL
Calcium (mg/L)	-	-	11.9	-	-	-	-	-	-
Chromium (µg/L)	100	-	-	BDL	BDL	BDL	BDL	BDL	BDL
Copper (µg/L)	1,300	1,000	-	BDL	BDL	BDL	BDL	BDL	BDL
Iron (µg/L)	-	300	**602**	**732**	**572**	**440**	**672**	**744**	**585**
Lead (µg/L)	15	-	BDL	**25**	7	**28**	7	8	13
Magnesium (µg/L)	-	-	2,000	-	-	-	-	-	-
Manganese (µg/L)	-	50	45	**157**	**56**	27	47	39	16
Mercury (µg/L)	2	-	-	BDL	BDL	BDL	BDL	BDL	BDL
Selenium (µg/L)	50	-	-	BDL	BDL	BDL	BDL	BDL	BDL
Thallium (µg/L)	2	-	-	BDL	BDL	BDL	BDL	BDL	BDL
Zinc (µg/L)	-	5,000	10	32	25	26	23	21	22

[a] Bold and shading indicates constituent average concentration exceeds primary/secondary drinking water standards.

[b] BDL—Below Detection Limit

primary drinking water standards (15 µg/L), with the highest average concentration (28 µg/L) at PR3. Lead does not occur naturally in this area and is probably present in these watersheds due to atmospheric deposition. Two sites, PR1 and PR2, had average concentrations above secondary drinking water standards (50 µg/L) for manganese.

RECOMMENDATION

The CPYRWMA should cooperate with ADEM to establish a monitoring program to monitor local water quality and maintain a water quality database to identify water-quality trends in the CPYRW. These data should be used to assess stream quality for biological resources, all current and future water users, and stream discharge entering Florida. The CPYRWMA should establish a dialogue with the state of Florida regarding stream discharge entering Florida.

MONITOR QUALITY AND FLOW ENTERING AND LEAVING STATE

The GSA published data on the quality of water leaving the state from the Choctawhatchee, Pea and Yellow Rivers, as discussed in the previous section. The CPYRWMA installed stream gauges at upstream and downstream sites on the Choctawhatchee River, a midstream site on the Pea River, and upstream and downstream sites on the Yellow River, which monitor stream levels in the CPYRW.

IDENTIFICATION OF FUTURE WATER SOURCES

SURFACE WATER

Development of future surface-water sources could include reservoirs and offstream storage. However, such future sources would require cooperative efforts with ADEM, USEPA, USACE, and local stakeholders and includes wetlands inventory and environmental impact assessments of proposed sites. Future surface-water sources could include existing reservoirs, including Lake Tholocco (a federal reservoir at Fort Rucker) and Lake Frank Jackson (a state-owned recreational reservoir). These reservoirs were previously evaluated by the GSA for viability as public water-supply sources (Cook and Moss, 2005). Impoundments on streams could also be considered, as previously published in a study by the GSA for five streams in the CPYRW (Cook and O'Neil, 2000). The GSA assessment concluded that Lake Frank Jackson had an estimated water production potential of 34 mgd (Cook and Moss, 2005). The Cook and O'Neil (2000) assessment evaluated the following watersheds: Blackwood Creek, Double Bridges Creek, and Little Double Bridges Creek, which could sustain water productions of 25, 19.5, and 14.5 mgd, respectively, at a maximum draft rate of 50%, which would ensure that the proposed reservoir would refill each year and have adequate downstream water release. Little Choctawhatchee River and Walnut Creek could support sustainable production of 74 and 11.5 mgd, respectively, at a 40% draft rate (Cook and O'Neil, 2000).

Offstream storage has the advantage of providing storage of surface water without impounding perennial flowing streams. A number of viable sites may be available in the CPYRW; however, no site has been formally assessed.

RECOMMENDATION

The CPYRWMA should cooperate with ADCDA OWR, ADEM, and GSA to establish a procedure for evaluation of the development of future surface-water resources based on need, availability, and environmental impacts.

POLICY OPTION

A comprehensive statewide water management plan should be developed to establish a process for future surface-water source development with local stakeholder input and support.

GROUNDWATER

Future groundwater resources in the CPYRW will require application of comprehensive scientific data to prudently develop existing and new aquifers. The city of Dothan recently commissioned a study to develop recommendations for improvements to the current municipal water supply system. Among the recommendations for the near term, were construction of three new public supply wells and current infrastructure rehabilitation (Dothan Eagle, 2013). Dothan's long-range future plans include construction of up to 13 wells in the panhandle of Houston County (Dothan Eagle, 2013). Other CPYRW water supply systems have taken steps to develop future supplies, including Ozark Utilities with a deep Tuscaloosa aquifer well (fig. 81), Enterprise, which is currently developing a new well field in Tertiary aquifers, and Bullock County Water Authority with plans for a new Gordo aquifer well.

RECOMMENDATION

Existing hydrogeologic data and adequate well spacing guidelines, in conjunction with current and future water use and demand estimates should be utilized to determine locations, well specifications, and sustainable production rates for additional groundwater source development.

POLICY OPTION

A comprehensive statewide water management plan should be developed that addresses pre-determined well spacing, sustainable production rates, and groundwater use priority designations.

HYBRID WATER SOURCES

Development of hybrid water supply sources (combinations of surface-water and groundwater sources) for future water needs will require development of surface-water sources to supplement existing groundwater supplies.

RECOMMENDATION

The CPYRWMA should take a lead role in determining adequacy of current water sources and development of comprehensive future water source planning so that surface-water sources can be evaluated and developed to ensure future water availability.

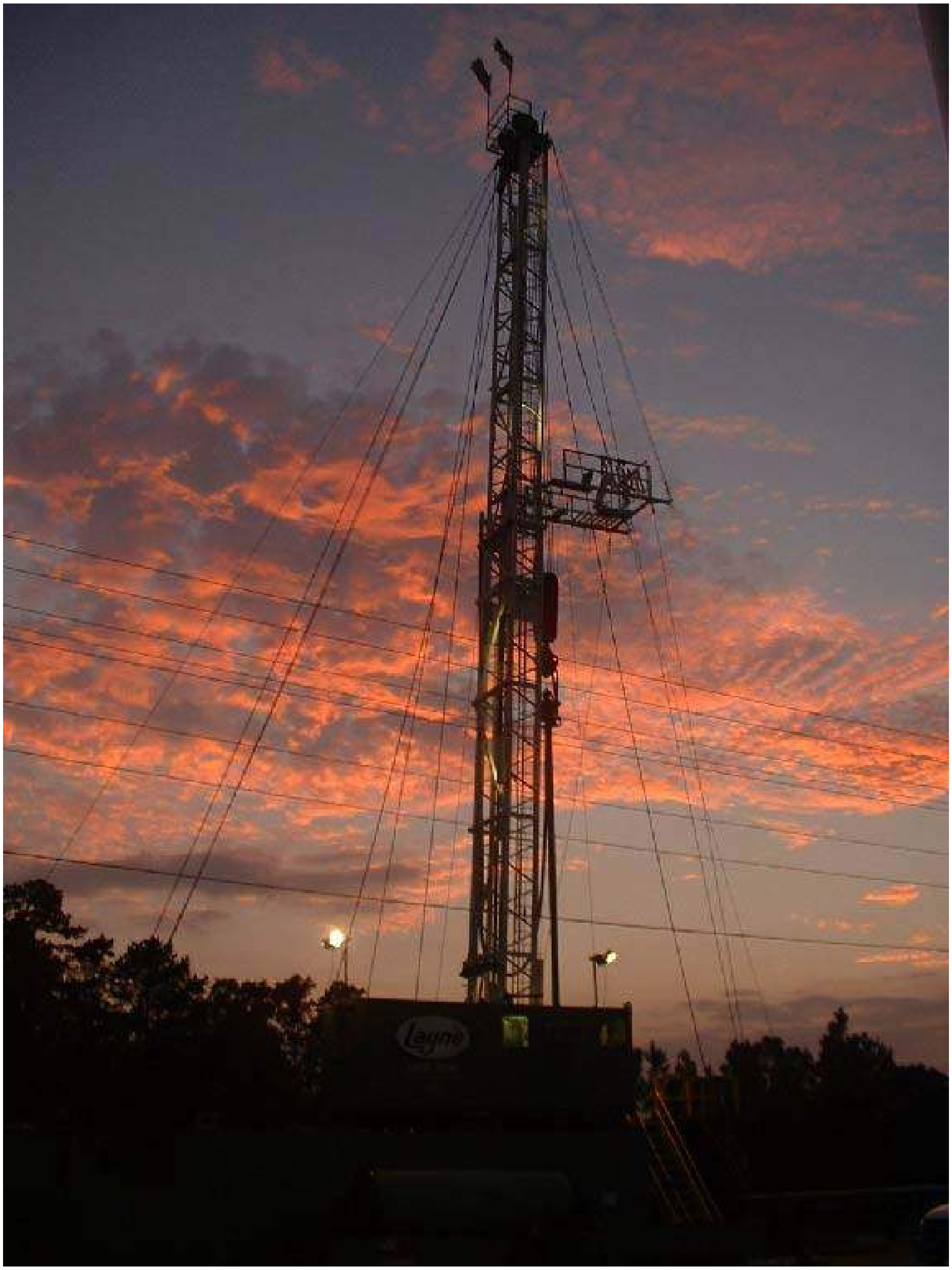

Figure 81.—Photo of the Ozark Utilities Tuscaloosa deep well rig.

WATER POLICY IMPLICATIONS

A comprehensive statewide water management plan should be developed that will address future water needs and source development.

WATER SOURCE SUSTAINABILITY

Water source sustainability can be defined as the practice of utilizing current water sources while ensuring that the ability of future generations to use the same sources is not impacted. Table 33 shows sustainability rates of renewal and environmental consequences. Increasing development, population growth, growing water demands, and events such as climate change can have significant effects on water quantity and quality. While drinking water providers strive to ensure that a plentiful supply of high-quality drinking water is available to the public, continued development upstream of existing and planned future supply sources can pose pollution threats and affect long-term sustainability of water resources. Source water protection activities undertaken by public water suppliers and their watershed partners can be considered to ensure sustainable quality of drinking water sources (Kenel and Witherspoon, 2005).

Table 33.—Sustainability rate of renewal (AWRA, 2010).

Consumption of renewable resources	State of environment	Sustainability
More than nature's ability to replenish	Environmental degradation	Not sustainable
Equal to nature's ability to replenish	Environmental equilibrium	Steady-state sustainability
Less than nature's ability to replenish	Environmental renewal	Sustainable development

To apply sustainable practices to water resource management, the American Water Resources Association (AWRA) suggests that a comprehensive systems view should be considered. The systems view must take into account the following concepts: long duration, reasonable use rate, moderate solutions and flexibility. Public policies that are intended to be permanent are aimed at the idea of long duration. These types of policy do not always provide a consistent and sustainable approach to water resource supply. Over the course of many years, humans have intervened in the natural hydrologic system to move water from its origin to where it is needed for supply. This policy becomes difficult as water supplies dwindle over time and adverse impacts have been discovered. This type of water delegation is being reconsidered. There are major population and economic centers in areas that could not have sustainable water resources without engineering intervention (AWRA, 2010).

A reasonable use rate must be determined which promotes sustainable water management. It would seem apparent that a natural resource like water cannot be used indefinitely at a greater rate than it can be renewed, which usually occurs via natural processes. Yet, the history of water use has been replete with examples of

water practices that have regarded the resource as boundless. Groundwater depletion has been, and in some cases continues to be, a major issue. The idea of "water mining" regards water as a resource to be used until exhausted, overlooking renewal entirely. In many cases, deep aquifers contain water that takes thousands of years to reach the aquifer, so the renewal rate is less than pumping rate by many orders of magnitude (AWRA, 2010).

Moderate public policies are those which tend to avoid extreme solutions to problems about water resources. Extreme solutions are those in which inordinate efforts are undertaken, often meaning very large investments in facilities. Liberal application of water, fertilizers, and pesticides to agricultural areas has led to runoff, soil erosion, and nonpoint source contamination. The extreme cases tend to be those where there is a large concentration of human activity. In this kind of decision making trap, each step seems to be relatively harmless, yet over time accumulated decisions lead to serious problems (AWRA, 2010).

Because public policy decisions are often regarded as the solution or end to a problem, often little thought is given to what could be done to address an action that turns out to be a serious mistake. The issue with these cases is commitment to a course of action without regard for unintended consequences. It is not possible to know all of the impacts of a decision when it is made. Policymakers should anticipate the need for revisiting these issues and be careful not to make commitments that are difficult to modify. To keep on the path of improving sustainability, periodic monitoring and flexibility should be practiced during and after the decision making process. It is important to learn from past mistakes to achieve a more sustainable future. These notions would be a valuable practice for future public water policy (AWRA, 2010).

The most effective protection strategies are based on a watershed approach to managing water supply. Source water protection requires the support of the community, as protection measures may involve voluntary actions, best management practices, or local zoning issues. To educate the community about water source sustainability, the results of the assessments need to be publicized. Drinking water protection actions must be linked with watershed protection actions to be most effective. In the past, water programs were developed to protect separate parts of the ecosystem or separate uses of its resources. This fragmented approach can be a barrier to public health protection. Rivers, streams, and groundwater that serve as drinking water sources also have ecological value, and their functions cannot be separated. Therefore it is important that all communities, institutional programs, and associated stakeholders work in harmony with each other to promote a sustainable water infrastructure through holistic resource management (Kenel and Witherspoon, 2005).

HOLISTIC WATER RESOURCE MANAGEMENT

Holistic watershed management for sustainable use of water resources is a topic of paramount interest to federal, state, and local agencies. Holistic water resource management is defined as practices and processes designed to achieve sustainable water resource use for the benefit of humans and the natural environment throughout the watershed (Mississippi State University, 2009). This concept embraces the idea that all aspects of the watershed—human resources, economic development, environmental quality, infrastructure development and public safety—must be

considered in a holistic watershed management decision-making process. There are many practices that can be employed to promote holistic water management.

Conjunctive water use is often implemented in holistic water resource management. Conjunctive use is the coordinated management of surface-water and groundwater supplies to maximize the yield of the overall water resource. An active form of conjunctive use utilizes artificial recharge, where surface water is intentionally percolated or injected into aquifers for later use. A passive method is to simply rely on surface water in wet years and use groundwater in dry years. The success of many of these programs, however, depends on purchasing available surface water from other users (Water Education Foundation, 2006).

Low impact development (LID) is another way to incorporate holistic watershed management. According to the Alabama Cooperative Extension System (ACES), LID is defined as an interdisciplinary systematic approach to stormwater management that, when planned, designed, constructed, and maintained appropriately, can result in improved stormwater quality, improved health of local water bodies, reduced flooding, increased groundwater recharge, more attractive landscapes, wildlife habitat benefits, and improved quality of life. Low impact development minimizes runoff and employs natural processes such as infiltration, evapotranspiration, and storage of stormwater at multiple fine scale locations to be as near to the source of stormwater as possible. Successful implementation of LID recreates a more natural hydrologic cycle in a developed watershed (ADEM, ACES, and Auburn University (AU), 2013).

The ADEM, ACES, and AU developed a Low Impact Development Handbook to provide guidance for LID, stormwater control, green infrastructure, and community planning that promotes holistic management for watersheds in the State of Alabama. The first step in LID is to consider the landscape that will be developed. It is critical to understand local soils, size constraints, groundwater level, native vegetation options, and other potential constraints so that the appropriate LID stormwater control measure practices can be selected to meet project goals. The LID stormwater practice should be designed to effectively store, infiltrate, or spread out stormwater in its landscape setting, ideally working as a system with the other practices in the development and watershed (ADEM, ACES, and AU, 2013). LID practices include bioretention; constructed stormwater wetlands; permeable pavement, grassed swales, infiltration swales, and wet swales; level spreaders and grassed filter strips; rainwater harvesting; green roofs; riparian buffers; rain gardens; curb cuts; and riparian buffers.

Bioretention cells (BRCs) remove pollutants in stormwater runoff through adsorption, filtration, sedimentation, volatilization, ion exchange, and biological decomposition. A BRC is a depression in the landscape that captures and stores runoff for a short time, while providing habitat for native vegetation that is both flood and drought tolerant. BRCs are stormwater control measures that are similar to the homeowner practice of using rain gardens, with the exception that BRCs have an underlying specialized soil media and are designed to meet a desired stormwater quantity treatment storage volume. Peak runoff rates and runoff volumes can be reduced and groundwater can be recharged when bioretention is located in an area

with the appropriate soil conditions to provide infiltration (ADEM, ACES, and AU, 2013).

Constructed stormwater wetlands are created wetland areas designed to treat stormwater and function similarly to natural wetlands (fig. 82). These systems use complex biological, chemical, and physical processes to cycle nutrients and breakdown other pollutants for treatment of stormwater runoff. Constructed stormwater wetlands mimic the filtration and cleansing capabilities of natural wetlands while providing temporary storage of stormwater above the permanent pool elevation and because of this, are often used for water quantity control. These systems are usually large and use shallow pools, complex microtopography, and both aquatic and riparian vegetation to effectively treat stormwater (ADEM, ACES, and AU, 2013).

Permeable pavement is a pervious surface used in place of traditional concrete or asphalt to infiltrate stormwater. Permeable pavement provides a volume reduction of stormwater runoff through temporary storage. It can be used to reduce peak flows and promote stormwater infiltration in urbanizing watersheds. The application of permeable pavement reduces impervious surface area runoff, which has been linked to stream bank erosion, flooding, nonpoint source pollution, and other water quality impairments. Permeable pavement refers to any pavement that is designed to temporarily store stormwater in a gravel base layer. Stormwater is held in the gravel base layer, or subbase, before leaving the system through exfiltration into surrounding soils or through an underdrain. These systems are suitable for residential driveways, walkways, overflow parking areas, and other low traffic areas that might otherwise be paved as an impervious surface (ADEM, ACES, and AU, 2013).

A water quality swale is a shallow, open-channel stabilized with grass or other herbaceous vegetation designed to filter pollutants and convey stormwater. Swales

Figure 82.—Example of a constructed stormwater wetland
(photo credit: Horry County Stormwater Management, 2014.

are applicable along roadsides, in parking lots, residential subdivisions, and commercial developments and are well suited to single-family residential and campus type developments. Water quality swales presented in the LID handbook are designed to meet velocity targets for the water quality storm design, may be characterized as wet or dry swales, may contain amended soils to infiltrate stormwater runoff, and are generally planted with turf grass or other herbaceous vegetation (ADEM, ACES, and AU, 2013).

Level spreaders are devices that create diffused or sheet flow that is evenly distributed or dispersed to decrease flow velocity and discourage erosive forces associated with concentrated flows. Most commonly, level spreaders are paired with grassed filter strips, riparian buffers, or a combination of the two to provide pollutant removal. The primary purpose of a level spreader is to disconnect impervious surfaces by creating non-erosive stormwater connectivity with grassed filter strips. A grassed filter strip is a linear strip of dense vegetation that receives sheet flow of stormwater runoff from a nearby impervious surface or level spreader in order to reduce peak discharge rates, encourage sediment deposition, and provide limited infiltration. Grassed filter strips are planted with turf grass, which is easy to maintain and blends seamlessly into urban landscapes. Grassed filter strips are most effective when combined with level spreaders (ADEM, ACES, and AU, 2013).

Rainwater harvesting is the collection of rainwater for reuse, typically from a rooftop, and can be used as a form of rooftop runoff management to reduce runoff from impervious surfaces. Rooftop systems typically collect stormwater through a connection to a rain gutter system. Rainwater harvesting systems may be above or below ground systems and can be large or small depending on the site, application, and intended use. When designed and used properly, these systems are an excellent way of saving water, energy, and money. Rain barrels are systems used for small-scale (50-60 gallons) applications such as residential areas and cisterns are larger storage tanks (100-10,000 gallons) that are better suited to residential or agricultural settings where large volumes of water are needed (ADEM, ACES, and AU, 2013).

Green roofs are landscaped roofs that use a specialized growing substrate, storage, drainage mat, and vegetation that is tolerant of extreme climates experienced on rooftops (fig. 83). Green roofs mitigate stormwater runoff, reduce the heat island effect of impervious surfaces from rooftops, extend roof membrane life, conserve energy, reduce noise and air pollution, provide wildlife habitat in urbanized settings, and improve fire resistance of buildings. These systems have been used in Europe for decades and are becoming more prevalent in the U.S. as stormwater retention practices that provide aesthetic value. As a stormwater control measure, green roofs are more effective at reducing runoff volumes resulting from small storms rather than providing pollutant load reductions from impervious surface runoff (ADEM, ACES, and AU, 2013).

Riparian buffers are permanently vegetated transition zones that connect upland areas to streams. Prior to development, most streams in the Southeast had naturally occurring riparian buffers. These streamside forests slow runoff velocity, create diffuse flow, and reduce nonpoint source pollution concentrations before runoff enters nearby streams or other water bodies. Buffers filter pollutants from agricultural, urban, suburban, and other land cover through natural processes such as deposition,

Figure 83.—Example of a green roof (photo credit: Organic Connect Magazine, 2012).

infiltration, adsorption, filtration, biodegradation, and plant uptake. Riparian buffers also stabilize stream banks and provide food and shelter to wildlife to connect otherwise fragmented wildlife communities in a watershed. Riparian buffers are often recommended as part of a holistic watershed management plan aimed at reducing nonpoint source pollution (ADEM, ACES, and AU, 2013).

Rain gardens are shallow depressions in a landscape that capture water and hold it for a short period of time to allow for infiltration, filtration of pollutants, habitat for native plants, and effective stormwater treatment for small-scale residential or commercial drainage areas. Rain gardens use native plants, mulch, and soil to filter runoff. As urbanization increases and pervious surfaces decrease, rain gardens are an excellent practice to promote infiltration of up to 30% more stormwater than traditional lawns. Residential stormwater management can often help homeowners save money on lawn irrigation when lawns are converted to rain gardens. These areas are designed to capture 3 to 6 inches of runoff after a storm, which allows water to infiltrate and return to groundwater, rather than being discharged to a stormwater conveyance system (ADEM, ACES, and AU, 2013).

Curb cuts convey stormwater into vegetated areas such as roadside swales, parking lot islands, rain gardens, or bioretention areas. Curb cuts are an easy retrofit that can be used in residential or commercial land use areas and are effective in moving stormwater to landscaped areas. Curb cuts are often used to convey stormwater into another LID practice. Curb cuts do not perform any pretreatment, but can minimize erosion by creating diffuse flow into other stormwater control measures. Curb cuts can also be installed to redirect stormwater into a grassy field.

While this is not directly considered a LID practice, it does reduce stormwater quantity in the receiving water body. Roadside curb cuts usually intercept perpendicular stormwater flow and in many cases multiple curb cuts are needed to adequately collect and move stormwater (ADEM, ACES, and AU, 2013).

Disconnected downspouts can direct rooftop runoff to vegetated areas through the disconnection of rooftop downspouts. By redirecting rooftop runoff, stormwater entering the stormwater conveyance network is reduced and groundwater recharge and runoff infiltration is increased. Disconnected downspouts are often used in conjunction with other stormwater infiltration practices by directing runoff to practices such as rain gardens, bioretention areas, and grassed swales. In doing so, the need for curbs, gutters, and conventional collection or conveyance of stormwater can be reduced (ADEM, ACES, and AU, 2013).

These practices may be found in detail in the Low Impact Development Handbook for the State of Alabama. The handbook includes site selection strategies; design guidance, formulas, and examples; construction activities; vegetation design guidelines and examples; maintenance schedules; pollutant removal tables; and references for each practice listed.

WATER CONSERVATION AND EFFICIENCY

Southeast Alabama continues to face threats to water supplies, such as stress from population growth and climate change. Local leaders and public water suppliers are challenged with the task of supplying clean, reliable water for current and future generations. In the past, building reservoirs was often the first choice of water utilities to develop additional water supplies, due to the apparent quick fix provided by creating large amounts of storage. Unfortunately, water supply reservoirs have significant negative environmental impacts on water quality and stream health and do not address the root problem of the need to use our limited water sources wisely. The elimination of flow makes the impounded area unsuitable habitat for native fluvial species and the physical, chemical and biological health of the downstream reaches may be greatly impacted due to numerous changes, including the alteration of sediment regime, water and food transport downstream, increased temperature and nutrients and low dissolved oxygen (USEPA, 2010). Not only do reservoirs cause disruption to the water cycle for the watershed and river basin, but they can also actually increase water loss due to evaporation and be very expensive to build in comparison to implementing water conservation and efficiency measures. Estimates are that dams and reservoirs can cost up to 8,500 times more than water efficiency measures (USEPA, 2010). For these reasons, building new dams should be the last alternative for solving water supply needs. To conserve water for future generations, water efficiency practices must be promoted in water resource management. The document "Hidden Reservoir" by American Rivers, Inc., published in October 2008, outlines several water efficiency policies that promote water conservation.

An important practice in water conservation is to stop leaks. Aging infrastructure and broken pipes lose large quantities of water through leaks. It is estimated that in the United States, over 6 billion gallons of water (or 14% of total water use) are lost each day (American Rivers, Inc., 2008). To address this problem, water suppliers should reduce leaks to as close to zero as possible, conduct self-audits to identify and

fix system leaks, and eliminate unmetered uses. Water must also be priced to cover costs and encourage efficiency. Pricing water accordingly can yield a 15% reduction in water use. Some water utilities adopt two-part fee systems, which establishes a flat service fee that covers all utility fixed costs, such as well and pipe maintenance and pump station operations; a variable fee for the volume of water consumed, charging significantly higher rates as water consumption increases, to discourage water waste and lower rates for conserving households and low and fixed income customers. Also, and higher fees associated with water waste funds conservation incentive programs and alleviates increased cost to lower and fixed income customers (American Rivers, Inc., 2008).

Another efficient practice is to meter all water users. Most apartments, condos, and commercial buildings include a flat rate for water in rent or monthly fees, effectively eliminating any market signals to encourage water efficiency. Water meters should be installed on all new homes, multi-family apartment buildings, and businesses. Incentives should be provided to retrofit existing multi-family and commercial buildings. Outdated appliances and fixtures wastes water. Installing water efficient fixtures and appliances can yield a 35% savings in household consumption. American Rivers, Inc., estimates if all U.S. households installed water efficient appliances, the country would save 8.2 billion gallons of water per day, an amount equal to approximately 20% of total U.S. public water supply, which could provide the Southeast with their entire public water supply (American Rivers, Inc., 2008). Communities should invest in voluntary incentive programs that provide rebates, swap-outs, or direct installations to retrofit wasteful water fixtures or appliances. They could also mandate retrofitting of antiquated fixtures and appliances upon resale of homes or establishment of a new water account and provide free audits for all customer sectors to assess where the most cost-effective and water efficient savings can be ensured. Landscaping to minimize water waste is also crucial. Communities could require dedicated irrigation meters for large landscapes (such as office parks, hospitals, and schools) and create a significantly higher water rate for irrigation purposes. Outdoor water use could also be reduced by requiring moisture or rain sensors for all irrigations systems, providing free irrigation system audits, and promoting different landscape models to reduce water-intensive plantings (American Rivers, Inc., 2008).

Many people in the U.S. know very little about the source and cost of their water supply. This leaves water users uniformed and disengaged. Communities and water suppliers should take simple steps to create an outreach campaign about smart, simple, and cost-effective water efficiency; display water bills by billing in gallon increments on a monthly basis and share historical usage data; and designate a staff member to coordinate water efficiency, conservation, and reuse programs (American Rivers, Inc., 2008). Water education is also mentioned in the "Education" section of this report. It is important to build efficient water infrastructure for the future. In order to do this, communities should enact policies that promote the use of alternative sources of water (grey water and rainwater) for uses that do not require drinking quality water; design homes and neighborhoods to capture and reuse stormwater onsite; require dual plumbing for new homes and businesses; and regularly update

building codes and ordinances to support or require water efficient technology (American Rivers, Inc., 2008).

Water conservation practices also need to promote ecological sustainability. Lack of water compromises the health of a river as well as its ability to sustain human and natural communities. To maintain healthy flows, a portion of water efficiency savings should be returned to the river. State level policy should be adopted that requires that river and community budgets be developed for every river, estuary, and aquifer in the state. Water budgets should provide an assessment of the ecologically sustainable flow (conservation or in-stream flow) for a healthy river; a determination of how much water can be sustainably harvested from a river; and an assessment of community priorities that establishes how the public's shared water resource should be used (American Rivers, Inc., 2008). Lastly, it is important to involve water users in decisions. Opportunities for significant water savings can be overlooked without having all stakeholders involved. Communities can involve water users by creating a standing advisory board, with representatives from all sectors including industrial, commercial and residential, to provide ideas, guidance and assistance with water supply policy and programs, and hosting town hall meetings about policy and rate changes to engage questions and develop support for rate changes, outdoor water regulations, and efficiency programs (American Rivers, Inc., 2008).

RECOMMENDATION

Water source sustainability should include developing water management policies with comprehensive water conservation and efficiency guidelines. The CPYRWMA should take a lead role in water conservation education, development of conservation guidelines, and implementation of guidelines in cooperation with local water users and governments. Recommendations given in the section above should be considered and implemented were practical.

POLICY OPTION

A comprehensive state water management plan should be developed with sustainability, conservation, and efficiency standards for water resource development and use. These plans should be implemented on the local level involving local stakeholders.

WATER REUSE

WASTEWATER RETURN DISCHARGE

A wastewater treatment plant survey was conducted using an online search of ADEM's public records in order to determine the number of wastewater treatment facilities and quantities of treated wastewater discharged to water bodies in the CPYRW. A search on ADEM's website yielded 26 wastewater treatment facilities for reporting year 2012 that discharge treated wastewater to water bodies in the CPYRW (fig. 84).

The average daily discharge from all 26 facilities for reporting year 2012 was 18 mgd, with a total flow of 6,570 million gallons per year (table 34). Based on the search

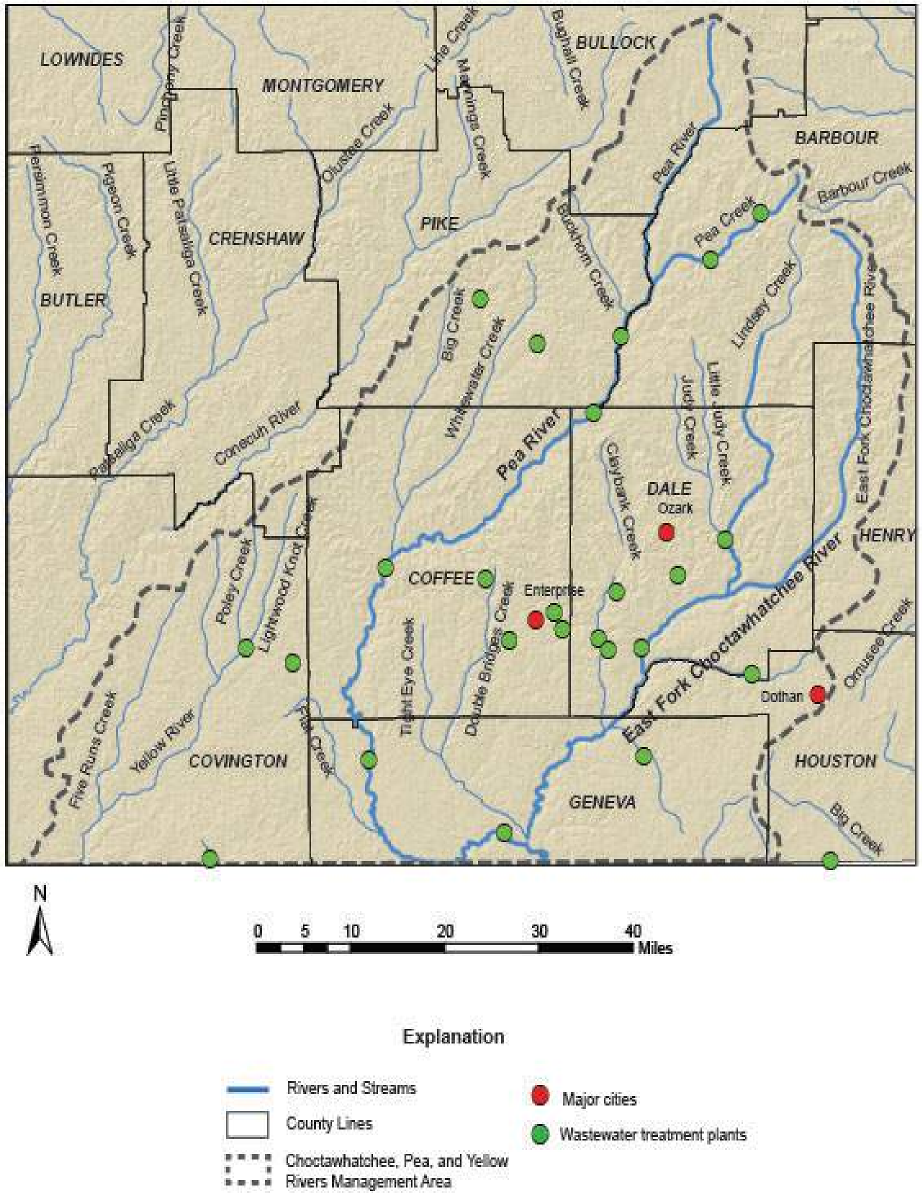

Figure 84.—Wastewater treatment plants that discharge to waters of the CPYRW.

results, the majority of the discharges occur in Houston County, which has an average of 5.75 mgd of treated wastewaters discharged in the CPYRW.

Currently in the U.S., estimates are that 7 to 8% of treated wastewater is being reused (USEPA, 2012a). Based on this estimate, about 520 million gallons per year, or 1.4 mgd, could be reused in the CPYRW. By comparing the estimated average daily water use for 2010 (178.64 mgd), estimated water saved by reuse would be less than 1% a day. Currently, Alabama has no reuse of treated wastewater.

Table 34.—Average daily wastewater discharges for treatment plants that discharge to waters in the CPYRW.

County	Permittee Name	NPDES Permit Number	Discharges to	Average Daily Flow (mgd)[1]	Total Yearly Flow (mgpy)[2]
Barbour	Town of Clayton Water and Sewer Board	AL0060461	Pea Creek (Tributary to Pea River)	0.23	82
Barbour	Clio Lagoon	AL0067181	Pea River	0.16	58
Barbour	Town of Louisville	AL0070980	Pea Creek (Tributary to Pea River)	0.04	15
Barbour	City of Union Springs	AL0060445	Bluff Creek (Tributary to Pea River)	0.63	230
Coffee	Enterprise WWTP[3] #2	AL0020036	UT[4] to Blanket Creek (Tributary to Upper Choctawhatchee River)	1.16	422
Coffee	Enterprise WWTP #3	AL0020044	UT to Cowpen Creek (Tributary to Upper Choctawhatchee River)	0.73	265
Coffee	City of Enterprise Northeast WWTP	AL0020061	Harrand Creek (Tributary to Upper Choctawhatchee River)	1.12	407
Coffee	Elba Lagoon	AL0020940	Pea River	0.21	76
Coffee	New Brockton WWTP	AL0055875	UT to Double Bridges Creek (Tributary to Upper Choctawhatchee River)	0.04	16
Covington	Opp Eastside WWTP	AL0021407	Cripple Creek (Tributary to Pea River)	0.20	72
Covington	Lockhart/Florala WWTP	AL0031925	Pond Creek (Tributary to Yellow River)	0.39	143
Covington	Opp Westside WWTP	AL0054313	Lightwood Knot Creek (Tributary to Yellow River)	0.85	312
Dale	Daleville Southeast Lagoon	AL0050261	Choctawhatchee River	0.20	73
Dale	Ozark Southeast WWTP	AL0056324	Klondike Creek (Tributary to Choctawhatchee River)	0.94	342
Dale	Ozark Northeast Lagoon	AL0058688	West Fork Choctawhatchee River	0.18	66
Dale	Daleville Westside WWTP	AL0062448	Claybank Creek (Tributary to Lake Tholocco)	0.22	81
Dale	Ariton Lagoon	AL0068551	Pea River	0.02	8
Dale	Arner Water Ft. Rucker Gairnes	AL0076813	UT to Claybank Creek (Tributary to Lake Tholocco)	0.03	12
Dale	Fort Rucker Main WWTP	AL0076813	UT to Claybank Creek (Tributary to Lake Tholocco)	0.53	195
Geneva	Geneva WWTP	AL0020273	Pea River	0.29	106
Geneva	Hartford Lagoon	AL0058947	Hurricane Creek (Tributary to Upper Choctawhatchee River)	0.19	69
Geneva	Town of Samson	AL0068896	Pea River	0.08	29
Houston	City of Dothan Little Choctawhatchee WWTP	AL0047465	Little Choctawhatchee River (Tributary to Upper Choctawhatchee River)	5.74	2,094
Houston	Houston County WWTP	AL0072669	UT to Spring Creek (Tributary to Lower Choctawhatchee River)	0.01	2
Pike	Troy Walnut Creek WWTP	AL0032310	Walnut Creek (Tributary to Pea River)	3.37	1,230
Pike	Brundidge WWTP	AL0044105	Whitewater Creek (Tributary to Pea River)	0.33	119

[1]mgd—million gallons per day
[2]mgpy—million gallons per year, calculated from multiplying the average daily flow by 365 days/year
[3]WWTP—wastewater treatment plant
[4]UT—unnamed tributary

WATER REUSE OPTIONS

Water reuse is one aspect of water conservation that could potentially decrease the daily demand for potable water. It involves the use of treated wastewater for activities such as industrial, environmental, recreational, and potable reuse (USEPA, 2012a). Water reuse is regulated at the state level, with guidelines suggested by the USEPA. The following states have well-established water reuse programs in place: Arizona, California, Florida, and Texas (USEPA, 2012a). In Alabama, the regulatory agency tasked with governing water reuse is ADEM. Currently, ADEM is in the process of developing water reuse regulations (AWAWG, 2012). Estimates for water reuse based on current wastewater discharge return rates in the CPYRW are discussed in the Water Quantity section of this WMP.

RECOMMENDATION

Water reuse regulations should be developed and implemented by ADEM. Treated wastewater reuse should be considered for agricultural irrigation and golf courses in areas in reasonable proximity to sources of treated wastewater.

POLICY OPTION

Polices related to the management of treated wastewaters should be established by ADEM and included in a state water management plan.

WATER QUALITY

SURFACE-WATER QUALITY ISSUES

Water quality is regulated by and water-quality policy is established between ADEM and USEPA.

CHARACTERIZATION OF SUPERFUND SITES

In 1980, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), also known as Superfund, was established to address the cleanup and remediation of uncontrolled hazardous waste sites by allowing the USEPA to ensure that responsible parties cleaned up the contaminated sites or reimbursed expenses incurred during cleanup procedures by the USEPA (USEPA, 2013a). The clean-up process for Superfund sites is both extensive and long-term. The process begins with a preliminary assessment/site inspection, followed by site listing on the National Priorities List. Then a remedial investigation/feasibility study is conducted to determine the nature and extent of contamination. Once the nature and extent of contamination is determined, a remedial action plan is put into place, in which the bulk of the site cleanup occurs, long-term response actions are put into place to provide long-term protection of human health and the environment, and eventually the site is designated for reuse or redevelopment (USEPA, 2013a).

American Brass, Inc., is the only Superfund site located in the CPYRW. The American Brass, Inc., site is located near Headland, in southern Henry County (fig. 85). American Brass, Inc., was a brass foundry that produced brass alloys from scrap metals and operated until 1992. Prior to that, a fertilizer plant was operated at the site (USEPA, 2013b). In 1999, the site was placed on the National Priorities List due to contaminated soil and groundwater, including contaminates such as metals (lead, copper, zinc, and boron) and polychlorinated biphenyls (PCBs) (USEPA, 2013b). Clean up activities at the site included demolition and removal of structures and pavement, excavation of contaminated soils and adding clean soils to the excavated areas, planting vegetative covering, restoring impacted wetlands, monitored natural attenuation to reduce concentrations of contaminants in groundwater, and engineering controls to control surface runoff (USEPA, 2013b).

CHARACTERIZATION OF KEY NONPOINT SOURCE POLLUTANTS AND SOURCES OF BACTERIAL CONTAMINATION

Nonpoint sources of pollution are originate from many sources, particularly human activities on land, and unlike point sources (which are regulated under the Clean Water Act), nonpoint sources cannot be directly tied to one specific source (USEPA, 2012b). Nonpoint source pollution can result from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modifications (USEPA, 2012b). Nonpoint sources can include excessive use of fertilizers, herbicides, and insecticides on agricultural and residential lands, oil, grease, and toxic chemicals from

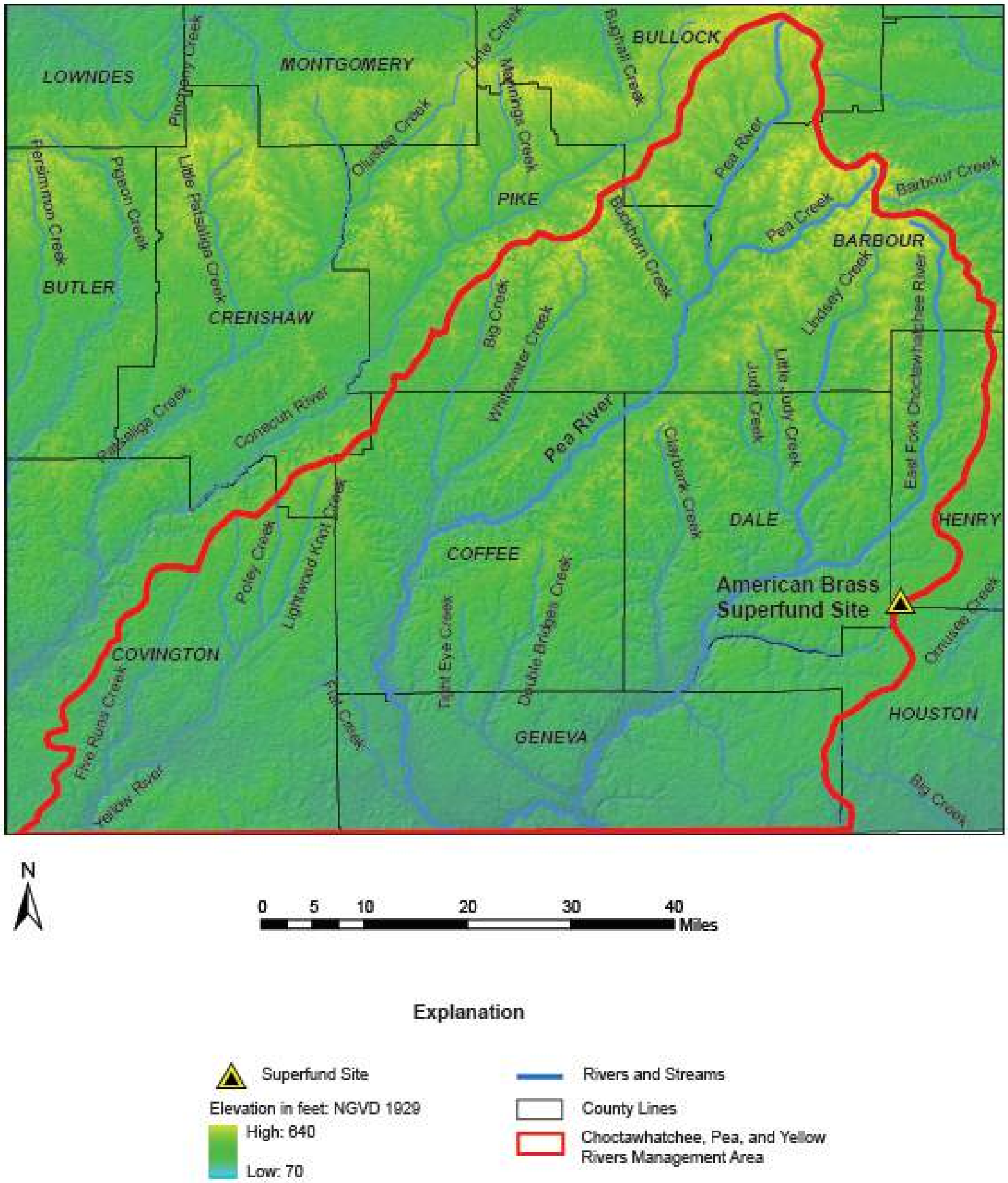

Figure 85.—Location of American Brass, Inc. superfund site in Henry County.

urban runoff and energy production, sediment from improperly managed construction sites, crop and forest lands, and eroding stream banks, salt from irrigation practices, acid drainage from abandoned mines, and bacteria and nutrients from livestock, pet wastes, and faulty septic systems (USEPA, 2012b). Constituents that result from these nonpoint sources can include sediments, nutrients, bacteria, and metals, as were previously discussed in this WMP.

SURFACE-WATER CLASSIFICATIONS

WATER USE CLASSIFICATIONS

There are seven use classifications currently employed by the State of Alabama: Outstanding Alabama Water, Public Water Supply, Swimming and Other Whole Body Water-Contact Sports, Shellfish Harvesting, Fish and Wildlife, Limited Warmwater Fishery, and Agricultural and Industrial Water Supply (ADEM, 2014a). Table 35 lists the stream classifications for the Choctawhatchee River Basin as compiled from the ADEM Administrative Code 335-6-11 (ADEM, 2014a). Based on these classifications, all water bodies within the Choctawhatchee River Basin are classified as Fish and Wildlife (F&W), with seven of the streams also classified as Swimming and Other Whole Body Water-Contact Sports (S). Table 36 lists the stream classification for Yellow River as compiled from the ADEM Administrative Code 335-6-11 (ADEM, 2014a).

STRATEGIC HABITAT UNITS

Strategic Habitat Units (SHUs) and Strategic River Reach Units (SRRUs) encompass a substantial portion of Alabama's remaining high-quality water courses and reflect a variety of aquatic habitats occupied by mussels, snails, crayfishes, rare fishes, and reptiles and amphibians (Wynn and others, 2012). The U.S. Fish and Wildlife Service (USFWS), in conjunction with the ADCNR, and the GSA are focusing conservation activities for managing, recovering, and restoring populations of these species in selected watershed and river segments in the five major HUC 4 subregions in Alabama (Wynn and others, 2012). The SHUs include areas with geomorphically stable stream and river channel, adequate stream flow to support normal behavior, growth, and survival of the species, acceptable water quality conditions, diversity of channel substrate types, few or no competitive species or predaceous nonnative species, and the presence of fish hosts with adequate living, foraging, and spawning areas for mussels (Wynn and others, 2012). The SRRUs were also selected based on the above listed habitat features and also include river reaches where restoration and recovery actions are already underway or planned for species (Wynn and others, 2012).

Within the CPYRW, there are three SHUs and two SRRUs (fig. 86). SHUs are located in the Upper Pea River in the Pea River Subbasin, West Fork Choctawhatchee River in the Upper Choctawhatchee River Subbasin, and Five Runs Creek in the Yellow River Subbasin. SRRUs are located in the Lower Pea River and the Choctawhatchee River. Threatened and/or endangered species endemic to these SHUs and SRRUs are listed in table 37, which is unpublished, but has been provided by the Ecosystems Investigations Program division at the GSA. This is not a complete list of threatened and endangered species in the CPYRW, simply a list of the species specific to SHUs and SRRUs. For a complete list of threatened and endangered species, including species specific to these SHUs and SRRUs, please see the *Ecosystem Resources* section.

Table 35.—ADEM water use classification for waterbodies in the Choctawhatchee River Basin.

Stream	From	To	Classification
Pea River	Choctawhatchee River	Its source	F & W[1]
Choctawhatchee River	Alabama-Florida state line	Alabama Highway 12	S/F & W[2]
Choctawhatchee River	Alabama Highway 12	Brooking Mill Creek	F & W
Choctawhatchee River	Brooking Mill Creek	Its source	S/F & W
Wright Creek	Alabama-Florida state line	Its source	F & W
Holmes Creek	Alabama-Florida state line	Its source	F & W
Ten Mile Creek	Alabama-Florida state line	Its source	F & W
Sandy Creek	Pea River	Samson	F & W
Flat Creek	Pea River	Junction with Eightmile Creek	F & W
Flat Creek	Junction with Eightmile Creek	Its source	S/F & W
Eightmile Creek	Flat Creek	Its source	F & W
Corner Creek	Eightmile Creek	Its source	F & W
Cripple Creek	Pea River	Its source	F & W
Samson Branch	Pea River	Its source	F & W
Whitewater Creek	Pea River	Its source	F & W
Big Creek	Whitewater Creek	Its source	F & W
Walnut Creek	Whitewater Creek	Its source	F & W
Mims Creek	Whitewater Creek	Its source	F & W
Pea Creek	Pea River	Its source	F & W
Double Bridges Creek	Choctawhatchee River	Its source	F & W
Blanket Creek	Double Bridges Creek	Its source	F & W
Claybank Creek	Choctawhatchee River	Lake Tholocco	F & W
Lake Tholocco	Dam	Its source	S/F & W
Claybank Creek	Lake Tholocco	Its source	F & W
Harrand Creek	Claybank Creek	Its source	F & W
Tributary of Harrand Creek	Harrand Creek	Its source	F & W
Hurricane Creek	Choctawhatchee River	Its source	F & W
Mill Creek	Hurricane Creek	Hardford	F & W
Little Choctawhatchee River	Choctawhatchee River	Its source	F & W
Newton Creek	Little Choctawhatchee River	Its source	F & W
Beaver Creek	Newton Creek	Its source	F & W
Hurricane Creek (Dale County)	Choctawhatchee River	Its source	F & W
West Fork of Choctawhatchee River	Choctawhatchee River	The falls approx. 0.5 mile upstream of Alabama Highway 27	S/F & W
West Fork of Choctawhatchee River	The falls approximately 0.5 mile upstream of Alabama Highway 27	Judy Creek	F & W
West Fork of Choctawhatchee River	Judy Creek	Its source	S/F & W
Judy Creek	West Fork Choctawhatchee River	Its source	F & W
Little Judy Creek	Judy Creek	Its source	F & W
Lindsey Creek	West Fork Choctawhatchee River	Its source	F & W
East Fork of Choctawhatchee River	Choctawhatchee River	Its source	S/F & W
Blackwood Creek	East Fork Choctawhatchee River	Its source	F & W
Lindsey Creek	West Fork Choctawhatchee River	Its source	F & W
East Fork of Choctawhatchee River	Choctawhatchee River	Its source	S/F & W
Blackwood Creek	East Fork Choctawhatchee River	Its source	F & W

[1]F & W, Fish and Wildlife
[2]S/F & W, Swimming and Other Whole Body Water-Contact Sports

Table 36.—ADEM water use classification for waterbodies in the Yellow River (Florida Panhandle Coastal Basin).

Stream	From	To	Classification
Yellow River	Alabama-Florida state line	Its source	F & W
Pond Creek	Alabama-Florida state line	Its source	F & W
Big Creek	Alabama-Florida state line	Its source	F & W
Horsehead Creek	Alabama-Florida state line	Its source	F & W
Fleming Creek	Alabama-Florida state line	Its source	F & W
Lake Jackson	Within Florala and north of Alabama-Florida state line	Its source	S/F & W
Five Runs Creek	Yellow River	Its source	F & W
Indian Creek	Yellow River	Its source	F & W
Lightwood Knot Creek	Yellow River	Its source	F & W
Cameron Creek	Lightwood Knot Creek	Its source	F & W
Bay Branch	Five Runs Creek	Its source	F & W

ECOREGIONS

Ecoregions can be identified as areas with similar ecosystems and type, quality, and quantity of environmental resources, which includes geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology (USGS, 2001). In Alabama, there are four levels of ecoregions: Level I, Level II, Level III, and Level IV. Level I is the coarsest, dividing North America into 15 ecological regions, of which Alabama is included in the Eastern Temperate Forests ecoregion, which extends from the Great Lakes to the Gulf of Mexico and from the Atlantic Coast to Texas, Oklahoma, Missouri, Iowa, and Minnesota (Commission for Environmental Cooperation (CEC), 1997). Level I is characterized by a moderate to mildly humid climate, relatively dense and diverse forest cover, and high density human population, with major activities including urban industries, agriculture, and forestry (CEC, 1997). Alabama is further subdivided into Level II, which is in the Southeastern USA Plains (CEC, 1997). In Level III, the CPYRW is located in the Southeastern Plains ecoregion (65), which is defined by a mild, humid subtropical climate, with hot, humid summers and mild winters (CEC, 2011).

The CPYRW is comprised of three different Level IV ecoregions: Southern Hilly Gulf Coastal Plain, Southern Pine Plains Hills, and Dougherty Plain (fig. 87). Ecoregions in the CPYRW study area are very similar in geographic extent to the physiographic districts discussed previously (CWP and GSA, 2005). The Southern Hilly Gulf Coastal Plains ecoregion corresponds to the Chunnenuggee Hills and Southern Red Hills districts and is defined by dissected irregular plains, northward facing cuestas, and low hills with broad tops, with various wide floodplains present with broad undulating terraces (CWP and GSA, 2005). The Southern Pine Plains and Hills ecoregion corresponds to the Dougherty Plain and Southern Pine Hills districts and is characterized by southward sloping dissected irregular plains with some open low hills, in addition to mostly broad, gently sloping ridgetops with steeper side slopes near drainages (CWP and GSA, 2005). The Dougherty Plain ecoregion refers to the

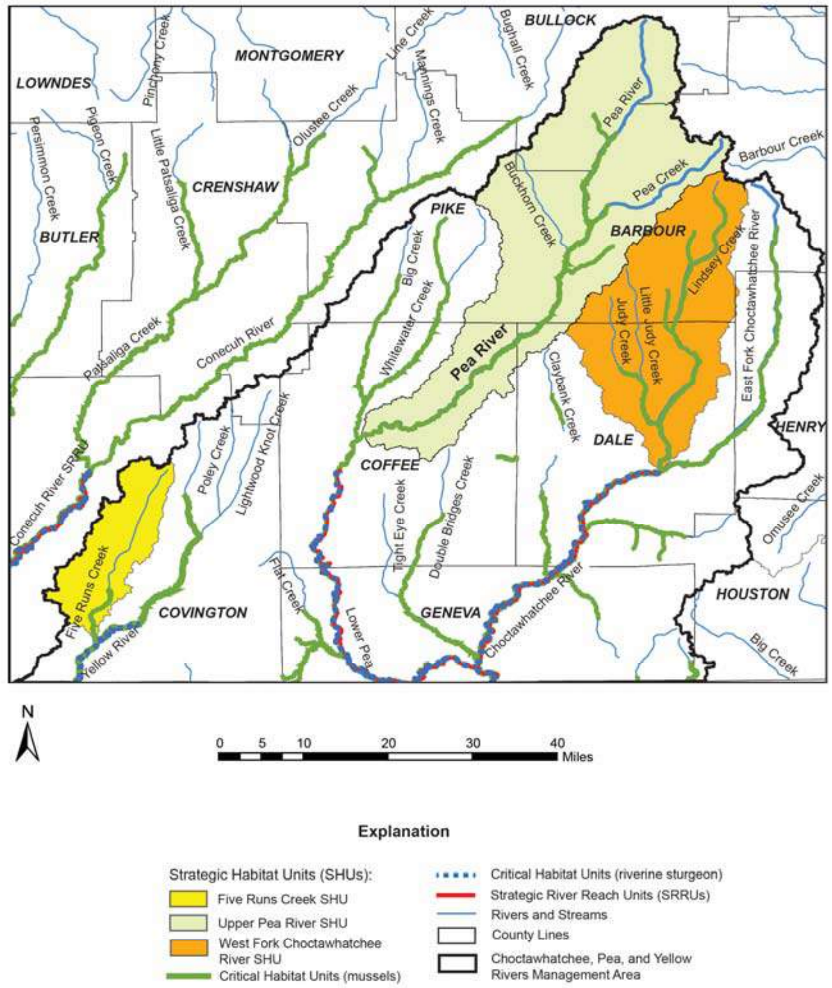

Figure 86.—Strategic Habitat Units (SHUs) and
Strategic River Reach Units (SRRUs) in the CPYRW.

same name in the physiographic districts and is described by lightly dissected irregular plains containing various flat plains, with low gradients with some areas of moderate relief (CWP and GSA, 2005).

LIST OF 303(d) IMPAIRED WATERS

Section 303(d) of the Clean Water Act requires states to identify waters for which technology based limitations of pollutants are not stringent enough to achieve water quality standards and these water bodies must be assigned priority rankings based on severity of pollution and intended uses of the waters (CWP and GSA, 2005). Total daily maximum loads (TMDLs), which is an estimate of the total load of pollutants

Table 37.—Aquatic species of conservation concern within the SHUs and SRRUs in the CPYRW.
(E—Endangered, T—Threatened, P1—Highest Conservation Concern, P2—High Conservation Concern, X—Present, H—Historic)

Scientific Name	Common Name	USFWS	Alabama	Five Runs Creek	Pea River	Upper Pea River	Choctaw-hatchee River	West Fork Choctawhatchee River
Mussels								
Elliptio arctata	Delicate Spike	-	P2	-	-	X	-	-
Fusconaia burkei	Tapered Pigtoe	T	P2	-	-	X	-	X
Hamiota australis	Southern Sandshell	E	P1	X	-	X	-	X
Medionidus penicillatus	Gulf Moccasinshell	E	P1	H	-	-	-	H
Obovaria choctawensis	Choctaw Bean	E	P2	X	X	X	X	X
Pleurobema strodeanum	Fuzzy Pigtoe	T	P2	X	X	X	X	X
Ptychobranchus jonesi	Southern Kidneyshell	E	P1	X	X	X	X	X
Snails								
Amnicola dalli	Peninsula Amnicola	-	P2	-	-	X	-	X
Elimia clenchi	Slackwater Elimia	-	P2	-	-	X	-	X
Lioplax pilsbryi	Choctaw Lioplax	-	P1	-	-	X	-	X
Notogillia wetherbyi	Alligator Siltsnail	-	P2	-	-	X	-	X
Spilochlamys conica	Conical Snail	-	P2	-	-	-	-	X
Crayfishes								
Fallicambarus byersi	Lavender Burrowing Crayfish	-	P2	-	-	-	-	-
Procambarus hubbelli	Jacknife Crayfish	-	P2	X	-	-	-	-
Procambarus okaloosae	Okaloosa Crayfish	-	P2	X	-	-	-	-
Fishes								
Acipenser oxyrinchus desotoi	Gulf Sturgeon	T	P2	-	X	-	X	-
Alosa alabamae	Alabama Shad	-	P1	-	X	-	X	-
Notropis chalybaeus	Ironcolor Shiner	-	P1	X	-	-	-	-
Pteronotropis welaka	Bluenose Shiner	-	P2	X	-	-	-	-
Reptiles and Amphibians								
Amphiuma pholeter	One-Toed Amphiuma	-	P2	X	-	-	-	-
Graptemys barbouri	Barbour's Map Turtle	-	P2	-	X	X	X	-
Macrochelys temminckii	Alligator Snapping Turtle	-	P2	X	X	X	X	X
Lithobates heckscheri	River Frog	-	P1	-	-	-	X	-
Lithobates capito	Gopher Frog	-	P1	X	-	-	-	-
Farancia erytrogramma	Rainbow Snake	-	P2	X	-	-	-	-

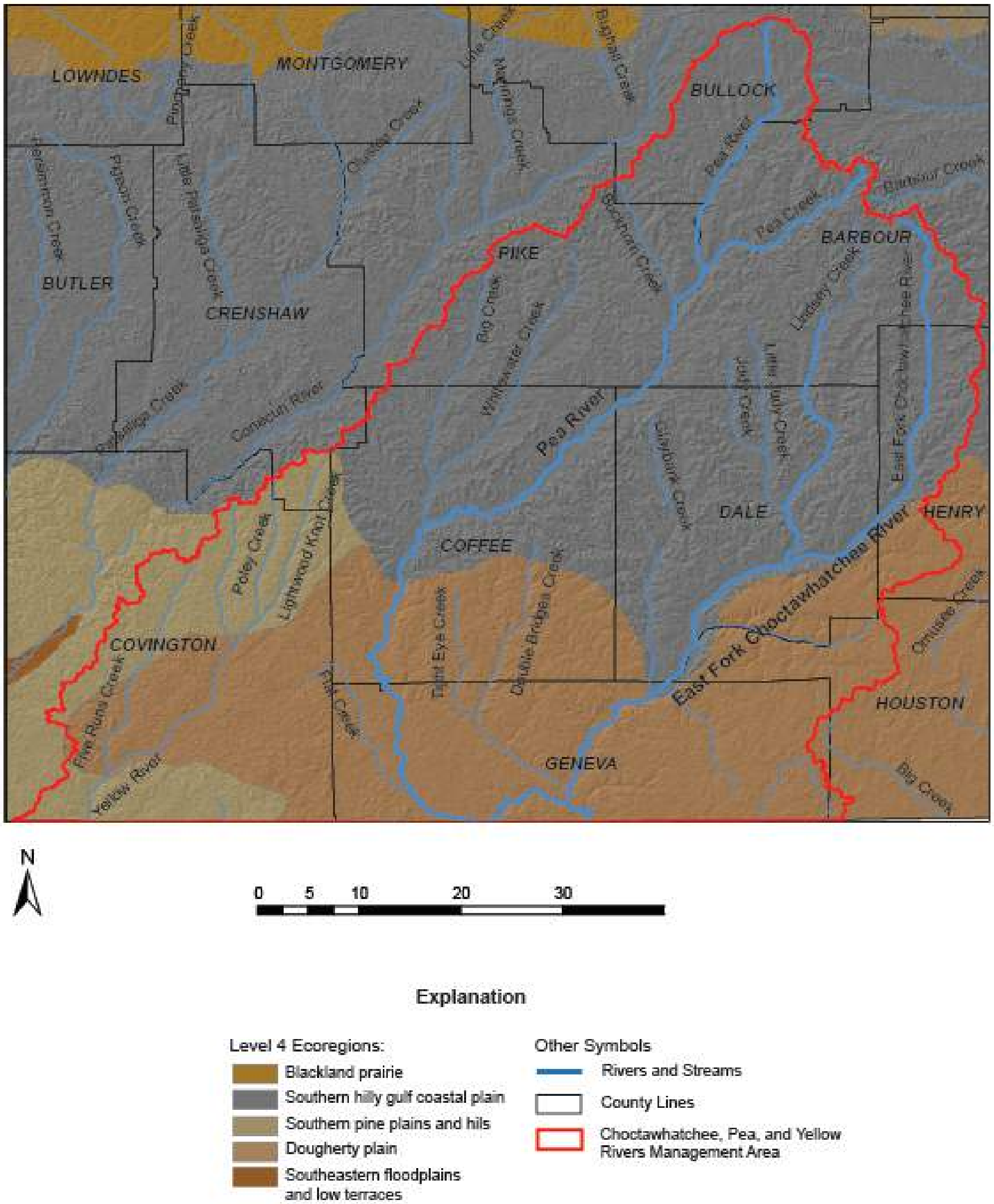

Figure 87.—Level IV ecoregions in the CPYRW.

(from point, nonpoint, and background sources) that a segment of water can receive without exceeding applicable water quality criteria, must be developed for these listed waters and submitted to USEPA for approval (CWP and GSA, 2005). Once a TMDL is established, the permitting authority (ADEM) must allocate the total pollutant load among the various sources discharging into the water body (CWP and GSA, 2005). Table 38 lists the current 13 streams and waterbodies on the draft 2014 303(d) list that are located in the CPYRW. All 13 streams are classified as F&W (ADEM, 2014b). Figure 88 shows the location of the draft 2014 303(d) listed streams within the CPYRW.

Table 38.—Draft 2014 303d listed streams and waterbodies in the CPYRW.

Waterbody ID and River Basin	Waterbody Name	County	Causes	Sources	Size	Downstream/ Upstream	Year Listed	Draft TMDL Date
AL03140201-0501-201 Choctawhatchee	Beaver Creek	Houston	Nutrients	Municipal, urban runoff/storm sewers	2.09 miles	Newton Creek/Dothan WWTP	1998	2015
AL03140201-0501-201 Choctawhatchee	Beaver Creek	Houston	Organic enrichment (CBOD, NBOD)	Municipal, urban runoff/storm sewers	2.09 miles	Newton Creek/Dothan WWTP	1998	2015
AL03140201-0501-201 Choctawhatchee	Dowling Branch	Geneva	Organic enrichment (CBOD, NBOD)	Agriculture, municipal, urban runoff/storm sewers	2.10 miles	Cox Mill Creek/ Its source	1998	2015
AL03140201-0901-100 Choctawhatchee	Harrand Creek	Coffee, Dale	Siltation (habitat alteration)	Urban runoff/storm sewers	9.71 miles	Claybank Creek/ Its source	2006	2015
AL03140201-0901-200 Choctawhatchee	Indian Camp Creek	Coffee	Siltation (habitat alteration)	Land development, urban runoff/storm sewers	3.98 miles	Harrand Creek/ Its source	2004	2015
AL03140201-1203-100 Choctawhatchee	Choctaw-hatchee River	Dale, Geneva	Metals (Mercury)	Atmospheric deposition	46.35 miles	Pea River/ Its source	2010	2020
AL03140201-1102-500 Choctawhatchee	Blanket Creek	Coffee	Organic enrichment (CBOD, NBOD)	Municipal	5.71 miles	Double Bridges Creek/ Its source	2010	2020
AL03140202-0906-100 Choctawhatchee	Pea River	Barbour, Bullock, Coffee, Dale, Geneva, Pike	Metals (Mercury)	Atmospheric deposition	157.23 miles	Choctaw-hatchee River/ Its source	2010	2020
AL03140201-1203-100 Choctawhatchee	Choctaw-hatchee River	Geneva	Metals (Mercury)	Atmospheric deposition	4.45 miles	AL-FL state line/Pea River	2010	2020
AL03140103-0102-102 Perdido-Escambia	Lightwood Knot Creek (Lake Frank Jackson)	Covington	Metals (Mercury)	Atmospheric deposition	956.26 acres	Lake Frank Jackson Dam/extent of reservoir	2010	2020
AL03140103-0102-700 Perdido-Escambia	UT to Jackson Lake 3-C	Covington	Organic enrichment (CBOD, NBOD), pathogens	Feedlots, pasture grazing	1.05 miles	Lake Frank Jackson/ Its source	1998	2020
AL03140103-0402-100 Perdido-Escambia	Yellow River	Covington	Metals (Mercury)	Atmospheric deposition	14.87 miles	AL-FL state line/North Creek	2004	2020
AL03140103-0601-300 Perdido-Escambia	Lake Jackson	Covington	Metals (Mercury)	Atmospheric deposition	415.46 acres	Within Florala and north of AL-FL state line	2010	2020

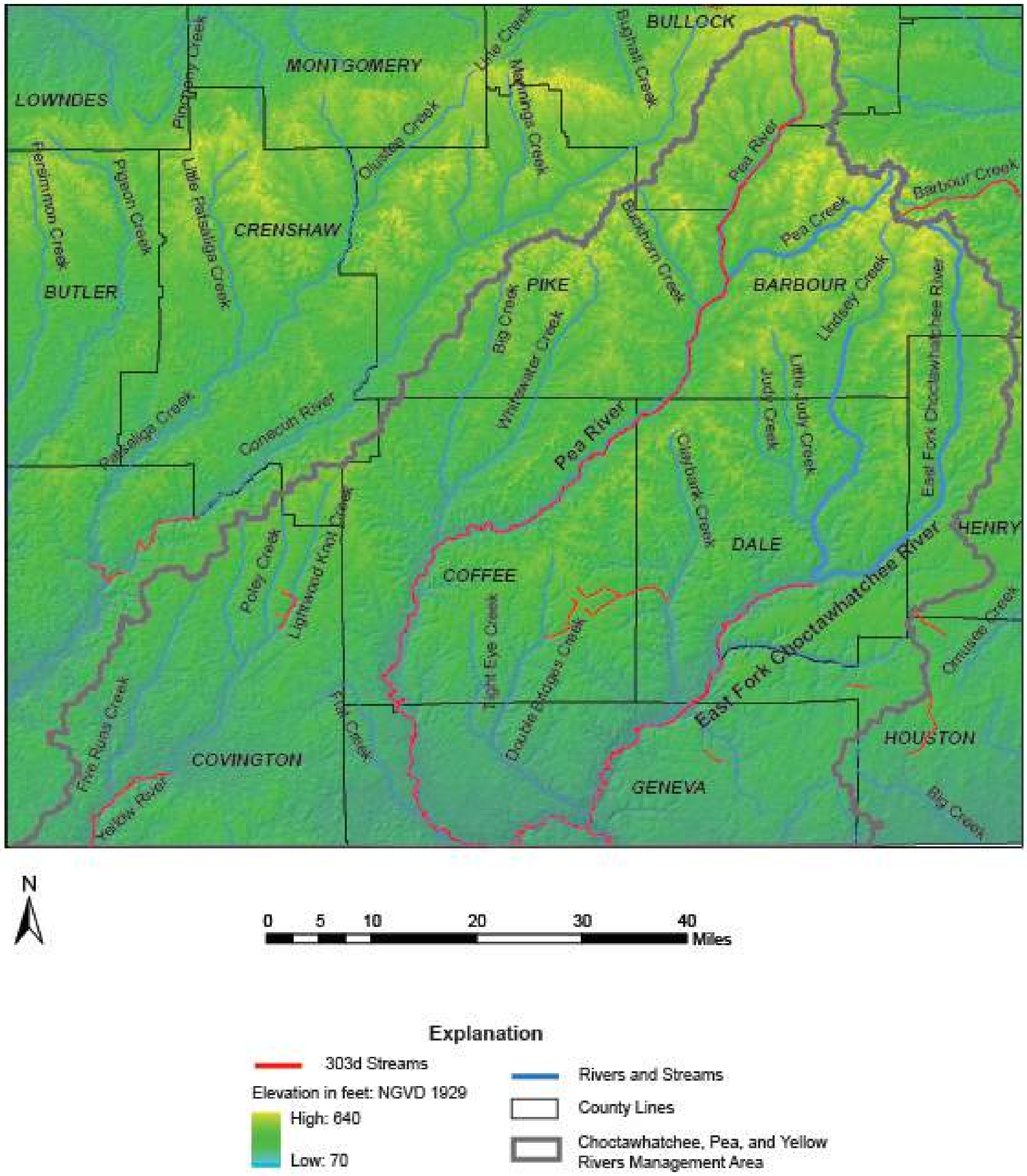

Figure 88.—Draft 2014 303d listed streams and water bodies in the CPYRW (modified from ADEM, 2014b).

RECOMMENDATION

The CPYRWMA and local entities, in cooperation with ADEM, should be aware of the current 303(d) listed streams. CPYRWMA should assist ADEM, whenever possible to facilitate strategies for programs and practices to produce positive impacts to the 303(d) listed streams.

STORMWATER RUNOFF ISSUES

Stormwater runoff occurs when excessive precipitation does not percolate into the subsurface, but flows over land or impervious surfaces and transports debris, chemicals, sediment, or other pollutants (USEPA, 2012c). The primary means to control stormwater discharge is through best management practices (BMPs), which are required under National Pollutant Discharge Elimination System (NPDES) permits. There are three types of NPDES coverage for stormwater: construction activities, industrial activities, and municipal systems (USEPA, 2012c). In Alabama, the permitting authority regulating coverage under the NPDES permitting system is ADEM.

CONSTRUCTION ACTIVITIES

Construction activities resulting in land disturbances equal to or greater than 1 acre, or from construction activities involving less than 1 acre and are part of a plan of development or sale equal to or greater than 1 acre are required to obtain NPDES covered under General Permit Number ALR100000 (ADEM, 2013a). A requirement of this General Permit is that operators/owners must implement and maintain a Construction Best Management Practices Plan that addresses effective sediment and erosion controls (ADEM 2013b). Pollutants associated with stormwater runoff from construction activities can include sediment, debris, and chemicals (USEPA, 2012c).

INDUSTRIAL ACTIVITIES

Industrial activities that result in discharges into waters of the state are covered under Individual and General Permits (ADEM, 2013b). The following industrial activities are covered under General Permits: asphalt (ALG020000), boat/ship (ALG030000), lumber and wood (ALG060000), concrete (ALG110000), metals (ALG120000), transportation (ALG140000), food (ALG150000), landfill (ALG160000), paint (ALG170000), salvage/recycling (ALG180000), plastic and rubber (ALG200000), stone/glass/clay (ALG230000), textile (ALG240000), noncontact cooling water (NCCW) (ALG250000), offshore (ALG280000), petroleum (ALG340000), hydroelectric (ALG360000), filter backwash from water treatment plants (ALG640000), hydrostatic test (ALG670000), noncoal/nonmetallic aggregate mining (ALG850000), pesticides (ALG870000), less than 5-acre small mining (ALG890000), and Phase II MS4 (Municipal Separate Stormwater Sewer Systems) (ALR040000) (ADEM, 2013b). General permits for industrial activities are required to have in place and implemented BMPs and, if necessary, a Spill Prevention Control and Countermeasures Plan. Facilities that cannot obtain a General Permit, due to restrictions within the General Permits, must apply for and obtain an Individual Permit, which generally has more stringent limitations than General Permits (ADEM, 2013b).

MUNICIPAL SEPARATE STORM SEWER SYSTEMS ACTIVITIES

Polluted stormwater can be transported through Municipal Separate Stormwater Sewer Systems (MS4s) and from there flow untreated into local waterbodies. Therefore, operators of MS4s must obtain an NPDES permit and develop a stormwater management program (USEPA, 2013c). MS4s are defined as being owned

by a state, city, town, or other public entity that discharges to waters of the United States, are designated or used to collect or convey stormwater, are not a combined sewer, and are not part of a Publicly Owned Treatment Works (USEPA, 2013c). There are two permits for MS4s: Phase I and Phase II. Phase I NPDES permits are required for medium and large cities with populations greater than 100,000 and Phase II NPDES permits are required for small MS4s in urbanized areas with populations of at least 50,000 and a population density of 1,000 people per square mile, as well as small MS4s outside urbanized areas as designated by the permitting authority (USEPA, 2013c).

NPDES PERMITS

An online search of USEPA's Permit Compliance System and Integrated Compliance Information System indicated that there are 486 active NPDES permits within the watershed boundary (fig. 89). These include NPDES permits for industrial, construction, stormwater, and municipal activities.

RECOMMENDATION

The CPYRWMA should be aware of stormwater runoff and NPDES permitted activities in the CPYRW and assist the ADEM, whenever possible, to implement regulations to control runoff and stream discharges.

GROUNDWATER QUALITY

Groundwater quality is critical in southeast Alabama because groundwater provides all public and domestic drinking water. Groundwater contaminants often occur naturally in soil, sediments, and rock. Water percolating through soils accumulates naturally occurring minerals, salts, and organic compounds. As water migrates downward, concentrations of dissolved minerals and salts typically increase through a process called mineralization. In some cases, percolating water accumulates mineral concentrations high enough that groundwater can no longer be used for public or industrial water supplies or irrigation, without treatment (University of California Agricultural Extension Service, 2002). The broad categorization of groundwater quality contaminants include: inorganic chemicals, organic chemicals, and radionuclides (see Appendix 4 for the USEPA list of water quality contaminants). Some of the more common natural contaminants include iron, manganese, lead, aluminum, selenium, hydrogen sulfide, radon, arsenic, petroleum, microorganisms, and brine (ADEM, 2001).

Contaminants may also be introduced into the subsurface through anthropogenic means. The most important way to have good quality groundwater is to prevent `contamination from human activities. Common sources of anthropogenic contaminants include septic tanks; underground storage tanks; areas where fertilizer, pesticides, or herbicides are used or stored; landfills; unauthorized dump sites; and underground injection control wells (see Appendix 5 for a complete list of potential sources of groundwater contamination). ADEM considers underground storage tanks and failing septic systems to be the most serious threats to groundwater in Alabama. Contaminants associated with human activity include bacteria, petroleum products,

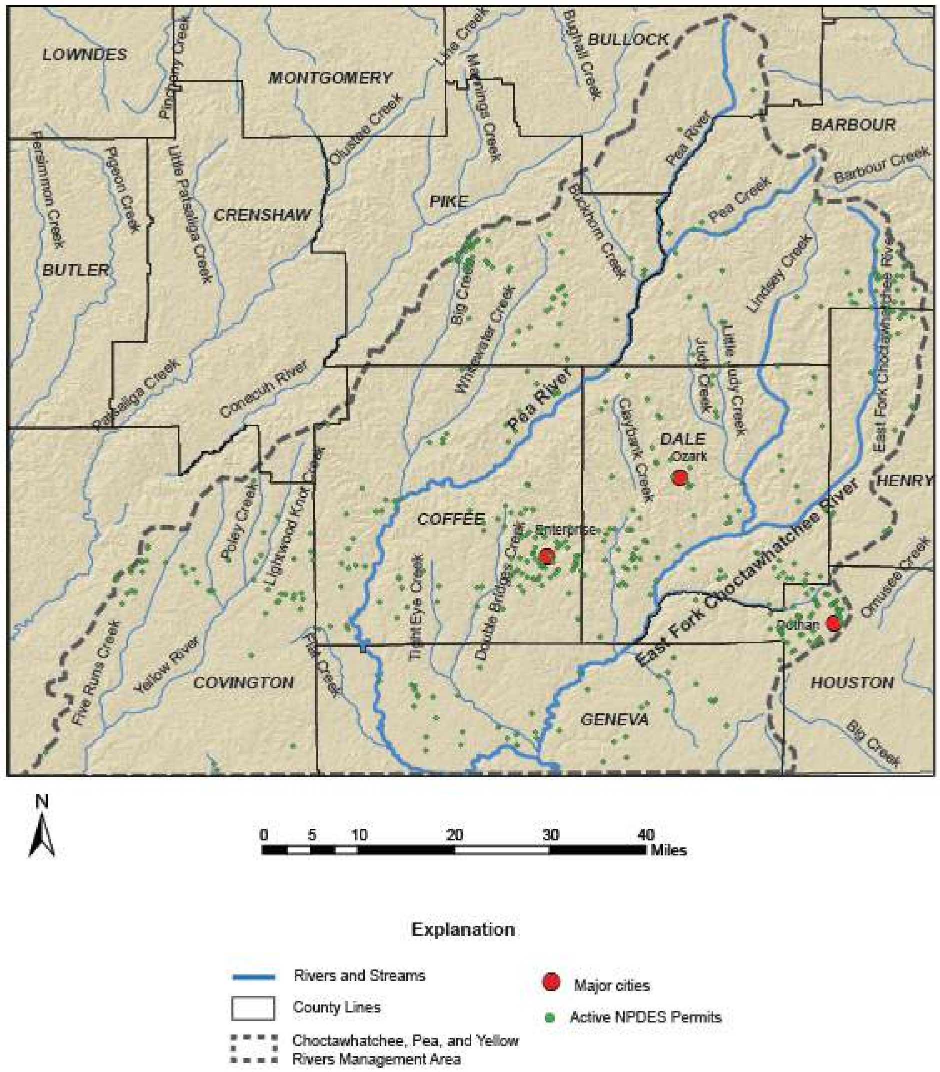

Figure 89.—Active NPDES Permits in the CPYRW.

natural and synthetic organic compounds, fertilizer, pesticides, herbicides, and metals (ADEM, 2001).

METALS IN GROUNDWATER

Dissolved metals are often found in harmful concentrations in groundwater. As previously mentioned, the presence of dissolved metals can be a naturally occurring phenomena, which originates from certain types of rock or may be introduced from industrial pollution. Dissolved metals in groundwater sources creates concern from a human consumption viewpoint, as well as for industries using groundwater for influent process or recycle and reuse processes. Urbanization and water demand in areas of industrial activity has increased the frequency of problem metals in groundwater sources used for both drinking and industrial purposes. When small

quantities of heavy metals naturally occur in aquifers, it is actually acceptable because they are nutritionally essential for a healthy life. Trace elements such as iron, copper, manganese, and zinc are commonly found naturally in foods we consume or as part of a vitamin supplement (Siemens Water Technologies, 2014).

Large amounts of heavy metals may cause acute or chronic toxicity (poisoning). The metals most often linked to human poisoning that cause learning disabilities, cancer, and death include copper, nickel, cadmium, chrome, arsenic, lead, and mercury. Many of these metals are required by humans in trace amounts but in larger, persistent doses, become toxic when they are not metabolized by the body and accumulate in the soft tissues. Heavy metal toxicity can result in damaged or reduced mental and central nervous system function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, or other vital organs. The most commonly encountered toxic heavy metals include arsenic, lead, mercury, cadmium, iron, and aluminum. Other heavy metals of concern are antimony, chrome, cobalt, copper, manganese, nickel, uranium, vanadium, and zinc (Siemens Water Technologies, 2014). Ion exchange is the most common way to remove dissolved metals from groundwater.

Iron and manganese are the most abundant dissolved metals that occur in water wells and aquifers in Alabama. Iron and manganese often occur together in groundwater, but manganese usually occurs in much lower concentrations than iron. They are readily apparent in drinking water supplies. Both impart a strong metallic taste to the water and cause staining (fig. 90). Water coming from wells and springs with high iron and/or manganese may appear colorless initially but orange-brown

Figure 90.—Example of iron staining from well water
(Photo credit: Hometalk, 2014).

(iron) or black (manganese) stains quickly appear as the water is exposed to oxygen. Iron and manganese are not health concerns in drinking water. Instead, they both have secondary or recommended drinking water standards because they cause aesthetic problems and a bitter, metallic taste. For these reasons, it is recommended that drinking water have no more than 0.3 mg/L (or 0.3 parts per million (ppm)) of iron and less than 0.05 mg/L of manganese. Iron and manganese may be removed by the following methods: water softening (ion exchange), polyphosphate addition, oxidizing filters, or oxidation followed by filtration (Penn State Extension, 2014).

RADIONUCLIDES IN GROUNDWATER

Radionuclides are radioactive isotopes or unstable forms of elements. Radioactivity is the release of energy in the form of gamma rays and energetic particles (alpha and beta particles) that occurs when unstable elements decompose to form more stable elements. The process by which an element changes from an unstable state to a more stable state by emitting radiation is called radioactive decay, which is measured in the time required for half of the initial amount of a radioactive element to decay, called the half-life. Gamma rays, alpha particles, and beta particles (which are given off during radioactive decay) have very different properties but are all ionizing radiation, meaning that each is energetic enough to break chemical bonds, thereby possessing the ability to damage or destroy living cells (USGS, 2000).

Radioactive elements are naturally present in a wide range of concentrations in all rocks, water, and soil. The occurrence and distribution of radionuclides in groundwater is controlled by the local geology and geochemistry of rock and water. The most common radioactive elements, uranium-238 and thorium-232, decay slowly and produce other radioactive "daughter elements" such as radium and radon (which have faster decay rates and emit different levels of radiation). Some radionuclides, which may be present in groundwater, include gross alpha emitters, beta particle and photon radioactivity, radium 226, radium 228, and uranium (see table 39 for USEPA Maximum Contaminant Levels (MCL)). When dissolved in water, radionuclides are colorless, odorless, and tasteless. Natural radioactivity in drinking water and its effect on human health have become a major environmental concern. Radioactive materials are also released from U.S. nuclear power plants under controlled, monitored conditions that meet the U.S. Nuclear Regulatory Commission's (USNRC) limits (USNRC, 2013).

Table 39.—EPA drinking water regulations for radionuclides.

PA Regulations for Radionuclides		
Radionuclides	MCLG	MCL
(Adjusted) Gross Alpha Emitters	Zero	15 picoCuries per liter
Beta Particle and Photon Radioactivity	Zero	4 millirems per year
Radium 226 and Radium 228 (Combined)	Zero	5 picoCuries per liter
Uranium	Zero	30 micrograms per liter

*MCL—maximum contaminant level
*MCLG —maximum contaminant level goal

ADEM regulates radionuclide standards and monitoring requirements for the state of Alabama. Natural radionuclides that ADEM monitors include gross alpha particles, combined radium-226 and radium-228, and uranium. Monitored manmade radionuclides are tritium, strontium 90, and beta particles and photons. Table 40 contains a list of ADEM MCLs and exceedance values for radionuclide contaminants for the state of Alabama. A common radionuclide of concern in Alabama is radon. Radon is a naturally occurring, colorless, odorless, water-soluble gas produced by the radioactive decay of radium. Radon gas may come from pitchblende or other uranium-containing minerals. Radon is quite common in the crust of the earth, so it is not unusual for it to seep into groundwater in both shallow and deep wells. Health risks of radon include stomach cancer (via ingestion) and lung cancer (via inhalation). The health risk of radon inhalation is believed to be many times greater than the risk resulting from direct ingestion of radon contained in water. Radon in water is emitted

Table 40.—ADEM drinking water regulations for radionuclides, 335-7-2-.08.

MCL's for Natural Radionuclides		
Contaminant	Unit of Measure	MCL
Gross alpha particle (including Radium-226 but excluding Radon and Uranium)	pCi/L	15
Combined Radium-226 and Radium-228	pCi/L	5
Uranium	µg/L	30
MCLs for Manmade Radionuclides		
Contaminant	Unit of Measure	MCL
Tritium	pCi/L	20,000
Strontium-90	pCi/L	8
Beta particle and photon	millirem/year radioactivity	4
Compliance for Other Radionuclide Contaminants		
Contaminant	Unit of Measure	Detection Limit
Gross alpha particle activity	pCi/L	3
Radium-226	pCi/L	1
Radium-228	pCi/L	1
Uranium	µg/L	1
Tritium	pCi/L	1,000
Strontium-89	pCi/L	10
Strontium-90	pCi/L	2
Iodin-131	pCi/L	1
Cesium-134	pCi/L	10
Gross Beta	pCi/L	4
Other Radionuclides		1/10 of the MCL

to the air, especially where water is agitated or sprayed. The USEPA has not set an MCL for radon in drinking water at this time, but recommends that any level of radon above 300 pCi/L picocuries per liter) should be a concern. Radionuclides can be treated in public water supply systems by ion exchange, reverse osmosis, and lime softening (ACES, 2014a). Gross alpha radiation in excess of the USEPA MCL was observed in two wells constructed in the Gordo aquifer in the CPYRW in Barbour and Henry Counties. Remedial actions pertaining to well construction were taken in the Barbour County well that reduced or eliminated the gross alpha concentrations.

MAJOR GEOCHEMICAL PARAMETERS BY COUNTY

For many years, the GSA, in cooperation with the Water Resources Division of the USGS, conducted water availability studies for each county within the state. These reports (published by GSA in the Special Map series) serve as valuable resources for groundwater quality data that is not widely available from other sources in this region of the state. The following water quality data, largely based on analyses from the Special Map series, will provide evaluations of chemical analyses of water from selected wells for each county within the CPYRW.

BARBOUR COUNTY

Chemical analyses available for groundwater in Barbour County indicates that excessive hardness and objectionable concentrations of iron are widespread. The hardness of water is objectionable for some domestic and industrial uses if it greatly increases soap consumption, a characteristic of water with hardness exceeding 120 ppm. Waters with lower hardness deposits scale in pipes, heating equipment, and boilers. The hardness of groundwater can be described as soft—0-60 ppm, moderately hard—61-120 ppm, and very hard—181 ppm or more. Water from the Clayton Formation is generally moderately hard to hard.

Chloride concentrations in wells sampled in Barbour County is generally low. However, data from oil and gas test wells indicate that water in the major northern aquifer (Tuscaloosa Group) becomes excessively mineralized beginning in the eastern part of the county, south of Eufaula and extending westward, south of Louisville. Chloride salts affect the suitability of water for many uses; in sufficient concentrations they give the water an objectionable taste. Iron concentrations in the Nanafalia Formation and the upper member of the Providence Sand exceeds the USEPA drinking water standard of 0.3 ppm. Water high in iron content occurs according to specific conditions of Eh and pH (Cook, 1993) and occurs locally in most of the geologic units in Barbour County (Newton and others, 1966).

BULLOCK COUNTY

The chemical quality of groundwater in Bullock County varies significantly from one aquifer to another and within each specific aquifer. Water from wells in the Ripley Formation is generally soft to very hard. Hardness values range from 5 to 300 mg/L of $CaCO_3$ with a median of 97 mg/L. The iron content of the water is generally high in shallower aquifers, although water from the deeper Eutaw aquifer is generally below the USEPA drinking water standard. The lowest observed iron concentration was 130 µg/L and the highest was 74,000 µg/L. The median value was 510 µg/L.

The Eutaw aquifer provides the majority of domestic use water supplies within the county. The water is generally soft; however, hardness ranged from 2 to 160 mg/L of $CaCO_3$ with the median value of 12 mg/L. Eutaw water in the southern part of Bullock County, which is included in the CPYRW area, is soft (0-60 mg/L). Hard water in the Eutaw occurs in the northern part of the county along the Macon County line. Iron content ranged from 5 to 1,000 µg/L with a median of 215 µg/L. The total dissolved solids from water in the Eutaw ranged from 175 to 275 mg/L with a median of 213 mg/L.

The Tuscaloosa Group is the deepest aquifer in Bullock County and provides most of the water used for public supply. Water from the Tuscaloosa is generally soft; hardness ranges from 2 to 86 mg/L of $CaCO_3$ with a median of 5 mg/L of $CaCO_3$. The iron content of the water is generally high in northern Bullock County and lower in the central and southern parts of the county, where the aquifer is deeper. The median value for iron concentration was 1,100 µg/L, and concentrations ranged from 50 to 18,000 µg/L. Filtration or aeration may be desired in some cases before water is used. Although the iron content of this water is high, water from wells in the Tuscaloosa aquifer is of good quality and can be used for most purposes (Gillett, 1990).

COFFEE COUNTY

Evaluation of chemical analyses in Coffee County indicate that hardness and objectionable amounts of iron, locally, are a problem, but overall quality of water is sufficient for most uses. Water from the Clayton and Nanafalia Formations is generally moderately hard to very hard; water from the Tuscahoma Sand is generally moderately hard to hard; and water from the Hatchetigbee and Tallahatta Formations undifferentiated and the Lisbon Formation is generally soft to hard. Water high in iron content occurs locally in most aquifers in Coffee County (Turner, Scott, Newton, and others, 1968).

COVINGTON COUNTY

Chemical analyses of groundwater in in Covington County indicates that the hardness of water and objectionable amounts of iron are problematic; however, the water is satisfactory for most uses throughout the county. Water from the Nanafalia formation is soft to moderately hard; water from the Tuscahoma Sand is generally moderately hard to very hard; water from the Tallahatta and Hatchetigbee Formations undifferentiated is generally soft to moderately hard; and water from the Lisbon and Moodys Branch Formations, Ocala Limestone, and Oligocene Series is generally soft to very hard. Water high in iron content occurs locally in most aquifers in Covington County (Turner, Scott, McCain and Avrett, 1968).

CRENSHAW COUNTY

Evaluation of chemical analyses for Crenshaw County indicates that the hardness of water, chloride in deep aquifers, and objectionable amounts of iron impact water quality in some parts of the county. The distribution of hardness of water from the Ripley Formation in the Luverne and Rutledge areas is less than 60 ppm and increases to over 180 ppm northward towards Highland Home. The part of Crenshaw County included in the CPYRW area has insufficient data for hardness in the Ripley Formation.

Based on data from adjacent counties, water from the Eutaw and Gordo Formations contains chloride in excess of 250 ppm in all except the northernmost part of Crenshaw County. Electric logs from oil and gas test wells indicate that water from the Ripley Formation contains chloride in excess of 250 ppm in the southernmost part of the county. Chloride concentrations in water from other aquifers in the county is generally low.

Iron concentrations in water from the Ripley Formation generally exceeds 0.3 ppm in the northern part of Crenshaw County, but is less than 0.3 ppm in the vicinity of Luverne. The iron content of water from the Clayton Formation is generally low, but locally exceeds 0.3 ppm. Iron concentrations in water from the Porters Creek Formation exceeds 0.3 ppm in the western part of the county and in the vicinity of Brantley, but elsewhere is less than 0.3 ppm (McWilliams Scott, Golden and Avrett, 1968).

DALE COUNTY

Chemical analyses of groundwater in Dale County indicate that hardness and objectionable amounts of iron are a problem locally, but generally water is satisfactory for most uses throughout the county. Water from the Providence Sand and the Clayton and Nanafalia Formations is generally moderately hard to hard; water from the Tuscahoma Sand is moderately hard to hard in the south-central and eastern parts of the county; and locally, water from the Ripley Formation and the Tallahatta and Hatchetigbee Formations undifferentiated is hard. Excessive concentrations of iron are present in the Clayton and Nanafalia Formations throughout the county; in the Tuscahoma Sand in the south-central and eastern parts of the county; and locally in the Ripley Formation, Providence Sand, and the Tallahatta and Hatchetigbee Formations undifferentiated (Newton, Golden, Avrett and Scott, 1968).

GENEVA COUNTY

Evaluations of chemical analyses of water wells in Geneva County indicate that water is suitable for most purposes and is available throughout the county. However, hardness and excessive amounts of iron and chloride are problems locally in some parts of the county. Water from the major deep aquifers (Nanafalia and Clayton Formations) is generally soft to moderately hard; water from the major shallow aquifers (Lisbon, Tallahatta, and Hatchetigbee Formations) is generally moderately hard to very hard.

Chloride affects the suitability of water for many uses if present in sufficient concentrations. Water from the major deep aquifer in the southwestern part of the county probably has a chloride content of more than 1,000 ppm, while water in the city of Geneva has a chloride content of 317 ppm. Chloride is not a problem in water from the major deep aquifer in the remainder of the county or in water from the major shallow aquifer. Water containing iron in excess of 0.3 ppm occurs locally throughout the county, except in the major deep aquifer (Scott and others, 1969).

HENRY COUNTY

Chemical analyses of groundwater in Henry County indicate that the hardness of water and levels of iron are problematic, but generally the water quality is satisfactory

for most uses. Water from the Tuscahoma and Providence Sands generally is moderately hard to hard; water from the Nanafalia Formation is moderately hard to hard in the southern part of the county; and water from the Clayton Formation is generally very hard. Water, high in iron content generally occurs in the Tallahatta and Hatchetigbee Formations undifferentiated and in the Clayton Formation throughout the county and in the Nanafalia Formation in most of the county, excluding areas near Edwin and southeast of Abbeville. High iron content also occurs in other geologic units that crop out in Henry County (Newton, McCain and Avrett, 1968).

HOUSTON COUNTY

Water of good chemical quality is available in major and minor aquifers in Houston County. Dissolved solids content is generally less than 250 ppm, but locally, water in all aquifers contains iron in excess of 0.3 ppm. Water from the major deep aquifers (Tuscahoma Sand, Nanafalia, and Clayton Formations) is generally moderately hard to hard. Water from the major shallow aquifers (Ocala Limestone, Moodys Branch, Lisbon, Tallahatta, and Hatchetigbee Formations) ranges from soft to very hard but generally is moderately hard to hard. Highly mineralized water occurs at great depths in Houston County, south of Dothan and near Cottonwood (Scott and others, 1967).

PIKE COUNTY

Water of good chemical quality is available generally throughout Pike County. Water from the Ripley Formation is soft to hard; water from the Providence Sand is soft to hard but generally is moderately hard; and water from the Clayton Formation is soft to very hard but is generally hard. Iron in excess of 0.3 ppm occurs locally in water from the Ripley Formation, Providence Sand, and Clayton Formation. Objectionable amounts of iron in water from the Ripley and Providence aquifers occur most commonly at or near their areas of outcrop. The major deep aquifer, consisting of the Eutaw Formation and the upper part of the Tuscaloosa Group (Gordo Formation) is soft and low in iron and chloride content (Shamburger and others, 1968).

DOWN-GRADIENT LIMITS OF FRESHWATER

Down-gradient limits of freshwater can be determined from analyses of water samples from deep water wells and electric logs from deep water wells and oil and gas test wells). Down-gradient limits of freshwater for selected aquifers within the CPYRW study area were determined in the Groundwater Availability in Southeast Alabama: Scientific Data for Water Resource Development, Protection, Policy, and Management Report by the GSA in 2014 and displayed on NPPI maps for each aquifer (Cook and others, 2014). Data presented from NPPIs in this report suggest downdip limits of water production are commonly a combination of NPPI thickness and water-quality (salinity) estimation from geophysical logs and limited water quality analyses.

Although data are limited, the likely downdip limit of freshwater for the Eutaw and Gordo aquifers extends through central Henry County, westward through central Dale, northern Coffee, and central Crenshaw Counties. The downdip limit of freshwater occurrence for the Ripley aquifer extends from southernmost Crenshaw County southeastward through Coffee County and thence in an easterly direction across southern Dale and Henry Counties. The probable downdip limit of freshwater

production in the Clayton aquifer extends across central Covington County to Geneva County, and continues eastward across the southern part of the study area. The downdip limit of fresh water for the Salt Mountain Limestone likely extends across south-central Covington and southwestern Geneva Counties.

The interpreted downdip limit of Nanafalia aquifer water production extends in a general northwest to southeast line across southern Covington County and southwestern Geneva County. This limit is the result of a general decrease in the net sand/limestone content and greater salinity to the southwest. Sands in the Tallahatta aquifer contain fresh water, except in the southwestern part of the CPYRW area where the water is increasingly saline. Due to insufficient geophysical log data, down-gradient limits of freshwater could not be determined for the following aquifers: Lower Cretaceous undifferentiated, Coker Formation, Eutaw Formation, Ripley Formation Cusseta Sand Member, Providence Sand, Tuscahoma Sand, Lisbon Formation, and the Crystal River Formation. Due to the shallow nature of the aquifers below the Tallahatta, all available water in Alabama is freshwater.

POTENTIAL SOURCES OF GROUNDWATER CONTAMINATION

UNDERGROUND INJECTION CONTROL WELLS

Underground injection control wells are defined as devices that place fluid deep underground into porous rock formations, such as sandstone or limestone, or into or below the shallow soil layer (USEPA, 2014c). Injected fluids may be water, wastewater, brine (salt water), or water mixed with chemicals. Injection wells have a range of uses that include long term (CO_2) storage, waste disposal, enhancing oil production, mining, and preventing salt water intrusion. Widespread use of injection wells began in the 1930s to aid in the disposal of brine generated during oil production. During the 1950s, chemical companies began injecting industrial waste into deep wells. As chemical manufacturing increased, so did the use of deep injection. In 2010, the USEPA finalized regulations for geologic sequestration of CO_2.This ruling created a new class of wells, Class VI. There are six classes of injection wells, based on similarity in the fluids injected, activities, construction, injection depth, design, and operating techniques (classes shown in table 41).

A federal Underground Injection Control (UIC) program was established under the provisions of the Safe Water Drinking Act of 1974. This federal program establishes minimum requirements for effective state UIC programs. Alabama has USEPA's approval to administer the UIC program in the state. Since groundwater is a major source of drinking water in Alabama, the UIC program requirements were designed to prevent contamination of Underground Sources of Drinking Water resulting from the operation of injection wells (ADEM, 2014c). The Groundwater Branch of ADEM administers and provides technical support for Alabama’s UIC program. The majority of injection wells regulated by ADEM are gravity flow field lines used to dispose of domestic wastewater from residences. Common uses of UIC wells in Alabama are for treated discharges from small car washes and laundromats, located in areas with no public sewer systems. Other treated discharges come from systems designed to cleanup groundwater contamination and small wastewater collection and treatment systems for residential areas.

Table 41.—UIC well classes and national inventory (modified from EPA, 2014).

Class	Use	National Inventory
Class I	Inject hazardous wastes, industrial non-hazardous liquids, or municipal wastewater beneath the lowermost USDW.	680 wells
Class II	Inject brines and other fluids associated with oil and gas production, and hydrocarbons for storage.	172,068 wells
Class III	Inject fluids associated with solution mining of minerals beneath the lowermost USDW.	22,131 wells
Class IV	Inject hazardous or radioactive wastes into or above USDWs. These wells are banned unless authorized under a federal or state ground water remediation project.	33 Sites
Class V	All injection wells not included in Classes I-IV. In general, Class V wells inject non-hazardous fluids into or above USDWs and are typically shallow, on-site disposal systems. However, there are some deep Class V wells that inject below USDWs.	400,000 to 650,000 *Estimation
Class VI	Inject Carbon Dioxide (CO_2) for long term storage, also known as Geologic Sequestration of CO_2	6 to 10 commercial wells expected by 2016

Currently, there are 525 UIC wells in the state of Alabama (State Oil and Gas Board of Alabama, 2014). According to ADEM, about 90% of permitted injection wells within the state are Class V wells. There are no UIC wells within the CPYRW study area; however, there are five UIC wells west of the watershed boundary in Covington County (fig. 91). The UIC well type, status, and operator of these wells are shown in table 42.

UNDERGROUND STORAGE TANKS

Underground storage tanks (UST) are features that consist of a tank and connected underground piping with at least 10% of its volume underground. USTs store petroleum and other hazardous substances and are often used at gas stations, refineries or other industrial sites. USTs with faulty installation or inadequate operation and maintenance can cause leaks or the potential for fire or explosions. In 1984, Congress added the Subtitle I to the Solid Waste Disposal Act, which required USEPA to develop a comprehensive regulatory program for USTs storing petroleum or certain hazardous substances. In 1986, Congress amended Subtitle I and created the Leaking Underground Storage Tank (LUST) Trust Fund, which is used to oversee cleanups by responsible parties and to pay for cleanups at sites where the owner or operator is unknown, unwilling, or unable to respond, or which require emergency action (USEPA, 2014e). The Energy Act of 2005 amended subtitle I and expanded the use of the LUST Trust Fund and included provisions regarding inspections, operator training, delivery prohibition, secondary containment and financial responsibility, and cleanup of releases that contain oxygenated fuel additives. In the American Recovery and Reinvestment Act of 2009, Congress appropriated $200 million from the LUST Trust Fund to USEPA for cleaning up UST leaks.

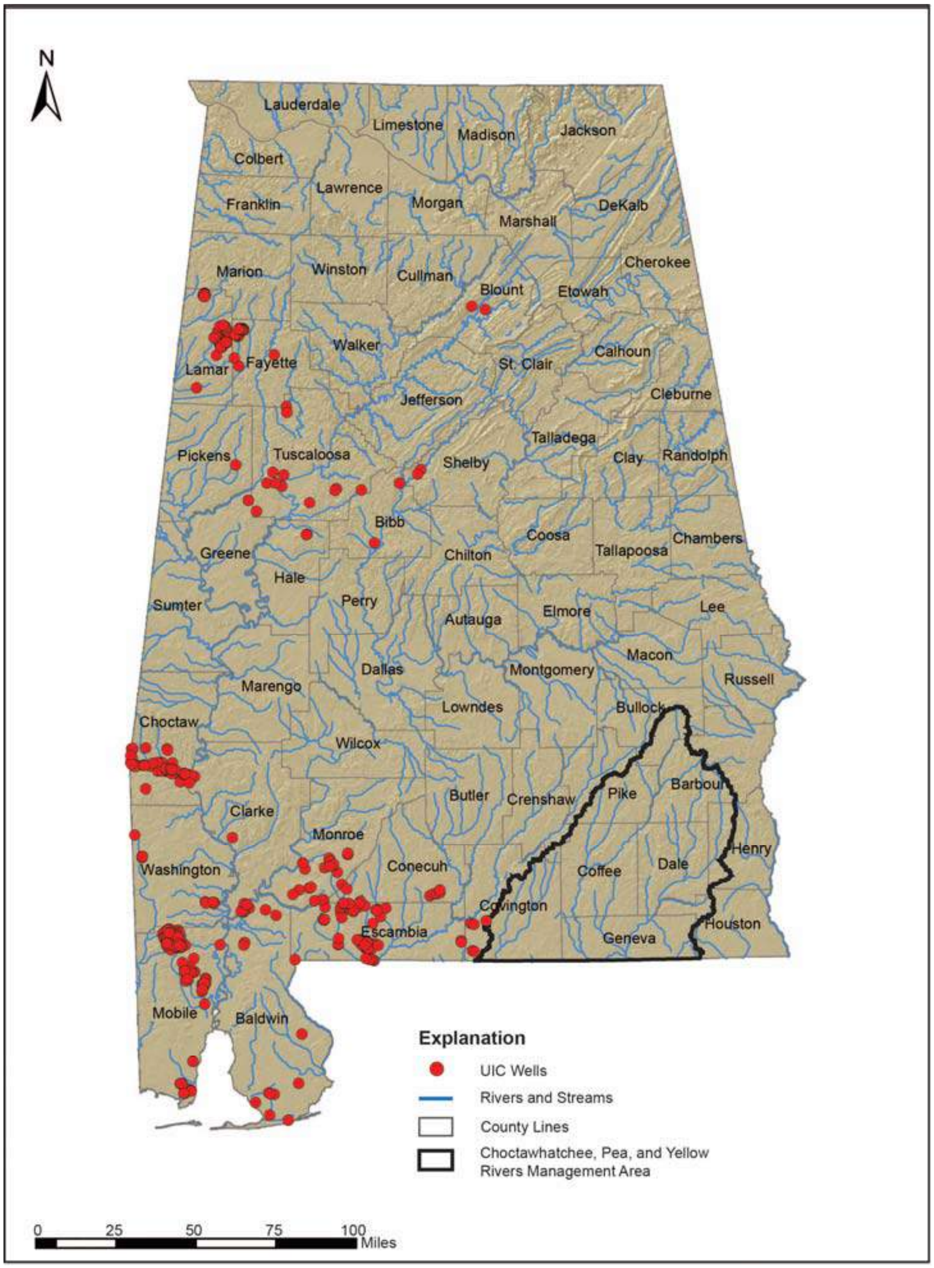

Figure 91.—Location of underground injection control (UIC) wells in Alabama (modified from Alabama Oil and Gas Board, 2014).

The ADEM Groundwater Branch administers the UST program in Alabama, which consists of a prevention program (the UST Compliance Program) and a cleanup program (the UST Corrective Action Program). On July 16, 2012, ADEM implemented new regulations for individuals who supervise installation, closure, and repair of UST systems. These individuals must be certified by an ADEM approved certifying organization as required by § 335-6-15-47. ADEM is also in charge of the Alabama

Table 42.—Covington County Underground Injection Control well data (modified from State Oil and Gas Board of Alabama, 2014).

Well Name	Well Type	Well Status	Current Operator
Paramount-Federal 16-14 #1	Water Injection	Active	EOR, LLC
Paramount-Federal 21-1 #1	Water Source	Permitted Well	EOR, LLC
Paramount-Wilder 5-8 SWD #1	Salt Water Disposal	Active	Ventex Operating Corp.
Smak-Dixon 31-10 SWD #1	Salt Water Disposal	Active	Gulf Coast Mineral, LLC
Lassiter 4-10 #1	Water Injection	Temporarily Abandoned	Ventex Operating Corp.

Underground and Aboveground Storage Tank Trust Fund, which reimburses eligible tank owners and operators for costs associated with the assessment and remediation of eligible releases from underground and above-ground storage tanks (ADEM, 2014c). According to ADEM, for the period of October 1, 2012, through September 30, 2013, there were 18,104 USTs in the state of Alabama. Table 43 shows the general UST information, summary of on-site inspections, and UST release data for this time period. As of 2013, there were approximately 600 identified USTs within the CPYRW area (fig. 92).

Table 43.—ADEM underground storage tank (UST) Data from October 1, 2012, to September 30, 2013 (modified from ADEM, unpublished data, 2013).

General Information	
Total number of UST Facilities:	5,762
Total number of USTs:	18,104
Summary Information for On-site Inspections	
Number of UST facilities inspected:	3,356
Percent compliance:	73.87
Summary Information for Releases	
Number of confirmed releases:	91
Number of unknown release sources:	50

IMPACTS OF SEPTIC SYSTEMS ON SHALLOW WELLS

The quality of drinking water from shallow domestic wells can be affected by seepage from nearby septic systems. Septic systems are the most common on-site domestic waste disposal systems in use. ADEM estimates that over 670,000 active septic systems exist in Alabama. There are over 20,000 new systems permitted annually. If septic systems are properly installed, used, and maintained, they should not pose a threat to water quality; however, the Alabama Department of Public Health (ADPH) estimates that 25% of all septic systems in Alabama could be failing. Each septic system that malfunctions is a potential source of groundwater contamination. Groundwater quality impacts may be observed beyond the homeowner's property line.

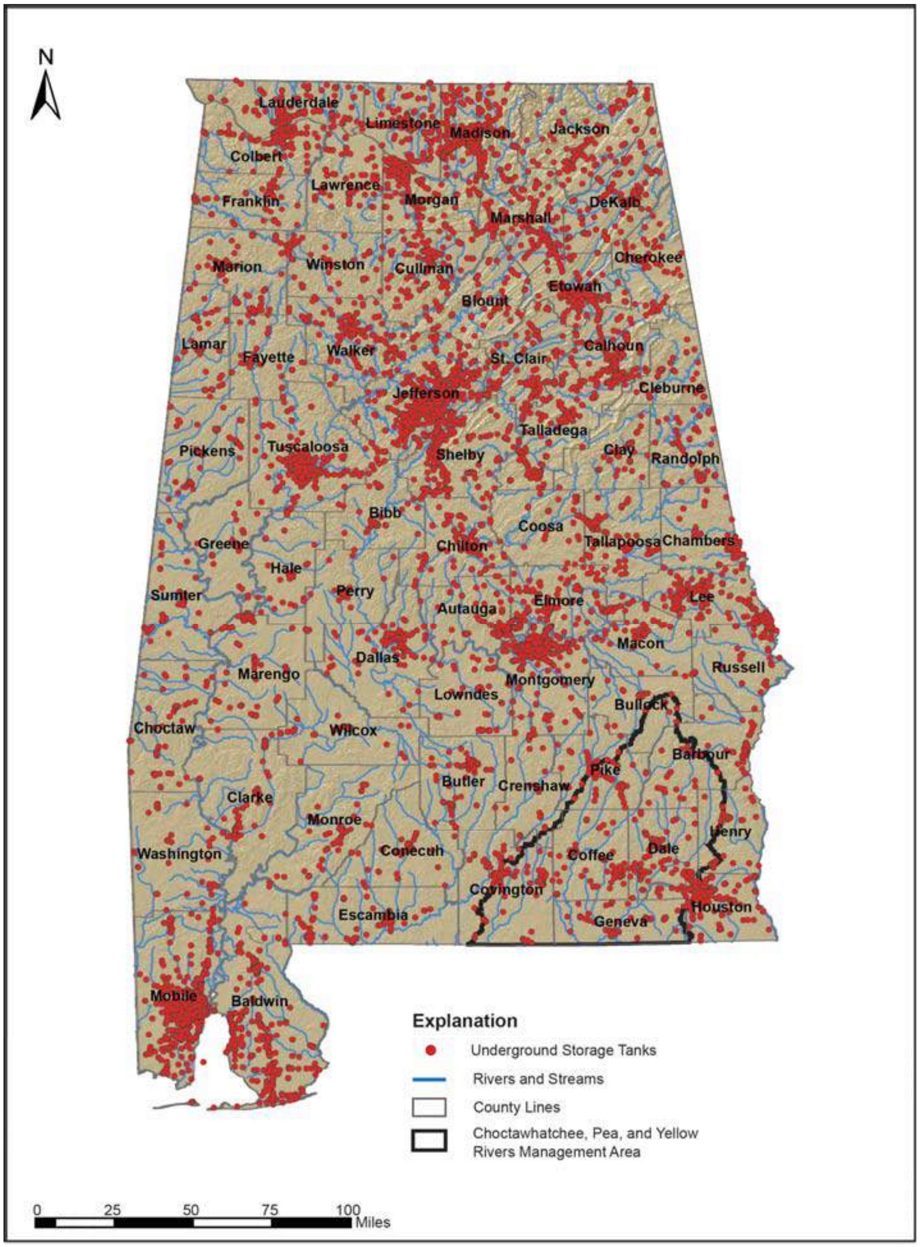

Figure 92.—Location of underground storage tanks (USTs) in Alabama (ADEM, unpublished data, 2013).

When septic systems are functioning properly, they are an effective way to manage household waste. When waste first enters a tank, solid materials settle out and become digested by bacteria. Solids must periodically be cleaned from the tank to prevent blockage of field lines and subsequent overflow (ADEM, 2014d). Liquid waste passes from the septic tank to field lines where it percolates through the soil column. The waste is broken down before it reaches the water table via bacterial action within the septic system and subsequently filtration through the soil. Introducing hazardous

household wastes such as oil, powerful cleaners, and other substances into the septic system may kill bacteria that break down waste and impair the system's efficiency. To provide adequate filtering of liquid wastes, septic systems require a fairly thick and moderately permeable unsaturated zone (ADEM, 2014d). In some locations, soils may be thin and the underlying rock may be impermeable. Coastal regions that have sandy soils may be too permeable or the water table may be too near the land surface to properly filter out contaminants. If a septic system ceases to function properly, contaminated wastewater may enter shallow aquifers, endangering the homeowner's well (fig. 93). Contaminants that result from failing septic systems may include bacteria and viruses (microbes are common indicators of fecal contamination), inorganic contaminants such as nitrogen, chlorides, and phosphorus, and organic compounds such as antibiotics, prescription, and nonprescription drugs. See Appendix 6 for a list of recommended water quality tests for domestic well owners.

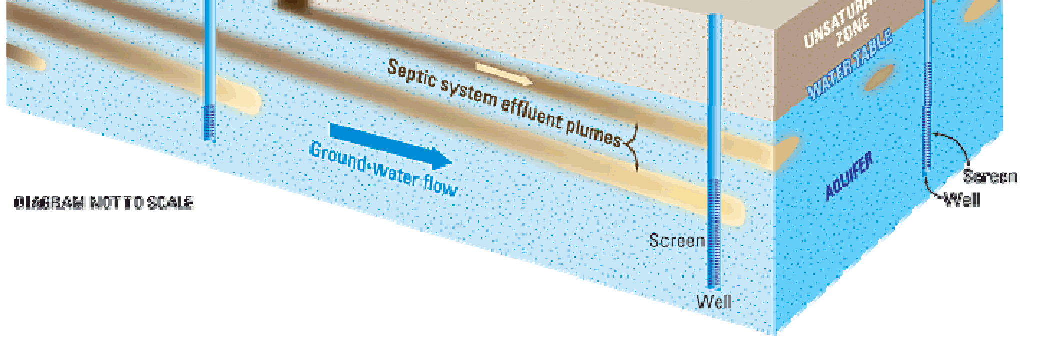

Figure 93.—Illustration of septic system impacts on groundwater well (modified from USGS, 2014b).

ECOSYSTEM RESOURCES

CHARACTERIZATION OF IMPERILED SPECIES

Aquatic and terrestrial animals considered imperiled and of conservation concern in the CPYRW include species of snails, mussels, crayfishes, fishes, reptiles and amphibians, birds, and mammals (table 44). State of Alabama conservation status for these species is listed in table 44 as either Priority 1 or Priority 2. The USFWS status is indicated as either threatened, endangered, candidate, or protected under the Bald and Golden Eagle Protection Act. Priority 1 species are of highest conservation concern and are taxa critically imperiled and at risk of extinction/extirpation because of extreme rarity, restricted distribution, decreased population trend/population viability problems, and specialized habitat needs/habitat vulnerability due to natural/human-caused factors (CPW and GSA, 2005). Priority 2 species are of high conservation concern and are taxa imperiled because of three of four factors that include rarity, very limited, disjunct, or peripheral distribution (CPW and GSA, 2005).

FRESHWATER MUSSELS

There are 25 species of freshwater mussels known in the Choctawhatchee River system (McGregor and others, 2004b), of which 14 species are of state conservation concern with nine listed by USFWS as threatened and(or) endangered, and one considered extinct. Mussels are filter feeders found on the bottom of lakes, rivers, and creeks (USFWS, 2014b) and are good indicators of water quality helping purify the aquatic system by acting as a filter (USFWS, 2014b).

The Rayed Creekshell (*Anodontoides radiates*) habitat includes Gulf Coast drainages from the Amite River system in Louisiana to the Apalachicola River system in Florida and Georgia. Based on known historical records, it appeared to not exist in the Choctawhatchee River drainage, but recently this species was found in small tributaries (Blalock-Herod and others, 2005). The Rayed Creekshell is most commonly found in small- to medium-sized coastal plain streams and typically occurs in sand or silt substrata in areas of low to moderate current. Population declines have been attributed to habitat degradation and declining population trends. This species is considered of high conservation concern in Alabama (ADCNR, 2012).

The Delicate Spike's (*Elliptio arctata*) distribution is unclear, but this species has been reported throughout the Mobile Basin, and has also been reported in the Escambia River system (Garner, 2004), Gangloff and Hartfield (2009) reported six individuals from among two stations in the Pea River in Coffee and Geneva Counties, and is considered widespread in the system (Williams and others, 2008). It prefers areas with coarse sand and gravel and under and around large rocks. Population declines have been attributed to its restricted distribution and specialized habitat and it is considered a species of high conservation concern in Alabama (ADCNR, 2012).

Table 44.—Species of conservation concern in the CPYRW.

Species, common name	Status[1]	USFWS[2]
Freshwater Mussels		
Anodontoides radiates, Rayed Creekshell	P2	-
Ellipto arctata, Delicate Spike	P2	-
Fusconaia burkei, Tapered Pigtoe	P2	T
Fusconaia escambia, Narrow Pigtoe	P2	T
Hamiota australis, Southern Sandshell	P2	E
Medionidus acutissimus, Alabama Moccasinshell	P1	T
Obovaria choctawensis, Choctaw Bean	P2	E
Obovaria haddletoni, Haddleton Lampmussel	Extinct	-
Pleurobema strodeanum, Fuzzy Pigtoe	P2	T
Ptychobrachus jonesi, Southern Kidneyshell	P1	E
Utterbackia peggyae, Florida Foater	P1	-
Villosa villosa, Downy Rainbow	P1	-
Crayfishes		
Procambarus capillatus, Capillaceous Crayfish	P2	-
Procambarus clemmeri, Cockscomb Crayfish	P2	-
Procambarus escambiensis, Escambia Crayfish	P1	-
Procambarus hubbelli, Jackknife Crayfish	P2	-
Procambarus okaloosae, Okaloosa Crayfish	P2	-
Fishes		
Acipenser oxyrinchus desotoi, Gulf Sturgeon	P2	T
Alosa alabamae, Alabama Shad	P1	-
Notropis chalybaeus, Ironcolor Shiner	P1	-
Pteronotropis welaka, Bluenose Shiner	P2	-
Reptiles and Amphibians		
Amphiuma pholeter, One-Toed Amphiuma	P2	-
Drymarchon couperi, Eastern Indigo Snake	P1	T
Farancia erytrogramma, Rainbow Snake	P1	-
Gopherus polyphemus, Gopher Tortoise	P2	C
Graptemys barbouri, Barbour's Map Turtle	P2	-
Lithobates capito, Gopher Frog	P1	-
Lithobates heckschri, River Frog	P1	-

Table 44.—Species of conservation concern in the CPYRW—continued.

Species, common name	Status[1]	USFWS[2]
Birds		
Aimophila aestivalis, Bachman's Sparrow	P2	-
Ammodramus henslowii, Henslow's Sparrow	P1	-
Anas rubripes, American Black Duck	P2	-
Asio flammeus, Short-Eared Owl	P2	-
Campephilus principalis, Ivory-Billed Woodpecker	Ex	E
Elanoides forficatus, Swallow-Tailed Kite	P2	-
Haliaeetus leucocephalus, Bald Eagle	-	P
Ixobrychus exilis, Least Bittern	P2	-
Mycteria americana, Wood Stork	P2	E
Picoides borealis, Red-cockaded Woodpecker	P1	E
Mammals		
Bison bison, Bison	Ex	-
Canis rufus, Red Wolf	Ex	E
Corynorhinus rafinesquii, Rafinesque's Big-Eared Bat	P1	-
Geomys pinetis, Southeastern Pocket Gopher	P2	-
Lasiurus intermedius, Northern Yellow Bat	P2	-
Mustela frenata, Long-Tailed Weasel	P2	-
Myotis austroriparius, Southeastern Myotis	P2	-
Myotis grisescens, Gray Myotis	P1	E
Myotis lucifugus, Little Brown Myotis	P1	-
Puma concolor, Puma	Ex	E
Spilogale putorius, Eastern Spotted Skunk	P2	-
Sylvilagus palustris, Marsh Rabbit	P2	-
Tadarida brasiliensis, Brazilian Free-Tailed Bat	P2	-

[1] P1—Highest Conservation Concern, P2—High Conservation Concern, Ex—Extirpated
[2] T—Threatened, E—Endangered, C—Candidate, P—protected under the Bald and Golden Eagle Protection Act.

The Tapered Pigtoe (*Fusconaia burkei*) is endemic to the Choctawhatchee River system of southern Alabama and western Florida, although it is now eliminated from much of its historical range and can only be found in a few locations in the headwaters tributaries of the Choctawhatchee River system (Blalock-Herod, 2004a), and Gangloff and Hartfield (2009) reported four individuals from a single station in the Pea River in Coffee County. *F. burkei* prefers medium sized creeks to large rivers in stable sand or sand and gravel substrata, and occasionally silty sand, in slow to moderate current (Blalock-Herod, 2004a). Its limited distribution, rarity and reduction of quality habitat makes it a species of high conservation concern in Alabama (Blalock-Herod, 2004a) and is considered imperiled (Blalock-Herod and others, 2005). *F. burkei* is listed as threatened by the USFWS (2014a).

The Narrow Pigtoe (*Fusconaia escambia*) is endemic to Gulf Coast drainages, known from the Escambia and Yellow River systems in Alabama and Florida, but is apparently extirpated from the Yellow River system (McGregor, 2004a). It prefers small to medium rivers with sand, gravel, or sandy gravel substrata and slow to moderate flow. Its limited distribution, rarity, and susceptibility to habitat degradation make it a species of high conservation concern in Alabama (ADCNR, 2012). The Narrow Pigtoe is listed as threatened by the USFWS (2014a).

The Southern Sandshell (*Hamiota australis*) is endemic to Gulf Coast drainages, occurring in the Escambia, Yellow and Choctawhatchee River systems in southern Alabama and western Florida (Blalock-Herod, 2004b). Gangloff and Hartfield (2009) reported 61 individuals from among six stations in the Choctawhatchee and Pea Rivers in Coffee, Dale, and Houston Counties. It is usually found in clear, medium sized creeks to rivers, with slow to moderate current and sandy substrata. This species has a very restricted distribution, is somewhat rare, has experienced recent declines in habitat, and is considered to be a species of high conservation concern in Alabama (ADCNR, 2012). Southern Sandshell is listed as endangered by the USFWS (2014a).

The Haddleton Lampmussel (*Obovaria haddletoni*) is known only in the Choctawhatchee River from two specimens (Blalock-Herod and others, 2005). Recent surveys have not encountered any specimens and it is considered extinct (Garner, 2004).

The Alabama Moccasinshell (*Medionidus acutissimus*) has not historically been considered part of the Choctawhatchee River drainage mussel fauna (Blalock-Herod and others, 2005) and was only thought to be endemic to the Mobile Basin in Alabama, Georgia, Mississippi, and Tennessee (Haag, 2004). This species is extremely rare or possibly extirpated in these drainages and no live specimens have been collected since the advent of modern molecular systematic techniques (Williams and others, 2008). It prefers lotic areas in a wide variety of stream types and is most frequently encountered in swift, gravel-bottomed shoals or riffles (Haag, 2004). Due to its small population, which is widely scattered and isolated, it is vulnerable to extinction and considered a species of highest conservation concern in Alabama (ADCNR, 2012). The Alabama Moccasinshell is listed as threatened by the USFWS (2014a).

The Choctaw Bean (*Obovaria choctawensis*) occurs in the Choctawhatchee, Escambia, and Yellow River systems in Alabama and Florida (McGregor, 2004c), and Gangloff and Hartfield (2009) reported seven individuals from among four stations in the Choctawhatchee and Pea Rivers in Coffee, Dale, Geneva, and Houston Counties. It occurs in small to medium rivers with sand or silty sand substrata in areas with moderate to swift current (McGregor, 2004c). Its limited distribution and habitat degradation within its range make this species susceptible to extinction, and it is considered a species of high conservation concern in Alabama (ADCNR, 2012). The Choctaw Bean is listed as endangered by the USFWS (2014a).

The Fuzzy Pigtoe (*Pleurobema strodeanum*) is native in the Choctawhatchee, Escambia, and Yellow River drainages in Alabama and Florida (McGregor, 2004d), and Gangloff and Hartfield (2009) reported 72 individuals from among five stations in the Choctawhatchee and Pea Rivers in Coffee, Dale, Geneva, and Houston Counties. Its preferred habitat is sand substrata in small to large streams with

scattered gravel, woody debris, and moderate flow (McGregor, 2004d). Its limited distribution and dwindling habitat quality make this species vulnerable to extinction, and it is considered a species of high conservation concern in Alabama (ADCNR, 2012). The Fuzzy Pigtoe is listed as threatened by the USFWS (2014a).

The Southern Kidneyshell (*Ptychobranchus jonesi*) occurs in the Choctawhatchee, Yellow, and Escambia River systems in Alabama and Florida (McGregor, 2004e), and Gangloff and Hartfield (2009) reported 13 individuals from among eight stations in the Choctawhatchee and Pea Rivers in Coffee, Dale, Geneva, and Houston Counties. It inhabits medium-sized creeks to small rivers, usually in silty sand substrata and slow current and can also be found in small, sand-filled depressions in clay substrata (McGregor, 2004e). It has suffered severe declines during the recent past and is vulnerable to extinction due to limited distribution and rarity, along with degrading habitat quality within its distribution. It is considered a species of highest conservation concern in Alabama (ADCNR, 2012). The Southern Kidneyshell is listed as endangered by the USFWS (2014a).

The Florida Floater (*Utterbackia peggyae*) has a distribution that includes Gulf Coast drainages, is known historically from 8 sites within the Choctawhatchee River drainage (Blalock-Herod and others, 2005), is considered extant throughout its Florida range, and is relatively common. However, its status in the upper reaches of the drainage are in question and its current distribution in Alabama is presumably extant, but uncommon, in isolated areas (Williams and others, 2008). Recent surveys yielded no specimens in historical sites, has not been reported at new sites, and is considered a species of highest conservation concern in Alabama (ADCNR, 2012).

The Downy Rainbow (*Villosa villosa*) is known from Gulf Coast drainages and in Alabama in Eight-Mile Creek of the Choctawhatchee River system (Herod, 2004).*V. villosa* prefers a variety of habitats, from spring-fed creeks to backwaters, with silt, mud, sand, or gravel (Herod, 2004). Limited distribution and rarity make this species vulnerable to extirpation from Alabama, and it is considered a species of highest conservation concern in Alabama (ADCNR, 2012).

CRAYFISH

There are 85 species of crayfish documented in Alabama (Smith and others, 2011), of which five are of conservation concern (ADCNR, 2012) in the CPYRW. Crayfish are omnivorous, largely nocturnal, utilize a variety of shelters, and are found in a variety of freshwater habitats (rivers, streams, springs and spring runs, lakes, marshes, swamps, vernal pools, roadside ditches, caves, and on the floodplains of rivers and streams) (Smith and others, 2011).

The Capillaceous Crayfish (*Procambarus capillatus*) is native to the Escambia River System in Alabama and Florida, prefers lentic (still) waters, is a secondary burrow in its habitat, and is of high conservation concern in Alabama (USFWS, 2008). The Cockscomb Crayfish (*Procambarus clemmeri*) is native to the Yellow River system in the CPYRW, prefers lotic (flowing) waters, and is of high conservation concern in Alabama (Smith and others, 2011). The Escambia Crayfish (*Procambarus escambiensis*) is distributed throughout North America and is native to the Escambia River system in Alabama, prefers temporarily flooded woodlands and floodplains, is a secondary burrower, and is of highest conservation concern in Alabama (USFWS,

2008). The Jacknife Crayfish (*Procambarus hubbelli*) is native to the Choctawhatchee and Yellow River systems in the CPYRW, preferring lotic (flowing) waters, is a secondary burrower in its habitat, and is considered a species of high conservation concern in Alabama (Smith and others, 2011). The Okaloosa Crayfish (*Procambarus okaloosae*) is native to the Yellow River system in the CPYRW, preferring lentic (still) and lotic (flowing) waters, and is considered of high conservation concern in Alabama (Smith and others, 2011).

FISH

Alabama has one of the richest fish faunas in North America, with around 300 freshwater and 50 estuarine species (Mirarchi and others, 2004b). Four species of freshwater fish in the CPYRW are considered species of conservation concern, with one species listed as threatened by USFWS (2014a).

The Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) occupies Gulf of Mexico tributaries from the Suwannee River in Florida to Lake Pontchartrain in Louisiana, with sporadic occurrences south to Florida Bay and west to the Rio Grande River, Texas. Spawning populations are found in the Suwannee, Apalachicola, Choctawhatchee, Yellow/Blackwater, Escambia, Pascagoula, and Pearl Rivers of Florida, Alabama, Mississippi, and Louisiana, and former spawning populations are documented from the Mobile and Alabama Rivers in Alabama, the Ochlockonee River in Florida, and the Tchefuncte River in Louisiana (Hastings and Parauka, 2004). Studies conducted from 1999 to 2001 estimated adult and subadult populations in the Choctawhatchee and Yellow Rivers at fewer than 3,000 and 550 individuals, respectively (Hastings and Parauka, 2004). The Gulf Sturgeon is an anadromous species, inhabiting estuaries, bays, and nearshore waters of the Gulf of Mexico during winter, mostly in waters less than 30 ft deep and migrating into coastal rivers in early spring (March through May) to spawn and remaining in the river systems the entire summer. Declining populations have been attributed to over-fishing, loss of river habitat, modifications to habitat associated with dredged material disposal, de-snagging, and other navigation maintenance activities; incidental take by commercial fishermen; poor water quality associated with contamination by pesticides, heavy metals, and industrial contaminants; and aquaculture and accidental introductions (Hastings and Parauka, 2004). The Gulf Sturgeon is a species of high conservation concern in Alabama (Hastings and Parauka, 2004) and is listed as threatened by the USFWS (2014a).

The Alabama Shad (*Alosa alabamae*) has been reported from several major tributaries of the Mississippi River and east in larger Gulf Coast river systems to the Suwannee River in northern Florida, with individuals previously collected in the upper and lower Tombigbee, Black Warrior, Cahaba, Coosa, and Alabama Rivers within the Mobile Basin, and also in the Choctawhatchee and Conecuh Rivers (Mettee, 2004). The Alabama Shad is an anadromous species, with adults living in marine and estuarine environments most of year and migrating into free-flowing rivers to spawn in spring. Declining populations have been attributed to high-lift navigational and hydroelectric dams that have blocked upstream migrations to inland spawning areas (Mettee, 2004). Dredging and other channel maintenance activities have eliminated other sections of their spawning habitat, with the only known self-sustaining

populations in Alabama occurring in the Choctawhatchee and Conecuh Rivers (Mettee, 2004). Major threats to these populations include increased sedimentation, herbicide and pesticide runoff from agricultural operations, prolonged drought, and possible reservoir construction for water supply on major tributaries. The Alabama Shad is a species of highest conservation concern in Alabama (ADCNR, 2012).

The Ironcolor Shiner (*Notropis chalybaeus*) occupies the lowland regions of Atlantic and Gulf seaboards from the lower Hudson River drainage in New York south to the vicinity of Lake Okeechobee in Florida, and west to the Sabine River drainage in Louisiana and Texas, and it ranges north in the Mississippi River Valley to the Wolf River in Wisconsin, and east to the Illinois River system in Illinois and Indiana and to the Lake Michigan drainage in southwestern Michigan (Boschung and Mayden, 2004). This species is uncommon in Alabama, but was known in all coastal streams in Florida from the Chipola River west to the Perdido River, as well as the Mobile Delta area and lower Tombigbee and Escatawpa River systems (Boschung and Mayden, 2004). In Alabama this species is associated with small, sluggish but clear creeks with sand substrates and abundant aquatic vegetation, as well as flowing swamps with stained acidic waters typical of coastal areas (Boschung and Mayden, 2004). The Ironcolor Shiner is rare, endangered, or extirpated in several states on the periphery of its distribution due to habitat degradation and is considered a species of highest conservation concern in Alabama (ADCNR, 2012).

The Bluenose Shiner (*Pteronotropis welaka*) inhabits the St. Johns River in Florida and Gulf Coast drainages from the Apalachicola River system to the Pearl River system in Mississippi; in Alabama, it is known only from sporadically distributed localities in the Alabama, Cahaba, Chattahoochee, and Tombigbee Rivers and smaller coastal drainages, all below the Fall Line (Johnston, 2004). It prefers small- to medium-sized streams with clear or black water and is associated with relatively deep, flowing water with vegetation and sand or muck substrate. Its sporadic distribution in Alabama, along with declining populations, short life span and probable limited dispersal ability contribute to the vulnerability of this species, and it is listed as a species of high conservation concern in Alabama (ADCNR, 2012).

REPTILES AND AMPHIBIANS

Reptiles and amphibians are an important component of Alabama's biodiversity, with 154 species, including 30 frogs, 43 salamanders, 12 lizards, 40 snakes, 28 turtles, and the alligator (Mirarchi and others, 2004a). Of these 154 species of reptiles and amphibians, seven are considered species of conservation concern, with one species listed as threatened, and one as a candidate for threatened and/or endangered classification.

The One-Toed Amphiuma (*Amphiuma pholeter*) is distributed from the eastern Gulf Coast north of Tampa, Florida, and west to the Pascagoula River in Mississippi, and in Alabama is known from one locality each in the Southern Coastal Plain and Southern Pine Plains and Hills in Mobile and Baldwin Counties (Means, 2004). It prefers deep, liquid, organic muck in alluvial swamps of larger streams (Means, 2004). Due to its restriction to the lower eastern Gulf Coastal Plain, small geographic distribution, and its confinement to specialized wetland habitats, it is considered a species of high conservation concern in Alabama (ADCNR, 2012).

The Eastern Indigo Snake (*Drymarchon couperi*) currently only occurs naturally in southern Georgia and in Florida, with historical occurrences reported in South Carolina, Alabama, and Mississippi (Godwin, 2004a). *D. couperi* is typically associated with xeric (dry) habitats (Godwin, 2004a). Agricultural and forestry practices, urban development, highway mortality, and deliberate killing have resulted in a population decline of this species, and is considered a species of highest conservation concern in Alabama (ADCNR, 2012). The Eastern Indigo Snake is listed as threatened by the USFWS (2014a).

The Rainbow Snake (*Farancia erytrogramma*) occurs in the Coastal Plain from Maryland and Virginia to Mississippi and Louisiana, extending southward into central Florida, and is limited in distribution in Alabama to rivers and large streams in the southeastern portion of the state (Hughes and Nelson, 2004). *F. erytrogramma* is semi-aquatic, preferring spring-fed runs, clear streams, and clear rivers (Hughes and Nelson, 2004). This species is infrequently encountered in Alabama and current population levels and status are unknown in Alabama. It is considered a species of highest conservation concern in Alabama (ADCNR, 2012).

The Gopher Tortoise (*Gopherus polyphemus*) occurs in extreme South Carolina, south through Georgia and peninsular Florida, and westward into the Florida Panhandle, southern Alabama, and southern Mississippi to extreme southeastern Louisiana, and in Alabama, where most populations are limited to areas below the Fall Line (Aresco and Guyer, 2004). The Gopher Tortoise prefers well-drained, deep sandy soils having a relatively open canopy (Aresco and Guyer, 2004). Population declines are the result of direct habitat loss, habitat degradation, and historic overexploitation, and is considered a species of high conservation concern in Alabama (ADCNR, 2012).

Barbour's Map Turtle (*Graptemys barbouri*) until recently was thought to be restricted to the Apalachicola River system, but since 1997 has been documented in the Pea and possibly Choctawhatchee Rivers (Godwin, 2004b). It inhabits flowing rivers, with greatest numbers in stretches with exposed limestone and abundant snags and stumps for basking and is occasionally found in swamps or impoundments (Godwin, 2004b). Alterations to occupied drainage systems makes the species very vulnerable, and impoundment and other alterations of rivers have seriously affected the species, as have pollution and depredation by humans for food and as pets, and it is considered a species of high conservation concern (ADCNR, 2012).

The Gopher Frog (*Lithobates capito*) occurs from Louisiana to Florida and northward in the Coastal Plain to North Carolina, with sightings in Alabama reported from Mobile, Baldwin, Barbour, Escambia, Covington, and Shelby Counties (Bailey and Means, 2004). It prefers open longleaf pine-scrub oak forests on sandy soils and requires isolated, temporary, wetland breeding sites (Bailey and Means, 2004). Due to its small population, rapid decline in quality and quantity of breeding and nonbreeding habitats, high probability of local extirpations, and the threat of disease, this species is of highest conservation concern in Alabama (ADCNR, 2012).

The River Frog (*Lithobates heckscheri*) is restricted to the lower Coastal Plain of southeastern United States, and in Alabama is only known to occur in six localities, one of which is the Choctawhatchee River East Fork in Henry County (ADCNR, 2014).

It prefers rivers and smaller streams in river floodplains (ADCNR, 2014). Due to its extremely restricted habitat in southern Alabama, it is considered a species of highest conservation concern (ADCNR, 2012).

BIRDS

Historically unrestrained exploitation has led to the demise of many species of birds, but out of this exploitation emerged national wildlife refuges and wildlife protection laws (Mirarchi and others, 2004a). Today, the decline of bird populations can be attributed to isolation and fragmentation of habitats through agriculture, silviculture, and predation (Mirarchi and others, 2004a). In the CPYRW, there are currently 10 species of birds of conservation concern, with one species protected under the Bald and Golden Eagle Protection Act and three listed as endangered.

Bachman's Sparrow (*Aimophila aestivalis*) is distributed throughout the southeastern United States, and can be found in Alabama where open-canopied pine forests exist (Tucker, 2004a). It is commonly found in open pine forests that contain a diverse ground cover of herbaceous vegetation (Tucker, 2004a). Population declines have been attributed to habitat fragmentation and isolation from breeding population, and loss and degradation of habitat due to fire suppression. Bachman's Sparrow is considered a species of high conservation concern in Alabama (ADCNR, 2012).

Henslow's Sparrow (*Ammodramus henslowii*) has two subspecies, eastern and western. The western subspecies winters along the Gulf Coastal Plain and the eastern subspecies winters along the Atlantic Coastal Plain (Tucker, 2004b). The eastern subspecies winters in southern Alabama on pitcher plant bogs. Data indicates that *A. henslowii* has had the most severe population declines of any bird species in North America for more than 30 years, with most of these declines attributed to loss of breeding habitat and also loss of wintering habitat, such as in the Gulf Coast where more than 97% of the pitcher plant bogs have been destroyed or altered (Tucker, 2004b). Henslow's Sparrow is considered a species of highest conservation concern in Alabama (ADCNR, 2012).

The American Black Duck (*Anas rubripes*) breeds from Canada southward into the United States to Virginia, Maryland, Delaware, and coastal areas of Virginia and North Carolina, with a few breeders documented at Wheeler National Wildlife Refuge in Alabama, and is also found wintering throughout the state (Hepp, 2004). The American Black Duck prefers a variety of habitats, particularly during the breeding season, which includes in coastal areas, salt marsh, coastal meadows, brackish and freshwater impoundments, and riverine marshes, and in inland areas includes freshwater woodland wetlands (Hepp, 2004). Population declines led to restrictive harvest regulations; however, populations are still declining. It is considered a species of highest conservation concern in Alabama (ADCNR, 2012).

The Short-Eared Owl (*Asio flammeus*) is one of the world's most widely distributed owls, with a breeding range in North America extending from northern Alaska and Canada south to the eastern Aleutian Islands, southern Alaska, central California, northern Nevada, Utah, northeastern Colorado, Kansas, Missouri, southern Illinois, western Kentucky, southern Indiana, central Ohio, Pennsylvania, New Jersey, and northern Virginia (Kittle, 2004). In Alabama, *A. flammeus* is rare during winter, spring, and fall in the Tennessee Valley and Inland Coastal Plain Regions and is

considered casual in the Gulf Coast region. Breeding habitats include prairies, meadows, tundra, shrub-steep, marshes, agricultural areas, and savanna (Kittle, 2004). Population declines have been attributed to loss of habitat from human activities and is considered a species of high conservation concern in Alabama (Kittle, 2004a).

The Ivory-Billed Woodpecker (*Campephilus principalis*) was formerly found year round in Cuba and the eastern states of North America, with the last reported sighting in Alabama in 1907, just north of Troy, Alabama, in a swamp associated with the Conecuh River (Haggerty, 2004). In North America, *C. principalis* preferred habitat included large tracts of mature, virgin bottomland forests containing oaks, sweetgum, green ash, hackberry, bald cypress, and pines. Loss of habitat is most likely the main factor for extirpation and probable extinction, and this species is considered extirpated in Alabama (ADCNR, 2012) and endangered by the USFWS (2014a).

The Swallow-Tailed Kite (*Elanoides forficatus*) has two recognized subspecies, *E. f. forticatus* and *E. f. yetapa*, with the former occurring in the southeastern United States and the latter occurring in southern Mexico to northern Argentina and southeastern Brazil (Soehren, 2004). This species formerly bred throughout the southeast and along the major drainages of the Mississippi Valley; however, currently it only breeds from South Carolina south to the upper Florida Keys, and west along the Gulf Coastal Plain to Louisiana and eastern Texas. In Alabama the Swallow-Tailed Kite is found mainly in the floodplains forests along the Alabama and lower Tombigbee Rivers and the Mobile-Tensaw River Delta and may also be found in similar habitats along the Conecuh, Pea, Choctawhatchee, and Lower Chattahoochee River floodplains (Soehren, 2004). Declining populations have been attributed to loss of habitat, indiscriminate shooting, and low reproductive rates. The Swallow-Tailed Kite is considered a species of high conservation concern in Alabama (ADCNR, 2012).

The Bald Eagle (*Haliaeetus leucocephalus*) is distributed throughout the continental United States and Canada and is found statewide in Alabama, where the species is concentrated along rivers and large bodies of water near coasts, bays, rivers, and lakes (Holsonback, 2008). The Bald Eagle is not listed as either Priority 1 or Priority 2 in Alabama but is protected federally under the Bald and Golden Eagle Protection Act (USFWS, 2014a).

The Least Bittern (*Ixobrychus exilis*) breeds in western North America, throughout most of eastern North America, and in Alabama is commonly found along the coast, a local and uncommon breeder in Inland Coastal Plain, and a rare breeder in the Tennessee Valley (Cooley, 2004). It prefers habitats that include tall emergent vegetation in freshwater marshes (Cooley, 2004). Although it is widely distributed in North America, its habitats are disappearing, and in Alabama, the loss of cattail marshes to development, sedimentation from agricultural operations, and the spread of common reed had led to declining populations (Cooley, 2004). The Least Bittern is a species of high conservation concern in Alabama (ADCNR, 2012).

The Wood Stork (*Mycteria americana*) occurs in the southeastern United States, along the Gulf Coast and the Atlantic Coast, and in Alabama is regular in summer and early fall in western Inland Coastal Plain (Major, 2004). It prefers freshwater habitats, such as marshes, swamps, lagoons, ponds, and flooded fields and ditches.

(Major, 2004). Population declines have been attributed to habitat degradation and disturbance (Major, 2004). The Wood Stork is a species of high conservation concern in Alabama (ADCNR, 2012) and is listed as endangered by the USFWS (2014a).

The Red-Cockaded Woodpecker (*Picoides borealis*) is endemic to pine forests of the southeastern United States, and in Alabama is restricted to a few isolated areas south of the Tennessee River (Tucker and Robinson, 2004). It requires a mature, open pine forest with grassy or sparse understory that is maintained by frequent fires (Tucker and Robinson, 2004). Population declines have been attributed to extensive logging of pine forests in the southeast. The Red-Cockaded Woodpecker is a species of highest conservation concern in Alabama (ADCNR, 2012) and is listed as endangered by the USFWS (2014a).

MAMMALS

Alabama's native mammalian fauna includes 64 species (20 rodents, 15 bats, 14 carnivores, 6 insectivores, 4 rabbits, 2 ungulates, 1 opossum, and 1 armadillo) (Mirarchi and others, 2004a), of which three species have been extirpated in the CPYRW (Red Wolf, Puma, and Bison), and 11 species are of conservation concern, with three of the 11 mammalian species listed as endangered.

The Bison (*Bison bison*) is the largest native terrestrial mammal in North America and was once abundant and widespread from Alaska to northern Mexico but now the only remaining completely free-ranging herd in the United States is in Yellowstone National Park. In Alabama this species was believed to have historically occurred in all but the most southern portion of the state (Best, 2004a). Bison prefer a mixture of habitats that includes woodlands and grasslands and was most likely extirpated from Alabama due to historical overhunting (Best, 2004a).

The Red Wolf (*Canis rufus*) historically occurred in the Mississippi River Valley and associated drainages, northward into Illinois and Indiana, southward through southern Missouri, eastern Oklahoma, Arkansas, Kentucky, and Tennessee to the Gulf Coast of Louisiana and Mississippi, westward from the coastal regional into central Texas, and eastward through Alabama to the Atlantic Coast in Georgia and Florida. Currently no native wild populations exist, but this species has been reintroduced into the wild with limited success (Best, 2004b). The Red Wolf was last known in Alabama from Walker County northwestward to Colbert County, but is believed to have historically inhabited all of Alabama except the southwestern portion. It prefers warm, moist, and densely vegetated habitats, which include pine forests and bottomland hardwood forests, and some parts of coastal prairies and marshes. Prior to its extirpation in the southeastern United States, humans were the greatest threat through deliberate killing and habitat modification. The Red Wolf is considered extirpated from Alabama and is listed endangered by the USFWS (2014a).

Rafinesque's Big-Eared Bat (*Corynorhinus rafinesquii*) is distributed from central Illinois and Indiana, south to the Gulf of Mexico, and from eastern Oklahoma and Texas to the Atlantic Ocean. Previous records in Alabama indicate that it potentially occurred throughout the state (Best, 2004c). It prefers forested habitats and is one of the least known bats in the southeastern United States, uncommon throughout most of its range. Rafinesque's Big-Eared Bat is considered a species of highest conservation concern in Alabama (ADCNR, 2012).

The Southeastern Pocket Gopher (*Geomys pinetis*) inhabits dry, sandy areas in the southeastern United States, and in Alabama has been recorded in 16 counties, all within the upper and lower coastal plain east of Mobile Bay and the Tombigbee and Black Warrior River systems (Jordan, 2004). Declining populations have been attributed to low reproductive and dispersal rates, and alteration and fragmentation of habitat. It is a species of high conservation concern in Alabama (ADCNR, 2012).

The Northern Yellow Bat (*Lasiurus intermedius*) is one of the largest bats in North America and is known from South Carolina to eastern Texas and south into Central America (Henry, 2004a). It is usually found in a mixture of forest and early successional habitats near water, but the habitat association is poorly known. Distribution of *L. intermedius* in Alabama is poorly known and this species is of high conservation concern in Alabama (ADCNR, 2012).

The Long-Tailed Weasel (*Mustela frenata*) is the smallest of three mustelids inhabiting the southeastern United States and is distributed from southern Canada to Bolivia, South America. However, in Alabama very little is known about its population (Mitchell and Sievering, 2004a). It prefers habitats with diverse and abundant prey, and population declines are attributed to a decline in high-quality, early successional habitats. The Long-Tailed Weasel is of high conservation concern in Alabama (ADCNR, 2012).

The Southeastern Myotis (*Myotis austroriparius*) is a large bat endemic to the southeastern United States, with distribution in Alabama poorly known, but possibly restricted to the coastal plain during the summer (Lewis, 2004). It prefers riparian zones and edge habitats. Life history and ecology are poorly known and this species is of high conservation concern in Alabama (ADCNR, 2012).

The Gray Myotis (*Myotis grisescens*), one of the largest species of *Myotis,* is distributed with two population centers: one in northeastern Oklahoma, southern Missouri, and northern Arkansas, and the other in Tennessee, Kentucky, and in Alabama, where small population centers in the central and southern portions exist (Best, 2004d). The Gray Myotis is a cave-roosting species and population declines have been attributed to human disturbance, vandalism, and large-scale destruction of habitat. It is a species of highest conservation in Alabama (ADCNR, 2012) and is listed as endangered by the USFWS (2014a).

The Little Brown Myotis (*Myotis lucifugus*) is a medium-sized bat that is distributed from northern Alaska into the southern United States and from coast to coast, but is uncommon in southern portions of its distribution and considered rare in Alabama (Best, 2004e). It creates colonies in tree cavities, underneath rocks, in piles of wood, in crevices, and in a variety of human-made structures. Surveys for the past 15 years in Alabama have yielded no observations and this species is considered a species of highest conservation concern in Alabama (ADCNR, 2012).

The Puma (*Puma concolor*) is among the largest native North American cats and once had the widest distribution of any terrestrial mammal in the Western Hemisphere, but it is now extirpated throughout most of its range (Best, 2004f). The Puma prefers rough, rocky, upland woods, large tracts of bottomland forest and swamps, and remote mountainous regions. The puma was historically found statewide in Alabama, but no self-sustaining populations are known, although occasional

sightings occur. Therefore, the Puma is considered extirpated in Alabama (ADCNR, 2012) and is listed as endangered by the USFSW (USFWS, 2014a).

The Eastern Spotted Skunk (*Spilogale putorius*) is one of two skunk species that inhabit the southeastern United States. In Alabama it occurs from the Gulf Coast northward along the southern Appalachian Mountains (Mitchell and Sievering, 2004b). It prefers rocky, shrubby, and forested areas with extensive vegetative cover and little is known about populations in Alabama. The Eastern Spotted Skunk is considered a species of high conservation concern in Alabama (ADCNR, 2012).

The Marsh Rabbit (*Sylvilagus palustris*) is primarily restricted to the coastal plain, preferring habitats that support brackish marshes along coastal areas and barrier islands, in addition to freshwater marshes associated with rivers, lakes, and swamps (Hart, 2004). Little is known about this species in Alabama and it is considered a species of high conservation concern in Alabama (ADCNR, 2012).

The Brazilian Free-Tailed Bat (*Tadarida brasiliensis*) is a medium sized bat that occurs in Alabama and prefers a variety of natural and artificial habitats (Kiser, 2004). Population declines have been attributed to exclusion from buildings and deliberate destruction of colonies and this species is considered of high conservation concern in Alabama (ADCNR, 2012).

PLANTS

Four species of plants are considered endangered in the CPYRW: Pondberry (*Lindera melissifolia*), Gentian Pinkroot (*Spigelia gentianoides*), Relict Trillium (*Trillium reliquum*), and American Chaffseed (*Schwalbea Americana*) (USFWS, 2014a). No critical habitats or conservation plans for the four plant species are available (USFWS, 2014a).

GENERAL CHARACTERIZATION OF BIOLOGICAL RESOURCES, HABITAT CONDITIONS, AND FISH CONSUMPTION ADVISORIES

BIOLOGICAL CONDITION

The science and practice of stream monitoring, assessment, and evaluation has grown substantially since passage of the Clean Water Act in 1972. Biological and habitat assessment methods have been added to the traditional chemical and physical measurements of stream water quality, and water resource and fisheries management professionals now have an expanded and enhanced toolbox for evaluating water resource conditions. Biological assessment methods incorporate a variety of taxonomic groups including algae, benthic macroinvertebrates, and fishes, all of which reflect stream water quality through the composition, structure, and functional relationships of their biological communities (Barbour and others, 1999). In particular, the Index of Biotic Integrity (IBI) method, based on the fish community (Karr, 1981), has proven to be an effective tool for evaluating stream health and in some states to provide a scientifically credible basis for numerically regulating and managing stream water quality.

In Alabama, the IBI has been used by the Tennessee Valley Authority throughout the Tennessee River basin since 1986 (Saylor and Ahlstedt, 1990) to evaluate stream biological conditions. The IBI has also been used by the GSA to assess biological

conditions in the upper Cahaba River system (Shepard and others, 1997), lower Cahaba River system (O'Neil and Shepard, 2000a), the upper Black Warrior River system (O'Neil and Shepard, 2000b; Shepard and others, 2002; Shepard and others 2004), Hatchet Creek (O'Neil and Shepard, 2004), Choccolocco Creek (O'Neil and Chandler, 2005), and the Choctawhatchee-Pea River system (Cook and O'Neil, 2000). The ADEM uses the IBI for stream screening assessments in their water-quality monitoring activities.

Based on historical IBI collection data in the GSA database, biological condition was determined for 35 sites (table 45) in the CPYRW by calculating the IBI using metrics (table 46) and scoring criteria (table 47) presented in O'Neil and Shepard (2012). Four sites rated very poor (12%), nine sites rated poor (26%), nine sites rated fair (26%), 11 sites rated good (30%), and two sites rated excellent (6%) (fig. 94). Samples taken at these 35 sites represented a range of stream water quality and habitat conditions and were taken for different reasons in the CPYRW. The distribution of these sampling sites is shown in figure 95. Around one-third of the sites had poor to very poor biological condition while two-thirds of the sites were fair or

Table 45.—Sampling stations for IBI biological condition assessments in the Choctawhatchee, Pea and Yellow Rivers watersheds.

Station Number	Stream Name	Latitude	Longitude	County	Watershed area (mi^2)	Eco IV	GSA No.	Date
1	Corner Creek at Corner Creek Road	31.0536	86.2548	Covington	17.3	65g	2237	17-Jun-08
2	Eightmile Creek at Co. Hwy. 10	31.0488	86.1450	Geneva	63.4	65g	2246	17-Jun-08
3	Flat Creek at Co. Hwy. 54	31.1091	86.1459	Geneva	83.7	65g	2248	17-Jun-08
4	Patrick Creek at Co. Hwy. 368	31.4384	86.1121	Coffee	9.14	65d	1361	17-Jul-08
5	Whitewater Creek at Co. Hwy. 215	31.5386	85.9818	Coffee	149	65d	2216	17-Jun-08
6	Big Creek at unnamed Co. Hwy. off Ala. Hwy. 87	31.7378	85.9831	Pike	8.53	65d	1364	2-Jul-08
7	Walnut Creek at U.S. Hwy. 231	31.7726	85.9251	Pike	21.2	65d	3576	28-Sep-99
8	Walnut Creek at Co. Hwy. 26	31.7983	85.9106	Pike	10.5	65d	2232	9-Jun-08
9	Bowden Mill Creek at Co. Hwy. 2	31.6690	85.7830	Pike	7.74	65d	2233	9-Jun-08
10	Tight Eye Creek at Co. Hwy. 43	31.1516	86.0100	Geneva	36.3	65g	2269	12-Jun-08
11	Little Double Bridges Creek at Co. Hwy. 636	31.2551	85.9523	Coffee	23.4	65d	3578	29-Sep-99
12	Double Bridges Creek at Co. Hwy. 636	31.2551	85.9464	Coffee	39.4	65d	3575	29-Sep-99
13	Double Bridges Creek at Co. Hwy. 610	31.2834	85.9160	Coffee	31.8	65g	2266	11-Jun-08
14	Blanket Creek at Co. Hwy. 610	31.2854	85.9149	Coffee	31.8	65g	2267	11-Jun-08
15	Harrand Creek trib. at Dixie Drive	31.3315	85.8298	Coffee	2.93	65g	1349	5-Jun-08
16	Spring Creek at Co. Hwy. 4	31.0336	85.8263	Geneva	48.3	65g	2268	12-Jun-08
17	Harrand Creek at Lowe Field Road	31.3371	85.7483	Dale	20.2	65d	1348	5-Jun-08
18	Judy Creek at Hwy. 105	31.5134	85.5735	Dale	82.3	65d	1356	11-Jul-08
19	Judy Creek at Co. Hwy. 15	31.5264	85.5835	Dale	51	65d	1355	11-Jul-08
20	Seabes Creek at Co. Hwy. 67	31.3893	85.4806	Dale	7.68	65d	2241	12-Jun-08
21	Blackwood Creek at Co. Hwy. 67	31.3764	85.4484	Dale	42	65d	3574	28-Sep-99
22	Panther Creek at Co. Hwy. 40	31.5462	85.3975	Henry	11.9	65d	1357	10-Jul-08
23	Little Choctawhatchee River at US Hwy. 84	31.2625	85.6688	Dale	159	65g	3577	28-Sep-99
24	Little Choctawhatchee River at US Hwy. 84	31.2625	85.6688	Dale	159	65g	1938	28-Jul-09
25	Mossy Camp Branch at Co. Hwy. 55	31.2822	85.6025	Dale	5.25	65g	1939	28-Jul-09
26	Panther Creek at Panther Creek Road	31.2433	85.5838	Dale	18.5	65g	1946	30-Jul-09
27	Little Choctawhatchee River at Co. Hwy. 9	31.2625	85.5700	Dale	112	65g	1347	5-Jun-08
28	Little Choctawhatchee River trib. at Co. Hwy. 563	31.2727	85.5647	Dale	4.5	65g	1940	30-Jul-09
29	Bear Creek at Fortner Road	31.2076	85.5463	Dale	19.1	65g	1945	30-Jul-09
30	Beaver Creek at Co. Hwy. 59	31.2165	85.4869	Houston	19.4	65g	1366	6-Jun-08
31	Beaver Creek at Brannon Stand Road	31.2178	85.4865	Dale	18.5	65g	1944	29-Jul-09
32	Murphy Mill Branch at Kelly Spring Road	31.2766	85.4615	Houston	4.75	65g	1941	29-Jul-09
33	Rock Creek at Deerpath Stand Road	31.2517	85.4431	Houston	7.5	65g	1943	29-Jul-09
34	Little Choctawhatchee River at US Hwy. 231	31.2642	85.4387	Houston	5.99	65g	1942	29-Jul-09
35	Wrights Creek at unnumbered dirt road	31.0335	85.5723	Geneva	17.6	65g	2265	10-Jun-08

Table 46.—IBI metric values for sampling stations in the Choctawhatchee, Pea and Yellow Rivers watersheds.

IBI Metrics Key

Total native species	1	% GSF + YB	7
Number shiner species	2	% Insectivorous cyprinids	8
Number sucker species	3	% Top carnivores	9
Number Centrarchidae species	4	% Anomalies + hybrids	10
Number darter + madtom species	5	% Simple lithophils	11
% Tolerant	6	% Manipulative miscellaneous	12

Station No.	IBI metrics (see IBI Metrics Key)											
	1	2	3	4	5	6	7	8	9	10	11	12
1	20	5	2	4	5	12.7	1.9	63.7	0.6	0.0	42.0	5.7
2	19	5	1	2	6	0.0	0.0	62.5	2.9	0.0	47.1	3.9
3	22	4	0	9	5	0.4	0.0	56.1	2.8	0.0	50.6	3.1
4	14	2	1	5	2	42.9	1.1	11.0	3.3	0.0	11.0	12.1
5	20	5	0	6	4	10.7	2.2	33.3	3.0	0.0	23.7	3.0
6	11	1	0	5	1	16.7	3.7	9.3	18.5	0.0	3.7	13.0
7	13	3	0	2	3	19.4	1.0	37.9	1.9	0.0	37.9	35.0
8	17	4	0	5	3	20.6	0.5	40.8	11.7	0.9	37.7	20.6
9	22	5	1	5	4	6.8	4.4	55.9	4.1	0.0	43.4	7.5
10	15	5	0	4	4	6.1	0.0	47.0	0.0	0.0	50.0	3.0
11	15	5	0	2	5	0.0	0.0	63.8	0.0	0.0	75.2	7.8
12	16	4	0	4	5	5.4	0.0	68.7	1.1	0.0	75.1	8.7
13	20	6	0	5	4	2.6	0.5	79.3	1.6	0.0	75.1	4.7
14	14	5	0	2	2	3.8	0.0	68.9	0.8	0.0	67.4	8.3
15	11	0	0	2	2	41.7	7.1	0.0	2.4	0.0	0.0	69.1
16	23	6	0	6	4	2.2	0.4	81.1	1.5	0.0	30.0	2.6
17	12	4	1	2	2	11.1	1.9	29.6	0.0	1.9	70.4	9.3
18	8	1	0	4	2	11.1	2.8	8.3	0.0	0.0	13.9	41.7
19	10	2	0	3	2	3.7	0.0	25.9	3.7	0.0	22.2	14.8
20	21	6	0	2	6	0.8	0.2	70.8	0.3	0.0	70.0	4.6
21	23	7	0	5	6	6.7	0.0	71.2	1.0	0.0	36.5	10.6
22	10	0	0	5	0	12.5	3.1	0.0	15.6	0.0	0.0	40.6
23	19	4	1	5	5	0.5	0.5	57.8	1.0	0.0	82.0	5.7
24	9	3	0	5	0	2.5	0.0	82.5	2.5	0.0	55.0	2.5
25	15	4	1	4	2	1.0	0.5	74.2	0.5	0.3	67.8	3.6
26	21	3	1	6	6	3.8	2.5	10.1	5.1	0.0	36.7	25.3
27	12	1	0	6	2	26.6	22.3	22.3	2.1	1.1	13.8	23.4
28	20	6	2	4	2	2.0	0.9	72.0	0.3	0.0	71.4	5.3
29	12	3	0	2	5	0.0	0.0	41.3	0.8	0.0	50.0	11.9
30	13	0	0	6	2	31.4	15.7	0.0	4.3	0.0	8.6	38.6
31	21	4	1	9	2	29.1	2.8	30.5	1.4	1.4	31.9	8.5
32	7	0	0	3	0	18.6	4.9	0.0	1.0	0.0	0.0	19.6
33	19	3	1	9	2	17.9	1.8	28.3	6.1	1.4	27.6	15.1
34	16	3	1	6	4	3.3	1.6	65.6	0.8	0.0	63.1	5.7
35	20	5	0	4	7	5.7	0.0	74.4	0.4	0.0	70.9	4.8

Table 47.—IBI scores for sampling stations in the Choctawhatchee, Pea and Yellow Rivers watersheds.

IBI Metrics Key

Total native species	1	% GSF + YB	7
Number shiner species	2	% Insectivorous cyprinids	8
Number sucker species	3	% Top carnivores	9
Number Centrarchidae species	4	% Anomalies + hybrids	10
Number darter + madtom species	5	% Simple lithophils	11
% Tolerant	6	% Manipulative miscellaneous	12

Station No.	IBI Metrics (see IBI Metrics Key)													
	1	2	3	4	5	6	7	8	9	10	11	12	IBI	BC[1]
1	3	5	5	3	5	3	3	5	1	5	3	3	44	G
2	3	3	3	1	5	5	5	5	3	5	3	5	46	G
3	3	3	1	5	3	5	5	3	3	5	3	5	44	G
4	3	3	3	5	3	1	3	1	5	5	1	3	36	F
5	3	3	1	3	3	3	3	3	3	5	1	5	36	F
6	3	1	1	5	1	1	3	1	5	5	1	3	30	P
7	3	3	1	1	3	1	5	3	3	5	3	1	32	P
8	3	3	1	3	3	1	5	3	5	1	3	1	32	P
9	5	5	3	5	5	3	3	3	5	5	3	3	48	G
10	3	3	1	3	3	3	5	3	1	5	3	5	38	F
11	3	5	1	1	5	5	5	5	1	5	5	3	44	G
12	3	3	1	3	3	3	5	5	3	5	5	3	42	F
13	3	5	1	3	3	5	5	5	3	5	5	5	48	G
14	3	3	1	1	1	5	5	5	1	5	5	3	38	F
15	3	1	1	3	3	1	1	1	3	5	1	1	24	VP
16	3	5	1	3	3	5	5	5	3	5	3	5	46	G
17	3	3	3	1	1	3	3	1	1	1	5	3	28	P
18	1	1	1	3	1	3	3	1	1	5	1	1	22	VP
19	1	1	1	1	1	5	5	1	5	5	1	3	30	P
20	5	5	1	3	5	5	5	5	1	5	5	5	50	E
21	3	5	1	3	5	3	5	5	1	5	3	3	42	F
22	3	1	1	3	1	3	3	1	5	5	1	1	28	P
23	3	3	1	3	3	5	5	3	1	5	5	3	40	F
24	1	1	1	3	1	5	5	5	3	5	3	5	38	F
25	3	5	3	3	3	5	5	5	1	3	5	5	46	G
26	5	3	3	5	5	5	3	1	5	5	3	1	44	G
27	1	1	1	3	1	1	1	1	3	1	1	1	16	VP
28	5	5	5	5	3	5	5	5	1	5	5	3	52	E
29	3	3	1	1	5	5	5	3	1	5	3	3	38	F
30	3	1	1	5	1	1	1	1	5	5	1	1	26	P
31	5	3	3	5	1	1	3	3	3	1	3	3	34	P
32	1	1	1	3	1	1	3	1	1	5	1	1	20	VP
33	5	3	3	5	3	1	3	1	5	1	1	1	32	P
34	5	3	3	5	5	5	3	5	1	5	5	3	48	G
35	3	5	1	3	5	3	5	5	1	5	5	5	46	G

[1]BC—Biological Condition: E–Excellent; G–Good; F–Fair; VP–Very Poor

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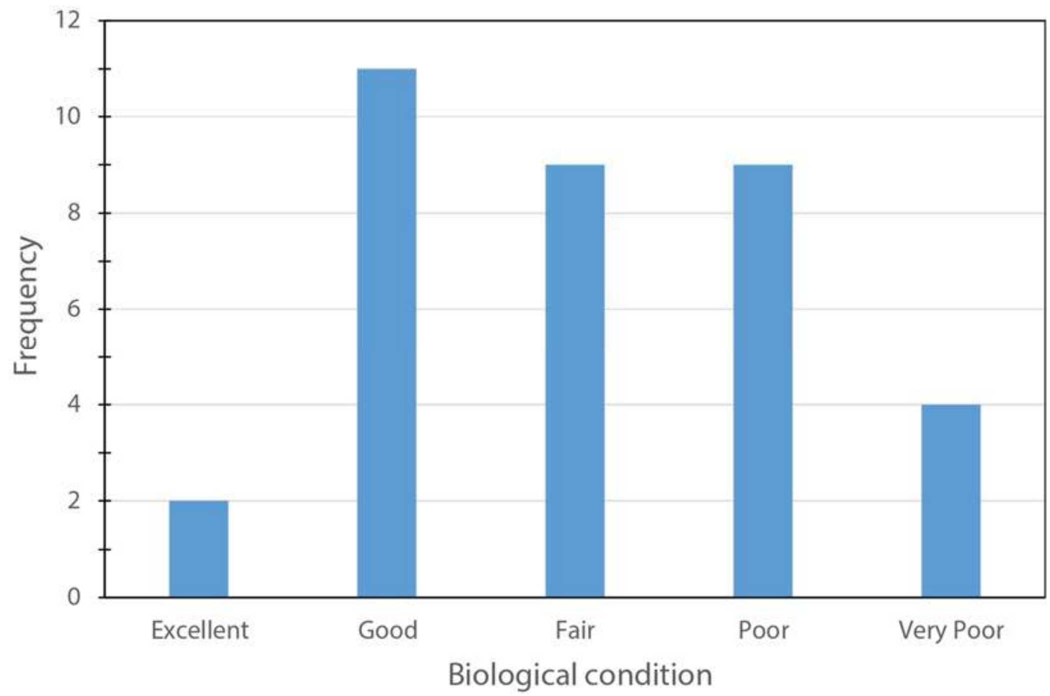

Figure 94.—Distribution of biological condition scores for selected sites in the Choctawhatchee, Pea and Yellow rivers watersheds.

better. The IBI varies seasonally reflecting natural fish community changes due to reproduction cycles, population recruitment and growth, and climate-related flood and drought cycles. As such, several samples should ideally be collected from different seasons to adequately characterize the statistical distribution of IBIs at any one site.

AQUATIC HABITAT ASSESSMENT

Habitat evaluations are an integral part of efforts to describe biological condition because good biological condition is quite often predicated on the presence of stable and diverse habitat. The term habitat, as applied herein, incorporates several features and processes in streams including the physical components such as rock and rubble, logs, mud, channel, and substrate condition; the chemical and physical components of water quality such as pH, dissolved chemical constituents, temperature, and dissolved gasses; and flow components such as flood and drought frequencies, velocity regimes, and discharge. For quantitative assessment, the habitat concept is generally narrowed to include the physical components of habitat and substrate structure, the degree of channel alteration, and the condition of banks and the adjacent riparian corridor. All of these components directly affect the structure and function of the aquatic biological community and they can be visually assessed for quality and relative degree of impairment.

Stream habitat assessments entail evaluating the structure of the surrounding physical habitat that influences water resource quality and thus the condition of the resident biological community (Barbour and others, 1999). Generally, three characteristics of habitat contribute to the maintenance and persistence of aquatic

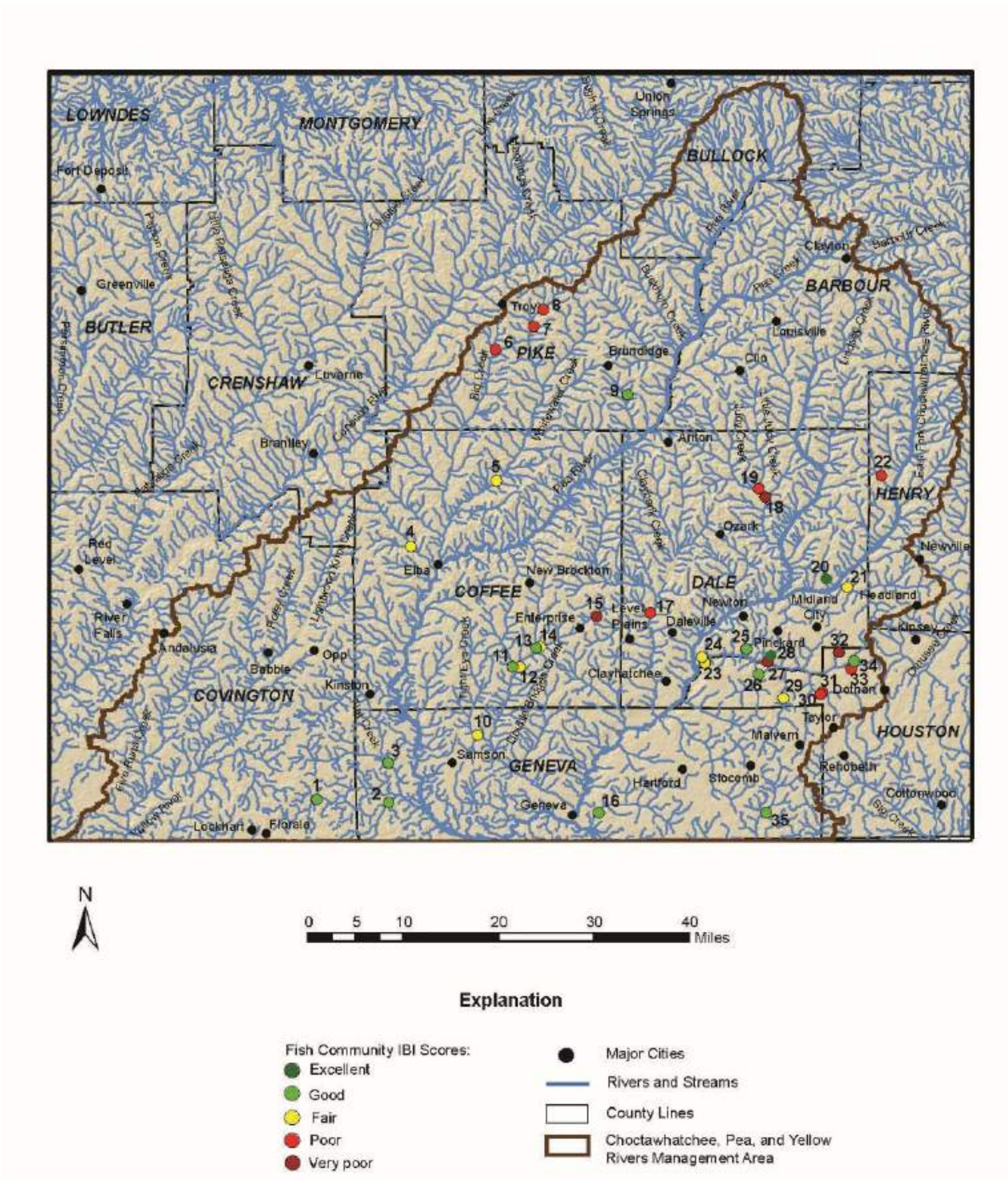

Figure 95.—Distribution of selected sites in the Choctawhatchee, Pea and Yellow rivers watersheds.

biological communities: the availability and quality of the habitat-substrate components and instream cover, morphology of the instream channel, and structure of the bank and riparian vegetation zone (Plafkin and others, 1989). Barbour and others (1999) developed two sets of habitat metrics, one for evaluating upland stream habitat dominated by riffle-run microhabitats and hard substrates and the other for evaluating lowland and Coastal Plain streams that are dominated by glide-pool and run-pool habitats with unconsolidated sandy substrates. The glide-pool method was used for assessing aquatic habitat in this evaluation.

A rapid habitat assessment was completed for each of the IBI bioassessment sites in table 45 plus an additional eight sites in the CPYRW. Habitat quality varied from

poor to optimal with only 1 site in the optimal range (>75% of the maximum habitat score), 8 sites in the suboptimal range (65 to 75% of the maximum habitat score), 26 sites in the marginal range (50 to 64% of the maximum habitat score), and 8 sites in the poor range (<50% maximum habitat score) (fig. 96). The high percentage of sites in the poor to marginal habitat classes is reflective of the generally degraded aquatic habitat experienced throughout the CPYRW which can be generally attributed to the high percentage of agriculture and associated sediment runoff issues in the region.

HABITAT

NatureServe, a non-profit organization that provides proprietary wildlife conservation-related resources, has identified 66 ecological systems in Alabama based on the National Vegetation Classification (ADCNR, 2008). Of these 66 ecological systems, 15 are considered habitats important to wildlife in Alabama (ADCNR, 2008). These 15 habitats include Dry Hardwood Forest, Mesic Hardwood Forest, Wet Pine Savanna and Flatwoods, Floodplain Forest, Dry Longleaf Pine Forest, Swamp, Maritime Forest and Coastal Scrub, Bogs and Seepage Communities, Glades and Prairies, Caves and Mines, Isolated Wetlands, Artificial Habitats, Beach and Dune, Estuarine and Marine, and Cliffs and Rockhouses (ADCNR, 2008).

AQUATIC BIODIVERSITY

The Choctawhatchee River Basin is home to 119 freshwater fish species and 25 mussel species, with recent surveys conducted by the GSA documenting 21 mussel species. The aquatic fauna is largely intact due to the absence of large impoundments in the CPYRW (ADCNR, 2008). Issues affecting aquatic habitats and species within this basin include degradation of water quality, habitat fragmentation, degradation and modification, and the impoundment on the Pea River (ADCNR, 2008).

The Yellow River Basin is home to 84 freshwater fish species and 18 crayfish species, with the aquatic fauna largely intact due to the absence of large impoundments in the drainage basin (ADCNR, 2008). Issues affecting aquatic habitats and species within this basin include degradation of water quality, habitat fragmentation, degradation and modification, lack of knowledge of species life history, biology, distribution, and status, and failure to control non-native crayfish (ADCNR, 2008).

FISH CONSUMPTION ADVISORIES

The ADPH publishes yearly lists regarding fish consumption advisories. The 2013 advisory guideline is available online (ADPH, 2014). Table 48 lists the 2013 fish consumption advisories for the CPYRW, with only three counties (Coffee, Covington, and Dale) having fish advisories.

GENERAL ECOSYSTEM CONDITIONS (ADCNR STRATEGIC HABITAT PLAN)

The ADCNR has developed a Comprehensive Wildlife Conservation Strategy (CWCS) that addresses the current wildlife conditions and actions to conserve wildlife and vital habitat, including elements of the Strategic Habitat Plan, which is currently being updated and revised (ADCNR, 2008). The CWCS has identified 314 aquatic and

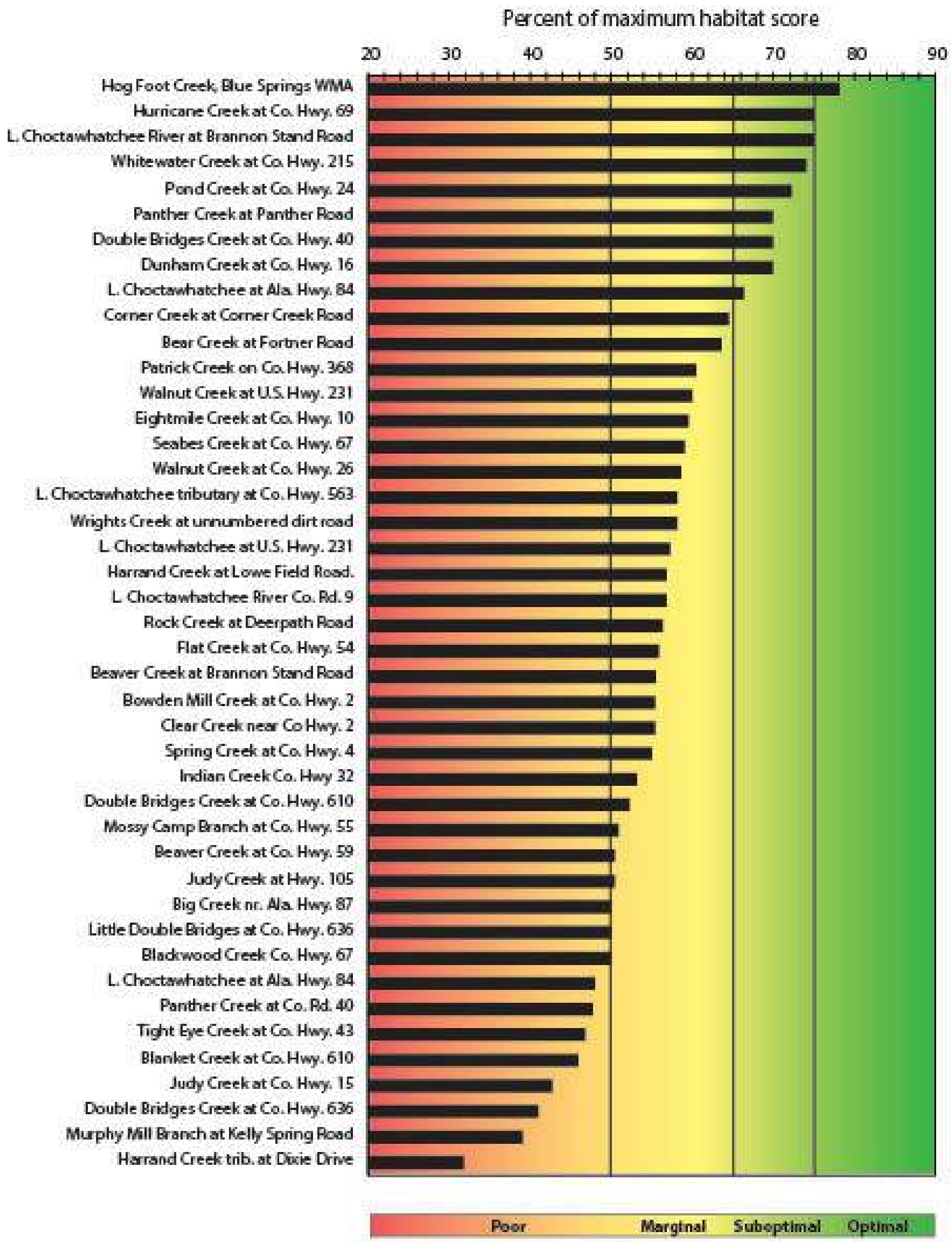

Figure 96.—Habitat scores for selected sites in the Choctawhatchee, Pea and Yellow Rivers watersheds.

Table 48.—2013 fish consumption advisories in the CPYRW.

Waterbody	Location	Fish Species	Advisory
Choctawhatchee River	Deepest point, main river channel, approximately 0.5 mile downstream of Little Choctawhatchee confluence, near State Highway 92 (Dale County)	Largemouth Bass	2 meals/month (Mercury)
Frank Jackson Reservoir	Deepest point, main creek channel, dam forebay (Covington County)	Largemouth Bass	1 meal/month (Mercury)
Lake Jackson	Approximate center of the lake (Covington County)	Largemouth Bass	2 meals/month (Mercury)
Pea River	Deepest point, main river channel, approximately 0.5 mile downstream of Beaverdam Creek/Pea River confluence, south of Elba, Alabama (Coffee County)	Largemouth Bass	2 meals/month (Mercury)
Pea River	Deepest point, main river channel, approximately 0.5 mile upstream of the confluence with Choctawhatchee River (Coffee County)	Spotted Bass	2 meals/month (Mercury)
Yellow River	Deepest point, main river channel, at County Road 4 bridge (Covington County)	Largemouth Bass Spotted Bass	1 meal/month (Mercury) 1 meal/month (Mercury)

terrestrial wildlife species in Alabama in greatest conservation need, including 24 mammals, 26 reptiles, 14 amphibians, 28 birds, 57 fish, 93 mussels, 34 aquatic snails, and 28 crayfishes throughout Alabama which are associated with 15 key habitats and 15 river basins (ADCNR, 2008). Table 49 lists the 15 species in greatest conservation need in the Choctawhatchee and Yellow Rivers Basins: 7 mussels, 4 fishes, 2 amphibians, and 2 reptiles (ADCNR, 2008). Threats to these species in greatest conservation need include habitat loss and fragmentation, loss of natural community integrity, impacts from disturbances and exotic species, and lack of adequate protection information, which are addressed through the CWCS by educational outreach and conservation actions (ADCNR, 2008).

Under this CWCS, conservation actions were proposed for these species of greatest conservation need, and included statewide conservation activities for all habitats, statewide conservation activities for rivers and streams (of which Alabama's 15 river basins are addressed separately), and statewide conservation activities for terrestrial and estuarine habitats (ADCNR, 2008).

General ecosystem conditions in the Choctawhatchee River include a largely intact fauna (ADCNR, 2008), 233 miles of streams within the basin listed as impaired on the current 303(d) list (ADEM, 2014b), and one major impoundment on the Pea River in Elba, Alabama (ADCNR, 2008). Issues affecting species and habitats within this basin include degradation of water quality, especially from nutrient enrichment; degradation and alteration of habitat from river dredging operations and drainage of bottomland forests and swamps, and fragmentation-loss of stream connectivity through fish passage barriers such as the Elba Dam on the Pea River, and lack of life history knowledge of many species (ADCNR, 2008). The CWCS addresses these issues

Table 49.—Species of greatest conservation need in the Choctawhatchee River Basin and Yellow River Basin.

Species	Status[1]	Species	Status[1]
Choctawhatchee River Basin		Yellow River Basin	
Mussels		***Mussels***	
Southern Sandshell	P1	Narrow Pigtoe	P2
Southern Kidneyshell	P1	Southern Sandshell	P2
Rayed Creekshell	P2	Southern Kidneyshell	P1
Tapered Pigtoe	P2	Rayed Creekshell	P2
Fuzzy Pigtoe	P2	Fuzzy Pigtoe	P2
Choctaw Bean	P2	Choctaw Bean	P2
Downy Rainbow	P1	***Crayfishes***	
Fishes		*Procambarus capillatus*	P2
Ironcolor Shiner	P1	*Procambarus escambiensis*	P1
Gulf Sturgeon	P2	***Fishes***	
Alabama Shad	P1	Ironcolor Shiner	P1
Bluenose Shiner	P2	Gulf Sturgeon	P2
Amphibians		Alabama Shad	P1
River Frog	P1	Bluenose Shiner	P2
One-toed Amphiuma	P2	***Amphibians***	
Reptiles		River Frog	P1
Rainbow Snake	P1	One-toed Amphiuma	P2
Barbour's Map Turtle	P2	***Reptiles***	
		Rainbow Snake	P2

[1]P1—Highest Conservation Concern, P2—High Conservation Concern

by identifying research and monitoring needs for the species of greatest conservation concern in this basin.

General ecosystem conditions in the Yellow River includes a good water quality (ADCNR, 2008), with a little more than 18 miles of streams within the basin listed as impaired on the current 303(d) list (ADEM, 2014b). Issues affecting species and habitats within this basin include degradation of water quality, especially from sedimentation and nutrient enrichment, degradation and alteration of habitat from river dredging operations and drainage of bottomland forests and swamps, lack of life history knowledge for many species, and failure to control non-native crayfish (ADCNR, 2008). The CWCS addresses these issues by identifying research and monitoring needs for the species of greatest conservation concern in this basin.

RECOMMENDATION

The CPYRWMA should establish dialogs with responsible parties, including USFWS, ADCNR, Alabama Rivers Alliance, Nature Conservancy, Troy University, Auburn University, and the University of Alabama regarding the current biological and ecosystem resources and preserving these resources for the future.

AGRICULTURAL ISSUES

The agricultural industry plays a critical role in southeast Alabama as a major contributor to the economy of Alabama and in particular of rural communities and as a provider or food and raw materials. Agriculture has a critical dependency on water resources that may be limited by population growth, industrialization, and climatic impacts on available water resources. In response to growing population, there is a worldwide challenge to produce almost 50% more food by the year 2030, and double production by 2050 (Organization for Economic Cooperation and Development (OECD), 2010). It will be important for future farmers to increase water use efficiency and improve agricultural water management. Agricultural water resources will likely draw on varying sources of water including: surface water, groundwater, rainwater harvesting, recycled wastewater, and desalinated water.

Alabama has more than 48,500 farms covering 9 million acres, which total approximately $1 billion in exports each year. Agriculture accounts for 30% of land use in the CPYRW, totaling 695,040 acres (1,086 mi^2). Major row crops in the CPYRW include peanuts, cotton, corn, and soybeans. About half of the peanuts grown in the United States are harvested within a 100-mile radius of Dothan, which includes much of the CPYRW. Houston, Geneva, Escambia, and Henry Counties are top peanut producing counties within the state. Houston and Geneva Counties are in the top five counties in cotton acreage and production. Alabama has 25,000 water acres of fish farms (215 aquaculture farms) and is the fourth leading state in aquaculture sales. Farm-raised catfish is the dominant species grown for harvest (ALFA, 2010). See the Land Use section and Watershed Trends for a detailed account of agriculture within the CPYRW.

IRRIGATION

Many farmers throughout the state are using irrigation systems to supplement water for crops in times of drought. Alabama has 150,000 acres of irrigated row crops, which is significantly less than neighboring states Mississippi and Georgia who irrigate a combined 3 million acres (Southeast Farm Press, 2014). Most Alabama farmers continue to rely on normal rainfall and take losses during prolonged periods of drought. The ACES has developed a state irrigation initiative, the Alabama Agricultural Irrigation Information Network, to develop agricultural irrigation water resources in a responsible manner from off-stream storage of high winter flows, upland storage of rainfall runoff, deep wells, and surface/groundwater combinations. ACES also aims to promote wise and effective irrigation water management as defined by USDA NRCS Conservation Practice Standard 449—Irrigation Water Management, as well as determining and controlling the volume, frequency, and application rate of irrigation water in a planned, efficient manner (ACES, 2014b).

There are several different types of irrigation techniques including flood (furrow) irrigation, drip irrigation (micro-irrigation), and spray irrigation (center pivots and lateral systems). In flood or furrow irrigation, water is pumped or brought to the fields

and is allowed to flow along the ground among the crops. This method is simple and cheap and is widely used by societies in less developed parts of the world as well as in the U.S. The problem is, 50% of the water used does not reach the crops. Several techniques have been used by farmers to make flood irrigation more efficient such as leveling of fields, surge flooding, and capture and reuse of runoff. Drip irrigation, or micro-irrigation, involves water sent through perforated pipes laid along rows of crops or buried along their rootlines. This method is often used for fruits and vegetables. Drip irrigation is more efficient than flood irrigation because the amount of evaporation is decreased and 25% of the water used is conserved. Spray irrigation is a more modern method of irrigating, in which pressurized water is sprayed over plants via machinery. Common types of spray irrigation are center pivot systems and lateral systems (fig. 97). Center pivot systems consist of a number of metal frames on rolling wheels that are controlled by an electric motor that moves the frame in a circle around the field while spraying water from sprinklers. The same equipment can be configured to move in a straight line resulting in a lateral irrigation system (USGS, 2014c).

Alabama farmers have become increasingly aware of irrigation as a tool for optimizing farm production. Development of advanced irrigation techniques has given farmers the ability to increase their effective water use from less than 50% to more than 90%. Properly managed irrigation allows farmers to utilize fertilizers and chemicals more effectively to maximize production and reduce water quality impacts from runoff. Efficient agricultural irrigation techniques ensure more predictable yields and increase production without increasing acreage (The Irrigation Association,

Figure 97.—Example of a lateral irrigation system
(photo credit: Carlson, 2014).

2014). During the irrigation planning process, farmers should consider these factors: managing soil moisture to promote desired crop response; optimizing the use of available water supplies; minimizing irrigation induced soil erosion; decreasing nonpoint source pollution of surface water and groundwater resources; managing salts in the crop root zone; managing air, soil, or plant micro-climate; maintaining proper and safe chemical or fertilizer use; and improving air quality by managing soil moisture to reduce particulate matter movement (USDA NRCS, 2006).

SURFACE WATER IRRIGATION

Surface water accounts for over 75% of all water withdrawn for agricultural purposes within the CPYRW (USDA, 2002). If groundwater is not available, farmers must rely on ponds or streams for irrigation. Surface water can be less expensive to develop but may generally have more water quality and quantity issues than groundwater. Surface-water sources are dependent upon annual rainfall, runoff from adjacent land, and/or groundwater from springs. One serious limitation on the use of streams for irrigation is that most pumping takes place in June, July, and August, when stream flows are lowest. As more farmers pump water from the same stream, downstream flow diminishes to the point that no further pumping for irrigation is possible. Also, detrimental environmental effects to the stream are possible. Water supply from a pond is more difficult to assess as it is subject to runoff from adjacent land or springs as well as evaporation and leakage (University of Massachusetts, 2009).

Surface water is subject to contamination from a number of sources such as sediments, chemicals, and algal growth, which may need to be removed prior to use in an irrigation system. Tests for total suspended solids, total dissolved solids, pH, conductivity and key ions should be the first step in evaluating a source of surface water for irrigation. The distance and elevation of the surface water source in relation to the irrigation system should also be considered. The amount of trenching needed and the location of the pump adds to the cost of installation. It is important to know the total cost of pumping water from the source before deciding if it is viable. Maintenance of the equipment and water source also adds to the cost. Fencing may be needed to keep animals and children out. The dam of a pond will require mowing and cleaning of overflow pipes. A buffer may be required to filter out sediment and pollutants (University of Massachusetts, 2009).

GROUNDWATER IRRIGATION

Groundwater supplied irrigation is an important component of the agricultural sector in the CPYRW (fig. 98). Alabama has about 450 irrigation wells that are used to supply 290 farms on 22,070 acres of land. Approximately 74 gpd of groundwater is used for irrigation in the state (National Groundwater Association, 2010). According to a study by the GSA in 2011, there are six aquifers capable of producing adequate quantities of water for sustainable irrigation water supply in southeast Alabama. These aquifers are the Gordo, Ripley (including the Cusseta Sand Member), Clayton (including the Salt Mountain Limestone, which is hydraulically connected), Nanafalia, Lisbon, and Crystal River Formations. All public water supplies in southeast Alabama are from groundwater sources. There are about 80 public water

Figure 98.—Groundwater sourced irrigation system
(photo credit: Agriculture and Ecosystems Blog, 2014).

supply systems that operate more than 300 production wells in and near to the CPYRW. Locations and aquifers that make up public water supply sources must be considered prior to development of large scale agricultural irrigation using groundwater (Cook and others, 2009).

Development of groundwater irrigation sources must include consideration of public water supply sources, proper well spacing, and sustainable production rates. Most of these aquifers are confined and are not drastically impacted by drought or surface sources of contamination. However, irrigation wells constructed in these aquifers must be evaluated for economic viability (Cook and others, 2009).

WATER HARVESTING

An alternative approach to securing irrigation water is to collect and store surface water during the nongrowing season, when rainfall and stream flows are high. This practice is called water harvesting. Where direct pumping is not feasible, either from streams or lakes or wells, water harvesting can make irrigation possible (fig. 99). This method has the potential to greatly expand irrigation in Alabama. There are three examples of harvesting capabilities. The first involves a case where a large creek flows by a farm, and a drainage basin leading into that creek has a site that would hold enough water to irrigate the farm if a dam were built across it. This drainage basin need not be able to fill the reservoir on its own. Water can be pumped from the large

Figure 99.—Example of water harvesting (photo credit: The Rain Catcher Inc., 2014).

creek or stream into the reservoir during the winter and spring, filling it and saving the water for summer use. This practice is feasible and has already been put into effect at some sites in Alabama (Curtis and Rochester, 1994).

The second example involves a hillside reservoir where an earthen embankment is constructed on two or three sides, or in a curved shape, to hold the desired amount of water. Then, water can be pumped from the nearby stream in winter and spring to fill the reservoir. Some recharge from natural drainage can be expected, depending on site topography, but this is likely to be limited. The third example is the most extreme case, which involves a circular or four-sided reservoir built on essentially flat land. This is the most expensive reservoir to build and would depend entirely on pumping from the nearby stream, as there would be practically no natural recharge (Curtis and Rochester, 1994).

The feasibility of off-stream water storage for irrigation depends on many factors, including seasonal stream flow rates, availability of suitable acreage for a reservoir, distance to crops to be irrigated, and the cost versus benefits of this type of irrigation for the crops to be grown.

RECOMMENDATION

The CPYRWMA should work closely with GSA, ADECA OWR, USDA NRCS, Soil and Water Conservation Districts, and the Irrigation Association of Alabama to

identify sources of irrigation, encourage more acreage under irrigation, and to monitor potential water-quantity and water-quality impacts.

POLICY OPTION

Develop a comprehensive state water management plan that addresses irrigation needs and development which also addresses competition for limited water sources.

IRRIGATION TAX CREDITS

In May 2012, the Alabama Legislature approved a bill to provide tax incentives to farmers who adopt irrigation technology. The Irrigation Incentives Bill provides a state income tax credit of 20% of the costs of the purchase and installation of irrigation systems. The bill also allows the tax credit on the development of irrigation reservoirs and water wells, in addition to the conversion of fuel-powered systems to electric power. The one-time credit cannot exceed $10,000 per taxpayer, and it must be taken in the year in which the equipment or reservoirs are placed into service. Before the bill was enacted, a decade of collaborative and comprehensive research conducted through the Alabama Agricultural Experiment Station at Auburn University in cooperation with the ACES, the University of Alabama in Huntsville, The University of Alabama, Alabama A&M, and Tuskegee University was used as a scientific platform to support the bill (AU, 2012).

Research has shown the economic benefits of using irrigation on Alabama crops. There are 2.5 million acres of optimal farmland in Alabama that could be irrigated, but less than 120,000 acres of available land is currently irrigated. Studies have shown that 1 million acres of irrigated land in Alabama could provide a boost in the agricultural industry equal to the same economic impact as two automobile plants, or 26,000 jobs. In a survey Agricultural Experiment Station researchers conducted in 2011 to determine the major barriers to irrigation in Alabama, the top obstacle was concern that the financial investment required to install, operate and maintain an irrigation system would not be cost-effective. Six out of 10 farmers surveyed, however, said they would be more likely to add irrigation if a cost-share program were available. A number of Alabama farmers have already adopted state-of-the-art irrigation strategies. The irrigation incentive bill has enabled farmers to increase crop yields and quality, boost farm income, energize the state's economy, and create jobs. Farmers who are considering irrigation installation in response to the tax incentive should contact local ACES representatives for guidance and information (AU, 2012).

RECOMMENDATION

The CPYRWMA should monitor water resource needs and conditions and recommend additional incentive programs to efficiently develop and protect water resources.

ANIMAL FEEDING OPRERATIONS

Animal feeding operations (AFOs) are agricultural enterprises where animals are kept and raised in confinement structures. AFOs congregate animals, feed, manure and urine, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in

pastures, fields, or on rangeland (USEPA, 2013e). Common examples of animal types within AFOs include poultry, swine and cattle. The ADEM regulates AFOs and concentrated animal feeding operations (CAFOs) within the state.

On April 1, 1999, the ADEM Administrative Code Chapter 335-6-7, which defines the requirements for AFOs to protect water quality was promulgated. This chapter establishes an AFO compliance assistance and assurance program and a CAFO NPDES registration by rule program. Under the rules, all CAFOs are required to register with ADEM, and all AFO/CAFOs are required to implement and maintain effective BMPs for animal waste production, storage, treatment, transport, and proper disposal or land application that meet or exceed USDA NRCS technical standards and guidelines. Currently, there are approximately 191 approved AFO/CAFO registrations within the counties of the CPYRW (fig. 100). The overwhelming majority of AFO/CAFOs are broilers (poultry farms). There are two AFO/CAFO Certified Animal Waste Vendors in the watershed: one in Barbour County and the other in Pike County. There are five AFO/CAFO Qualified Credential Professionals in the CPYRW: one in Barbour County, one in Crenshaw County, one in Dale County, and two in Pike County (ADEM, 2014e).

Waste from agricultural livestock operations has been a long-standing concern with respect to contamination of water resources, particularly in terms of nutrient pollution. However, the recent growth of CAFOs presents a greater risk to water quality because of both the increased volume of waste and the contaminants that may be present that have both environmental and public health importance

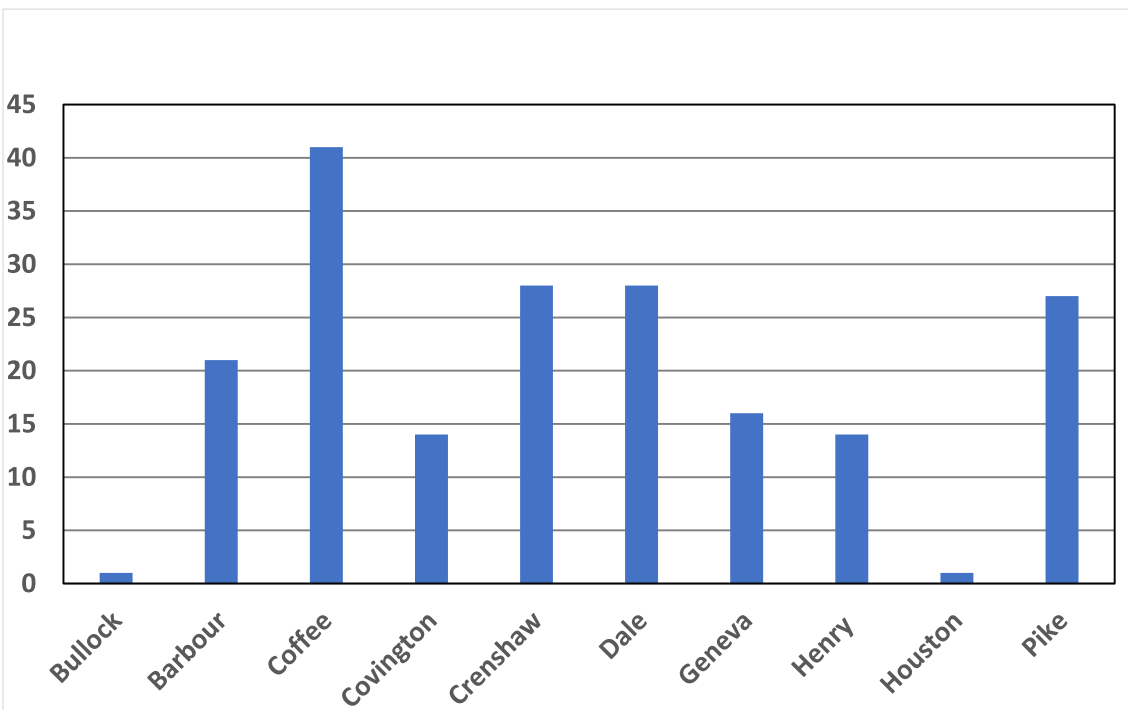

Figure 100.—Number of AFO/CAFO approved registrations by county (modified from ADEM, 2014e).

(Environmental Health Perspectives, 2006). CAFO wastes have value as nutrient sources for plants, but can also contain pathogens, heavy metals, antibiotics, and hormones. CAFO waste releases in the eastern United States have prompted a closer evaluation of the environmental impact on surface waters, and regulations have been developed to protect surface water quality. Regulations mandate that CAFOs have site specific Nutrient Management Plans, which are one of the few risk-management tools available for protection of groundwater quality following land application of CAFO wastes. It is assumed that Nutrient Management Plans, if successful for prevention of groundwater contamination by nutrients, will be equally protective regarding hormones and other stressors (such as antibiotics), but this has not been tested for land application of CAFO wastes (USEPA, 2013f).

NUTRIENTS

Plant nutrients, which come primarily from chemical fertilizers, manure, and in some cases sewage sludge, are essential for crop production. When applied in proper quantities and at appropriate times, nutrients (especially nitrogen, phosphorus, and potassium) help achieve optimum crop yields. However, improper application of nutrients can cause water quality problems both locally and downstream. Nutrient management is the practice of using nutrients wisely for optimum economic benefit, while minimizing impacts on the environment. Farmers often apply fertilizer soon after the previous year's harvest, since equipment and labor are readily available then. Fertilizer can also be applied in the spring, near the time it is needed by the plant, usually at planting, or as side-dress after the crop has started to grow. In general, the greatest efficiency results when fertilizer is applied at planting time or during the early part of growing season. It can be difficult to decide how much fertilizer to apply. Soil tests are used to determine soil deficiencies for nutrients such as phosphorus and potassium. It is more difficult to determine nitrogen needs in advance, and many farmers simply use standard nitrogen recommendations based on crop yield goals (USEPA, 2013g). Recommendations on nutrient management may be provided by the ACES. BMPs should be enacted to ensure maximum yields while protecting water resources.

Standard soil tests may be used to determine the soil's nutrient-supplying capacity as well as amounts of nutrients needed by the crop. It is important to follow soil test recommendations because a deficiency of one nutrient or an undesirable soil pH will limit crop response to other nutrients. Choosing the most suitable nitrogen source for a crop is essential because the nitrogen source can affect nitrogen loss from soils for a few months after application. Applying nitrogen and phosphorous correctly is essential because they are less likely to be lost by erosion or runoff if they are banded directly into the soil or applied to the soil surface and promptly mixed into the soil by disking, plowing, or rotary tilling. Subsurface banding also makes it possible for nutrients to be placed directly where the crop can make the best use of them. It is important to practice conservation tillage and other erosion-control techniques to minimize loss of phosphorus that is attached to the soil. One of the most crucial practices is to improve the timing of fertilizer application by applying nutrients just before they are needed by the crop. The timing of application is more important with

nitrogen than with any other nutrient because nitrogen is applied in large amounts to many crops and is very mobile (North Carolina Cooperative Extension, 1997).

EUTROPHICATION

Water quality problems can occur when nutrients are added to the soil at a time when they could be removed in surface runoff from precipitation at rates exceeding the rate of uptake by the crop, or if applied at times that they cannot be utilized by the crop. When nitrogen or phosphorus are present in lakes or rivers in high concentrations, a condition called "eutrophication" or biological enrichment can occur (fig. 101). Eutrophication is defined as an increase in the rate of supply of organic matter in an ecosystem. High concentrations of nitrates and phosphates promote excessive growth of algae (algal blooms) which eventually dies, decomposes, and depletes available oxygen, causing the death of other organisms. Eutrophication is a natural, slow-aging process for a water body, but is accelerated by anthropogenic activity (USGS, 2014d).

Figure 101.—Eutrophication caused by agricultural runoff
(photo credit: Das, 2014).

The USEPA MCL for nitrate in drinking water is 10 mg/L. Typical nitrate (NO_3 as N) concentrations in streams vary from 0.5 to 3.0 mg/L. Concentrations of nitrate in streams without significant nonpoint sources of pollution vary from 0.1 to 0.5 mg/L. Streams fed by shallow groundwater draining agricultural areas may approach 10 mg/L (Maidment, 1993). Nitrate concentrations in streams without significant nonpoint sources of pollution generally do not exceed 0.5 mg/L (Maidment, 1993). The

critical nitrate concentration in surface water for excessive algae growth is 0.5 mg/L (Maidment, 1993).

High nitrogen from agricultural activities near the Mississippi River has caused a hypoxic or "dead" zone in the Gulf of Mexico. In this area, excess algae grow in response to the enriched nutrient solution and few fish inhabit the waters. When the algae die, their decomposition consumes enough dissolved oxygen to suffocate fish and other marine life. Sources of nitrogen contributing to the problem include agricultural runoff and fertilizer leaching, manure from CAFOs, aquaculture operations, sewage treatment plants, atmospheric nitrogen, and other sources. It is important to practice BMPs while applying fertilizer and managing AFOs in the CPYRW, not only to protect water quality in the CPYRW, but to realize that discharge from the CPYRW ultimately ends up in Florida estuaries and the Gulf of Mexico. Excessive nitrate in groundwater can also present a direct health hazard to very young infants. Ingestion of nitrate (NO_3) can bind with hemoglobin in the infant's bloodstream and cause a condition called methemoglobinemia or "blue baby" syndrome. Nitrate does not bind to soil particles and is quite soluble, making it susceptible to leaching into groundwater if not used by the crop (USEPA, 2013g).

The natural background concentration of total dissolved phosphorus is approximately 0.025 mg/L. Phosphorus concentrations as low as 0.005 to 0.01 mg/L may cause algae growth, but the critical level of phosphorus necessary for excessive algae is around 0.05 mg/L (Maidment, 1993). Although no official water-quality criterion for phosphorus has been established in the United States, total phosphorus should not exceed 0.05 mg/L in any stream or 0.025 mg/L within a lake or reservoir in order to prevent the development of biological nuisances (Maidment, 1993). In many streams phosphorus is the primary nutrient that influences excessive biological activity. These streams are termed “phosphorus limited.”

SEDIMENTATION

Areas of agricultural and urban development are primary sources of erosion and sedimentation in rivers, lakes, estuaries, and oceans. Pollution by sediment has two major dimensions: physical and chemical. The physical dimension involves soil loss and land degradation by gullying and sheet erosion which leads to excessive levels of turbidity in receiving waters, and causes off-site ecological and physical impacts from deposition in river and lake beds (fig. 102). High levels of turbidity limit penetration of sunlight into the water column, which in turn prohibits growth of aquatic fauna. In spawning rivers, gravel beds are blanketed with fine sediment which inhibits or prevents spawning of fish. In both cases, the consequence is disruption of the aquatic ecosystem by destruction of habitat.

CPYRWMA was the recipient of a 2001 Gulf Guardian award for “Recommended Standard Procedures Manual for Maintenance of Unpaved Roads” project under the EPA Gulf of Mexico Program. The EPA Gulf of Mexico Program began in 1988 to protect, restore, and maintain the health and productivity of the Gulf of Mexico ecosystem in economically sustainable ways. Award entries came from the five states bordering the Gulf of Mexico, Texas, Louisiana, Mississippi, Alabama, and Florida. The project produced a “manual of practice” for the maintenance of dirt roads, a video targeting motor grader operators, and a series of classroom and field workshops for

Figure 102.—Sedimentation in south Alabama
(photo credit: University of South Alabama, 2014)

road crews. More than 125 individuals from Alabama, Florida, and Georgia attended the training sessions. Requests for copies of the manual have been received from across the U. S. and some foreign countries. The project shows that effective maintenance of dirt roads can minimize the amount of sediment going into the streams which in turn protects aquatic habitat and enhances natural resource conservation.

Sediment loads in streams are composed of relatively small particles suspended in the water column (suspended solids) and larger particles that move on or periodically near the streambed (bed load). High levels of sedimentation in rivers leads to physical disruption of the hydraulic characteristics of the channel. Excessive sedimentation causes changes in base level elevation of streams in the watershed and triggers downstream movement of the material as streams reestablish base level equilibrium (Cook, 2008). This can have serious impacts on natural river hydraulics and processes, as well as navigation through reduction in depth of the channel, and can lead to increased flooding because of reductions in capacity of the river channel to efficiently route water through the drainage basin. The chemical aspect of sedimentation involves the silt and clay fraction (<63 millimeter fraction), which is a primary carrier of adsorbed chemicals, especially phosphorus, chlorinated pesticides and most metals, which are transported by sediment into the aquatic system (Food and Agriculture Organization of the United Nations, 2014).

Erosion is costly in agriculture because it causes loss of top soil which generates loss of nutrients and organic matter that are essential for productive yields, and ultimately leads to economic loss. These nutrients must be replaced by fertilizer at a

considerable cost to the farmer in order to maintain soil productivity. Control of agricultural sedimentation usually begins with measures to control erosion and sediment runoff. Best management practices to prevent pollution by agricultural sedimentation include erosion control methods such as maintaining a soil cover, managing the soil for maximum water infiltration and storage, maintaining vegetation on ditch banks and in drainage channels, sloping field roads toward the field, seeding roads with permanent grass cover, shaping and seeding field edges to filter runoff as much as possible, and using windbreaks and conservation tillage to control wind erosion.

Water management is closely related to erosion control, and some practices overlap. In general, erosion is minimized when water flow is slowed or stopped. Some specific practices include slowing water flow by using contour tillage, diversions, terraces, sediment ponds, and other methods to slow and trap runoff. The carrying capacity of running water is directly proportional to the flow rate. When water is still, sediments can settle out. Production practices such as installing water-control structures, such as flashboard risers, on field ditches in poorly drained soils benefit water quality significantly by reducing downstream sediments, phosphorus, and nitrogen which also prevents eutrophication. Sediments and associated phosphorus settle out of runoff and nitrogen can be denitrified or used by instream vegetation. Suspended sediments and nutrients can also be removed by moving discharge points or runoff into filter areas. Discharge points must be located properly to minimize adverse impacts on the filter areas since high water flows can cause erosion and damage filter vegetation. Lastly, buffer strips may be placed between farmland and environmentally sensitive areas to prevent sedimentation (North Carolina Cooperative Extension, 1997).

Urban erosion and sedimentation is related to land-surface disturbance in construction areas and stream channel degradation associated with runoff from areas of impermeable cover. Uncontrolled or under controlled erosion from excavated sites deposits large volumes of sediment into stormwater drainage systems. When combined with large volumes of high velocity runoff from urban impervious surfaces, sediment moves quickly downstream, eroding stream channels, destroying habitat, and polluting downstream receiving water bodies. Urban runoff is controlled by adequate onsite practices that control runoff and erosion and keep sediment on site. These include excavated area cover, silt fencing, on-site runoff detention, stream flow velocity checks, and stream channel armoring.

RECOMMENDATION

The CPYRWMA should continue to commission water quality monitoring projects to track conditions related to nutrient concentrations and sedimentation rates and disclose findings to regulatory authorities and local stakeholders. The CPYRWMA should work closely with ADEM, USDA NRCS, ADCNR, and USFWS to assist with regulatory and agricultural programs designed to control erosion, sedimentation, water quality, and habitat protection. The CPYRWMA should continue to sponsor and fund local projects designed to control erosion and sedimentation and to work with partners to promote projects for stream and habitat restoration.

POLICY OPTIONS

The CPYRWMA should be an integral part of local implementation of a state water management plan and should receive state funding at a level to adequately support its participation in policy and regulatory and nonregulatory programs to protect water quality.

RECREATIONAL ISSUES

Recreational opportunities within watersheds promote river conservation, boost local economies, and encourage good environmental and social policy. Many recreational opportunities exist along the CPYRW such as paddling, fishing, hiking, and observing wildlife. These types of recreation may be used to stimulate economic activity in rural communities within the watershed. There is currently a strong interest in developing a Choctawhatchee River Trail through cooperation between the CPYRWMA, the Alabama Scenic River Trail (ASRT), and local partners. Water trail development within the watershed could help achieve goals of economic diversification and improve the quality of life in surrounding communities (National Park Service, 2001).

Non-consumptive tourism refers to responsible recreational activities that do not consume or harm the natural environment. This is a form of tourism that is intended to be a low-impact and small-scale alternative to mass tourism which can often lead to environmental degradation. These practices are particularly important when dealing with water resources, as water quantity and quality must be maintained in order to satisfy both environmental and recreational needs. Non-consumptive tourism often raises awareness about conservation and provides education on stewardship and social responsibility. Developing the Choctawhatchee River Trail would be a good opportunity to provide non-consumptive river recreation and to publicize recreational opportunities within the CPYRW.

Water trails are an effective approach to rural economic development and recreational access while also enhancing the natural and cultural qualities of a community. Travel and tourism is one of the largest industries in many state economies. Non-consumptive tourism based on Alabama's natural resources is a growing commodity within the state, and water trails are becoming popular within the industry. Innovative community management of water trails within a dynamic local economy can be economically rewarding. Case studies of community trends indicate that there are between 2,200 and 16,000 paddle outings annually, with paddlers spending between $27 and $63 per day. A destination paddler on a multiple-day water trail trip will spend about $88 in a community. Eating and drinking establishments, lodging and camping businesses, retail sales and recreational service industries see direct economic impacts from water trail paddlers (Johnson, 2002).

Water trails are beneficial, providing rural communities with a sense of stewardship, leading to successful retail and service businesses as the community builds a reputation as a paddling destination. Many popular water trails have impressive paddler profiles, which increases use rates and the amount of recreational users who desire a quality natural environment. As popularity of water trails increases, communities often capture profits from paddlers by offering overnight lodging opportunities and access to downtowns from the water trail with an assortment of activities for travelers. A shared vision for the water trail and existing tourism support facilities are important community considerations. Events, regional

and state level coordination, and local support, including strong volunteer groups and management partnerships influence the water trail's success (Johnson, 2002).

ALABAMA SCENIC RIVER TRAIL

The ASRT is 631 miles of river that stretches from the Coosa River at Cedar Bluff to the Mobile-Tensaw Delta just below Claiborne, to the Gulf of Mexico. The trail is designed for paddling and powerboat experiences and offers exploration along 3,000 miles of accessible waterways, with amenities and campsites to support activities such as long-distance touring, organized paddling trips, races, and overnight trips. The ASRT is geared towards whitewater enthusiasts, naturalists, and families seeking recreation (fig. 103). The main waterways of the trail include the Alabama River, Coosa River, Tensaw River, Tennessee River, Cahaba River, Terrapin Creek, Hatchett Creek, Weogufka Creek, and the Mobile-Tensaw delta. The Choctawhatchee River, which flows from Ozark, Alabama, to Choctawhatchee Bay, Florida, is currently being considered as an addition to the trail (ASRT, 2014).

Figure 103.—Paddler on the Choctawhatchee River
(photo credit: Mullen, 2014a).

The ASRT has succeeded in bringing together communities in an effort to protect rivers and instill a sense of stewardship in future generations. The mission focus of the ASRT is to create tourism travel in Alabama for all boaters; strengthen communities' tourism economies through travel on nearby waterways; extend recreational opportunities with promotion of the waterway cooperating with public and private entities, volunteer organizations, municipalities and counties; highlight

the historic significance of these waterways from Indian trade to the present; and establish and fund a nonprofit association to maintain the trail and coordinate community, private and public partnerships and riverside events (ASRT, 2014).

The Choctawhatchee River offers paddlers both shoals and small falls on its West Fork in Dale County and seasonally on Judy Creek in Dale County. The middle and lower sections of the river offer scenic vistas and ample sandbars for paddlers to camp during overnight trips. Currently, the resource is underutilized and use has declined over the past couple of decades due to drought conditions and economic stress. In the past, when there was an outfitter operating in Newton, it was reported that people renting boats came from 38 different states and several foreign countries to participate in boating activities on the river. Actions to enhance recreation use would provide direct and indirect benefits to both communities on the river and to the region (Mullen, 2014a). Promoting the Choctawhatchee River as part of the ASRT could provide recreational opportunities within the CPYRW and enhance the southeast Alabama tourist industry with consumptive tourism.

WATER ACCESS ISSUES

In order to provide a recreational infrastructure for the Choctawhatchee River, water access points must be improved along the river. Reasonable access to the river currently exists at many locations, so no new access points need to be constructed (fig. 104). Improvements are needed to make existing access points safer and to minimize water quality issues that are present at several locations. Promotional efforts and signage are needed to inform potential users of access point locations, trip

Figure 104.—Access point at Geneva City Park, the confluence of the Pea and Choctawhatchee Rivers (photo credit: Jim Felder, ASRT, 2013).

descriptions, available camp sites, and critical health and safety information. Alabama law allows camping on sandbars, but irresponsible recreationists often cause friction with nearby landowners. Efforts may be needed to identify sites where landowners allow camping by constructing signage along designated camp sites. Currently, there are no known outfitters that provide boat rentals along the Alabama portion of the Choctawhatchee River. There is an outfitter on Holmes Creek in Vernon, Florida. Efforts are needed to promote business ventures that will provide outfitting operations along the river and offer boat rentals to recreationists. This might involve finding funding to subsidize outfitter operations for the first few years. There will also be a need for cooperative publicity efforts through website development, local travel information listings, and signage to direct people to the outfitter services (Mullen, 2014a).

The quality of experience is always important in any recreational venture. In order to provide a full and positive experience for boaters on the Choctawhatchee River, periodic cleanups and law enforcement will be needed to prevent and remove litter from streams and access points as well as graffiti from bridges. Trash along the river and access points not only degrades downstream water quality, but deters landowners from accepting recreational use and cooperating with water trail stakeholders. Old access sites have been fenced off and posted with no trespassing signs after repeated littering occurred (Mullen, 2014b).

Promotional activities are needed to stimulate recreational activity on the river, bring economic benefits associated with the trail, and encourage outfitters to start businesses along the trail. In order to accomplish these tasks, website coverage is needed to stimulate recreational interest in the Choctawhatchee River Basin. Website promotion should include trip guides, information on day trips as well as longer trips available on the river, and outfitter information when available. The website also needs to include contact information for the Wiregrass Canoe and Kayak Club as well as social media for boating enthusiasts. Signage needs to be installed to direct potential users to river access points and to provide descriptions for trip starting points, paddle times, and destinations. A brochure should be made about the Choctawhatchee River Trail system at state welcome centers and locations frequented by tourists. A variety of events might be used to draw attention to the recreational opportunities on the Choctawhatchee River. Such events might include a multi-stage canoe and kayak race, concerts, charity events, or triathlons. These events could be held in conjunction with existing events such as the Festival on the Rivers (Mullen, 2014b).

RECOMMENDATION

The CPYRWMA should develop strategies for increased recreational use of Southeast Alabama water resources, coordinated with ADCNR, county, municipal government, Southeast Alabama Regional Planning Commission, ASRT, and USACE for regulations and requirements.

FORESTRY ISSUES

The Alabama Forestry Commission (AFC) is committed to protecting and sustaining Alabama's forest resources by utilizing professionally applied stewardship principles and education (AFC, 2013). The AFC will ensure Alabama's forests contribute to abundant timber and wildlife, clean air and water, and a healthy economy (AFC, 2013). Information regarding the forestry issues in the CPYRW were obtained from Nick Granger, Coffee County Forester, AFC.

RECOMMENDATION

The CPYRWMA should coordinate with the AFC to educate and encourage stakeholders to follow recommendations set forth by the AFC (discussed above).

POLICY OPTIONS

Healthy and abundant forests are critical to water quality and quantity. A comprehensive state water management plan should include links between forestry and water quality and quantity issues.

TIMBERLAND PROTECTION

INCENTIVE PROGRAMS

The AFC assists landowners with managing their forest through multiuse and sustainable forest management recommendations, which are adapted to each landowner's management objective, such as wildlife, timber production, aesthetics, and recreation (N. Granger, AFC, written communication, 2013). Management recommendations can consist of a single timber type on a landowner's property or a 10-year forest management plan that address all of the landowner's property (N. Granger, AFC, written communication, 2013). Landowners can also be recognized and have their property certified in any/all of the following programs: Tree Farm, Treasure Forest, and Stewardship Certifications (N. Granger, AFC, written communication, 2013). Landowners are certified through these programs by having a written management plan in place for their property and by completing forest management recommendations that meet the landowner's objectives (N. Granger, AFC, written communication, 2013). Certifications in Tree Farm, Treasure Forest, and Stewardship all require that BMPs be followed, including Alabama's voluntary BMPs (N. Granger, AFC, written communication, 2013).

COST–SHARE PROGRAMS

Several cost share programs are available for landowners from various state and federal agencies to assist landowners with protecting timberland.

The AFC offers a Southern Pine Beetle Prevention and Restoration Thinning Program. This program is designed to control southern pine beetles, which are the

number one killer of pines in Alabama, through thinning of dense, slow-growing pine stands, and stimulating growth and vigor in young stands (AFC, 2014)

The ADCNR offers a Landowner Incentive Program. This is a Federal grant program available through the USFWS, with the goal of providing technical and/or financial assistance to private landowners for the direct benefit of conserving, enhancing, or managing the habitats of species in greatest conservation need, with the primary emphasis on longleaf pine habitat restoration within the historical longleaf pine range (AFC, 2014).

The USDA NRCS offers six different cost share programs. The Cooperative Conservation Partnership Initiative (CCPI), Conservation Stewardship Program (CSP), Environmental Quality Incentives Program (EQIP), Wildlife Habitat Incentive Program (WHIP), Wetland Reserve Program (WRP), and Emergency Watershed Protection Program (EWP). The CCPI is a voluntary conservation initiative that enables the use of certain conservation programs with resources of eligible partners to provide financial and technical assistance to owners and operators of agricultural and nonindustrial private forest lands. Eligible producers in a nine-county project area of the Black Belt may apply for program assistance (AFC, 2014). The CSP is a new voluntary conservation program that encourages agricultural and forestry producers to maintain existing conservation activities and adopt additional ones in their operations by providing financial and technical assistance to conserve and enhance soil, water, air, and related natural resources on their lands (AFC, 2014). The EQIP provides programs to improve forest health, wildlife habitat, and declining threatened and endangered species on agricultural lands (AFC, 2014). The WHIP is a voluntary program that encourages the creation of high quality wildlife habitats that support wildlife populations. Landowners may receive technical and financial assistance to develop upland, wetland, riparian, and aquatic habitat areas on their property. The program is designed to enhance and restore threatened and endangered species as well as rare and declining ecosystems (AFC, 2014). The WRP is a voluntary program that provides technical assistance and financial incentives to restore, protect, and enhance wetlands in exchange for retiring marginal land from agriculture, with the emphasis on restoring wet cropland to bottomland hardwoods (AFC, 2014). The EWP assists in relieving the hazards to life and property from floods caused by natural disasters and the products of erosion created by natural disasters that cause a sudden impairment of a watershed (AFC, 2014).

The Alabama Soil and Water Conservation Districts offer the Alabama Agricultural and Conservation Development Commission Program, which is funded through the State of Alabama Soil and Water Conservation Committees, and includes forestry practices such as firebreak establishment, prescribed burning, site preparation, and tree planting (AFC, 2014).

The USDA Farm Service Agency offers two cost share programs: Regular Conservation Reserve Program (CRP) and Continuous CRP (Forestry and Wildlife Programs). The Regular CRP is a voluntary program for landowners. The intent is to take highly erodible cropland out of production and stabilize soil loss through planting permanent cover crops. Three tree planning practices are available under this CRP: longleaf and other softwood tree planning (CP3), hardwood tree planting (CP3A), and trees already established (CP11) (AFC, 2014). The Continuous CRP includes filter

strips (CP21), riparian forest buffers (CP22), bottomland timber establishment on wetlands (CP31), field borders (CP33), longleaf pine initiative (CP36), and blackland prairie habitat restoration (CP38). Filter strips (CP21) are designed to reduce pollution and protect surface water and subsurface water quality by removing nutrients, sediment, organic matter, pesticides, and other pollutants (AFC, 2014). Riparian forest buffer (CP22) is designed to reduce pollution and protect surface water and subsurface water quality by removing nutrients, sediment, organic matter, pesticides, and other pollutants (AFC, 2014). Bottomland timber establishment on wetlands (CP31) works to improve air and water quality in addition to increasing wildlife habitat along wetland areas (AFC, 2014). Field borders (CP33) involves the Northern Bobwhite Quail Habitat and introduces conservation practices to create 250,000 acres of early successional grass buffers along agricultural field borders (AFC, 2014). The Longleaf pine initiative (CP36) seeks to increase long leaf pine forests (AFC, 2014). The blackland prairie habitat restoration program (CP38) seeks to enroll 3,800 acres to improve native grassland habitats for rare, threatened, endangered, and declining species that are dependent on native prairie communities found within the Black Belt Prairie region of Alabama (AFC, 2014).

The USFWS offers three programs: Partners for Fish and Wildlife, Safe Harbor Program, and Private Individual Grants. Partners for Fish and Wildlife provides technical and financial assistance to private landowners to restore and enhance fish and wildlife habitat on their property, with the focus on restoring vegetation and hydrology to historic conditions (AFC, 2014). Safe Harbor Program provides guarantees for landowners who manage their pine forests in a manner beneficial to the red-cockaded woodpecker (AFC, 2014). Private Individual Grants is designed to promote wetland conservation and associated habitats for migratory birds and support efforts to restore natural resources and establish or expand wildlife habitat (AFC, 2014).

The Longleaf Alliance Programs offer two cost share programs: Longleaf Pine Restoration Program and Longleaf Legacy Program. Both are designed to restore longleaf pine on cutover sites, with funding provided by the USFWS Partners for Fish and Wildlife Programs for Longleaf Pine Restoration Program and funding provided by American Forest Foundation grants for Longleaf Legacy Program (AFC, 2014).

REPLANTING

Regulations regarding replanting include that site preparation treatments and tree planting activities should have minimal displacement of soil and be managed to diminish adverse environmental effects and *Alabama's Best Management Practices for Forestry*, which are nonregulatory guidelines except in areas designated as wetlands by the USACE (N. Granger, AFC, written communication, 2013).

The benefits of replanting or natural regeneration include improved air and water quality (N. Granger, AFC, written communication, 2013). Natural regeneration and reforestation protects soil and water through reducing erosion (N. Granger, AFC, written communication, 2013). Forests provide better air quality through removing carbon dioxide from the air and releasing oxygen back into the atmosphere (N. Granger, AFC, written communication, 2013). Forests also provide wildlife with food, water, and habitat. Forests also benefit the economy with jobs, and products, such as

paper, that are used daily come from forests (N. Granger, AFC, written communication, 2013).

HARVESTING BMPS

Harvesting activities should be conducted to ensure long-term maintenance of water quality through the following suggested BMPs: temporary access roads and landing locations, felling, skidding, cut-to-length harvest systems, and trash disposal (AFC, 2007). Temporary access roads and landing locations should be planned before operations commence to minimize soil disturbance, with road construction kept to a minimum and landings kept as small as feasible, and both must be located on firm ground, outside of Streamside Management Zones and above the ordinary high water mark of streams, and both should be stabilized with water diversion devices and/or vegetation after activities have ceased (AFC, 2007). Felling should be done so as to minimize the impact of subsequent phases of logging operations on water quality (AFC, 2007). Skidding should be utilized to avoid disrupting natural drainages, prevent excessive soil displacement, and minimize the impacts of rutting, compaction, and puddling on water quality and soil stability, with stream channel and natural drainages not utilized for skidding (AFC, 2007). Cut-to-length harvesting systems maximize timber production and protect water quality and other forest resources, with the primary benefit of using forwarders (or prehaulers), which are capable of hauling wood off the ground for long distances and need only minimum skid trails or landings, resulting in less soil displacement (AFC, 2007). Trash should also be disposed of properly throughout the operation in accordance with all applicable laws, and fuel, lubricants, and other toxic chemicals should be disposed of properly (AFC, 2007).

FIRE CONTROL

Alabama Forestry Commission's number one priority goal is to suppress wildfires and protect Alabama's homes and forest land (N. Granger, AFC, written communication, 2013). Local paid and volunteer fire departments and the local AFC office can be dispatched to the scene of a wildfire by calling 911 (N. Granger, AFC, written communication, 2013). The AFC suppresses wildfires by constructing firebreaks, which removes the fuel from the fire (N. Granger, AFC, written communication, 2013). Alabama BMPs for firebreak construction are required for AFC wildfire suppression and prescribed burning and are randomly monitored by the AFC on an annual basis (N. Granger, AFC, written communication, 2013).

Prescribed burning and timber harvesting are good forest management practices which can reduce wildfire intensity (N. Granger, AFC, written communication, 2013). Prescribed burning and timber harvesting reduces fuel loading, controls undesirable competition, and promotes herbaceous browse for wildlife (N. Granger, AFC, written communication, 2013). The AFC recommends that all prescribed burns be planned and conducted by an Alabama Certified Burn Manager and include a written burn plan, smoke monitoring screening, and obtaining a burn permit. Timber harvesting removes poor quality, diseased, and suppressed trees to allow growth spacing (water, nutrients, and sunlight) for more desirable, dominant trees (N. Granger, AFC, written communication, 2013).

INVASIVE SPECIES

Invasive species have several negative impacts, which can include stopping or hampering productive land use, destroying wildlife habitats, degrading ecosystems, diminishing biodiversity, loss of recreational value, and devastating impacts on threatened and endangered species' habitats (N. Granger, AFC, written communication, 2013). There are five invasive species of importance in the CPYRW: Cogongrass, Kudzu, Japanese climbing fern, Tallowtree, and Privet (N. Granger, AFC, written communication, 2013).

Cogongrass is an aggressive colony-forming perennial grass native to Southeast Asia and often forms in circular infestations. This species grows in full sunlight to partial shade, and can aggressively invade a range of sites, such as rights-of-way, new forest plantations, open forests, old fields, and pastures. It colonizes by rhizomes and spreads by wind-dispersed seeds (N. Granger, AFC, written communication, 2013).

Kudzu is a twining, trailing, and mat-forming wood vine that is native to Asia. Kudzu is a leguminous nitrogen fixer. This species occurs in old infestations, along rights-of-way, forest edges, and stream banks. It colonizes by vines rooting at nodes and spreads by dispersed seed from wind, animals, and water. Seed viability varies depending on habitat and region (N. Granger, AFC, written communication, 2013).

Japanese climbing fern is a climbing and twining perennial vine-like fern native to Asia and tropical Australia. This species spreads along highway rights-of-way (preferring under and around bridges), and invades into open forests, forest road edges, and stream and swamp margins. Scattered in open timber stands and road edges, this species can quickly increase into cover to form mats, covering shrubs and trees (N. Granger, AFC, written communication, 2013).

Tallowtree, also known as Chinese tallowtree or Popcorntree, is native to Asia. This species invades stream banks, riverbanks, and wet areas, such as ditches as well as upland sites. This species thrives in both freshwater and saline soils. Tallowtree is spreading widely through ornamental plantings, and bird-dispersed and water-dispersed seeds (N. Granger, AFC, written communication, 2013).

Privet is a non-native evergreen shrub from Asia. Widely planted as ornamental, this shrub generally escapes cultivation. It has invaded both lowland and upland habitats. Privet spreads by abundant animal-dispersed seeds and colonizes by root sprouts (N. Granger, AFC, written communication, 2013).

BUFFERS

Streamside Management Zones are the primary buffers along drainages and waterways (N. Granger, AFC, written communication, 2013). The Streamside Management Zone is a strip of land immediately adjacent to a water body, where soils, organic matters, and vegetation are maintained to protect the physical, chemical, and biological integrity of surface waters adjacent to and downstream from forestry operations (AFC, 2007). Width requirements depend on erodibility of soil, steepness of slope, and waterway type (perennial stream, intermittent stream, or river), and must always be wide enough to maintain water quality (N. Granger, AFC, written communication, 2013). Although Streamside Management Zones are mostly voluntary, they are highly recommended and are required for forest certification

programs and most cost share programs (N. Granger, AFC, written communication, 2013).

FLOOD CONTROL

Flooding is a major concern for those who live in or own property near the floodplains of the Choctawhatchee, Pea and Yellow Rivers or their tributaries. Elevations of flood waters during flood events determine the risk of damage to property or infrastructure in these flood plains. Surface-water elevations are significantly affected by both man-made and natural factors. Construction in flood plains causes increased flood levels and reduced rates of infiltration. Land use change and modifications to vegetation, wetlands, and topography in floodways may have profound consequences on surface-water levels and resulting frequency and severity of floods. Anthropogenic influence on upland areas affects rates of infiltration and runoff, which influences stream flow and flood levels. Natural factors such as precipitation patterns, tributary drainage patterns and contribution of discharge, and streambed geology and geometry affect surface-water elevations (Cook and others, 1997).

Precipitation amounts and patterns in Alabama are affected by the Gulf of Mexico and the Appalachian Mountains. Annual precipitation averages about 55 inches statewide, and ranges from 50 inches in central Alabama to 65 inches near the Gulf of Mexico. Seasonal rainfall patterns result in more than one half of the average rainfall between December and May except on the gulf coast. Hurricanes, which usually enter the state along the coast, can produce torrential rainfall that causes disastrous floods. The major causes of floods in Alabama are intense precipitation and high coastal waters associated with hurricanes, tropical storms, and tropical depressions; thunderstorms; and slow moving or stationary frontal systems. The probability of flooding increases during the spring when rivers and creeks, already full with spring runoff, receive additional rainfall (USGS, 2014e).

The proximity of the CPYRW to the Gulf of Mexico causes concern about the threat of heavy precipitation that often accompanies tropical cyclonic storms which move into or near the watershed. The term “tropical cyclone” is defined by NOAA as any area of closed circulation that originates over tropical waters, in which the winds rotate counter-clockwise in the Northern Hemisphere or clockwise in the Southern Hemisphere (NOAA, 2013). During the course of a tropical cyclone, the storm passes through phases of intensification and dissipation that are defined by wind speed near the center of circulation. Intense, short duration rainfall events, such as those associated with tropical cyclonic storms pose the greatest threat of flooding in the watershed. According to a study by NOAA in 1993, evaluation of general directions of storm movement indicates that 67% of tropical cyclones between 1878 and 1994 moved through the watershed from southwest to northeast. This is significant when compared to precipitation trends in the area, which indicate the largest rainfall events occur near the southern portion of the watershed and along the southwestward trend of the Choctawhatchee and Pea River valleys (Cook and Kopaska-Merkel, 1995).

Previous research from Cook and Kopaska-Merkel (1995), indicates that the difference in topographic relief across the watershed affects local and subregional temperature, wind speed, and wind direction, which affect the movement of cyclonic storms and total amounts of precipitation. The northeastward trend of the Choctawhatchee and Pea Rivers Valleys corresponds to the direction of movement of many of the cyclonic storms that affect the watershed. There appears to be a "funneling" effect that directs heavy precipitation along the southern portions of the river valleys. This hypothesis is further sustained by an evaluation of monthly precipitation in the watershed. Therefore, intense, short duration rainfall events are most likely to occur in and near the Choctawhatchee and Pea River Valleys (Cook and Kopaska-Merkel, 1995).

IDENTIFICATION OF FLOOD-PRONE AREAS

Primary areas of concern for potential flood threats in the Choctawhatchee-Pea Rivers basins are the towns of Elba, Geneva, Ariton, Newton, Ozark, and Daleville, Alabama. The cities of Elba and Geneva are the two most prominent locations which are prone to frequent and severe flooding within the CPYRW. The presence of the city of Elba in the floodplain of the Pea River has affected the flow and water-surface elevations of the river. Before renovation of the levee system by the USACE in 2004, the majority of flooding in Elba was caused by localized flood waters trapped behind the levee system during periods of intense rainfall. There are several obstructions in the Pea River floodplain near Elba that contribute to flood events, including two highway bridges, one railway bridge, a levee system, a gravity flow dam, confluences of five tributaries, and various buildings, structures, and surface-water impoundments. In a 1997 flood assessment conducted by the Cook and others (1997), surface-water profiles for the Pea River floodplain at Elba were simulated for three flood events based on field measurements of stream discharge and stage. The maximum flood has a 60-year recurrence interval and is represented by the 1990 event. There is a 1.7% chance that this flood may occur at Elba during any year. The minimum flood is represented by the 1973 event and has a 5-year recurrence interval. This event has a 20% chance of occurring at Elba in any year. The 1975 flood was selected as the intermediate flood. This event has a 25-year recurrence interval and a 4% chance of occurring in Elba in any year (Cook and others, 1997).

Three major influences on stream flow and water surface elevations of the Pea River occur near downtown Elba, including the confluence of Whitewater Creek and the Pea River, the Elba levee, and the highway 84 bridge across the Pea River. Additional discharge to the Pea River from Whitewater Creek is the primary cause of increased water levels in the river near downtown Elba. Hydraulic jumps caused by Whitewater Creek are 4.0 ft for the 60-year flood, 3.1 ft for the 25-year flood, and 0.8 ft for the 5-year flood. Prior to levee enhancements, the primary effect of the old levee on the Pea River was a significant increase in discharge velocity. Constriction of the floodplain by the levee was the major cause of a simulated velocity increase from 4.8 feet per second (ft/s) upstream from the levee to 18.2 ft/s downstream from the levee. The hydraulic jump caused by the highway 84 bridge and former levee system was approximately 1 foot for the 60-year and 25-year events. No discernable hydraulic jump was noted for the 5-year flood (Cook and others, 1997).

Beaverdam Creek flows into the Pea River immediately downstream from downtown Elba and causes a simulated hydraulic jump of 1.2 ft for the 60-year flood, 1.3 ft for the 25-year flood, and 0.66 ft for the 5-year event. The Elba Dam was suspected as a cause of increased water surface elevations along the Pea River in Elba. An evaluation of the results from the 1997 GSA study indicates that the dam causes hydraulic jumps of less than 1 foot for all analyzed flood events. Therefore, the dam does not affect the river levels at Elba (Cook and others, 1997).

The City of Geneva has a history of frequent flooding due to its location on the floodplains of the Choctawhatchee and Pea Rivers. The city is bordered on three sides by major streams that may flood during periods of heavy rainfall. Infrastructure development at Geneva includes three bridges and a levee. Double Bridges Creek flows along the northern boundary of downtown Geneva and enters the Choctawhatchee River near the eastern limit of the city. During the 1997 GSA study, surface water profiles were simulated for two flood events based on field measurements and stream discharge and stage. The maximum flood has a 55-year recurrence interval and is represented by the 1929 event. Statistical analysis indicates that there is 1.8% chance that this flood may occur at Geneva during any year. The minimum flood is represented by the 1975 event and has an 8-year recurrence interval. This event has a 12.5% chance of occurring at Geneva in any year (Cook and others, 1997).

The highway 52 bridge was evaluated and found to have no hydraulic jump for either of the flood events. There was also no hydraulic jump associated with the confluence of the Choctawhatchee River and Double Bridges Creek. However, a simulated hydraulic jump of 0.51 foot was observed at the confluence of the Pea and Choctawhatchee Rivers. Before levee enhancement, the Geneva levee along Double Bridges Creek, constricted the floodplain of the creek for more than a mile. However, the levee has no apparent effect on flood levels along the creek. The highway 27 bridge crosses Double Bridges Creek approximately 1 mile from its mouth. However, no hydraulic jump occurs as a result of the bridge (Cook and others, 1997).

The Pea River flows adjacent to the southern boundary of Geneva for approximately 3 miles. The downtown area is protected from flood waters of the Pea River by a floodway approximately 2,500 ft. wide and a levee along the southern margin of the city. Studies indicate that no hydraulic jump occurs as a result of the levee. The results of modeling the Choctawhatchee and Pea Rivers and their tributaries indicate that the major cause of flooding at Elba and Geneva is the location of these cities relative to the streams. Both levee systems have been enhanced by the U.S. Army Corps of Engineers to effectively reduce or prevent flooding at Elba and Geneva (Cook and others, 1997).

HISTORICAL FLOOD EVENTS

Floods in the CPYRW have been associated with a variety of weather disturbances and have affected many areas within the region. One of the largest floods to impact the watershed occurred in March 1929. A period of heavy rain occurred on February 27 and 28, then again on March 4 and 5 of that year causing water levels to remain high. Then, from March 12-15, extreme rainfall occurred throughout the entire state. During this period, Elba received 30 inches of rain, and the area from Brewton to

Ozark received 15 to 25 inches of rain. This produced severe flooding along the Pea River in Elba, along the Choctawhatchee River in Geneva, and along the Conecuh River and its tributaries in Brewton and Flomaton. Both Elba and Geneva were inundated by 10 ft or more of water (fig. 105). This was the most devastating flood to occur within the modern period of record and was termed the "Great Flood of March 1929." Thousands of people were stranded on rooftops in Elba and could not be accessed by rescue teams for three days (National Weather Service (NWS), 2010).

Figure 105.—The town of Elba during the March 1929 Flood (photo credit: NWS, 2010).

The next significant flood event in the CPYRW occurred in March 1990. Heavy rainfall from 8 to 16 inches occurred from March 15-17, producing record or near-record flooding along several rivers in southeast Alabama. Extensive damage occurred to roads and bridges, closing several major highways. The most severe flooding occurred along the Pea River at Elba where a crest of 43.28 ft occurred. A levee constructed around Elba was overtopped by a small stream on the morning of March 17, which created a 175-yard break in the levee that quickly flooded the town. Over 1,500 people evacuated, 130 businesses were either destroyed or damaged, and over 1,000 homes in the area were flooded (fig. 106). On the Choctawhatchee River, a record crest of 40.32 ft occurred at Newton on the 18th of March, exceeding the crest of 39.4 ft in March 1929. Considerable residential and commercial flooding occurred in

Figure 106.—Flooding in Elba during March 1990 (photo credit: NWS, 2010).

Newton and Daleville. Further downstream at Geneva, the river crested at 38.54 ft on the 19th and flooded 500 homes outside of a levee built to protect the town. This crest was second only to the one which occurred in the flood of 1929 (NWS, 2010).

Major flooding also occurred along rivers in southeast Alabama following very heavy rainfall spawned by remnants of Tropical Storm Alberto during the first week of July 1994. The most serious and devastating flooding occurred in the CPYRW along the Choctawhatchee and Pea Rivers. Only the Great Flood of March 1929 and the flood of March 1990 exceeded this flood in the modern period of record. Tropical Storm Alberto moved ashore in the Florida panhandle on July 3 and moved northeast near Atlanta before it finally made its way into Alabama. During this time, 15-20 inches of rainfall occurred in southeast Alabama causing major flooding along the Choctawhatchee and Pea Rivers (fig. 107). Near-record crests were measured at many locations along the Choctawhatchee River. At Newton, the river crested at 37.95 ft, making it the third highest crest recorded there. At Geneva, the river crested at 42.42 ft, making it the second highest crest. The Pea River at Elba crested at 38.33 ft, making this the third highest crest recorded in that location (NWS, 2010).

On March 8, 1998, significant flooding occurred on the Beaver Dam Creek. Three days of heavy rain produced floodwaters that breached the levee in Elba. Half of the city's residents had to evacuate as the downtown area was inundated by 6 ft of water. The flood happened suddenly, with little warning causing more damage than the 1990 flood even though the crest was smaller (ABC News, 2014).

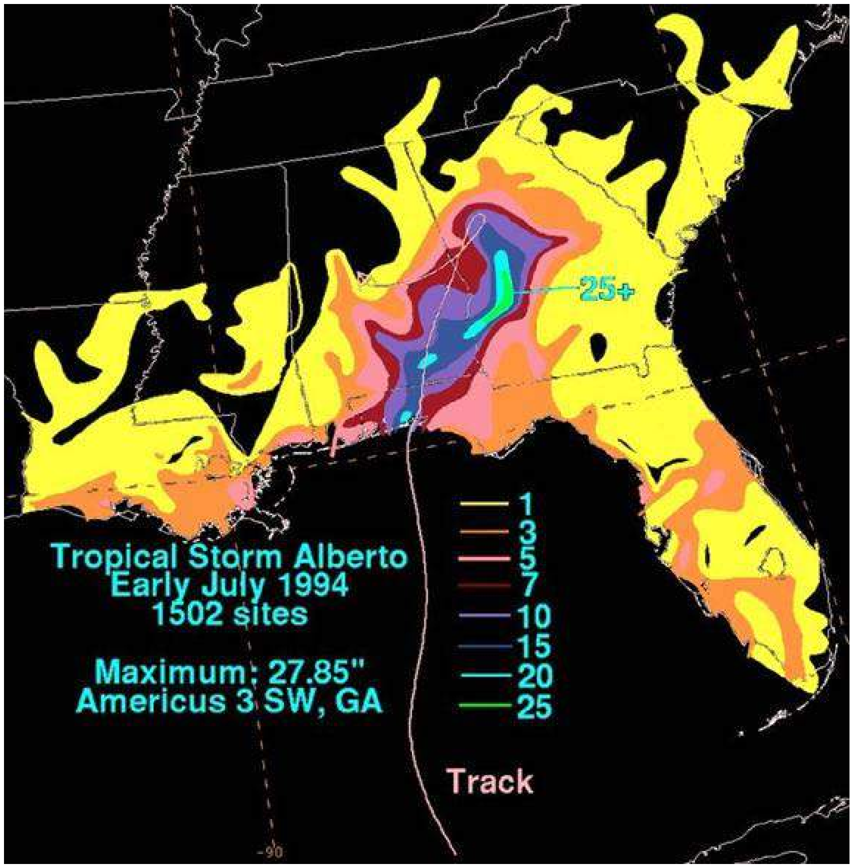

Figure 107.—Storm Total Precipitation for Tropical Storm Alberto (photo credit: NWS, 2010).

FEDERAL AND STATE FLOOD MAPPING

The ADECA OWR, Floodplain Management Unit is charged with floodplain management for the state. They work closely with the Federal Emergency Management Agency (FEMA) and local communities to build relationships to strengthen mitigation plans, protect residents, and reduce flood risks through flood research and mapping (ADECA OWR, 2012c). ADECA OWR's Floodplain Management Unit provides flood resources such as Risk MAP, the Alabama Flood Risk Information System (AL FRIS), County Flood Map Information and Status, Letters of Map Revision (LOMR), and the National Flood Insurance Program (NFIP).

Risk Mapping, Assessment, and Planning (Risk MAP) is the FEMA Program that provides communities with flood information and tools to enhance mitigation plans through more precise flood map products, risk assessment tools, and planning. Through collaboration with State, Tribal, and local entities, Risk MAP provides data that increases public awareness and leads to action, which reduces risk to life and property (FEMA, 2011). Risk MAP is intended to offer services beyond the traditional Flood Insurance Rate Map (FIRM). It emphasizes a broader, more holistic approach to perform engineering and mapping analyses on a watershed scale. Alabama's

floodplain management program benefits from a strong partnership with FEMA in updating flood maps and assisting local communities. Since partnering with FEMA in 2003, the Floodplain Management Unit has digitally mapped all 67 counties, studying over 1,050 miles of streams using detail methods and 30,000 miles of streams using approximate methods (ADECA OWR, 2012c). The Risk MAP currently lists the Upper Choctawhatchee Watershed (HUC ID 03140201) as a funded site for proposed flood mapping in the following cities: Enterprise, Daleville, Ozark, Geneva, Hartford, Malvern, Samson, Slocomb, Bellwood, Kinston, New Brockton, Midland, Pinkard, Black, Eunola, Coffee Springs, Ariton, Clayhatchee, Level Plains, Newton, Fort Rucker, Grimse, Napier Field, and Elba. See figure 108 to view FEMA Risk MAP Progress in the CPYRW.

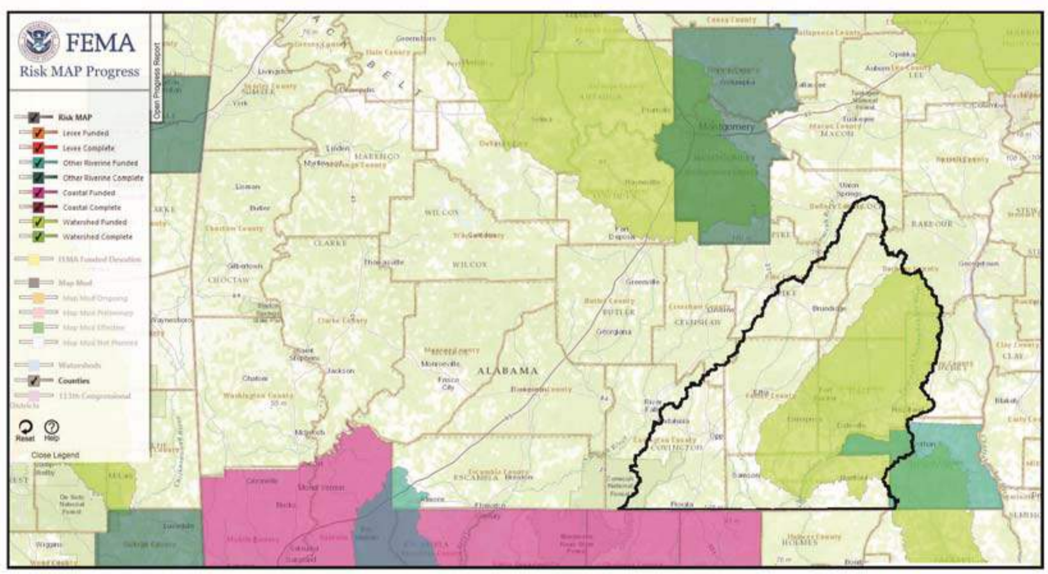

Figure 108.—FEMA Risk Map Progress for the CPYRW.

The Floodplain Management Unit is in the process of developing an interactive flood mapping application called the Alabama Flood Risk Information System (AL FRIS). The AL FRIS includes digital Flood Insurance Rate Maps (FIRMs) for Alabama, Flood Insurance Study Reports and various flood risk datasets developed by ADECA OWR in cooperation with FEMA. The interactive map application allows users to view flood zones, cross sections, DFIRM panels, LOMR, building footprints, benchmarks, political areas, and structures. AL FRIS also allows for map and data export, risk information, and measure tools. AL FRIS also displays how properties may be impacted according to new FEMA revisions including the expansion for due process procedures for new or modified Base Flood Elevations (BFEs) or base flood depths shown on a Flood Insurance Rate Map (FIRM), including the addition or modification of any Special Flood Hazard Area (SFHA) boundary or zone designation, or regulatory floodway (ADECA OWR, 2012c). See figure 109 for an example of the AL FRIS interactive mapping interface.

The Floodplain Management Unit also offers county flood map information and status. The County Status application provides the latest available digital data and

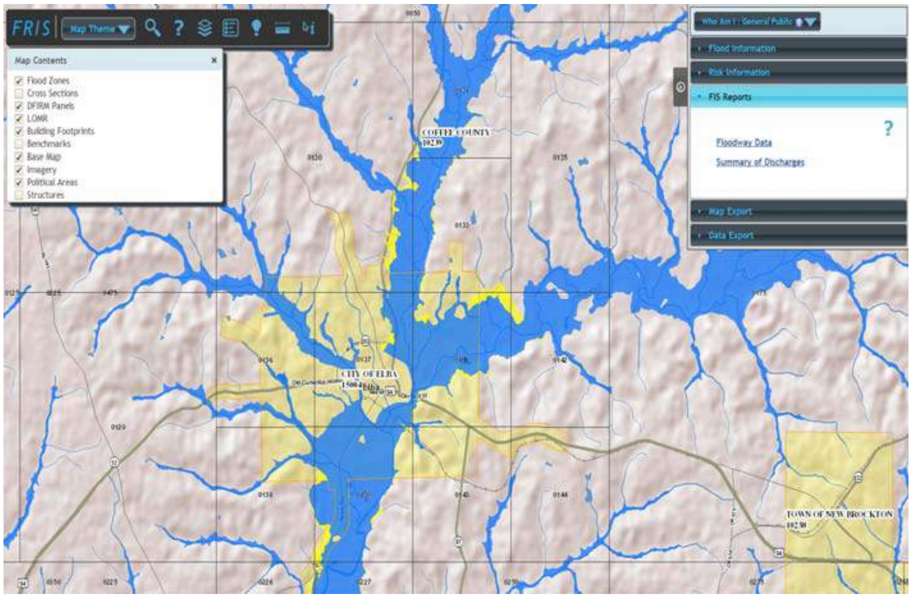

Figure 109.—AL FRIS Interactive Map displaying City of Elba flood zones.

flood maps along with community meeting dates, current proposed map changes and products delivered to communities. This data is provided to keep local communities and residents informed about available tools and resources for identifying, planning, and assessing flood risk (ADECA OWR, 2012c).

ORDINANCES FOR FLOODPLAIN DEVELOPMENT

The U.S. Congress established the NFIP with the passage of the National Flood Insurance Act of 1968. The federal program enables property owners in participating communities to purchase insurance as a protection against flood losses in exchange for community floodplain management regulations that reduce future flood damages. Buildings constructed in compliance with the program's building standards suffer approximately 80% less damage annually than those not built in compliance. Community participation in the program is voluntary. If a community adopts and enforces a floodplain management ordinance to reduce future flood risk, the federal government will make flood insurance available within the community as a financial protection against flood losses. This insurance is designed to provide an insurance alternative to disaster assistance to reduce the escalating costs of repairing flood damage to buildings and their contents. Currently, 428 communities are participating in the NFIP in Alabama with the Floodplain Management Unit coordinating the program for the state. Alabama currently has more than 58,000 NFIP policies providing over $12.3 billion in coverage (ADECA OWR, 2012c).

The Flood Mitigation Assistance (FMA) program provides funds for projects to reduce or eliminate risk of flood damage to buildings that are insured under the NFIP on an annual basis. There are three types of FMA grants available: (1) planning grants (to prepare flood mitigation plans), (2) project grants (to implement measures to reduce flood losses, such as elevation, acquisition or relocation of NFIP-insured

structures), and (3) management cost grants (for the grantee to help administer the FMA program and activities). Eligible applicants for the FMA include states, territories, commonwealths, and Indian tribal governments. Eligible subapplicants include: state agencies, Indian tribal governments, and local governments or communities (FEMA, 2014).

Hazard mitigation grants have been awarded to both the cities of Elba and Geneva. After the 1994 flood, the GSA evaluated flooding in Elba and recommended a mitigation strategy involving flood water storage and removal. Elba applied for a hazard mitigation grant to install a stormwater drainage system, which was approved by FEMA in July 1994. The system was built in 1997 by widening and clearing the abandoned Beaverdam Creek channel and floodplain and installing two pumps at low-lying points in the town's southeast quarter. The pumps, designed to remove water quickly from flooded areas, are each capable of moving 17,500 gallons per minute. Geneva also applied for hazard mitigation grant funds to acquire structures most at risk. FEMA agreed to fund the buyout of dozens of buildings within the floodway of Double Bridges Creek in Baptist Bottoms (Association of State Floodplain Managers, 2000).

As a result of the 1990, 1994, and 1998 floods, a long term Recovery Action Plan was issued in April 1998 by President Bill Clinton to upgrade the levees and provide flood mitigation to the cities of Elba and Geneva, AL. Through continued efforts by U.S. Senator Richard Shelby; Alabama State Senator Jimmy Holley; Mr. Ferrin Cox, Chairman of the Governor's Long Range Task Force Committee of the Levee Project; Congressman Terry Everett; Alabama State EMA Director Lee Helms; and Barbara Gibson, Director of the CPYRWMA, funding was allocated to the USACE to upgrade the levees through the Water Resources Development Act.

In May 2002, the USACE began construction for the revitalization of the Elba levee. The levee, which was initially 3.2 miles long, was fortified with a core, increased in height by 6 ft, and the base was widened by 65 ft. Side slopes of the levee changed from a 2:1 grade to a 3:1 grade. The total cost of the project was estimated to be about $12.9 million. Non-federal cost share paid by the State of Alabama was approximately $4,655,000. For comparison, the cost of the 1990 flood was $150,000,000 including cleanup, restoration, and relocation of schools to higher ground (NOAA, 2002).

The rehabilitation of the 2.6 mile levee in Geneva began in 2004 at a total cost of $16.6 million of which $10.8 million was paid by the Federal government. The remaining $5.8 million was allocated by the Alabama Legislature. White clay from Wyoming was used to inject a new core into the clay barrier which was initially constructed in the 1930s. The height of the levee was increased and the base was widened from 60 to 100 feet.

FLOOD MITIGATION

Flood control methods can be employed to prevent, reduce, and mitigate the risk of damages associated with flooding. Methods of flood control have been practiced since ancient times. These methods include planting vegetation to retain excess water, terracing hillsides to slow flow downhill, and the construction of floodways (International Water Association, 2009). The best defense against flood related issues and levee failure is to identify problems early and repair them immediately. Biannual

levee inspections and effective high water patrolling may be used to prevent seepage beneath levees, erosion of levee embankments, and overtopping resulting from surface-water elevations higher than the levee or embankment. Flood control agencies are encouraged to organize patrol teams to identify potential problems such as boils, seepage, erosion, cracks, and sloughing. Patrol teams should be prepared to advise officials of the district or agency responsible for emergency assistance for help or flood warning services (California Natural Resources Agency, 2012).

Rivers prone to flooding are often carefully managed and defenses, such as levees, dikes, dams, reservoirs, weirs, and retention ponds, are employed to prevent inundation s. When these defenses fail, emergency measures such as sandbags or portable inflatable tubes are used. Sandbags may be used to construct temporary walls on levees to raise low areas during high water periods to prevent overtopping of levees, streams and riverbanks, small earthen dams, and roadways. Sandbag barriers may also be constructed to divert water or debris flows away from structures (fig. 110). Barriers constructed of sandbags or lumber can also be used to channel mud and debris away from property improvements.

Figure 110.—Example of a temporary sandbag barrier
(photo credit: The Prepper Journal, 2013).

The FEMA suggests seven categories of flood mitigation measures or BMPs to protect properties from flooding (table 50).

1. *Drainage Improvements*: Drainage systems moves surface water through channels to a receiving body of water. The system itself contains several conveyance mechanisms that carry water away and may contain storage facilities to store excess water until it can be removed. Examples of improvements to regional or local drainage systems include modifying a

culvert, stream, or river channel to provide a greater carrying capacity to move floodwaters off areas where damage occurs (FEMA, 2007).

Table 50.—FEMA mitigation measures for floodprone structures.

Category	Flood Mitigation Measure
1	Drainage Improvements
2	Barriers
3	Wet Floodproofing
4	Dry Floodproofing
5	Elevation
6	Relocation
7	Acquisition

2. *Use of Barriers*: Examples of barriers include building a floodwall or levee around a structure or a group of structures to hold back floodwaters. Levees are usually embankments of impacted soil, and floodwalls are usually built of concrete or masonry. Levees require more space than a floodwall since the sides of a levee are sloped to provide stability and resist erosion. An alternative to a permanent barrier is a temporary one, such as large filled tubes or bladders, metal walls lined with impermeable materials, and expandable gates that block floodwaters from entering structures through openings such as doors or windows (FEMA, 2007).
3. *Wet Floodproofing*: Wet floodproofing a structure involves making uninhabited portions of the structure resistant to flood damage and allowing water to enter during flooding. Damage to a structure is reduced since water is allowed to enter and balances the hydrostatic pressure. National Flood Insurance Program regulations require that buildings on extended wall foundations or that have enclosures below the base flood elevation must have wet floodproofing. Wet floodproofing openings prevent the foundation or enclosure walls from weakening or collapsing underneath hydrostatic forces during a 100 year flood event. The openings allow flood waters to reach equal levels on both sides of the foundation and minimize the potential for damage from hydrostatic pressure (California Natural Resources Agency, 2012).
4. *Dry Floodproofing*: Dry floodproofing involves sealing structures to prevent floodwaters from entering. Waterproof coatings or impermeable membranes may be employed to dry floodproof a structure to prevent seepage through walls, doors and windows, and sewer backup prevention measures may be employed (FEMA, 2007).
5. *Elevation*: Elevating a structure consists of raising the lowest floor to or above the flood level. This can be done by elevating the entire structure, including the floor, or by leaving the structure in its existing position and constructing a new, elevated floor within the structure. The method used depends on the construction type, foundation type, and flooding conditions.
6. *Relocation*: Relocating a structure includes moving the structure out of the floodplain to higher ground where it will not be exposed to flooding.
7. *Acquisition*: Acquisition involves buying and tearing down a structure. The property owners would then move to another property located outside of the

floodplain. A new building that meets all building and flood protection code requirements may be built or the lot can remain as open space (FEMA, 2007).

Other flood control measures to reduce flood risks include structural controls such as infiltration devices, ponds, filters, and constructed wetlands. BRCs, constructed depressions in the landscape, may be built to capture and store stormwater runoff and promote infiltration. BRCs provide stream channel protection through minimized peak discharges. Constructed stormwater wetlands are manmade wetland areas designed to treat stormwater and function similarly to natural wetlands. They provide temporary storage of stormwater and act as flood attenuation for improved water quality while reducing peak flows downstream and reducing sediment loads. Permeable pavement also temporarily stores stormwater runoff. The application of permeable pavement reduces impervious surface runoff and decreases flooding. Methods such as those previously listed may be used to mitigate flood risks by reducing peak flows and promoting stormwater infiltration in urbanized areas of the watershed (ADEM, ACES and AU, 2014).

Flood recovery plans for areas of the CPYRW are a coordinated effort of the respective State EMA offices, FEMA, USACE, and local communities. The CPYRWMA has no jurisdiction over flood recovery plans already in place, should an event occur. The CPYRWMA actively participates in on-going meetings and planning activities related to flood plans in the area (CPYRWMA, 2013a).

FLOOD WARNING SYSTEM

Past flood conditions have demonstrated the need for real-time flood warnings for communities in southeast Alabama. The CPYRWMA operates a Flood Warning System (FWS), which was designed and installed by the USACE Mobile district. The FWS was federally funded (75%) because it was needed as a mitigation tool for flooding for the towns of Elba and Geneva. The purpose of the FWS is to provide timely, reliable, and accurate warnings to persons residing along the Choctawhatchee, Pea and Yellow Rivers, which could be subject to flooding conditions during periods of excessive rainfall. It is the responsibility of the CPYRWMA to operate and maintain all components of the system to ensure it is fully capable of identifying, monitoring, and forecasting potential flood conditions (CPYRWMA, 2013b).

The FWS is the only basin-wide Flood Warning System installed in the State of Alabama. It consists of 21 gauging sites in eight counties (table 51). Gauges electronically measure rainfall in increments of 0.04 inch and monitor stream water levels (stage). Base computers in the towns of New Brockton, Elba, and Geneva receive these data, which may then be disseminated in real time to local agencies and officials who use the data to forecast stream flood levels. The home base computer is located in offices provided by the Coffee County Emergency Management Agency in New Brockton, which also contributes a portion of the funding for the operation and maintenance of the system. The National Weather Service utilizes data from the FWS in determining potential flood threats for issuing flood forecasts in these river systems (CPYRWMA, 2013b).

Table 51.—CPYRWMA Flood Warning System gauges and locations.

County	FWS River Gauge Site
Barbour	Star Hill at Highway 239 South
Barbour	Texasville at Highway 131 South
Coffee	Big Creek at Highway 87 North
Coffee	Elba at Highway 84 East
Coffee	Folsom Bridge at Highway 167 North
Coffee	Lowry Mill at Highway 215
Coffee	New Brockton at 1065 McKinnon Street
Coffee	Enterprise at 137 Lester Drive
Covington	Yellow River at Highway 55 North
Covington	Yellow River at Highway 84
Dale	Ariton at U. S. Highway 231
Dale	Daleville at Highway 84 West
Dale	Newton at Highway 123 South
Dale	Skipperville at Highway 105 North
Dale	Ozark at Highway 231
Geneva	Geneva at Highway 52 East
Geneva	Sellersville at County Road 40
Henry	East Fork of Choctawhatchee River at Highway 27 East
Pike	Collegeview Building at 400 Pell Avenue, Troy, AL
Pike	Shiloh at Highway 130 West
Houston	Dothan at Brannon Stand Road

Primary areas of concern for potential flood threats in the CPYRW are the towns of Elba, Geneva, Ariton, Newton, Ozark, and Daleville. As previously mentioned, levees are in place around Elba and Geneva to provide protection from flooding. Floods or potential flood conditions that have occurred during past decades have escalated the need for modern enhancements to provide forewarnings of potential threatening flood conditions to these communities. Although the aforementioned cities and towns receive primary benefits from the FWS, all areas and communities in the CPYRW also benefit. The system is designed to provide city or county agencies with necessary information to forewarn all citizens that may be affected by potential flood conditions (CPYRWMA, 2013b). Appendix 7 provides a list of supporting agencies for the FWS by county.

The FWS is kept in a continual state of readiness. During periods of extreme weather that could pose a threat of possible flood conditions, the FWS Specialist, or someone fully capable of assisting this position, monitors the system constantly, and data from the system are distributed to the National Weather Service, local EMA offices, and other appropriate agencies. During a possible flood event, rainfall and river stage data is given to local EMA offices by telephone or by radio communications provided by the EMA network. EMA officials provide this information to the local towns or communities in their respective counties. Instructions for responding to flood threats in the FWS service area are developed by EMA staffs, county or city municipalities, and local law enforcement organizations. EMA staffs and local authorities rely on warning sirens, local radio, other news media, and personal contact

to disseminate information and instructions to the public for their response to impending flood emergencies (CPYRWMA, 2013b).

The local FWS Specialist issues no flood warnings. The National Weather Service has the formal and legal authority to monitor potential flood threats and to issue formal flood warnings in the Choctawhatchee, Pea and Yellow River systems. The National Weather Service or the respective Emergency Management Agency offices will issue all warnings or bulletins. The FWS computer in New Brockton also sends data to the CPYRWMA website (www.cpyrwma.alabama.gov). These data can be accessed through an internet connection by any EMA Director and emergency personnel. The system updates data approximately every 30 minutes and provides rainfall data and river stage levels (CPYRWMA, 2013b).

Flood Warning System training is provided by vendors when upgrades or enhancements are available for the system. Supporting agencies that benefit from the system are included in vendor training sessions. If supporting agencies are unable to attend, the CPYRWMA will provide a training session for these clients. Tailgate training is given quarterly to key clients by the Flood Warning System Specialist when visits are made to the base field sites. Flood Fighting Workshops are scheduled every two years and are conducted by the CPYRWMA. Workshops provide an opportunity for the USACE, and the AEMA to introduce and discuss new technology and programs involving methods of addressing threatening weather events. Flood Fighting Workshops train city, county, and state personnel, along with first responders and volunteers, in proper and effective flood fighting techniques, levee maintenance, flood warning response and responsible management of localized flooding. The workshops also describe how data from the CPYRWMA FWS gauges may be tracked to provide early warning to citizens and communities (CPYRWMA, 2013b). The FWS is also mentioned in the Water Monitoring section of this report. State Climatologist John Christy has recommendations on potential gauge sites for the expansion of the FWS to have a more comprehensive and efficient flood warning and mitigation structure within the CPYRW.

RECOMMENDATION

Flood preparedness should include CPYRWMA Flood Warning System expansion of rain/river gauges, with at least one gauge in each county (with exception of Bullock and Crenshaw Counties) and distribution of information during flood events to impacted stakeholders in real time. Annual flood preparedness seminars should be offered in the CPYRW, perhaps in coordination with state hurricane preparedness week.

EDUCATION

DEVELOP "RECOMMENDED WATER CONSERVATION GUIDE"

Water use and demand increases as populations increase. Therefore, a water conservation plan for more efficient and sustainable water use would aid to diminish impacts from increasing water demand (Georgia Department of Natural Resources (GDNR), 2010). Water conservation can be obtained through educating people on the benefits of reducing water use, water waste, and water loss (GDNR, 2010). Water conservation guides should focus on specific water use, including agricultural, industrial and commercial, electric generation and use, golf courses, landscape irrigation, and domestic and non-industrial public uses (GDNR, 2010). An effective water conservation plan should include the following elements: water conservation goals, benchmarks, best practices, and implementation actions (GDNR, 2010). After details of the water conservation elements are determined, a guide can be drafted and used to educate the public regarding water use and conservation. A water conservation guide may be used as a foundation for decisions regarding water use and water management (GDNR, 2010).

The first step in a water conservation guide is setting goals. Goals should be specific for water use and efficiency, yet be flexible so they are applicable to users with varying circumstances (GDNR, 2010). Goals can include: training water users through education and outreach; incentives to encourage efficient water use, enhanced data collection, monitoring, research, and evaluation of water use; measuring water-use efficiency; planning for future water needs; integrating water conservation and energy conservation; and securing funding for water conservation efforts (GDNR, 2010). Benchmarks, which measure the efficiency of the goals, should be set, and can then be used to determine the progress on long-term water conservation goals (GDNR, 2010). Best practices should provide options for practices utilized to aide in achieving benchmark goals, but not all practices are applicable for all users and should be flexible (GDNR, 2010). Implementation actions are activities that provide technical guidance or financial assistance, or evaluate general conservation trends (GDNR, 2010).

DEVELOP PLANS FOR WATERSHED EDUCATION

WEBSITE DEVELOPMENT AND ENHANCEMENT

The current website for the CPYRWMA provides history, information, and maps concerning the Choctawhatchee, Pea and Yellow Rivers watersheds, information about the Board of Directors and board meetings, the Flood Warning System, application forms, projects, and water resource studies. Recommendations for enhancement of the website include an update to HTML5 and Javascript, which allow more user-friendly and responsive site interaction (webpages adjust automatically to the device using the webpage). Graphics should be updated, with inclusions of an updated watershed map and Flood Warning System map.

LEGISLATIVE DELEGATION BRIEFING

A bulletin of activities, concerns, ongoing research, and watershed happenings could be published quarterly and delivered to legislators and municipal and county officials.

SCHOOL WATERSHED EDUCATION INITIATIVES

Education regarding the watersheds is important and should be initiated at a young age, which will allow for more increased awareness of the environment and sense of ownership of the watershed. A plan for educating children could include packets, composed of watershed information, educational activities to promote environmental stewardship, and activities for children to do with others, such as building simple watershed models to show how human actions affect environmental quality of the watersheds. The CPYRWMA is currently involved in local county groundwater festivals and should remain involved with these outreach opportunities. The CPYRWMA should also participate in the Alabama Scenic River Trail "River Kids Program."

CPYRWMA BOARD OF DIRECTORS WORKSHOP

A workshop for the CPYRWMA Board of Directors is an imperative. A workshop should include education concerning, board responsibilities and actions, government and regulatory processes, public, agricultural, and industrial water supply sources and production, basic hydrogeology, hydrology, biology, economic development, and cultural resources. Field trips should be provided to demonstrate actual examples of watershed resources and processes..

CONFERENCES AND SYMPOSIA

Conferences and/or symposia could be held either semiannually or annually and to address watershed issues and education. Invited experts would provide information on timely topics, and field excursions would provide hands-on experience of watershed resources and issues.

GOALS

Each conference and/or symposia should be linked by a common interest, such as focusing on one goal for each conference and/or symposia, with the intent of educating the public on issues related to the watersheds.

TARGET AUDIENCE

The target audience for each conference and/or symposia should be decided upon during the determination of the agenda. Target audiences can includes decision makers, students, citizens, and professionals.

INTERAGENCY EFFORTS

Interagency cooperation and participation provides information and resources to address issues impacting the CPYRW. See Appendix 8 for a list of supporting agencies and involved stakeholders of the CPYRWMA.

INFORMATION DISTRIBUTION PLAN

Information concerning the CPYRW can be distributed in numerous ways including printed matter, verbal presentations through meetings and press events, symposia, and internet and other social media. Development of an information distribution strategy and plan should be considered.

ARTIFACT HUNTING

Archaeological artifacts, both historic and pre-historic, are important indicators of peoples and cultures that inhabited the land in the past. Archaeological sites in the CPYRW are primarily characterized by aboriginal (human, animal, and plant inhabitants prior to colonization or introduction of species) artifacts (Cook and others, 2002). Artifact hunting should be restricted to professionals only, who know how to properly preserve historical artifacts. The CPYRW, can include a topic on artifact hunting in a bulletin or as part of an educational series or symposium to educate the public on proper protocols regarding artifacts.

RECOMMENDATION

The educational topics discussed above are recommendations. In order to implement a CPYRWMA education program—including developing a "Water Conservation Guide," offering training sessions, conferences and symposia, establishing an information distribution system, and providing cultural resources education—additional legislative funding should be requested by CPYRWMA. A CPYRWMA educational program should be coordinated with cooperating entities such as ADEM, ADECA OWR, AFC, ADCNR, USDA NRCS, GSA, ARWA, ADAI, and Troy University.

POLICY OPTIONS

A comprehensive state water management plan should include educational components including water availability and conservation to be implemented on the local level.

EMERGING ISSUES

Emerging issues in the watershed include interbasin transfers, water reuse, water conservation or instream flows, agricultural tax credits, permitting, metering, water quality standards, Flood Warning Systems, and riparian versus nonriparian issues. These issues are discussed throughout this WMP but should be addressed by the CPYRWMA in detail in the future.

CONCLUSION

The management of watersheds in Alabama has historically been based on the abundance of natural resources, including plants, wildlife, minerals, and water, and very little strategic planning for future conservation, protection and use was needed. However, impacts of population growth, industrial development, and climate require a more organized prudent approach guided by scientific knowledge and a realization that watershed resources are finite.

By utilizing the "watershed management authority" concept, the Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority (CPYRWMA) conducted vast water resource scientific assessments along with numerous remediation and educational projects, created involvements with stakeholders, and partnered with local, state, and federal water-related entities, all of which resulted in this comprehensive Watershed Management Plan. It represents the best available current science and will be updated annually to include new data for each addressed topic.

The document contains current information concerning protection, development, and management of the natural resources in the Choctawhatchee, Pea and Yellow River Watersheds. In each of the 32 categories contained in the Watershed Management Plan, recommendations for action items pertaining to each issue as well as policy development options are provided.

For 24 years, the CPYRWMA has been a leader in promoting and addressing natural resource issues to ensure the citizens of southeast Alabama continue to enjoy a quality of life enhanced by sustainable natural resources. This Watershed Management Plan is an important tool that will provide valuable information needed for future strategic planning for the watersheds of southeast Alabama.

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APPENDIX 1.

CHOCTAWHATCHEE, PEA AND YELLOW RIVERS WATERSHED MANAGEMENT AUTHORITY WATERSHED MANAGEMENT PLAN ADVISORY COMMITTEE

1. Stan Cook, Fisheries Division, Department of Conservation & Natural Resources (ADCNR)
2. Lynn Sisk, Alabama Department of Environmental Management (ADEM)
3. Chris Johnson, ADEM
4. Mark Sport, ADEM
5. Glen Zorn, Department of Agriculture & Industries (ADAI)
6. John Christy, Alabama State Climatologist
7. Tom Littlepage, Alabama Department of Economic and Community Affairs Office of Water Resources (ADECA OWR)
8. Mitch Reid, Alabama Rivers Alliance
9. Kathy Horne, Alabama Rural Water Association (ARWA)
10. Nick Granger, Alabama Forestry Commission (AFC)
11. Mike Kensler, Auburn Water Institute
12. Billy Mayes, Utilities Manager, City of Dothan, AL
13. Randy Morris, General Services Director, City of Dothan, AL
14. Representative Alan Boothe, Choctawhatchee, Pea, and Yellow Rivers Water Management Authority (CPYRWMA)
15. Barbara Gibson, CPYRWMA
16. Bennett Bearden, University of Alabama Water Policy and Law Institute
17. Pat O'Neil, Geological Survey of Alabama (GSA)
18. Marlon Cook, GSA
19. Mike Mullen, Choctawhatchee Riverkeeper
20. Dr. Jack Mills
21. Don Hallford, CPYRWMA
22. Randolph Hall, CPYRWMA
23. Jack Pelfrey, CPYRWMA
24. Carl Garner, CPYRWMA
25. Ken Weathers, Fisheries Division-Dept. of Conservation & Natural Resources
26. George Marodis, Alabama Rural Water Association

APPENDIX 2.

DETAILED LAND USE CLASSES AND PERCENTAGES FOR THE CHOCTAWHATCHEE, PEA AND YELLOW RIVERS WATERSHED STUDY AREA

2013 Cropland Data Layer

(from USDA National Agricultural Statistics Service Cropland Data Layer, 2013)

Class	Cell Size (30x30)	Count	Area (m^2)	Area (mi^2)	Percentage (%)
Alfalfa	900	55	49,500	0.0	0.0
Aquaculture	900	5	4,500	0.0	0.0
Background	900	1,225	1,102,500	0.4	0.0
Barren	900	2,971	2,673,900	1.0	0.0
Blueberries	900	5	4,500	0.0	0.0
Corn	900	96,272	86,644,800	33.5	0.9
Cotton	900	368,319	331,487,100	128.0	3.5
Cucumbers	900	1	900	0.0	0.0
Dbl Crop Corn/Soybeans	900	9	8,100	0.0	0.0
Dbl Crop Oats/Corn	900	987	888,300	0.3	0.0
Dbl Crop Soybeans/Oats	900	569	512,100	0.2	0.0
Dbl Crop WinWht/Corn	900	478	430,200	0.2	0.0
Dbl Crop WinWht/Cotton	900	23,399	21,059,100	8.1	0.2
Dbl Crop WinWht/Sorghum	900	4,467	4,020,300	1.6	0.0
Dbl Crop WinWht/Soybeans	900	11,054	9,948,600	3.8	0.1
Deciduous Forest	900	1,385,903	1,247,312,700	481.6	13.2
Developed/High Intensity	900	14,074	12,666,600	4.9	0.1
Developed/Low Intensity	900	104,795	94,315,500	36.4	1.0
Developed/Med Intensity	900	31,609	28,448,100	11.0	0.3
Developed/Open Space	900	504,204	453,783,600	175.2	4.8
Dry Beans	900	1	900	0.0	0.0
Evergreen Forest	900	3,267,923	2,941,130,700	1,135.6	31.2
Fallow/Idle Cropland	900	506,622	455,959,800	176.0	4.8
Grassland/Pasture	900	870,783	783,704,700	302.6	8.3
Herbaceous Wetlands	900	2,235	2,011,500	0.8	0.0
Herbs	900	5,663	5,096,700	2.0	0.1
Millet	900	8,057	7,251,300	2.8	0.1
Mixed Forest	900	646,356	581,720,400	224.6	6.2
Oats	900	3,898	3,508,200	1.4	0.0
Open Water	900	82,602	74,341,800	28.7	0.8
Other Crops	900	818	736,200	0.3	0.0
Other Hay/Non Alfalfa	900	469,937	422,943,300	163.3	4.5
Peanuts	900	279,745	251,770,500	97.2	2.7
Peas	900	792	712,800	0.3	0.0
Pecans	900	3,063	2,756,700	1.1	0.0
Rye	900	936	842,400	0.3	0.0
Shrubland	900	1,298,916	1,169,024,400	451.4	12.4
Sod/Grass Seed	900	6,493	5,843,700	2.3	0.1
Sorghum	900	5,898	5,308,200	2.0	0.1
Soybeans	900	21,590	19,431,000	7.5	0.2
Sweet Potatoes	900	37	33,300	0.0	0.0
Tomatoes	900	7	6,300	0.0	0.0
Watermelons	900	35	31,500	0.0	0.0
Winter Wheat	900	12,600	11,340,000	4.4	0.1
Woody Wetlands	900	419,299	377,369,100	145.7	4.0
Total		**10,464,707**	**9,418,236,300**	**3,636.4**	**100**

2011 National Land Cover Data

(from Jin and others, 2013)

NLCD 2011 Classes	Cell Size (30x30)	Count	Area (m^2)	Area (mi^2)	Percentage (%)
Woody Wetlands	900	618,174	556,356,600	214.8	5.9
Shrub/Scrub	900	1,527,973	1,375,175,700	531.0	14.6
Open Water	900	89,776	80,798,400	31.2	0.9
Mixed Forest	900	873,763	786,386,700	303.6	8.3
Herbaceous	900	234,005	210,604,500	81.3	2.2
Hay/Pasture	900	1,138,106	1,024,295,400	395.5	10.9
Evergreen Forest	900	2,740,105	2,466,094,500	952.2	26.2
Emergent Herbaceous Wetlands	900	36,393	32,753,700	12.6	0.3
Developed, Open Space	900	526,919	474,227,100	183.1	5.0
Developed, Medium Intensity	900	41,116	37,004,400	14.3	0.4
Developed, Low Intensity	900	112,919	101,627,100	39.2	1.1
Developed, High Intensity	900	15,742	14,167,800	5.5	0.2
Deciduous Forest	900	1,319,477	1,187,529,300	458.5	12.6
Cultivated Crops	900	1,180,771	1,062,693,900	410.3	11.3
Barren Land	900	9,468	8,521,200	3.3	0.1
Total		**10,464,707**	**9,418,236,300**	**3,636.4**	**100**

APPENDIX 3.

PUBLIC WATER SUPPLIERS

County	Permit Number	Water Authority	Well Name
Barbour	AL0000079	Bakerhill Water Authority	Well #10, 500 gpm
Barbour	AL0000079	Bakerhill Water Authority	Well 9
Barbour	AL0000079	Bakerhill Water Authority	Well 8
Barbour	AL0000079	Bakerhill Water Authority	Well 7
Barbour	AL0000079	Bakerhill Water Authority	Well #6, 500 gpm
Barbour	AL0000079	Bakerhill Water Authority	Well #5, 600 gpm (White Oak Hill)
Barbour	AL0000079	Bakerhill Water Authority	Well #4, 400 gpm
Barbour	AL0000079	Bakerhill Water Authority	Well #3, 325 gpm
Barbour	AL0000079	Bakerhill Water Authority	Well 2
Barbour	AL0000079	Bakerhill Water Authority	Well 1
Barbour	AL0000081	Blue Springs Water Works	Well #2, 125 gpm
Barbour	AL0000081	Blue Springs Water Works	Well
Barbour	AL0000082	Clayton Water Works & Sewer	Well #2, 160 gpm
Barbour	AL0000082	Clayton Water Works & Sewer	Well #4, 700 gpm
Barbour	AL0000082	Clayton Water Works & Sewer	Well #3, 200 gpm
Barbour	AL0000083	Clio Water Works	Well #4, 700 gpm
Barbour	AL0000083	Clio Water Works	Well #3, 180 gpm
Barbour	AL0000083	Clio Water Works	Well 2
Barbour	AL0000084	Eufaula Youth Center	Well
Barbour	AL0000085	Eufaula Water Works	Well #8, 725 gpm
Barbour	AL0000085	Eufaula Water Works	Well #7, 670 gpm
Barbour	AL0000085	Eufaula Water Works	Well #6, 500 gpm
Barbour	AL0000085	Eufaula Water Works	Well #5, 565 gpm
Barbour	AL0000085	Eufaula Water Works	Well #4, 525 gpm
Barbour	AL0000085	Eufaula Water Works	Well #3, 525 gpm
Barbour	AL0000085	Eufaula Water Works	Well #2, 550 gpm
Barbour	AL0000085	Eufaula Water Works	Well 1
Barbour	AL0000086	Elamville Water Authority	Well 2
Barbour	AL0000086	Elamville Water Authority	Well 1
Barbour	AL0000087	West Barbour County Water Authority	Well #2, 200 gpm
Barbour	AL0000087	West Barbour County Water Authority	Well #1, 150 gpm
Barbour	AL0000088	Louisville Water Works	Well #2, 180 gpm
Barbour	AL0000088	Louisville Water Works	Well #1, 210 gpm
Barbour	AL0001460	Cowikee Water Authority	Well #2, 85 gpm
Barbour	AL0001460	Cowikee Water Authority	Well #1, 140 gpm
Barbour	AL0001688	Paragon Panels of Alabama	Well 2 (Front of Plant)
Barbour	AL0001688	Paragon Panels of Alabama	Well 1 (Old Well)
Barbour	AL0001794	Equity Group–Eufaula Division, LLC	Well 4
Barbour	AL0001794	Equity Group–Eufaula Division, LLC	Well 3
Barbour	AL0001794	Equity Group–Eufaula Division, LLC	Well 2
Barbour	AL0001794	Equity Group–Eufaula Division, LLC	Well 1
Bullock	AL0000116	Midway Water Works	Well 2 (Smith)
Bullock	AL0000116	Midway Water Works	Well 3 (Layne)
Bullock	AL0000117	South Bullock County Water Authority	Simsville Well
Bullock	AL0000117	South Bullock County Water Authority	Peachburg Well
Bullock	AL0000117	South Bullock County Water Authority	Halls Crossroads Well
Bullock	AL0000117	South Bullock County Water Authority	Sardis Well
Bullock	AL0000117	South Bullock County Water Authority	Greenwood Well
Bullock	AL0000118	Union Springs Utility Board	Well 2A
Bullock	AL0000118	Union Springs Utility Board	Well 5
Bullock	AL0000118	Union Springs Utility Board	Well 4
Bullock	AL0000118	Union Springs Utility Board	Well 3
Bullock	AL0000118	Union Springs Utility Board	Well 2

County	Permit Number	Water Authority	Well Name
Coffee	AL0000292	Pilgrims Pride Corp. of Delaware	Well 2 on Hwy. 14
Coffee	AL0000292	Pilgrims Pride Corp. of Delaware	Well 1 In Plant Yard
Coffee	AL0000293	Curtis Water & Fire Pro Authority	Well 2
Coffee	AL0000294	Damascus Water Works	Well
Coffee	AL0000295	Elba Water Works	Well #6, 500 gpm
Coffee	AL0000295	Elba Water Works	Well #5, 600 gpm
Coffee	AL0000295	Elba Water Works	Well #4, 603 gpm
Coffee	AL0000295	Elba Water Works	Well #3, 440 gpm
Coffee	AL0000295	Elba Water Works	Well 2
Coffee	AL0000295	Elba Water Works	Well 1
Coffee	AL0000296	Enterprise Water Works	Well 15 Hwy. 134
Coffee	AL0000296	Enterprise Water Works	County Rd. 601 Well #13, 1,000 gpm
Coffee	AL0000296	Enterprise Water Works	Double Bridges Well, 1,000 gpm
Coffee	AL0000296	Enterprise Water Works	Macedonia Well #2, 400 gpm
Coffee	AL0000296	Enterprise Water Works	Macedonia Well #1, 350 gpm
Coffee	AL0000296	Enterprise Water Works	Shellfield Rd. Well, 750 gpm
Coffee	AL0000296	Enterprise Water Works	Hunters Ridge Well, 1,000 gpm
Coffee	AL0000296	Enterprise Water Works	Goodman Well #2, 300 gpm
Coffee	AL0000296	Enterprise Water Works	Goodman Well 1
Coffee	AL0000296	Enterprise Water Works	Cotton Gin Well, 750 gpm
Coffee	AL0000296	Enterprise Water Works	Airport Well, 750 gpm
Coffee	AL0000296	Enterprise Water Works	Moates Rd. Well, 750 gpm
Coffee	AL0000296	Enterprise Water Works	Rucker Blvd. Well, 750 gpm
Coffee	AL0000296	Enterprise Water Works	Highway 167 Well, 650 gpm
Coffee	AL0000296	Enterprise Water Works	Daleville Well, 750 gpm
Coffee	AL0000296	Enterprise Water Works	Bypass Well, 750 gpm
Coffee	AL0000296	Enterprise Water Works	Railroad St. Well, 430 gpm
Coffee	AL0000296	Enterprise Water Works	North Main St. Well, 500 gpm
Coffee	AL0000297	Wayne Farms LLC	Well 2
Coffee	AL0000297	Wayne Farms LLC	Well 1
Coffee	AL0000298	Jack Water System, Inc.	Well #1, 135 gpm
Coffee	AL0000299	Kinston Water Works	Well 2
Coffee	AL0000299	Kinston Water Works	Well #1, 90 gpm
Coffee	AL0000301	Mt Pleasant-Batten Water Works Board	Well 2 Mt. Pleasant Well
Coffee	AL0000301	Mt Pleasant-Batten Water Works Board	Well 1 Battens Well
Coffee	AL0000302	New Brockton Water Department	Well #5, 150 gpm
Coffee	AL0000302	New Brockton Water Department	Well #4, 400 gpm
Coffee	AL0000302	New Brockton Water Department	Well #6, 400 gpm
Coffee	AL0000302	New Brockton Water Department	Well #3, 290 gpm
Coffee	AL0000302	New Brockton Water Department	Well 2
Coffee	AL0000303	New Hope Water System (Coffee Co.)	Well #1, 200 gpm
Coffee	AL0001639	Skelly Aaf	Well
Coffee	AL0001789	Coffee County Water Authority	Well #5 (New Hope), 200 gpm
Coffee	AL0001789	Coffee County Water Authority	Well #2, 500 gpm
Coffee	AL0001789	Coffee County Water Authority	Well #1, 100 gpm
Coffee	AL0001789	Coffee County Water Authority	Well #3, 350 gpm
Coffee	AL0001789	Coffee County Water Authority	Well #4, 400 gpm
Covington	AL0000356	Andalusia (Utilities Board of)	Well #13 North Pinewood Rd
Covington	AL0000356	Andalusia (Utilities Board of)	Well #12, 1100 gpm
Covington	AL0000356	Andalusia (Utilities Board of)	Well #11, 1100 gpm
Covington	AL0000356	Andalusia (Utilities Board of)	Well #10, 1100 gpm
Covington	AL0000356	Andalusia (Utilities Board of)	Well #4, 530 gpm
Covington	AL0000356	Andalusia (Utilities Board of)	Well #5, 480 gpm
Covington	AL0000356	Andalusia (Utilities Board of)	Well #9, 825 gpm
Covington	AL0000356	Andalusia (Utilities Board of)	Well #6, 850 gpm
Covington	AL0000356	Andalusia (Utilities Board of)	Well #7, 630 gpm

County	Permit Number	Water Authority	Well Name
Covington	AL0000356	Andalusia (Utilities Board of)	Well #8, 730 gpm
Covington	AL0000358	Johnston Textiles, Inc., Micolas Mill	Well
Covington	AL0000359	Florala Rest Area (U.S. 331)	Well
Covington	AL0000361	Covington County Water Authority	Wing Well, 120 gpm
Covington	AL0000361	Covington County Water Authority	Loango Well, 290 gpm
Covington	AL0000361	Covington County Water Authority	Antioch Well, 500 gpm
Covington	AL0000361	Covington County Water Authority	Onycha Well, 250 gpm
Covington	AL0000361	Covington County Water Authority	Boykin Well, 230 gpm
Covington	AL0000361	Covington County Water Authority	Rose Hill Well, 530 gpm
Covington	AL0000363	Florala Water Works & Sewer Board	Well #2, 265 gpm
Covington	AL0000363	Florala Water Works & Sewer Board	Well #3, 580 gpm
Covington	AL0000372	Lockhart Water Works	Little Well, 145 gpm
Covington	AL0000372	Lockhart Water Works	Big Well, 250 gpm
Covington	AL0000375	Opp Utilities Board	Friendship Well, 1,000 gpm
Covington	AL0000375	Opp Utilities Board	Us Hwy 84 Well, 1,000 gpm
Covington	AL0000375	Opp Utilities Board	8Th Street Well, 151 gpm
Covington	AL0000375	Opp Utilities Board	Us Hwy 331 Well, 250 gpm
Covington	AL0000375	Opp Utilities Board	Park Well, 185 gpm
Covington	AL0000375	Opp Utilities Board	Monroe Well, 230 gpm
Covington	AL0000377	Pleasant Home School	Well 1
Covington	AL0000377	Pleasant Home School	Well 2
Covington	AL0000378	Red Level Water Works	Well #1, 150 gpm
Covington	AL0000379	River Falls Water System	Well #1, 200 gpm
Covington	AL0000593	Solon Dixon Forestry Education Center	Well 2/Stand-By Well
Covington	AL0000593	Solon Dixon Forestry Education Center	Well 1
Covington	AL0001499	Crs Water, Inc.	Well 2
Covington	AL0001499	Crs Water, Inc.	Well 1
Crenshaw	AL0000385	Brantley Water Works	Well # 1
Crenshaw	AL0000387	Dozier Water Works	Well # 1
Crenshaw	AL0000388	Glenwood Water Works	Well
Crenshaw	AL0000390	Luverne Water & Sewer Department	Well # 3
Crenshaw	AL0000390	Luverne Water & Sewer Department	Well # 2
Crenshaw	AL0000390	Luverne Water & Sewer Department	Well # 1
Crenshaw	AL0000392	Rutledge Water Works	Well # 2 (Co Rd 35)
Crenshaw	AL0000392	Rutledge Water Works	Well # 1 (City Hall)
Crenshaw	AL0000397	South Crenshaw County Water Authority	Mt. Ida Well (Well #5)
Crenshaw	AL0000397	South Crenshaw County Water Authority	Leon Well (Well #4)
Crenshaw	AL0000397	South Crenshaw County Water Authority	Bullock Well #2 (Well #3)
Crenshaw	AL0000397	South Crenshaw County Water Authority	North Well (Well # 2)
Crenshaw	AL0000397	South Crenshaw County Water Authority	Bullock Well #1 (Well #1)
Crenshaw	AL0001508	Quint-Mar Water Authority	Well # 7 (Hwy. 331- Deep Well)
Crenshaw	AL0001508	Quint-Mar Water Authority	Well # 1 (Centenary Rd)
Crenshaw	AL0001508	Quint-Mar Water Authority	Well # 6 (Quail Tower Rd)
Crenshaw	AL0001508	Quint-Mar Water Authority	Well # 5 (Lapine) (Air Gap)
Crenshaw	AL0001508	Quint-Mar Water Authority	Well # 4 (Petry)
Crenshaw	AL0001508	Quint-Mar Water Authority	Well # 3 (Ballard Rd.)
Crenshaw	AL0001508	Quint-Mar Water Authority	Well # 2 (Gear Dr.)
Dale	AL0000415	Dale County Water Authority	Mt Hebron Well, 260 gpm
Dale	AL0000415	Dale County Water Authority	Dillard Well, 460 gpm
Dale	AL0000415	Dale County Water Authority	Bertha Well, 300 gpm
Dale	AL0000415	Dale County Water Authority	Echo Well, 500 gpm
Dale	AL0000416	Ariton Water Works	Well #3, 90 gpm
Dale	AL0000416	Ariton Water Works	Well #1, 90 gpm
Dale	AL0000416	Ariton Water Works	Well #2, 215 gpm
Dale	AL0000420	Daleville Water & Sewer Board	Well #4, 700 gpm
Dale	AL0000420	Daleville Water & Sewer Board	Well #3, 750 gpm
Dale	AL0000420	Daleville Water & Sewer Board	Well #2, 500 gpm

County	Permit Number	Water Authority	Well Name
Dale	AL0000420	Daleville Water & Sewer Board	Well #1, 400 gpm
Dale	AL0000422	Dogwood Acres Trailer Court	Well 3
Dale	AL0000422	Dogwood Acres Trailer Court	Well 2
Dale	AL0000436	Level Plains Water System	Well #2, 190 gpm
Dale	AL0000436	Level Plains Water System	Well #1, 180 gpm
Dale	AL0000436	Level Plains Water System	Well #4, 300 gpm
Dale	AL0000436	Level Plains Water System	Well #3, 200 gpm
Dale	AL0000438	Midland City Water Department	Well #3, 400 gpm
Dale	AL0000438	Midland City Water Department	Well #2, 400 gpm
Dale	AL0000438	Midland City Water Department	Well 1 (Inactive)
Dale	AL0000439	Newton Water Works Board	Well #2, 360 gpm
Dale	AL0000439	Newton Water Works Board	Well #1, 260 gpm
Dale	AL0000441	Ozark Utilities Board	Well #9, 1,500 gpm
Dale	AL0000441	Ozark Utilities Board	Well #8, 750 gpm
Dale	AL0000441	Ozark Utilities Board	Well #7, 1,059 gpm
Dale	AL0000441	Ozark Utilities Board	Well #5, 750 gpm
Dale	AL0000441	Ozark Utilities Board	Well #4, 584 gpm
Dale	AL0000441	Ozark Utilities Board	Well #3, 735 gpm
Dale	AL0000441	Ozark Utilities Board	Well #2, 700 gpm
Dale	AL0000441	Ozark Utilities Board	Well #6, 750 gpm
Dale	AL0000443	Pinckard Water Department	Mcnab Lane Well, 600 gpm
Dale	AL0000443	Pinckard Water Department	Highway 134 Well, 300 gpm
Dale	AL0001489	Fort Rucker–American Water	Well #9, 500 gpm
Dale	AL0001489	Fort Rucker–American Water	Well #7, 1,000 gpm
Dale	AL0001489	Fort Rucker–American Water	Well #6, 500 gpm
Dale	AL0001489	Fort Rucker–American Water	Well #3, 350 gpm
Dale	AL0001489	Fort Rucker–American Water	Well #11, 500 gpm
Dale	AL0001489	Fort Rucker–American Water	Well #10, 500 gpm
Dale	AL0001489	Fort Rucker–American Water	Well #8, 500 gpm
Dale	AL0001630	Ech Aaf	Well
Dale	AL0001637	Lowe Aaf	Well
Dale	AL0001719	Range Control	Well
Dale	AL0001800	Lake Tholocco Recreation Area–American	Wildlife Well
Dale	AL0001800	Lake Tholocco Recreation Area–American	Engineer Beach Well
Dale	AL0001800	Lake Tholocco Recreation Area–American	West Beach Well 2
Dale	AL0001800	Lake Tholocco Recreation Area–American	West Beach Well 1
Dale	AL0001800	Lake Tholocco Recreation Area–American	East Beach Well 2
Dale	AL0001800	Lake Tholocco Recreation Area–American	East Beach Well 1
Dale	AL0001800	Lake Tholocco Recreation Area-American	Singing Pines Well 1
Dale	AL0001800	Lake Tholocco Recreation Area-American	Singing Pines Well 2
Dale	AL0001802	Forward Operating Base	Ttb–Well 2
Dale	AL0001802	Forward Operating Base	Fob–Well
Dale	AL0001804	Training Area-15	Well
Geneva	AL0000615	Black Water Works	Well #1, 100 gpm
Geneva	AL0000617	Camp Victory	Well 3
Geneva	AL0000617	Camp Victory	Well 1
Geneva	AL0000618	Coffee Springs Water System	Well #3, 100 gpm
Geneva	AL0000619	CMI, Inc. (Clinton Mills)	Well
Geneva	AL0000621	Merle Wallace Purvis Center	Well 1
Geneva	AL0000622	Geneva Water Works	Well #4A, 300 gpm

County	Permit Number	Water Authority	Well Name
Geneva	AL0000622	Geneva Water Works	Well #8, 300 gpm
Geneva	AL0000622	Geneva Water Works	Well #7, 500 gpm
Geneva	AL0000622	Geneva Water Works	Well #6, 330 gpm
Geneva	AL0000622	Geneva Water Works	Well #2A, 280 gpm
Geneva	AL0000622	Geneva Water Works	Well #5, 285 gpm
Geneva	AL0000622	Geneva Water Works	Well 4
Geneva	AL0000622	Geneva Water Works	Well 3
Geneva	AL0000624	Hartford Water Works	Well #3, 350 gpm
Geneva	AL0000624	Hartford Water Works	Well #2, 300 gpm
Geneva	AL0000624	Hartford Water Works	Well #1, 300 gpm
Geneva	AL0000626	Malvern Water Department	Well #2, 100 gpm
Geneva	AL0000626	Malvern Water Department	Well #1, 100 gpm
Geneva	AL0000628	Samson Water Works	Well #2, 350 gpm
Geneva	AL0000628	Samson Water Works	Well #1, 420 gpm
Geneva	AL0000629	Slocomb Water Works And Sewer Board	Well #4, 550 gpm
Geneva	AL0000629	Slocomb Water Works And Sewer Board	Well 2
Geneva	AL0000629	Slocomb Water Works And Sewer Board	Well #3, 350 gpm
Geneva	AL0000633	North Geneva County Water Authority	Well #1, 100 gpm
Geneva	AL0000646	Geneva Motel	Well
Geneva	AL0001533	Bellwood Water & Fire Auth.	Well #1
Geneva	AL0001633	High Bluff Aaf	Well
Geneva	AL0001642	Tac-X Aaf	Tac-X Well
Henry	AL0000657	Abbeville Water Works & Sewer Board	Well #6, 450 gpm
Henry	AL0000657	Abbeville Water Works & Sewer Board	Well #5, 457 gpm
Henry	AL0000657	Abbeville Water Works & Sewer Board	Well #4, 385 gpm
Henry	AL0000657	Abbeville Water Works & Sewer Board	Well #3, 305 gpm
Henry	AL0000657	Abbeville Water Works & Sewer Board	Well #2, 350 gpm
Henry	AL0000663	Henry County Water Authority	Well 6
Henry	AL0000663	Henry County Water Authority	Haleburg Well
Henry	AL0000663	Henry County Water Authority	Well #3, 400 gpm
Henry	AL0000663	Henry County Water Authority	Well #2, 400 gpm
Henry	AL0000663	Henry County Water Authority	Well #1, 400 gpm
Henry	AL0000663	Henry County Water Authority	Well #4, 400 gpm
Henry	AL0000663	Henry County Water Authority	Well #5, 400 gpm
Henry	AL0000664	Headland Water Works	Well #4, 500 gpm
Henry	AL0000664	Headland Water Works	Well #1, 135 gpm Emergency
Henry	AL0000664	Headland Water Works	Well #3, 500 gpm
Henry	AL0000664	Headland Water Works	Well #2, 500 gpm
Henry	AL0000666	Newville Water System	Well #2
Henry	AL0001555	Ala. Warehouse/Lower Pool #2	Well
Houston	AL0000671	Ashford Water Works	Well 3
Houston	AL0000671	Ashford Water Works	Well 2
Houston	AL0000671	Ashford Water Works	Well #5, 400 gpm
Houston	AL0000671	Ashford Water Works	Well #4, 350 gpm
Houston	AL0000673	Farley Nuclear Construction Site	Well 1
Houston	AL0000673	Farley Nuclear Construction Site	Well 2
Houston	AL0000676	Columbia Water Works	Well #1, 350 gpm
Houston	AL0000677	Cottonwood Water Works	Well #2, 250 gpm
Houston	AL0000677	Cottonwood Water Works	Well #1, 350 gpm
Houston	AL0000677	Cottonwood Water Works	Well #3, 300 gpm
Houston	AL0000678	Cowarts Water System	Well #3, 400 gpm
Houston	AL0000678	Cowarts Water System	Well #2, 400 gpm
Houston	AL0000678	Cowarts Water System	Well #1, 200 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #35–Denton Road, 1,500 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #34–Faulker Road, 1,500 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #33, 1500 gpm

County	Permit Number	Water Authority	Well Name
Houston	AL0000681	Dothan Utilities (City of)	Well #29–Landmark Park, 1,500 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #28–Beverlye School, 750 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #30–Westgate Park, 550 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #27, 800 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #S4, 300 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #S3, 400 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #4–Napier Field, 445 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #25–John Odom Dr., 775 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #22–Napier Field Rd, 580 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #15–Twitchell Rd, 400 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #12–Greentree Ave, 450 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #S2, 400 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #S1, 360 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #2–Napier Field, 355 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #26–Westgate Parkway, 760 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #24–Oakdale Circle, 760 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #23 Industrial Park, 800 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #21–Hodgesville Rd, 500 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #20–Plum St, 580 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #17–E Spring St, 500 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #16–Tate & Moates St, 450 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #14–Cottonwood Rd, 500 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #13–Hwy 84 E, 500 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #11–S Alice St, 445 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #10–S Cherokee Ave, 400 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #9–W. Powell St, 400 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #S7–Washington, 400 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #32, 1,500 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #31, 1,500 gpm
Houston	AL0000681	Dothan Utilities (City of)	Well #S5, 400 gpm
Houston	AL0000685	Gordon Water Works	Well #2, 250 gpm
Houston	AL0000686	Harmon School/Houston Co Board of Education	Well
Houston	AL0000689	Kinsey Water System	Well #2, 500 gpm
Houston	AL0000689	Kinsey Water System	Well 1
Houston	AL0000702	Taylor Water System	Well #2, 1,000 gpm
Houston	AL0000702	Taylor Water System	Well #1, 600 gpm
Houston	AL0000708	Webb Water System	Well #3, 300 gpm
Houston	AL0000708	Webb Water System	Well #2, 100 gpm
Houston	AL0000708	Webb Water System	Well #1, 100 gpm
Houston	AL0000709	Wicksburg School/Houston Co Board of Education	Smith Well
Houston	AL0001491	Farley Nuclear Plant	Production Well # 4
Houston	AL0001491	Farley Nuclear Plant	Construction Well 2 (West)
Houston	AL0001491	Farley Nuclear Plant	Construction Well 1 (East)
Houston	AL0001491	Farley Nuclear Plant	Production Well 3
Houston	AL0001491	Farley Nuclear Plant	Production Well 1
Houston	AL0001491	Farley Nuclear Plant	Production Well 2
Houston	AL0001549	West Bank Damsite/George W Andrews	Well
Houston	AL0001628	Allen Aaf	Well
Houston	AL0001643	Toth Field	Well
Houston	AL0001755	Houston County Water Authority	Well #1, 1,000 gpm
Pike	AL0001108	Banks Water System	Well # 1 @ Tank

County	Permit Number	Water Authority	Well Name
Pike	AL0001110	Brundidge Water Department	County Road 6 Well
Pike	AL0001110	Brundidge Water Department	College Street Well
Pike	AL0001110	Brundidge Water Department	Elm Street Well
Pike	AL0001114	Goshen Water Works	Well 1
Pike	AL0001120	Pike County Water Authority	Well 9–Crawley Well (U.S. Hwy. 29)
Pike	AL0001120	Pike County Water Authority	Well 8–Elam Rodgers Well
Pike	AL0001120	Pike County Water Authority	Well 7 Sandfield Well (Cr 6611)
Pike	AL0001120	Pike County Water Authority	Well 6 Mt. Carmel Well (Cr 5521)
Pike	AL0001120	Pike County Water Authority	Well 5 Spring Hill Well (Cr 2262)
Pike	AL0001120	Pike County Water Authority	Well 4 Orion Well (Cr 7715)
Pike	AL0001120	Pike County Water Authority	Well 3 Josie/Enon Well (Cr 6631)
Pike	AL0001120	Pike County Water Authority	Well 2 Senn Well
Pike	AL0001120	Pike County Water Authority	Well 1 Carter Well (AL Hwy. 29)
Pike	AL0001124	Troy Utilities (City of)	Well 9–Sportsplex–Enzor Rd
Pike	AL0001124	Troy Utilities (City of)	Well 5 (Scheduled To Be Abandoned)
Pike	AL0001124	Troy Utilities (City of)	Well 4–Franklin Dr.
Pike	AL0001124	Troy Utilities (City of)	Well 3–Park St.
Pike	AL0001124	Troy Utilities (City of)	Well 2 (Properly Abandoned In 1997)
Pike	AL0001124	Troy Utilities (City of)	Well 1 (Properly Abandoned In 1997)
Pike	AL0001124	Troy Utilities (City of)	Well 8–Baron
Pike	AL0001124	Troy Utilities (City of)	Well 7–Brazzwell
Pike	AL0001124	Troy Utilities (City of)	Well 6–Industrial Park

APPENDIX 4.

USEPA LIST OF WATER-QUALITY CONTAMINANTS

(from USEPA, 2009)

National Primary Drinking Water Regulations

Contaminant		MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
OC	Acrylamide	TT[4]	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/ wastewater treatment	zero
OC	Alachlor	0.002	Eye, liver, kidney or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops	zero
R	Alpha/photon emitters	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation	zero
IOC	Antimony	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	0.006
IOC	Arsenic	0.010	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards; runoff from glass & electronics production wastes	0
IOC	Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits	7 MFL
OC	Atrazine	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops	0.003
IOC	Barium	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	2
OC	Benzene	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills	zero
OC	Benzo(a)pyrene (PAHs)	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines	zero
IOC	Beryllium	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries	0.004
R	Beta photon emitters	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation	zero
DBP	Bromate	0.010	Increased risk of cancer	Byproduct of drinking water disinfection	zero
IOC	Cadmium	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints	0.005
OC	Carbofuran	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa	0.04
OC	Carbon tetrachloride	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities	zero
D	Chloramines (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort; anemia	Water additive used to control microbes	MRDLG=4[1]
OC	Chlordane	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide	zero
D	Chlorine (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort	Water additive used to control microbes	MRDLG=4[1]
D	Chlorine dioxide (as ClO_2)	MRDL=0.8[1]	Anemia; infants, young children, and fetuses of pregnant women: nervous system effects	Water additive used to control microbes	MRDLG=0.8[1]
DBP	Chlorite	1.0	Anemia; infants, young children, and fetuses of pregnant women: nervous system effects	Byproduct of drinking water disinfection	0.8
OC	Chlorobenzene	0.1	Liver or kidney problems	Discharge from chemical and agricultural chemical factories	0.1
IOC	Chromium (total)	0.1	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits	0.1
IOC	Copper	TT[5]; Action Level = 1.3	Short-term exposure: Gastrointestinal distress. Long-term exposure: Liver or kidney damage. People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits	1.3
M	*Cryptosporidium*	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero

LEGEND

- D — Disinfectant
- DBP — Disinfection Byproduct
- IOC — Inorganic Chemical
- M — Microorganism
- OC — Organic Chemical
- R — Radionuclides

Contaminant		MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
IOC	Cyanide (as free cyanide)	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories	0.2
OC	2,4-D	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops	0.07
OC	Dalapon	0.2	Minor kidney changes	Runoff from herbicide used on rights of way	0.2
OC	1,2-Dibromo-3-chloropropane (DBCP)	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards	zero
OC	o-Dichlorobenzene	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories	0.6
OC	p-Dichlorobenzene	0.075	Anemia; liver, kidney or spleen damage; changes in blood	Discharge from industrial chemical factories	0.075
OC	1,2-Dichloroethane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	zero
OC	1,1-Dichloroethylene	0.007	Liver problems	Discharge from industrial chemical factories	0.007
OC	cis-1,2-Dichloroethylene	0.07	Liver problems	Discharge from industrial chemical factories	0.07
OC	trans-1,2-Dichloroethylene	0.1	Liver problems	Discharge from industrial chemical factories	0.1
OC	Dichloromethane	0.005	Liver problems; increased risk of cancer	Discharge from drug and chemical factories	zero
OC	1,2-Dichloropropane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	zero
OC	Di(2-ethylhexyl) adipate	0.4	Weight loss, liver problems, or possible reproductive difficulties	Discharge from chemical factories	0.4
OC	Di(2-ethylhexyl) phthalate	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories	zero
OC	Dinoseb	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables	0.007
OC	Dioxin (2,3,7,8-TCDD)	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories	zero
OC	Diquat	0.02	Cataracts	Runoff from herbicide use	0.02
OC	Endothall	0.1	Stomach and intestinal problems	Runoff from herbicide use	0.1
OC	Endrin	0.002	Liver problems	Residue of banned insecticide	0.002
OC	Epichlorohydrin	TT[4]	Increased cancer risk; stomach problems	Discharge from industrial chemical factories; an impurity of some water treatment chemicals	zero
OC	Ethylbenzene	0.7	Liver or kidney problems	Discharge from petroleum refineries	0.7
OC	Ethylene dibromide	0.00005	Problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer	Discharge from petroleum refineries	zero
M	Fecal coliform and *E. coli*	MCL[6]	Fecal coliforms and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes may cause short term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a special health risk for infants, young children, and people with severely compromised immune systems.	Human and animal fecal waste	zero[6]
IOC	Fluoride	4.0	Bone disease (pain and tenderness of the bones); children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories	4.0
M	*Giardia lamblia*	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
OC	Glyphosate	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use	0.7
DBP	Haloacetic acids (HAA5)	0.060	Increased risk of cancer	Byproduct of drinking water disinfection	n/a[9]
OC	Heptachlor	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide	zero
OC	Heptachlor epoxide	0.0002	Liver damage; increased risk of cancer	Breakdown of heptachlor	zero
M	Heterotrophic plate count (HPC)	TT[7]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment	n/a

LEGEND

D Disinfectant	IOC Inorganic Chemical	OC Organic Chemical
DBP Disinfection Byproduct	M Microorganism	R Radionuclides

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
OC Hexachlorobenzene	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories	zero
OC Hexachlorocyclopentadiene	0.05	Kidney or stomach problems	Discharge from chemical factories	0.05
IOC Lead	TT5; Action Level=0.015	Infants and children: Delays in physical or or mental development; children could show slight deficits in attention span and learning abilities; Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits	zero
M *Legionella*	TT7	Legionnaire's Disease, a type of pneumonia	Found naturally in water; multiplies in heating systems	zero
OC Lindane	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber, gardens	0.0002
IOC Mercury (inorganic)	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands	0.002
OC Methoxychlor	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, livestock	0.04
IOC Nitrate (measured as Nitrogen)	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	10
IOC Nitrite (measured as Nitrogen)	1	Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	1
OC Oxamyl (Vydate)	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes	0.2
OC Pentachlorophenol	0.001	Liver or kidney problems; increased cancer risk	Discharge from wood-preserving factories	zero
OC Picloram	0.5	Liver problems	Herbicide runoff	0.5
OC Polychlorinated biphenyls (PCBs)	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals	zero
R Radium 226 and Radium 228 (combined)	5 pCi/L	Increased risk of cancer	Erosion of natural deposits	zero
IOC Selenium	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum and metal refineries; erosion of natural deposits; discharge from mines	0.05
OC Simazine	0.004	Problems with blood	Herbicide runoff	0.004
OC Styrene	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills	0.1
OC Tetrachloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners	zero
IOC Thallium	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories	0.0005
OC Toluene	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories	1
M Total Coliforms	5.0 percent[8]	Coliforms are bacteria that indicate that other, potentially harmful bacteria may be present. See fecal coliforms and *E. coli*	Naturally present in the environment	zero
DBP Total Trihalomethanes (TTHMs)	0.080	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection	n/a[9]
OC Toxaphene	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle	zero
OC 2,4,5-TP (Silvex)	0.05	Liver problems	Residue of banned herbicide	0.05
OC 1,2,4-Trichlorobenzene	0.07	Changes in adrenal glands	Discharge from textile finishing factories	0.07
OC 1,1,1-Trichloroethane	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories	0.2
OC 1,1,2-Trichloroethane	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories	0.003
OC Trichloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories	zero

LEGEND

- D Disinfectant
- DBP Disinfection Byproduct
- IOC Inorganic Chemical
- M Microorganism
- OC Organic Chemical
- R Radionuclides

Contaminant		MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
M	Turbidity	TT[7]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause short term symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff	n/a
R	Uranium	30µg/L	Increased risk of cancer, kidney toxicity	Erosion of natural deposits	zero
OC	Vinyl chloride	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories	zero
M	Viruses (enteric)	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
OC	Xylenes (total)	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories	10

LEGEND

D	Disinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

NOTES

1 Definitions

- Maximum Contaminant Level Goal (MCLG)—The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
- Maximum Contaminant Level (MCL)—The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.
- Maximum Residual Disinfectant Level Goal (MRDLG)—The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
- Maximum Residual Disinfectant Level (MRDL)—The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
- Treatment Technique (TT)—A required process intended to reduce the level of a contaminant in drinking water.

2 Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million (ppm).

3 Health effects are from long-term exposure unless specified as short-term exposure.

4 Each water system must certify annually, in writing, to the state (using third-party or manufacturers certification) that when it uses acrylamide and/or epichlorohydrin to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows: Acrylamide = 0.05 percent dosed at 1 mg/L (or equivalent); Epichlorohydrin = 0.01 percent dosed at 20 mg/L (or equivalent).

5 Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10 percent of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

6 A routine sample that is fecal coliform-positive or *E. coli*-positive triggers repeat samples--if any repeat sample is total coliform-positive, the system has an acute MCL violation. A routine sample that is total coliform-positive and fecal coliform-negative or *E. coli*-negative triggers repeat samples--if any repeat sample is fecal coliform-positive or *E. coli*-positive, the system has an acute MCL violation. See also Total Coliforms.

7 EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:

- *Cryptosporidium*: 99 percent removal for systems that filter. Unfiltered systems are required to include Cryptosporidium in their existing watershed control provisions.
- Giardia lamblia: 99.9 percent removal/inactivation
- Viruses: 99.99 percent removal/inactivation
- *Legionella*: No limit, but EPA believes that if *Giardia* and viruses are removed/inactivated according to the treatment techniques in the surface water treatment rule, *Legionella* will also be controlled.
- Turbidity: For systems that use conventional or direct filtration, at no time can turbidity (cloudiness of water) go higher than 1 nephelolometric turbidity unit (NTU), and samples for turbidity must be less than or equal to 0.3 NTU in at least 95 percent of the samples in any month. Systems that use filtration other than conventional or direct filtration must follow state limits, which must include turbidity at no time exceeding 5 NTU.
- HPC: No more than 500 bacterial colonies per milliliter
- Long Term 1 Enhanced Surface Water Treatment; Surface water systems or ground water systems under the direct influence of surface water serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (e.g. turbidity standards, individual filter monitoring, *Cryptosporidium* removal requirements, updated watershed control requirements for unfiltered systems).
- Long Term 2 Enhanced Surface Water Treatment; This rule applies to all surface water systems or ground water systems under the direct influence of surface water. The rule targets additional *Cryptosporidium* treatment requirements for higher risk systems and includes provisions to reduce risks from uncovered finished water storages facilities and to ensure that the systems maintain microbial protection as they take steps to reduce the formation of disinfection byproducts. (Monitoring start dates are staggered by system size. The largest systems (serving at least 100,000 people) will begin monitoring in October 2006 and the smallest systems (serving fewer than 10,000 people) will not begin monitoring until October 2008. After completing monitoring and determining their treatment bin, systems generally have three years to comply with any additional treatment requirements.)
- Filter Backwash Recycling: The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

8 No more than 5.0 percent samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or *E. coli*. If two consecutive TC-positive samples, and one is also positive for *E. coli* or fecal coliforms, system has an acute MCL violation.

9 Although there is no collective MCLG for this contaminant group, there are individual MCLGs for some of the individual contaminants:

- Haloacetic acids: dichloroacetic acid (zero); trichloroacetic acid (0.3 mg/L)
- Trihalomethanes: bromodichloromethane (zero); bromoform (zero); dibromochloromethane (0.06 mg/L)

National Secondary Drinking Water Regulation

National Secondary Drinking Water Regulations are non-enforceable guidelines regarding contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, some states may choose to adopt them as enforceable standards.

Contaminant	Secondary Maximum Contaminant Level
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

For More Information

EPA's Safe Drinking Water Web site:
http://www.epa.gov/safewater/

EPA's Safe Drinking Water Hotline:
(800) 426-4791

To order additional posters or other ground water and drinking water publications, please contact the National Service Center for Environmental Publications at :
(800) 490-9198, or
email: nscep@bps-lmit.com.

EPA United States Environmental Protection Agency

EPA 816-F-09-004
May 2009

APPENDIX 5.

POTENTIAL SOURCES OF GROUND WATER CONTAMINATION (BASED UPON LISTS COMPILED BY EPA AND ADEM)

1. Improperly functioning septic tanks
2. Gas stations/service stations
3. Dry cleaners
4. Agricultural chemicals, fertilizer, and pesticides spreading/spraying
5. Truck terminals
6. Fuel oil distributors/storage
7. Oil pipelines
8. Auto repair shops
9. Body shops
10. Rustproofers
11. Auto chemical suppliers/wholesalers/retailers
12. Pesticide/herbicide/insecticide wholesalers/retailers
13. Small engine repair shops
14. Furniture strippers
15. Painters/finishers
16. Photographic processors
17. Printers
18. Car Washes
19. Laundromats
20. Beauty salons
21. Medical/dental/veterinarian offices
22. Research laboratories
23. Food processors
24. Meat packers/slaughterhouses
25. Concrete/asphalt/tar/coal companies
26. Treatment plant lagoons
27. Railroad yards
28. Stormwater impoundments
29. Cemeteries
30. Airport maintenance shops
31. Airport fueling areas
32. Airport firefighter training areas
33. Industrial manufacturers
34. Machine shops
35. Metal platers
36. Heat treaters/smelters/descalers
37. Wood preservers
38. Chemical reclamation sites
39. Boat builders/refinishers
40. Industrial waste disposal sites
41. Wastewater impoundment areas
42. Municipal wastewater treatment plants and land application areas
43. Landfills/dumps/transfer stations
44. Junk/salvage yards
45. Subdivisions
46. Individual residences
47. Heating oil storage(consumptive use) sites
48. Golf courses/parks/nurseries
49. Sand and gravel mining/other mining
50. Abandoned wells
51. Manure piles/other animal waste
52. Feedlots
53. Agricultural chemical storage sites
54. Construction sites
55. Transportation corridors
56. Fertilized fields/agricultural areas
57. Petroleum tank farms
58. Existing wells
59. Nonagricultural applicator sites
60. Sinkholes
61. Recharge areas of shallow and highly permeable aquifers
62. Injection wells
63. Drainage wells
64. Waste piles
65. Materials stockpiles
66. Animal burial sites
67. Open burning sites
68. Radioactive disposal sites
69. Salt-water intrusion
70. Mines and mine tailings

APPENDIX 6.

RECOMMENDED WATER QUALITY TESTS FOR DOMESTIC WELL OWNERS

(from California State Water Resources Control Board, 2011)

Recommended Test		Interpreting the Results	
Test	**Frequency**	**Lab Results**	**Actions**
Coliform Bacteria	Test for total coliform annually; fecal if total coliforms are detected.	Present	First re-test another sample to verify results. Eliminate cause, disinfect, and retest. Increase testing frequency; if problem persists, consult a water treatment professional.
Nitrate (NO_3)	Annually	≥ 45 mg/L as NO_3 or ≥10 mg/L as N	First re-test another sample to verify the results. Install a treatment system or find an alternate water supply. Consult a water treatment professional for more advice.
Electrical Conductivity (EC)	Annually	> 1,600 µmhos/cm or significantly different from previous result.	Test for minerals, nitrate, and/or VOCs to determine the possible cause of the high EC
Minerals:	Every 5-10 years or if the following significant changes occur: • Electrical conductivity • Taste • Color • Odor • Surrounding land use change		Compare to previous results. Consider retesting for high results. Install a treatment system or find an alternative water supply. The appropriate treatment system depends on your overall water chemistry and the constituents that need to be removed. Consult a water treatment professional for more advice.
Aluminum (Al)		Al >0.2 mg/L	
Arsenic (As)		As >0.01 mg/L	
Barium (Ba)		Ba >1.0 mg/L	
Cadmium (Cd)		Cd >0.005 mg/L	
Chromium (Cr)		Cr >0.05 mg/L	
Fluoride (F)		F >2.0 mg/L	
Iron (Fe)		Fe >0.3 mg/L	
Lead (Pb)		Pb >0.015 mg/L	
Manganese (Mn)		Mn >0.05 mg/L	
Mercury (Hg)		Hg >0.002 mg/L	
Selenium (Se)		Se >0.05 mg/L	
Silver (Ag)		Ag >0.1 mg/L	
Volatile Organic Compounds (VOCs)	See Minerals above	Any detection	Ask lab to re-test. If confirmed, consult a water treatment professional for more advice.

APPENDIX 7.

CHOCTAWHATCHEE, PEA, AND YELLOW RIVER WATERSHED MANAGEMENT AUTHORITY FLOOD WARNING SYSTEM SUPPORTING AGENCIES

Name	Title/Agency	Telephone
GENEVA COUNTY AREA		
Margaret Mixon	Geneva County EMA Director	(334) 684-5677
Phillip Carter	Mayor of Geneva	(334) 684-2485
Tony Helms	Geneva County Sheriff	(334) 684-5660
Tony Clemmons	Geneva Police Chief	(334) 684-2777
Probate Judge Fred Hamic	Geneva County Commission Chairman	(334) 684-5610
Justin Barfield	Geneva County Engineer	(334) 684-3450
COFFEE COUNTY AREA		
Larry Walker	Coffee EMA Director	(334) 894-5415
Mickey Murdock	Mayor of Elba	(334) 897-2333
Kenneth Boswell	Mayor of Enterprise	(334) 348-2602
Dave Sutton	Coffee County Sheriff	(334) 894-5535
Freddie Hanchey	Elba Police Chief	(334) 897-2555
T. D. Jones	Enterprise Police Chief	(334) 347-1211
Tom Grimsley	Coffee County Commission Chairman	(334) 894-5556
Randall Tindell	Coffee County Engineer	(334) 894-6112
DALE COUNTY AREA		
Vacant	Dale County EMA Director	(334) 774-2214
Wally Olson	Dale County Sheriff	(334) 774-2335/7996
Mark Blankenship	Dale County Commission Chairman	(334) 774-6025
Derrick Brewer	Dale County Engineer	(334) 774-5875
Jivas Sutton	Mayor of Ariton	(334) 762-2266
Lehman Irby	Mayor of Newton	(334) 299-3361
Claudia Wigglesworth	Mayor of Daleville	(334) 598-2345
Billy Blackwell	Mayor of Ozark	(334) 774-5393
COVINGTON COUNTY AREA		
Susan Carpenter	Covington County EMA Director	(334) 427-4911
Dennis Meeks	Covington County Sheriff	(334) 428-2640
Bill Godwin	Covington County Commission Chairman	(334) 428-2610
Darren Capps	Covington County Engineer	(334) 428-2620
Robert Williamson	Mayor of Florala	(334) 858-3612
Earl Johnson	Mayor of Andalusia	(334) 222-3313
John E. Bartholomew	Mayor of Opp	(334) 493-4571
PIKE COUNTY AREA		
Jeanna Barnes	Pike County EMA Director	(334) 670-6600
Russell Thomas	Pike County Sheriff	(334) 566-4347
Homer Wright	Pike County Commission Chairman	(334) 566-6374
Russell Oliver	Pike County Engineer	(334) 566-4508
Jason Reeves	Mayor of Troy	(334) 566-0177
James T. Ramage, III	Mayor of Brundidge	(334) 735-3333
John McCall	Troy University Police Chief	(334) 670-3215

Name	Title/Agency	Telephone
BARBOUR COUNTY AREA		
David Logan	Barbour County EMA Director	(334) 687-1521
LeRoy Upshaw	Barbour County Sheriff	(334) 775-1103
Kenneth Earl Gilmore	Barbour County Commission Chairman	(334) 775-3203
Patrick McDougald	Barbour County Engineer	(334) 775-3420
Rebecca Beasley	Mayor of Clayton	(334) 775-9176
Jamey Williams.	Clayton Police Chief	(334) 775-8011
HENRY COUNTY AREA		
Ronnie Dollar	Henry County EMA Director	(334) 585-6702
William K. Maddox	Henry County Sheriff	(334) 585-3131
David Money	Henry County Commission Chairman	(334) 585-3708
Chris Champion	Henry County Engineer	(334) 585-2735
Jim Giganti	Mayor of Abbeville	(334) 585-6444
HOUSTON COUNTY AREA		
Steve Carlisle	Houston County EMA Director	(334) 677-4834
Mark Culver	Houston County Commission Chairman	(334) 677-4740
Barkley Kirkland	Houston County Engineer	(334) 792-4149
Mike Schmitz	Mayor of Dothan	(334) 615-3000
Larry Whiddon	Mayor of Taylor	(334) 677-4740
Donald Valenza	Houston County Sheriff	(334) 677-8775
NATIONAL WEATHER SERVICE - Tallahassee, Florida		
Kelly G. Godsey	National Weather Service	(850) 942-8833
Website	*www.srh.noaa.gov/tlh*	
CHOCTAWHATCHEE, PEA AND YELLOW RIVERS WATERSHED MANAGEMENT AUTHORITY, Troy, Alabama		
Don Hyde	Flood Warning System Specialist	(334) 894-6705
Barbara Gibson	Executive Director	(334) 670-3780
Website	*www.cpyrwma.alabama.gov*	
U.S. ARMY CORPS OF ENGINEERS, MOBILE DISTRICT		
Douglas Otto, Jr. P.E.	Chief, Engineering Division	(251) 690-2709
Jonathan A. Ashley	Chief, Hydraulics and Hydrology	(251) 690-2730
OTHER SUPPORTING AGENCIES		
David Ford Consulting Engineers	Nathan Pingel Technical Support	(916) 447-8779
U.S. Geological Survey	Rick Treece Technical Support	(334) 395-4126

APPENDIX 8.

CPYRWMA SUPPORTING AGENCIES AND INVOLVED STAKEHOLDERS

1. Alabama Legislature
2. Geological Survey of Alabama
3. Alabama Department of Agriculture and Industries
4. Alabama Department of Conservation and Natural Resources
5. Alabama Department of Environmental Management
6. Alabama Department of Public Health
7. Alabama Emergency Management Agency
8. Alabama Forestry Commission
9. Alabama Soil and Water Conservation Committee
10. Alabama Soil and Water Conservation Districts in ten southeastern Alabama Counties
11. Alabama Water Watch Association
12. Alabama Cooperative Extension System
13. Alabama Office of Water Resources (Division of ADECA)
14. Alabama Water Resources Commission
15. Alabama Water Resources Council
16. Alabama Drought Assessment and Planning Team
17. Alabama Hazard Mitigation Council
18. South Alabama Electric Cooperative
19. Alabama Peanut Producers Association
20. Alabama Farm Service Agency
21. Alabama Rural Water Association
22. Alabama Scenic River Trail
23. Alabama Power Company
24. Alabama Rivers Alliance
25. National Weather Service
26. Barbour County Commission and County Engineer
27. Bullock County Commission and County Engineer
28. Coffee County Commission and County Engineer
29. Covington County Commission and County Engineer
30. Crenshaw County Commission and County Engineer
31. Dale County Commission and County Engineer
32. Geneva County Commission and County Engineer
33. Henry County Commission and County Engineer
34. Houston County Commission and County Engineer
35. Pike County Commission and County Engineer
36. Barbour County EMA Director
37. Bullock County EMA Director
38. Coffee County EMA Director
39. Covington County EMA Director
40. Crenshaw County EMA Director
41. Dale County EMA Director
42. Geneva County EMA Director
43. Henry County EMA Director
44. Houston County EMA Director
45. Pike County EMA Director
46. Governmental officials in Barbour, Bullock, Coffee, Covington, Crenshaw, Dale, Geneva, Henry, Houston, and Pike Counties
47. U.S. Army Corps of Engineers
48. U.S. Geological Survey
49. U.S. Fish and Wildlife Service
50. USDA Natural Resource Conservation Service (NRCS)
51. County Water Authorities
52. Lurleen Wallace Community College, Opp, AL
53. Troy University
54. Auburn University
55. University of Alabama
56. Alabama Treasure Forest Association
57. Choctawhatchee Basin Alliance, Niceville, FL

CHOCTAWHATCHEE, PEA AND YELLOW RIVERS WATERSHED

By
Alana L. Rogers
2015

EXPLANATION

- Cities
- County lines
- Rivers and streams
- Lakes, ponds, and reservoirs
- Choctawhatchee, Pea and Yellow Rivers Watershed
- Limited access interstate
- Highway
- Major road
- 85 Interstate highway
- 431 United States highway
- 10 State highway

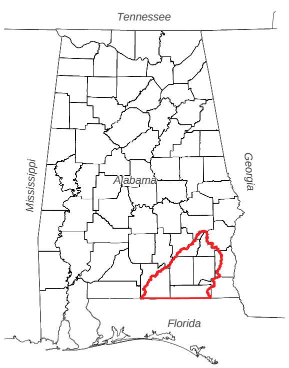
10-Digit Hydrologic Unit Boundaries

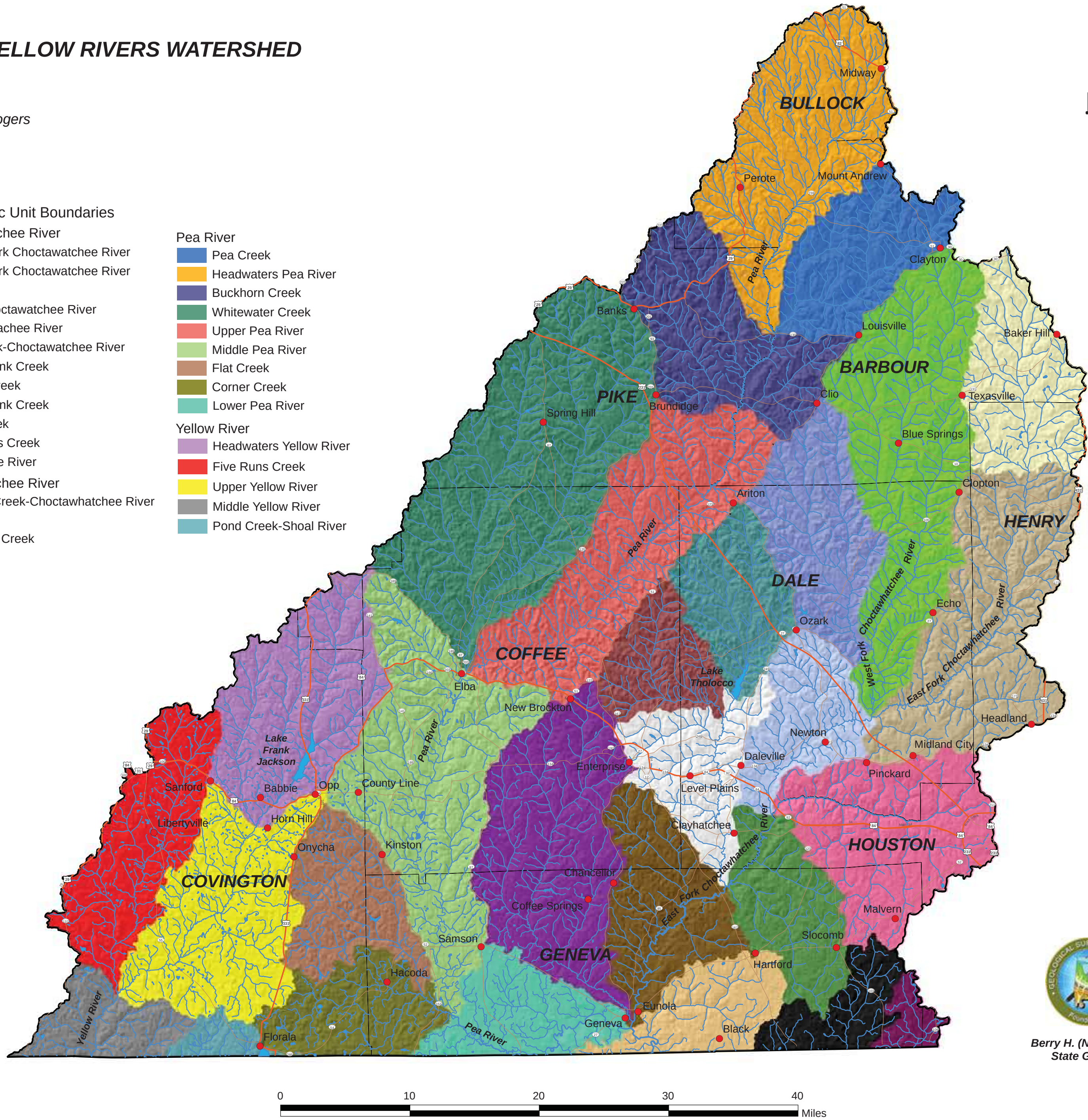
Upper Choctawhatchee River
- Upper East Fork Choctawhatchee River
- Lower East Fork Choctawhatchee River
- Judy Creek
- West Fork Choctawhatchee River
- Little Choctawachee River
- Klondike Creek-Choctawachee River
- Upper Clay Bank Creek
- Steep Head Creek
- Lower Clay Bank Creek
- Hurricane Creek
- Double Bridges Creek
- Choctawatchee River

Lower Choctawhatchee River
- East Pittman Creek-Choctawhatchee River
- Wrights Creek
- Upper Holmes Creek

Pea River
- Pea Creek
- Headwaters Pea River
- Buckhorn Creek
- Whitewater Creek
- Upper Pea River
- Middle Pea River
- Flat Creek
- Corner Creek
- Lower Pea River

Yellow River
- Headwaters Yellow River
- Five Runs Creek
- Upper Yellow River
- Middle Yellow River
- Pond Creek-Shoal River





Berry H. (Nick) Tew. Jr.
State Geologist

CHOCTAWHATCHEE, PEA AND YELLOW RIVERS WATERSHED LAND-USE/LAND-COVER

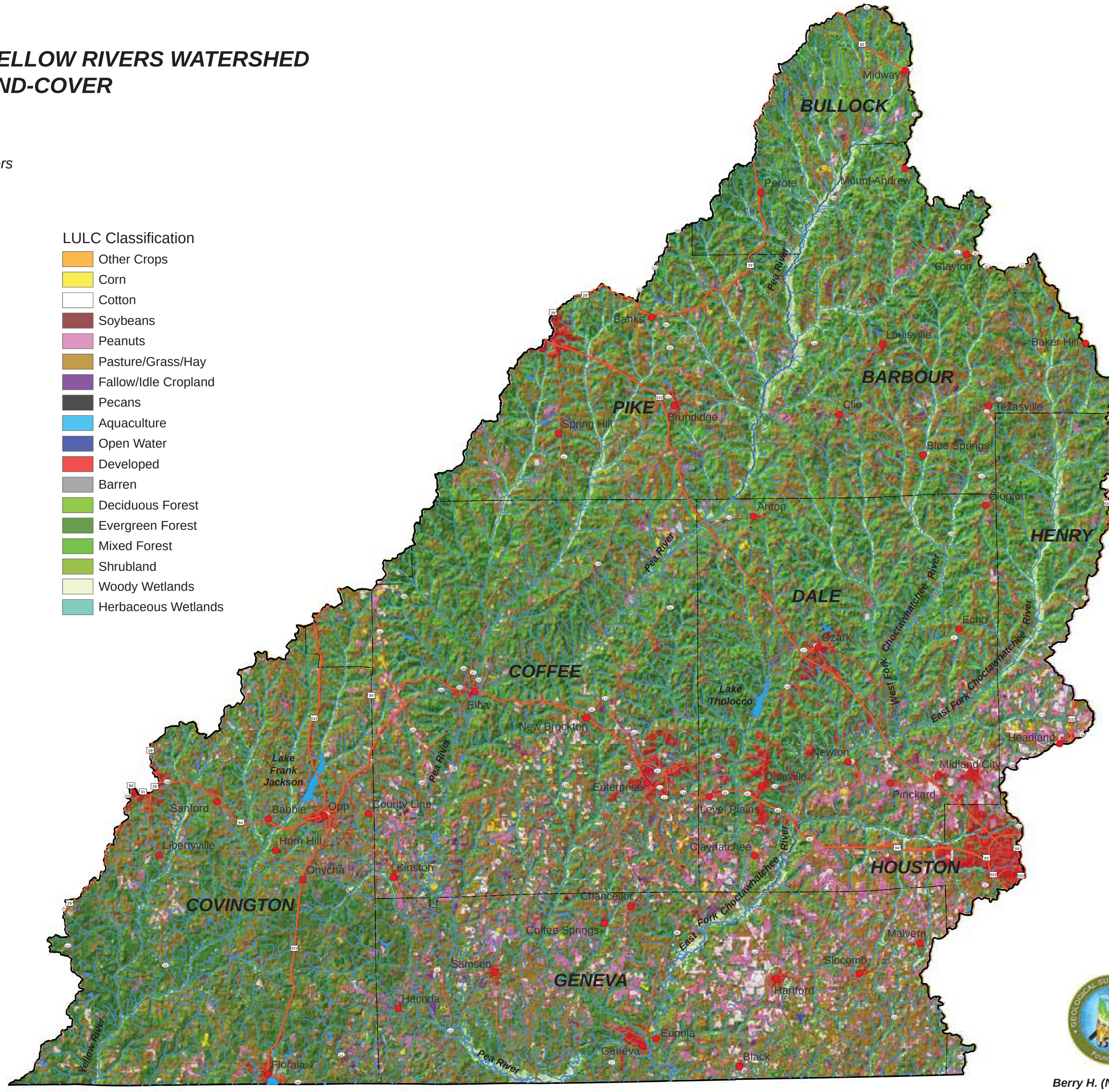
By
Alana L. Rogers
2015

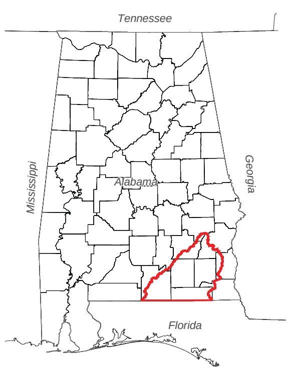
EXPLANATION

- Cities
- County lines
- Rivers and streams
- Lakes, ponds, and reservoirs
- Choctawhatchee, Pea and Yellow Rivers Watershed
- Limited access interstate
- Highway
- Major road
- 85 Interstate highway
- 431 United States highway
- 10 State highway

LULC Classification

- Other Crops
- Corn
- Cotton
- Soybeans
- Peanuts
- Pasture/Grass/Hay
- Fallow/Idle Cropland
- Pecans
- Aquaculture
- Open Water
- Developed
- Barren
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrubland
- Woody Wetlands
- Herbaceous Wetlands





0 10 20 30 40 Miles

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CHOCTAWHATCHEE, PEA AND YELLOW RIVERS WATERSHED GEOLOGY AND RECHARGE

By
Alana L. Rogers
2015

EXPLANATION

- Cities
- County lines
- Rivers and streams
- Lakes, ponds, and reservoirs
- Choctawhatchee, Pea and Yellow Rivers Watershed
- Limited access interstate
- Highway
- Major road
- 85 Interstate highway
- 431 United States highway
- 10 State highway

Geologic Formations

Quaternary
- Alluvial, coastal, and low terrace deposits
- High terrace deposits

Miocene
- Miocene Series undifferentiated

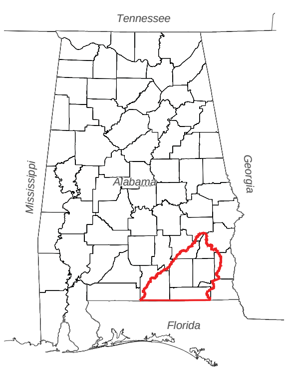
Oligocene
- Oligocene Series undifferentiated

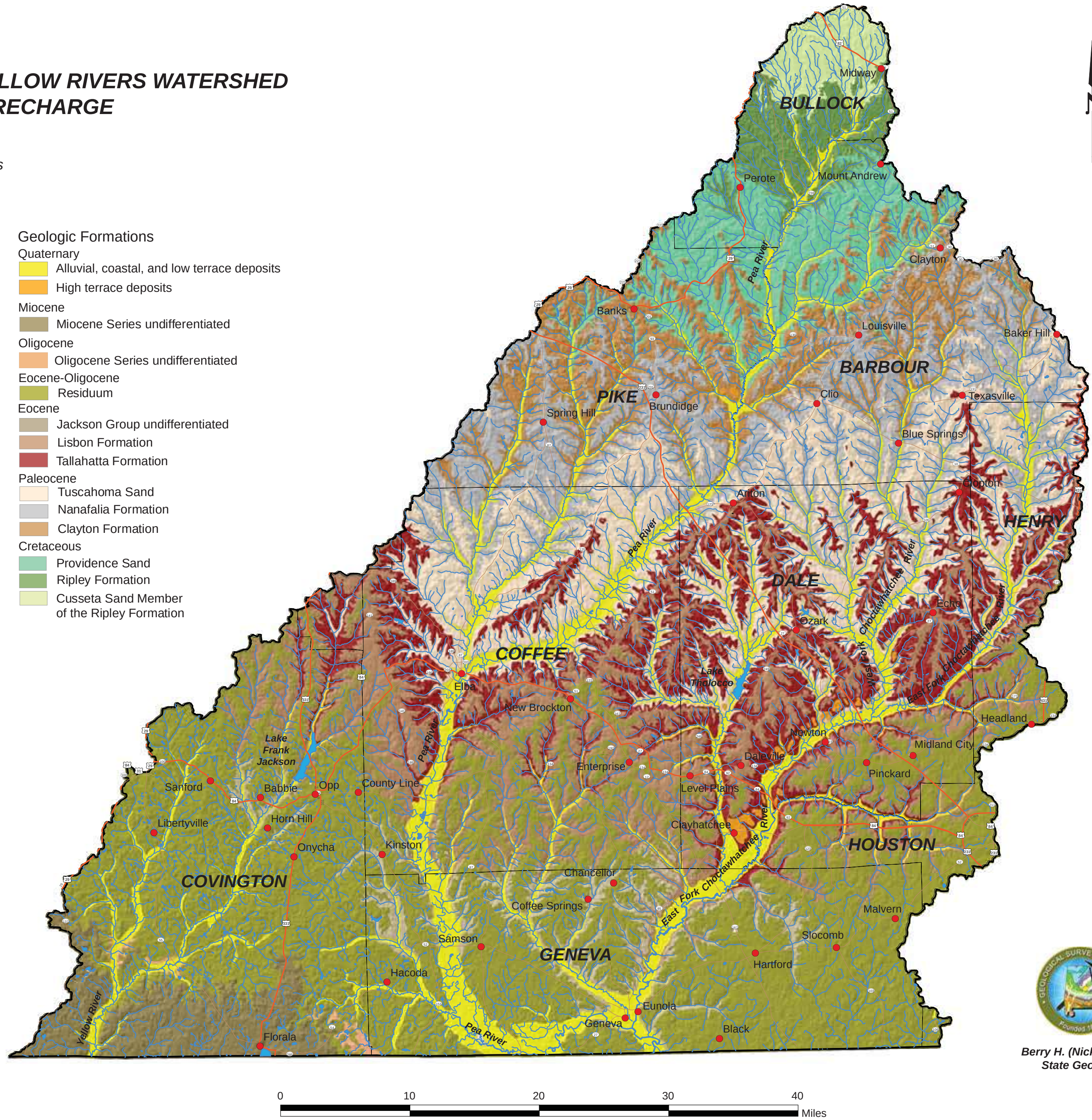
Eocene-Oligocene
- Residuum

Eocene
- Jackson Group undifferentiated
- Lisbon Formation
- Tallahatta Formation

Paleocene
- Tuscahoma Sand
- Nanafalia Formation
- Clayton Formation

Cretaceous
- Providence Sand
- Ripley Formation
- Cusseta Sand Member of the Ripley Formation





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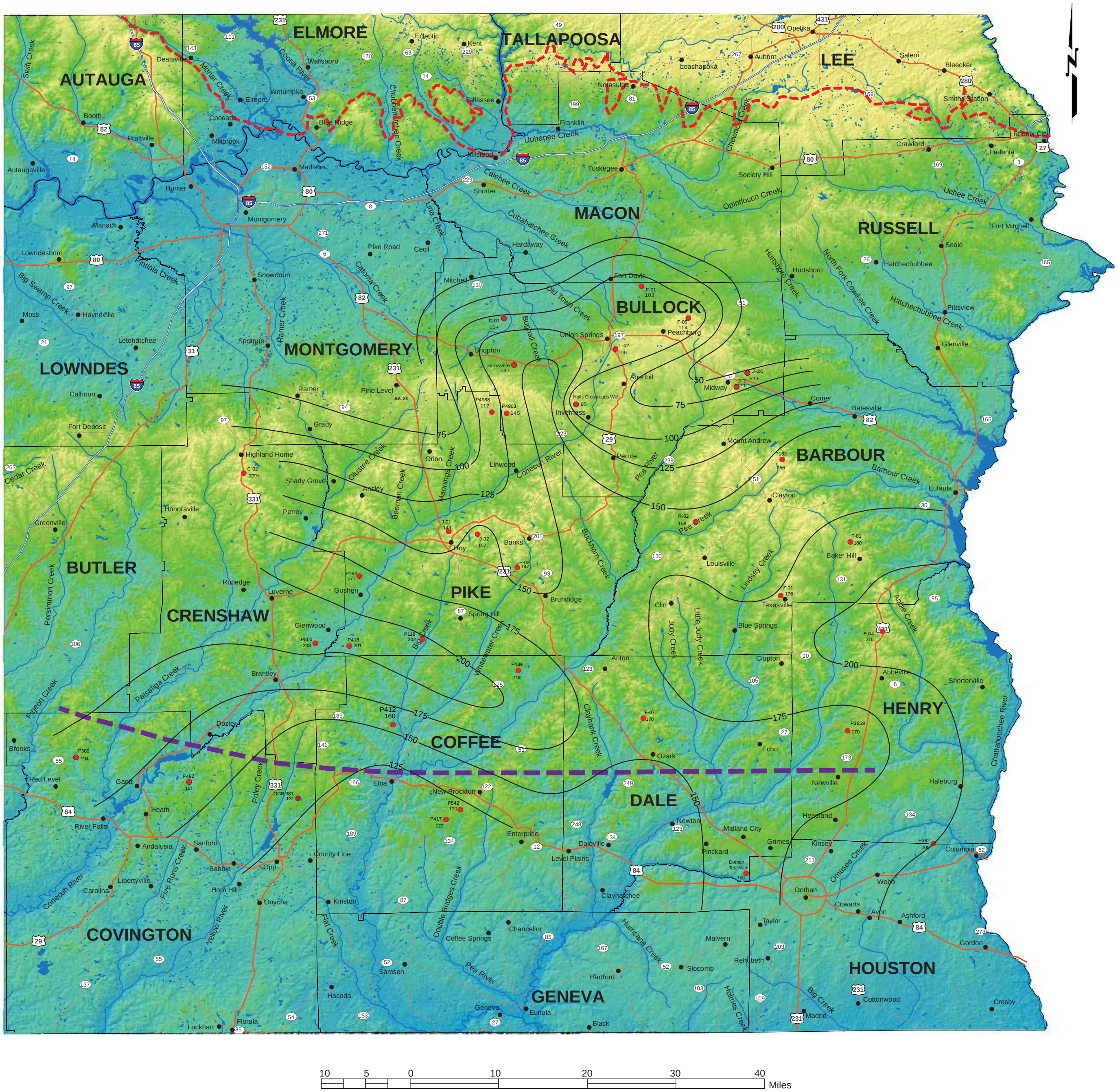


Explanation

Elevation in feet above NGVD 1929
High: 295
Low: 15

Other Symbols

City

J-01 143 Water well, alphanumeric designation, and value of net potential productive interval (ft.)

P500 208 Oil and gas test well, permit number, and value of net potential productive interval

125 Contour of net potential productive interval thickness (contour interval: 25 ft.)

Southeast Alabama assessment area

County boundary

Rivers, lakes, and reservoirs

Suggested downdip limit of freshwater production

Updip limit of the Gordo aquifer

Limited access interstate

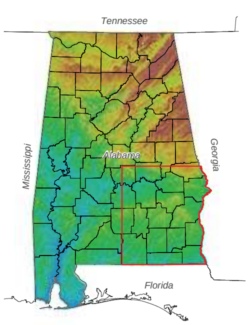
Highway

Major road

Interstate highway

United States highway

State highway



NET POTENTIAL PRODUCTIVE INTERVAL ISOPACH FOR THE GORDO AQUIFER, SOUTHEAST ALABAMA

By
Stephen P. Jennings, Marlon R. Cook, and K. Michael Smith
2015

Berry H. (Nick) Tew, Jr.
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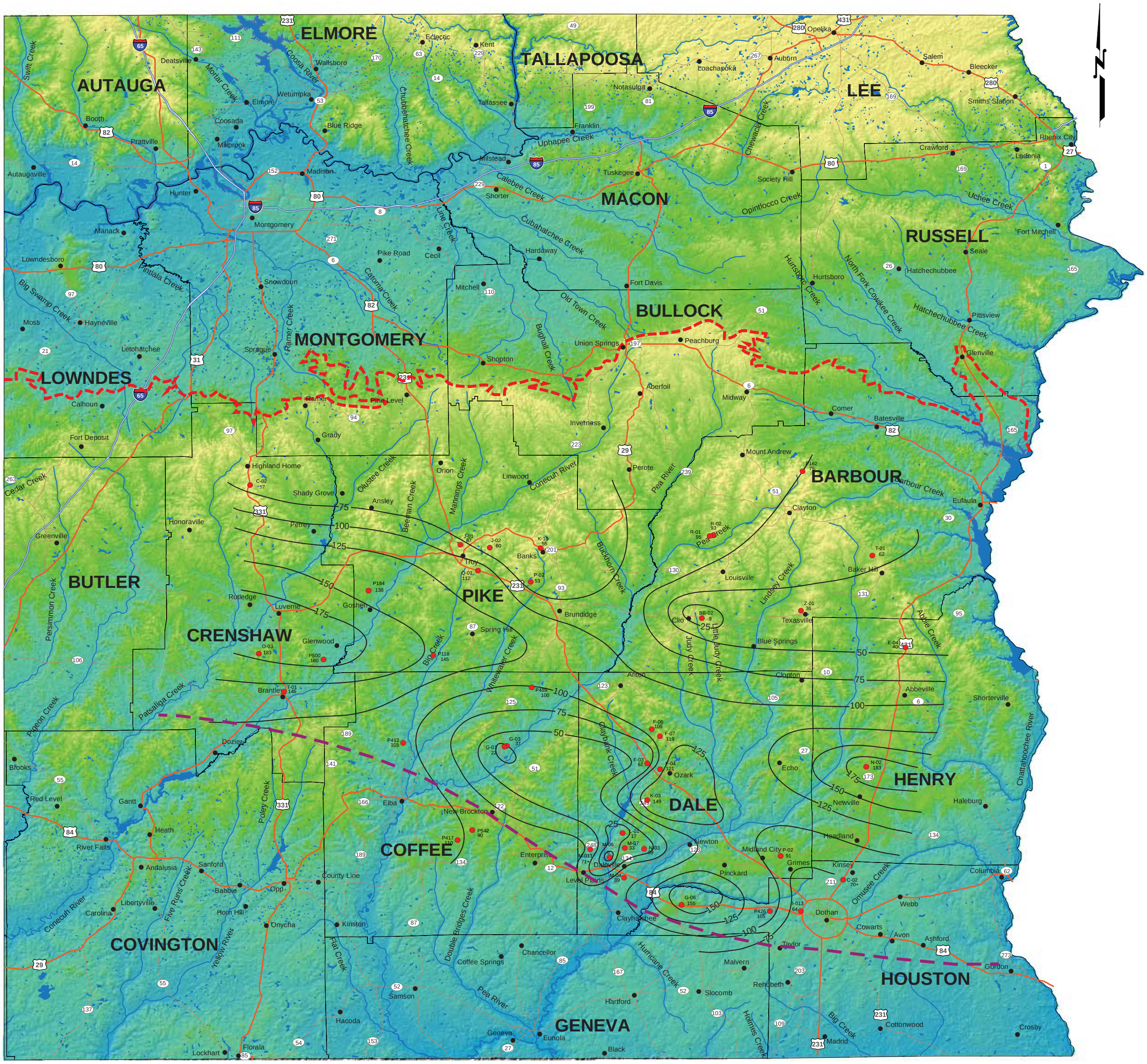
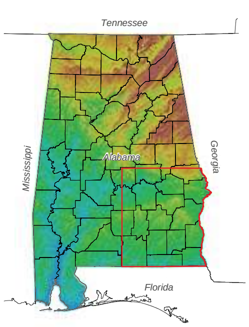


10 5 0 10 20 30 40 Miles

Explanation

Elevation in feet above NGVD 1929
- High: 295
- Low: 15

Other Symbols
- City
- P500 / 208 — Oil and gas test well, permit number, and value of net potential productive interval (ft.)
- J-01 / 143 — Water well, alphanumeric designation, and value of net potential productive interval
- Southeast Alabama assessment area
- County boundary
- Rivers, lakes, and reservoirs
- 125 — Contour of net potential productive interval thickness (contour interval: 25 ft.)
- Suggested downdip limit of freshwater production
- Updip limit of Ripley/Cusseta outcrop
- Limited access interstate
- Highway
- Major road
- Interstate highway
- United States highway
- State highway

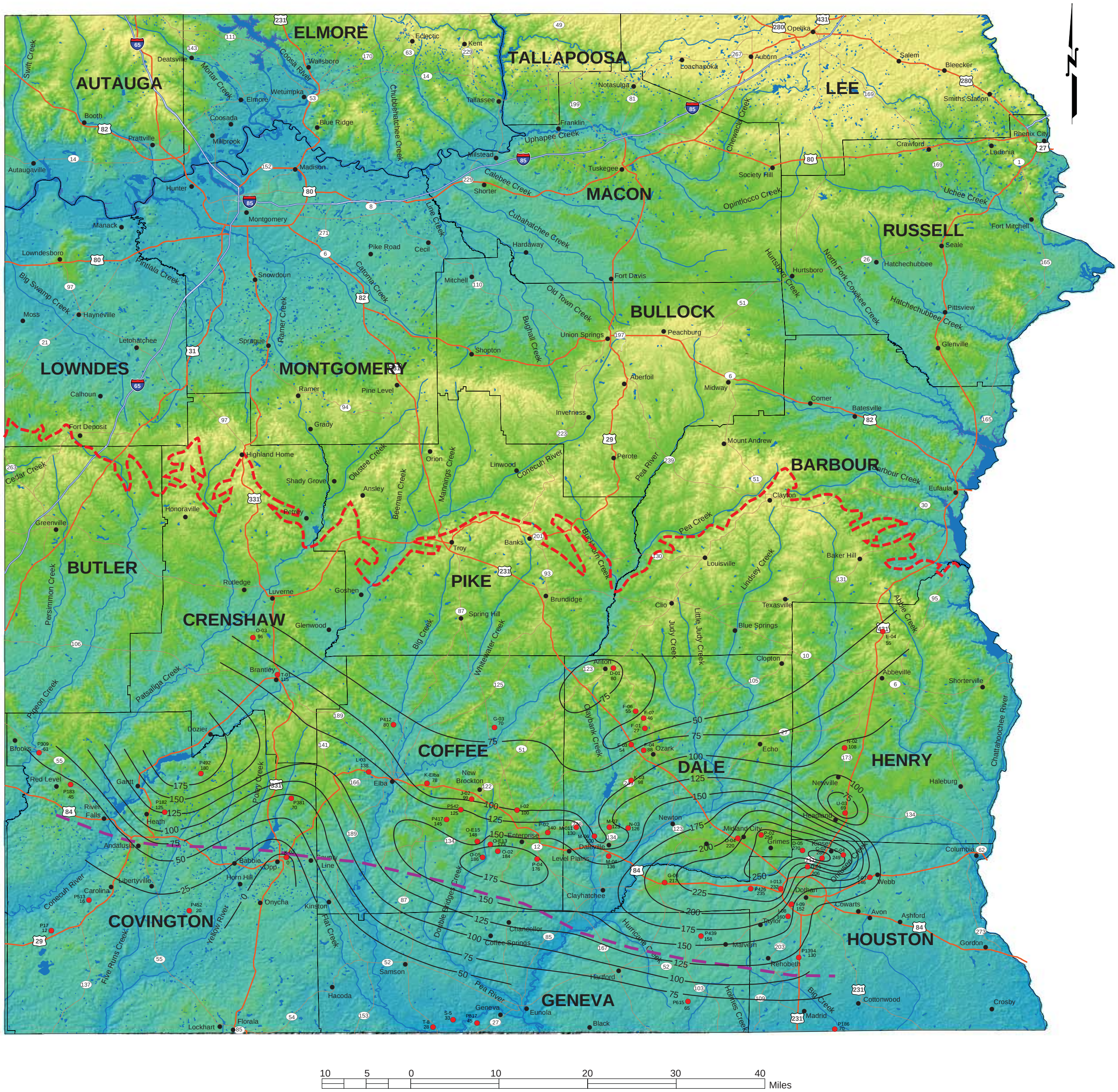


NET POTENTIAL PRODUCTIVE INTERVAL ISOPACH FOR THE RIPLEY/CUSSETA AQUIFER, SOUTHEAST ALABAMA

By
Stephen P. Jennings
2015

GEOLOGICAL SURVEY OF ALABAMA Founded 1848

Berry H. (Nick) Tew, Jr.
State Geologist



Explanation

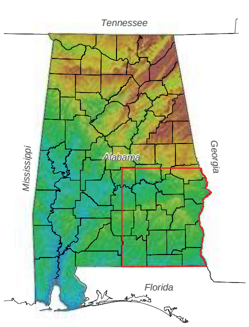
Elevation in feet above NGVD 1929

High: 295

Low: 15

Other Symbols

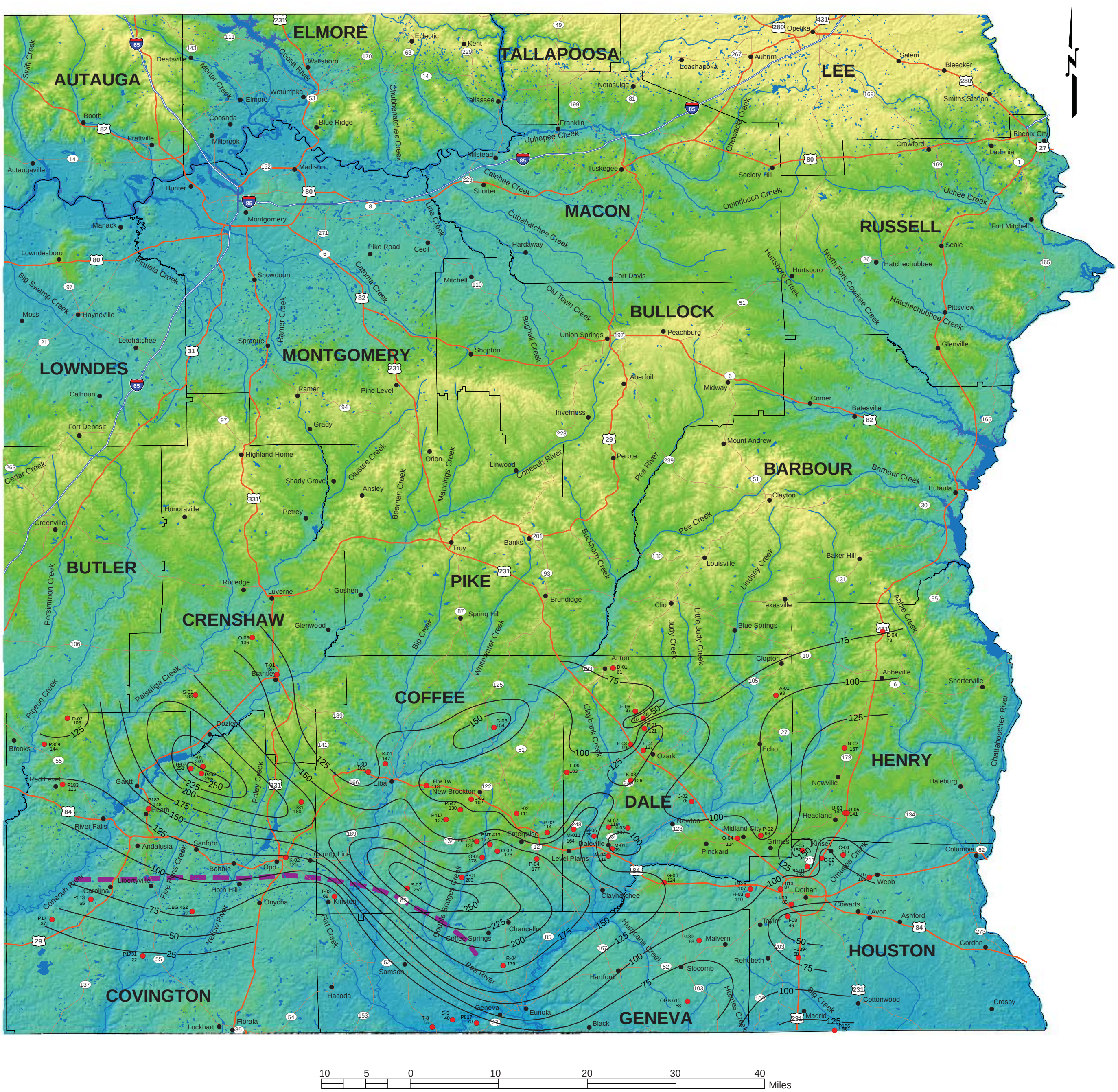
- City
- P500 208 Oil and gas test well, permit number, and value of net potential productive interval (ft.)
- J-01 143 Water well, alphanumeric designation, and value of net potential productive interval
- Southeast Alabama assessment area
- County boundary
- Rivers, lakes, and reservoirs
- 125 Contour net potential productive interval thickness (contour interval: 25 ft.)
- Suggested downdip limit of freshwater production
- Updip limit of Clayton outcrop
- Limited access interstate
- Highway
- Major road
- 65 Interstate highway
- 231 United States highway
- 109 State highway



NET POTENTIAL PRODUCTIVE INTERVAL ISOPACH FOR THE CLAYTON AQUIFER, SOUTHEAST ALABAMA

By
Stephen P. Jennings
2015

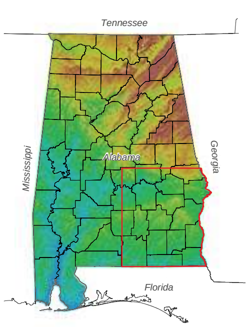
Berry H. (Nick) Tew, Jr.
State Geologist



Explanation

Elevation in feet above NGVD 1929
- High: 295
- Low: 15

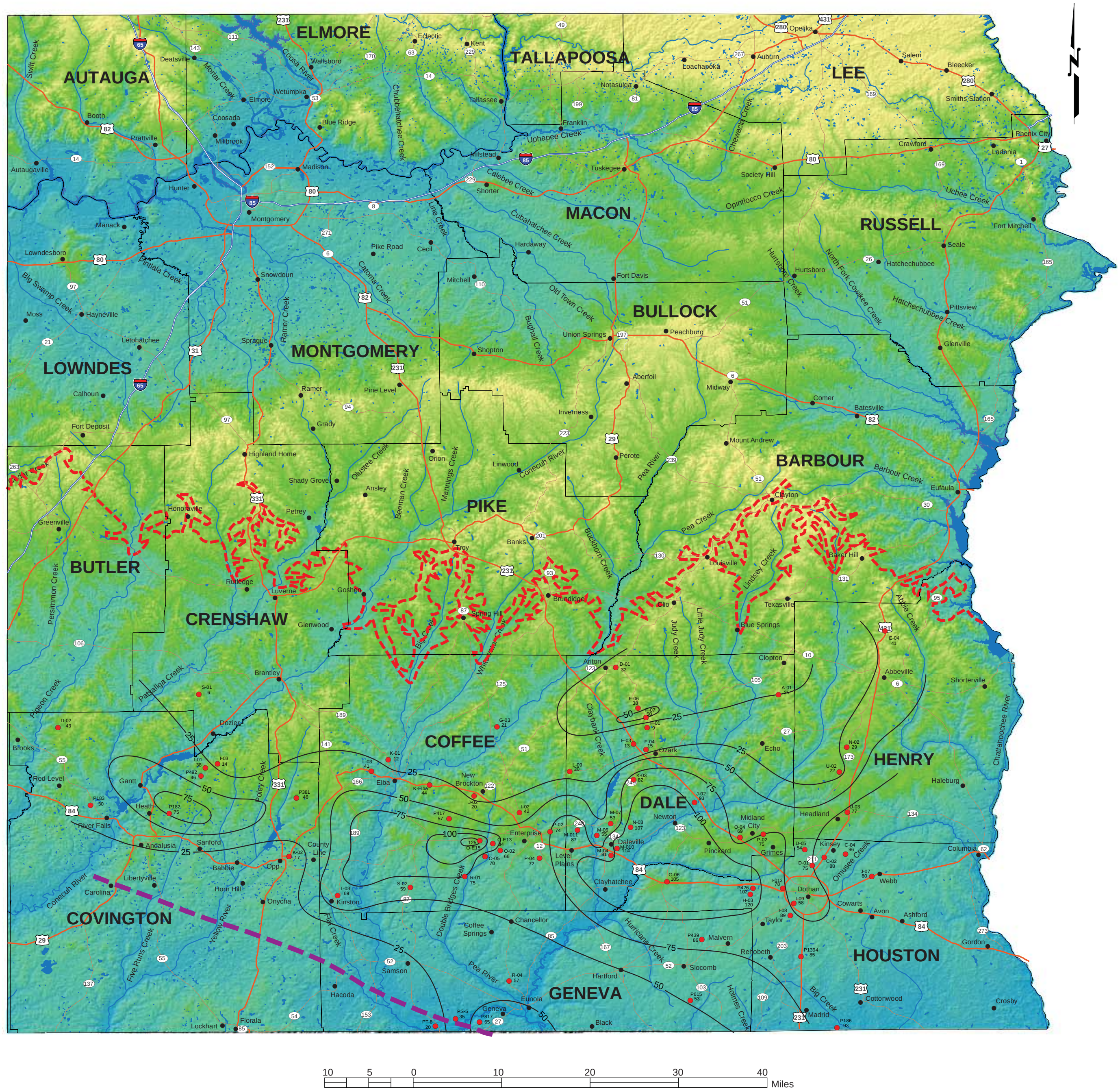
Other Symbols
- City
- A-9 / 143 — Water well, alphanumeric designation, and value of net potential productive interval (ft.)
- P500 / 208 — Oil and gas test well, permit number, and value of net potential productive interval
- 125 — Contour of net potential productive interval thickness (contour interval: 25 ft.)
- Southeast Alabama assessment area
- County boundary
- Rivers, lakes, and reservoirs
- Suggested downdip limit of freshwater production
- Limited access interstate
- Highway
- Major road
- Interstate highway
- United States highway
- State highway



NET POTENTIAL PRODUCTIVE INTERVAL ISOPACH FOR THE SALT MOUNTAIN AQUIFER, SOUTHEAST ALABAMA

By
Stephen P. Jennings
2015

Berry H. (Nick) Tew, Jr.
State Geologist



Explanation

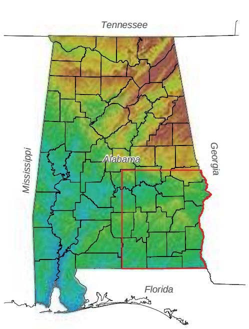
Elevation in feet above NGVD 1929

High: 295

Low: 15

Other Symbols

- City
- P500 208 — Oil and gas test well, permit number, and value of net potential productive interval (ft.)
- J-01 143 — Water well, alphanumeric designation, and value of net potential productive interval
- Southeast Alabama assessment area
- County boundary
- Rivers, lakes, and reservoirs
- 125 — Contour of net potential productive interval thickness (contour interval: 25 ft.)
- Suggested downdip limit of freshwater production
- Downdip limit of Nanafalia outcrop
- Limited access interstate
- Highway
- Major road
- Interstate highway
- United States highway
- State highway

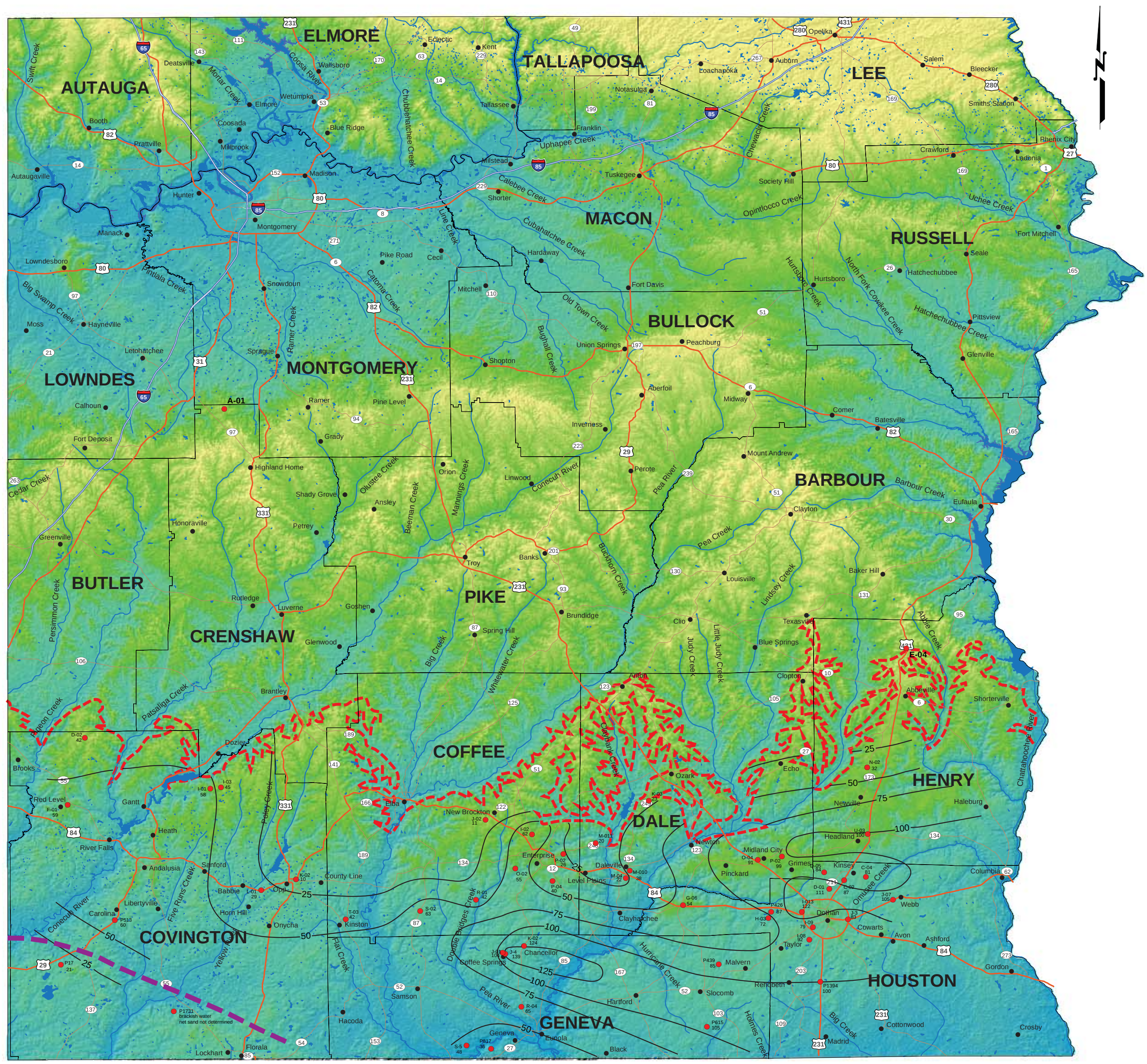


NET POTENTIAL PRODUCTIVE INTERVAL ISOPACH FOR THE NANAFALIA AQUIFER, SOUTHEAST ALABAMA

By
Stephen P. Jennings
2015

GEOLOGICAL SURVEY OF ALABAMA Founded 1848

Berry H. (Nick) Tew, Jr.
State Geologist

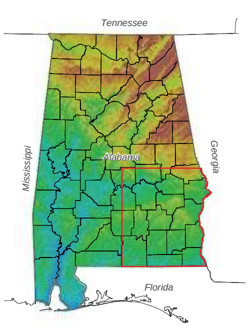


10 5 0 10 20 30 40
Miles

Explanation

Elevation in feet above NGVD 1929
High: 295
Low: 15

Other Symbols
- City
- J-01 143 — Water well, alphanumeric designation, and value of net potential productive interval (ft.)
- P500 208 — Oil and gas test well, permit number, and value of net potential productive interval
- 125 — Contour of net potential productive interval thickness (contour interval: 25 ft.)
- Southeast Alabama assessment area
- County boundary
- Rivers, lakes, and reservoirs
- Suggested downdip limit of freshwater production
- Updip limit of the Tallahatta aquifer
- Limited access interstate
- Highway
- Major road
- Interstate highway
- United States highway
- State highway



NET POTENTIAL PRODUCTIVE INTERVAL ISOPACH FOR THE TALLAHATTA AQUIFER, SOUTHEAST ALABAMA

By
Stephen P. Jennings
2015

GEOLOGICAL SURVEY OF ALABAMA Founded 1848

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Published by

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