Arkansas Water Plan 2014 Update

Appendix B
Regional Water Resource Planning Area Reports

B1 – North Regional Water Resource Planning Area Report

B2 – East Regional Water Resource Planning Area Report

B3 – West-central Regional Water Resource Planning Area Report

B4 – South-central Regional Water Resource Planning Area Report

B5 – Southwest Regional Water Resource Planning Area Report

ARKANSAS WATER PLAN UPDATE
TASK NO. 6 - NORTH ARKANSAS
WATER RESOURCES PLANNING REGION

AUGUST 11, 2014

ARKANSAS WATER PLAN UPDATE
TASK NO. 6 - NORTH ARKANSAS
WATER RESOURCES PLANNING REGION

Prepared for

Arkansas Natural Resources Commission
101 East Capitol Avenue, Suite 350
Little Rock, AR 72201-3813

Prepared by

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, Arkansas 72211

FTN No. 03015-0003-001

AUGUST 11, 2014

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ACS	American Community Survey
ADEQ	Arkansas Department of Environmental Quality
ADH	Arkansas Department of Health
ADPCE	Arkansas Department of Pollution Control and Ecology (now ADEQ)
AGFC	Arkansas Game and Fish Commission
AHTD	Arkansas State Highway and Transportation Department
ANHC	Arkansas Natural Heritage Commission
ANRC	Arkansas Natural Resources Commission
APCEC	Arkansas Pollution Control and Ecology Commission
ASWCC	Arkansas Soil and Water Conservation Commission (now the ANRC)
AWAG	Arkansas Watershed Advisory Group
AWP	Arkansas Water Plan
BCE	Before the common era
BMP	Best management practice
CERCLA	Comprehensive Environmental Response and Liability Act
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
CWA	Clean Water Act
DO	Dissolved oxygen
E. coli	Escherica coli
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
cfs	Cubic feet per second
GCGW	Governor’s Commission on Global Warming
gpm	Gallons per minute
HUD	United States Department of Housing and Urban Development
IRWP	Illinois River Watershed Partnership
MBHI	Migratory Bird Habitat Initiative
MCL	Maximum contaminant level
mg/L	Milligrams per liter
mgd	Million gallons per day
MS4	Municipal separate storm sewer system
NAWRPR	North Arkansas Water Resources Planning Region
n.d.	No date
NCDC	National Climatic Data Center
NEPA	National Environmental Policy Act
NFH	National Fish Hatchery
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NPS	Non point source

LIST OF ACRONYMS (CONTINUED)

NRCS	United Stated Department of Agriculture Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
NWR	National wildlife refuge
NWS	National Weather Service
PCB	Polychlorinated biphenyl
PCP	Pentachlorophenol
PDSI	Palmer Drought Severity Index
RCRA	Resource Conservation and Recovery Act
RSWMD	Regional Solid Waste Management District
SDWA	Safe Drinking Water Act
SGCN	Species of greatest conservation need
SFHA	Special Flood Hazard Area
SPL	State Priority List
Su	Standard units
TCE	Trichloroethene
TDS	Total dissolved solids
TMDL	Total maximum daily load
TOC	Total organic carbon
TSS	Total suspended solids
U of A	University of Arkansas
US	United States
USACE	United States Army Corps of Engineers
USDA	United Stated Department of Agriculture
USDI	United States Department of the Interior
USFS	United States (USDA) Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WIP	Western Interior Plains
WMA	Wildlife management area
WRDA	Water Resources Development Act

1.0 INTRODUCTION

The Arkansas Natural Resources Commission (ANRC) is responsible for preparing and periodically updating a statewide water resources planning document. The previous update of the Arkansas Water Plan (AWP) was completed in 1990. In 2012, ANRC initiated an update of the 1990 AWP to be completed in 2014.

This document was prepared as part of the 2014 update of the AWP (Project Task 6). This document provides background information about the North Arkansas Water Resources Planning Region (NAWRPR) that will be used in the 2014 AWP update. The NAWRPR is one of five state water resources planning regions being addressed in the 2014 AWP update. The information in this document will serve as background for updated discussion and analysis of state water supplies, water demand, and alternatives for meeting the water resources needs in the NAWRPR. This background information includes a description of the history of the planning region, its physical characteristics, natural resources, water resources, demographics, and economy. Finally, the regulatory and institutional framework for water resources management in this planning region is outlined.

2.0 GEOGRAPHY AND HISTORY

This section provides a general description of the geography of the NAWRPR, a brief history of the regional culture, and an overview of historical water resources management.

2.1 Geography

The NAWRPR encompasses approximately 12,400 square miles in northern Arkansas (Figure 2.1). This region is bounded on the west by Oklahoma and on the north by Missouri. The eastern boundary roughly follows the fall line, the division between the Coastal Plain and the Interior Highlands. The southern boundary roughly follows the hydrologic boundary of the White River Basin and the Little Red River watershed. In general, the planning region boundary follows county boundaries to facilitate the use of data (e.g., economic, census, and water use data) aggregated at the county level.

All or part of 19 counties are located within the planning region. Table 2.1 lists these counties, the area of each county that is in the planning region, and the corresponding percentage of the county in the planning region. Major cities in the planning region include Bentonville, Rogers, Springdale, and Fayetteville.

2.2 History

This section summarizes the history of the NAWRPR, including the culture of the region from several thousand years ago to present. The history of water resource development in the region is summarized separately.

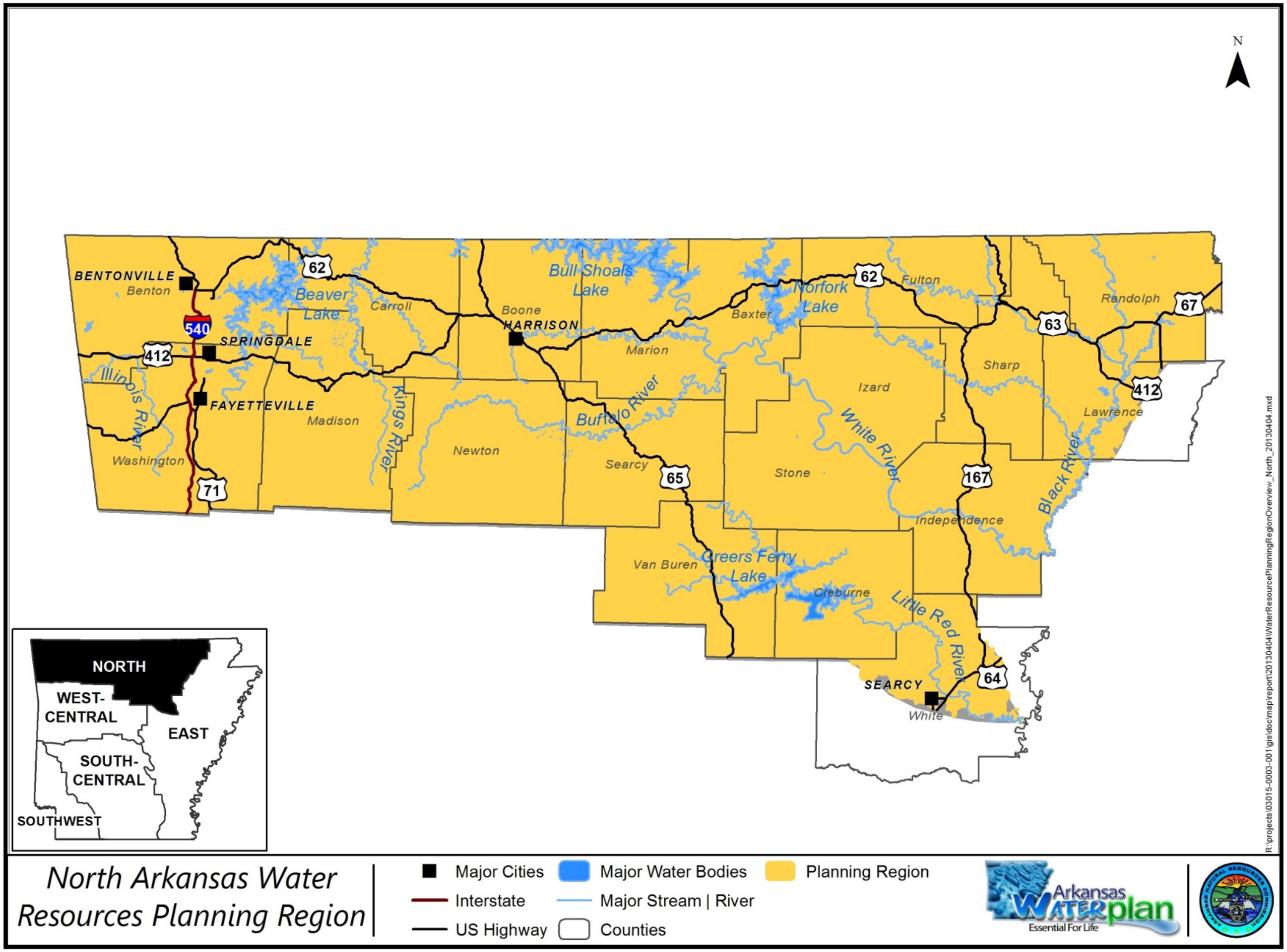

Figure 2.1. Map of the NAWRPR.

Table 2.1. Counties in the NAWRPR (US Census Bureau 2012a).

County	County Area in Planning Region (square miles)	Percentage of County Area in Planning Region
Independence	763.95	100%
Lawrence	375.10	64%
Randolph	652.19	100%
Sharp	604.44	100%
Washington	941.97	100%
Madison	834.26	100%
Newton	820.90	100%
Fulton	618.19	100%
Izard	580.58	100%
Stone	606.41	100%
Baxter	554.28	100%
Marion	597.01	100%
Boone	590.23	100%
Carroll	630.09	100%
Benton	847.36	100%
Cleburne	553.69	100%
Van Buren	708.14	100%
White	416.82	39%
Searcy	666.10	100%
Total	**12,361.71**	

2.2.1 Cultural

Archeological evidence indicates that humans inhabited bluff shelters in the NAWRPR as much as 13,500 years ago. Sometime around 6,000 BCE, native people began to mine and trade chert and other stones and minerals from the planning region. Around 2,500 years ago, people in the region began to practice agriculture, growing squash and gourds, as well as other native plants. It is believed that this is one of the first areas in the state where corn was grown. However, by the time Europeans came to Arkansas, it appears there were few Native American settlements in the region. The extreme eastern portion of the planning region was considered Quapaw territory, while the western portion of the planning region was claimed by the Osage as hunting grounds (Key 2012).

There was no significant European exploration or settlement of northern Arkansas until after the War of 1812. The first settlers in the region came from southwest Missouri, travelling along the Southwest Trail. Batesville was one of the first settlements in the region, being strategically located on the White River along the Southwest Trail and other early roads (Bolton 2012, Lankford 2013). In 1817, all land in the planning region south of the White River was granted to the Cherokee. However, roughly ten years later, the Cherokee gave up claim to this land and moved to Oklahoma (Stewart-Abernathy 2011a). In 1819, the War Department cut a road along the White River from the Mississippi River to North Fork, then east to around current-day Rogers. The original purpose of this road was to facilitate movement of eastern Native American tribes to the West; however, it was also used by whites to settle the region (McLeod 1978, Berry 1977). This road is one of the Trail of Tears routes in the state (Arkansas Department of Parks and Tourism 2013a).

The survey of land in Arkansas began in 1815, and one of the original land sales offices in the state was located in Batesville in 1822. Shortly thereafter, a few additional land offices were established, one in Fayetteville. The influx of settlers from the eastern states increased dramatically in the 1830s. Around 1840, the majority of the white population in the state lived in the northern region. However, twenty years later, the agricultural productivity of the eastern and southern parts of the state had resulted in these areas becoming more populated than the northern areas of the state. Politics and culture in the northern region of the state tended to differ from that of the regions of plantation agriculture in the east and south. A significant number of residents in the northern region of the state opposed the secession of Arkansas from the union. (Bolton 2012, DeBlack 2012).

During the early years of the Civil War, a number of battles were fought in the northern region of the state (DeBlack 2012). Around 1868, a public university, forerunner of the University of Arkansas (U of A), was established in Fayetteville.

After Reconstruction, the railroad moved into the region. In 1881 a major railroad line was constructed in northwest Arkansas, spurring rapid economic growth in the region.

Overtime, Northwest Arkansas has become a major hub of the food and commercial industries, with large companies like Wal-Mart and Tyson calling it home. Also, immigration rates to the area are high, and the region is a popular vacation area in the state (Department of Arkansas Heritage 2013).

2.2.2 Water Resources Development

A range of water resources development activities have occurred in this region throughout its history, as attitudes and policies have changed. Historically, human activities that have affected water resources in this planning region have included river transportation and navigation, development of industries including tourism, fisheries, and hydroelectric power, and the development of manmade reservoirs along rivers in the region.

2.2.2.1 Navigation

During the early years of European settlement in Arkansas, rivers were important transportation corridors, because travel over land in this region was so difficult. In the 1820s, steamboats began traveling the White River. By the 1830s, steamboats were active also on the Black River. Steamboat travel also eventually occurred along the Buffalo River (Stewart-Abernathy 2011b). Keelboat travel was also popular along rivers in north Arkansas. Keelboat posts were established near Sylamore, which is near the Buffalo River, and in Marion County on the White River (Huddleston, Rose and Wood 1998). Steamboats were able to travel much of the White River, though some parts of the section north of the confluence with the Buffalo River was considered more challenging.

None of the rivers in north Arkansas are still used for commercial transportation. The lower White River still allows for navigation, but only from Newport (in Jackson County) to the Mississippi River (Arkansas Waterways Commission 2012).

Several ferrying locations also existed along the White River. Even portions of the White River in Northwest Arkansas had ferries, including near War Eagle Creek and Eureka Springs. Many other ferries existed along the White River in portion upstream of Jacksonport to the Missouri state line. Some of these ferries were in use as late as the 1970's.

2.2.2.2 Pearl Industry

Freshwater pearls found in both the White River and Black River set off a "pearl rush" in northeast Arkansas in the late 1880s (Shoults 2011). A pearl button factory was established in northeast Arkansas around 1900 to take advantage of the large freshwater mussel populations in the White River and Black River. This was a thriving industry in the area until the late 1940s (Cavaneau 2012).

2.2.2.3 Aquatic Habitat Conservation

Just after the turn of the Twentieth Century, preservation of migratory waterfowl game birds became a national priority. The first wildlife management areas (WMAs) established by the Arkansas Game and Fish Commission (AGFC) in the NAWRPR during the 1950s were for the protection of habitat for migratory waterfowl (Table 2.2). The US Fish and Wildlife Service (USFWS) established a national wildlife refuge (NWR) in the planning region in 1993 to protect additional habitat for migratory waterfowl. A number of recent Farm Bill programs encouraged conservation and enhancement of waterfowl habitat in the region with economic incentives for activities such as setting up wetland conservation easements, and flooding fields in the winter. These programs are available in Independence, White, Randolph, and Lawrence Counties (NRCS 2010) (NRCS 2013a).

Table 2.2. History of aquatic habitat conservation in the NAWRPR.

Name	Type	Area (acres)	Counties	Year Established	Management	Purpose
Jones Point Wildlife Management Area	WMA	1,200	Marion	--	AGFC	--
Wedington Wildlife Management Area	WMA	16,000	Benton, Washington	--	USFS	Hunting, fishing
Beaver Lake	WMA	7,781	Benton, Carroll, Madison	--	USACE	Hunting, fishing
Shirey Bay-Rainey Brake Wildlife Management Area	WMA	10,711	Lawrence	1950s	AGFC	Waterfowl habitat, hunting
Dave Donaldson Black River Wildlife Management Area	WMA	25,000	Randolph	1957	AGFC	Preserve bottomland habitat
Henry Gray/Hurricane Lake Wildlife Management Area	WMA	17,000	White	1958	AGFC	Bottomland hardwood, waterfowl habitat
Gene Rush/Buffalo River Wildlife Management Area	WMA	17,652	Newton, Searcy	1966	AGFC	Wildlife habitat conservation

Table 2.2. History of aquatic habitat conservation in the NAWRPR (continued).

Name	Type	Area (acres)	Counties	Year Established	Management	Purpose
Piney Creeks Wildlife Management Area	WMA	176,000	Newton	1967	AGFC	Protect species, provide recreation
Greers Ferry Lake	WMA		Cleburne, Van Buren	1968	USACE	Fishery habitat
Sweden Creek Falls	WMA, natural area	136	Madison	1977	ANHC	Ecosystem preservation, rare plants
Big Creek	Natural area	1,508	Cleburne	1978	ANHC	Protect river habitat
Kings River Falls	Natural area	1,059	Madison	1979	ANHC	Kings River Falls access
Slippery Hollow	WMA, natural Area	1,155	Marion	1985	ANHC	Ecosystem preservation
Cave Springs Cave	Natural area	57	Benton	1985	ANHC	Ozark cavefish habitat
Hell Creek	Natural area	211	Stone	1985	ANHC	Protect cave habitat, endangered cave species
Logan Cave National Wildlife Refuge	NWR	123	Benton	1989	USFWS	Refuge of endangered species
Rock Creek	Natural area	415	Sharp	1991	ANHC, AGFC	Protect rare plant habitat
Cow Shoals Riverfront Forest	Natural area	63	Cleburne	1992	ANHC, AGFC	Protect riverfront forest
Bald Knob National Wildlife Refuge	NWR	14,800	White	1993	USFWS	Protect, provide feeding/resting area for migratory waterfowl
Pine Hollow	Natural area	132	Newton	1998	ANHC	Protect Buffalo River water quality
Foushee Cave	WMA, natural area	2,725	Independence	2011	ANHC	Protect cave habitat and species
Devil’s Eyebrow	Natural area	1,726	Benton	2012	AGFC, ANHC	Rare plant habitat

In 1972, the Buffalo River was designated as the first National River in the country. The Flood Control Act of 1938 authorized damming of the Buffalo River for hydropower. In the 1960's opposition to damming one of the few unpolluted free-flowing rivers in the lower 48 states became well organized. In 1966, after Arkansas Governor Faubus denied support for damming the Buffalo River, the USACE withdrew the plans for developing hydropower on the river. Legislation to establish the Buffalo River National Park was first introduced to the US Congress in 1967. The legislation naming the Buffalo River as a National River was passed in 1972 (Rogers 2010).

Late in the 20th Century, preservation of cave habitats and associated rare and endangered species became a priority at the state and national level. The Arkansas Natural Heritage Commission (ANHC) established several natural areas centered around caves where endangered cave species were present. The US Fish and Wildlife Service (USFWS) established a National Wildlife Refuge (NWR) to protect the Logan Cave ecosystem in 1989 (Table 2.2).

In 1968, the US Congress created the National Wild and Scenic Rivers System to preserve free-flowing rivers with outstanding recreational, cultural, and/or natural features. In 1979, the Arkansas legislature created the Arkansas Natural and Scenic Rivers System to protect selected rivers from damming and channel alterations (ANHC 2012). In 1992, portions of three rivers in the NAWRPR were added to the National Wild and Scenic Rivers System (Table 2.3). A section of the Strawberry River was listed in the Arkansas Natural and Scenic Rivers System in 1985 (Arkansas Code 15-23-313).

Table 2.3. History of wild/natural and scenic rivers in the NAWRPR (ANHC 2012, Interagency Wild and Scenic Rivers Council n.d.).

River	System	Length (miles)	County	Year designated	Agency
Strawberry River	State	43	Fulton, Izard	1985	ANHC
Buffalo River	National	15.8	Newton	1992	USFS
North Sylamore Creek	National	14.5	Stone	1992	USFS
Richland Creek	National	16.5	Searcy	1992	USFS

2.2.2.4 Aquaculture

There are three National Fish Hatcheries (NFH) located in the NAWRPR. The Norfork NFH is home to cold water production of trout that are used to restock the tailwaters downstream of dams, including Norfork and Bull Shoals (USFWS 2010a). Mammoth Spring NFH is one of the oldest fish hatcheries in the country and is the location of interjurisdictional fish restoration, endangered and threatened species recovery, restoration of fish in the White River Watershed, and production of recreational fish for NWRs (USFWS 2010b). The Greers Ferry NFH provides trout for streams in both Arkansas and Oklahoma. It also participates in research on threatened and endangered aquatic species (USFWS 2013).

2.2.2.5 Flood Control

In 1938, US Congress enacted the Flood Control Act, and the White River basin was chosen as one of the candidates for flood control. Several reservoirs have been created in the White River Basin. Beaver Lake in Benton and Carroll Counties is the most upstream reservoir, stretching from near Fayetteville to Eureka Springs, Arkansas. Other reservoirs along the White River are Lake Taneycomo in Missouri and Table Rock Lake and Bull Shoals Lake in both Arkansas and Missouri. In 2004, the USACE estimated that lakes along the White River helped to prevent over $67 million in flood loss (Branyan 2013).

Flood control reservoirs have also been constructed on White River tributaries in the NAWRPR. Greers Ferry Lake on the Little Red River, and Norfork Lake on North Fork River, were also constructed to provide flood control. Norfork Dam was built in the 1940s. Greers Ferry Dam was completed in 1962.

2.2.2.6 Hydropower

Arkansas has the potential to produce a significant amount of its electrical energy from hydroelectricity, however only 3% of the electricity produced in 2006 was from hydroelectric sources. In the NAWRPR the four USACE reservoirs constructed on the White River and its tributaries for flood control are also authorized for hydropower (Table 2.4). Three hydropower dams were constructed on the White River in the 21st century (Table 2.4). These new dams were built at the locations of abandoned locks upstream of Newport.

Table 2.4. Hydroelectric plants in the NAWRPR (Reynolds, Hydroelectricity 2012).

Plant	County	River	Year Completed	Agency
Norfork	Baxter	North Fork	1944	USACE
Bull Shoals	Marion/Baxter	White	1952	USACE
Greers Ferry	Cleburne	Little Red	1964	USACE
Beaver	Carroll	White	1965	USACE
Marcella	Stone	White	2006	IC
Earnhardt	Independence	White	2007	IC
Batesville	Independence	White	2007	IC

USACE United States Army Corps of Engineers
IC Independence County

2.2.2.7 Arkansas River Basin Compact

In 1955, the US Congress authorized Oklahoma and Arkansas to begin negotiating a compact to resolve disputes over rights to water in the Arkansas River and its tributaries. In 1970, after 15 years of negotiations, the states of Arkansas and Oklahoma signed an agreement concerning water apportionment in the Arkansas River Basin along the Arkansas-Oklahoma border. Two subbasins in the NAWRPR, the Spavinaw Creek Watershed and Illinois River Watershed, are discussed as part of the compact. The two states are in agreement that Arkansas has the rights to water in both subbasins within the state's borders, with the limitation that annual yield does not deplete more than 50% in the Spavinaw Creek Watershed and 60% in the Illinois River Watershed (Arkansas River Compact Committee 1970). This compact is described in greater detail in Section 6.1.7.

3.0 PHYSICAL CHARACTERISTICS

This section summarizes the physical and biological characteristics of the North Arkansas Water Resources Planning Region. This includes the physiographic, geology, climate, and land use, as well as descriptions of the ecological, surface water, and groundwater resources within the planning region.

3.1 Physiography

The NAWRPR is located primarily in the Interior Highlands physiographic region. A small area of this planning region is located in the Gulf Coastal Plain (Figure 3.1). Physiographic provinces of the Interior Highlands that are present in the planning region are the Ozark Plateaus and Ouachita Mountains. The physiographic province of the Gulf Coastal Plain present in the planning region is the Mississippi Alluvial Plain. Because the Ouachita Mountain and Mississippi Alluvial Plain provinces comprise such small areas of the planning region, they will not be described in this document. Descriptions of the Ouachita Mountain and Mississippi Alluvial Plain provinces can be found in the background reports for other planning regions.

The Ozark Plateaus physiographic province is divided into three physiographic subdivisions that are defined by stratigraphic interval and geologic age. From north to south, these subdivisions are the Salem Plateau, Springfield Plateau, and the Boston Mountains (Adamski, Petersen, et al. 1995).

The Salem Plateau is mainly north and east of the White River in Arkansas (Figure 3.1). Elevations are generally 500 to 1,000 feet above sea level. Streams are gradually dissecting the broad uplands and the area is undulating to hilly, with relief seldom exceeding 200 feet.

The Springfield Plateau is found in northwestern Arkansas and in a narrow belt eastward (Figure 3.1). Elevations generally are from 1,000 to 1,500 feet. Extensive relatively level areas exist in Washington and Benton counties but relief of 200 to 300 feet occurs along major streams. Outliers of the Boston Mountains appear as isolated low mountains on the Plateau, the most notable being the Boat Mountain group near Harrison.

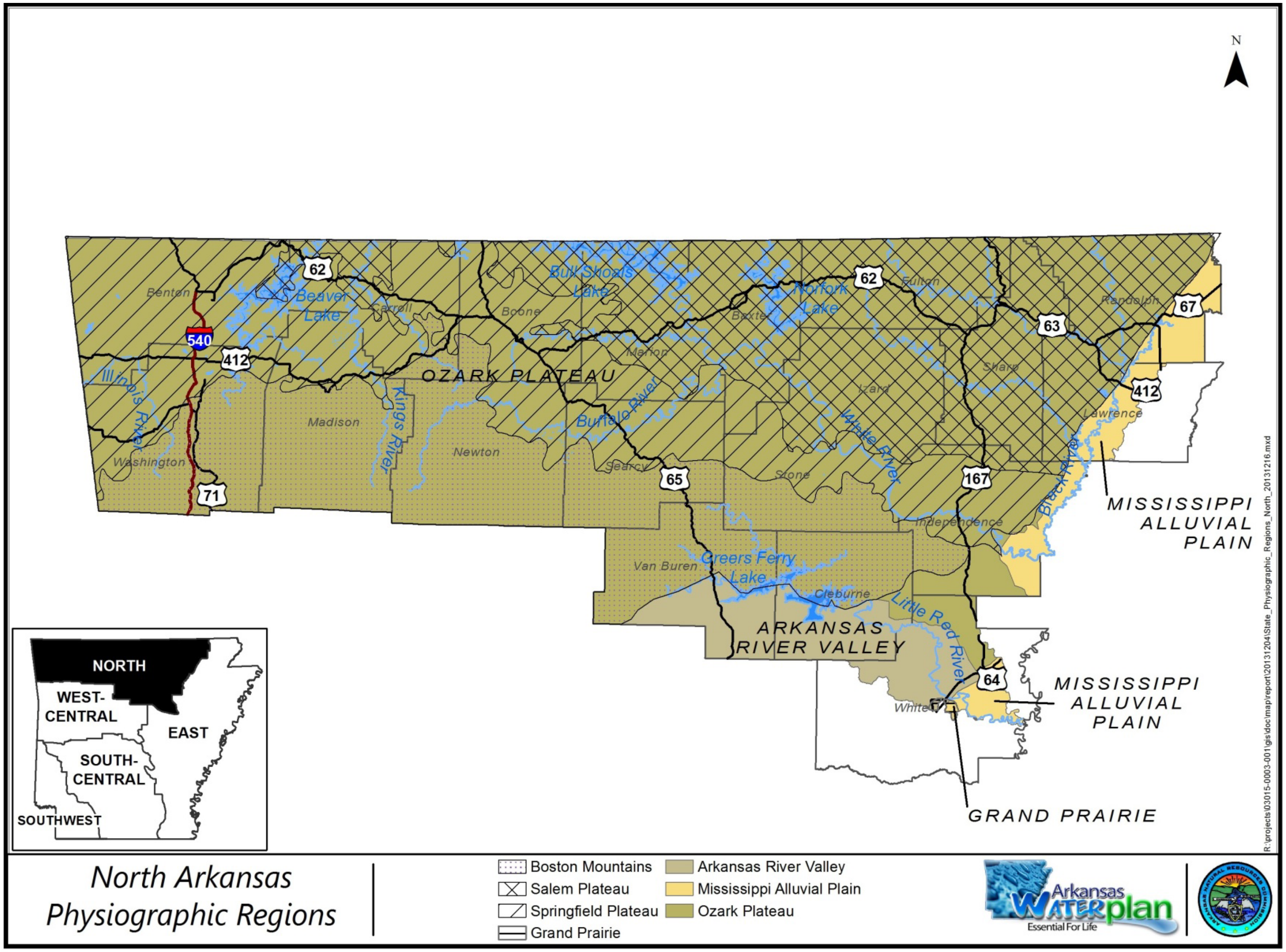

Figure 3.1. Physiographic regions of the NAWRPR.

The Boston Mountains physiographic subdivision consists of the higher southern edge of the Ozark Plateau province, and makes up most of the southern boundary of the planning region (Figure 3.1). These mountains are primarily flat-topped, with the summit ridges representing the original erosion surface of the plateau. Great stream dissection has occurred, creating steep sided mountains and deep narrow valleys. Elevations generally range between 1,500 and 2,200 feet but exceed 2,500 feet. Relief is mainly within the 500 to 1,000 feet range but exceeds 1,600 feet. The northern boundary is well marked by a retreating escarpment in most areas, being especially prominent in its central extent from Jasper to Mountain View.

3.2 Geologic Setting

Geologic formations underlying the NAWRPR range in stratigraphic order from the earliest deposited layers of the Ordovician Period in the Ozark Plateaus Province to Quaternary Alluvium in the Mississippi Alluvial Plain Province. Figure 3.2 displays the surface geology of the planning region. The geology of the Ozark Plateaus and Ouachita Mountain provinces are described below. The geology of the Mississippi Alluvial Plain province is described in the background report for the East Water Resources Planning Region.

Generally, the hydrogeology of the Interior Highlands can be described as an area of consolidated formations which yield relatively low volumes of water to wells. The low specific capacity in these wells is a direct result of the lithological nature of the strata itself. The consolidated formations typically are confined with most of the water yielded to wells coming through secondary porosity found in fractures and bedding plains. Typically, the most noted aquifer within NAWRPR is the deep Ozark aquifer. Groundwater resources of the NAWRPR are further described in Section 3.8

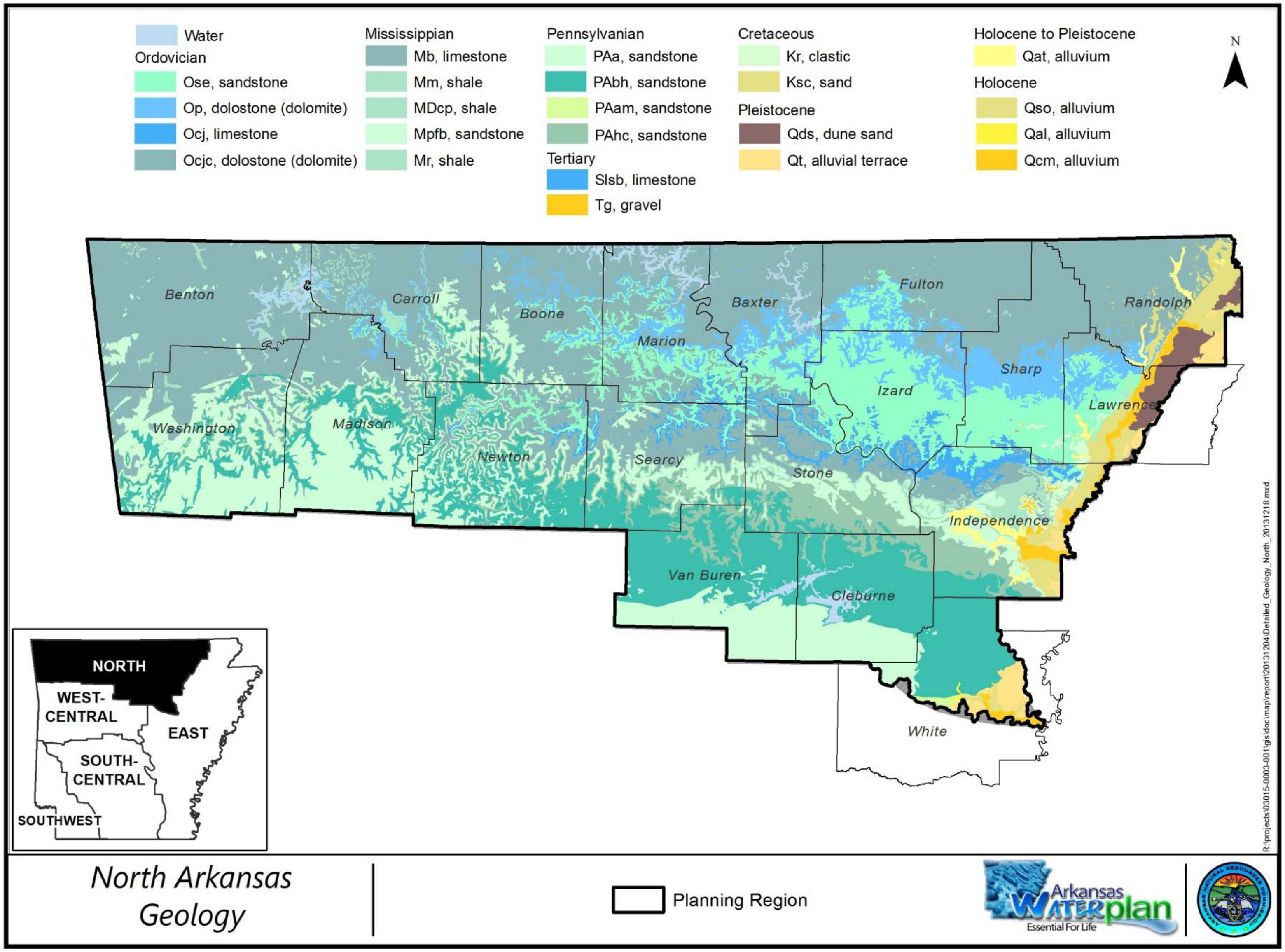

Figure 3.2. Detailed surface geology of the NAWRPR.

3.2.1 Geology of the Ozark Plateaus Province

The Ozark Plateaus are underlain by a structural dome formed by a series of uplifts that occurred between 1 billion and 280 million years ago (Precambrian through Permian). Most of the uplift is believed to have occurred between 325 and 280 million years ago (Carboniferous through Permian) when a continent-to-continent collision occurred along the southern border of North America, known as the Ouachita orogeny (Rogers 1987). The uplift of the Ozark Plateaus caused extensive faulting, joints, and fractures to occur. Major faults are oriented northwest and downthrown to the south. Gentle folding of very low amplitude is occasionally observed (McFarland 2004). The Ozark Plateaus represent a depositional environment of a relatively shallow continental shelf, sloping toward deeper water generally to the south.

The surface rocks of the Salem Plateau are the oldest of the Ozark Mountains, younger ones having been removed by erosion. They are predominantly dolomite and limestone of Ordovician age with some sandstone and shale (Figure 3.2). The Cotter dolomite of Lower Ordovician age, a massive formation 500 feet thick, covers most of the eastern and northern portions of this region. The Everton Limestone is the prominent formation in the western and southern areas. The Calico Rock Sandstone, a white colored sand, is at the base of the Everton. Dolomite and silica-rich sand are quarried. The former zinc-producing area of Arkansas is centered in the Ordovician rocks of Marion County but zinc was mined in numerous other areas where the same strata were exposed by stream cutting. Some lead is associated with the zinc deposits.

The Springfield Plateau is the surface feature of northwestern and north-central Arkansas and is generally underlain by limestones and cherty limestones of Mississippian age. It is commonly recognized at land surface as the Boone Formation, consisting of limestone and chert. Weathering more easily reduces the limestone, leaving large pieces of chert which are especially prominent on hillsides where the finer materials have been eroded away. The limestone is quarried in many localities. The St. Joe marble member is at the base of the Boone and is locally quarried for commercial purposes. The St. Joe Member is also the source rock for the majority of springs flowing in the Springfield Plateau. Outliers of the Boston Mountains are especially common in the western part of the Springfield Plateau. They consist largely of sandstone and shale found in the Boston Mountains but lack the Atoka formation which caps the mountains.

The Boston Mountains are surfaced primarily in sandstone and shale of Pennsylvanian age. The massive Atoka Formation, over 1,500 feet thick, is the most prominent. The Atoka sandstone forms the bluffs at the top of the Boston Mountains.

The highly soluble nature of carbonate rocks (limestone and dolostone) along fractures and faults in the Springfield and Salem Plateaus has formed a unique karst terrain. Karst features include cave networks; dissolutionally enhanced fractures, faults, and bedding planes; sinkholes, losing stream segments, and cutters and pinnacles (Brahana 1997). Karst features do not exhibit a surface expression in many areas of the Springfield Plateau because cher t and clay tend to form a regolith cover which mantles the upper surface and masks the underlying karst features. Surface-karst features are generally only visible when carbonate rocks are within the zone of shallow groundwater circulation (less than 30 feet below land surface) (Fanning 1994). While a regolith still mantels underlying karstic bedrock in the Salem Plateau, karst features of the Salem Plateau are typically more abundant, are more concentrated, and are larger in size than karst features of the Springfield Plateau (Adamski, Petersen, et al. 1995).

3.2.2 Geology of the Arkansas River Valley

The subdivision of the Ouachita Mountain province that underlies the NAWRPR is southern Van Buren and Cleburne Counties, and White County, is the Arkansas River Valley, also known geologically as the Arkoma Basin. The central and eastern portions of the valley are dominated by the alternating sandstone and shale of the Hartshorne and Atoka Formation. There are numerous natural gas fields in this region, producing a dry gas.

The Arkoma Basin is a structural low trending east-west across central Arkansas that was created by compression from the Ouachita orogeny (Adamski, Petersen, et al. 1995). This province is dominated by Pennsylvanian age sandstone, siltstone, and shale that were originally sediments deposited on the margin of a continental shelf primarily by deltas and subsequently reworked by marginal marine processes (McFarland 2004). The sedimentary section in the Arkoma Basin is reported to range in thickness from 3,000 to 35,000 feet (Manger and Lloyd 2008). The structural geology of the area consists of relatively broad synclinal folds with relatively narrow intervening anticlinal folds that trend east-west (McFarland 2004). In vicinity of the planning region, the structural geology is characterized by normal (growth) faulting and gentle folds (Hutto and Rains 2011).

3.3 Ecoregions

Ecoregions denote areas within which ecosystems, and the type, quality, and quantity of environmental resources, are generally similar (EPA 2010). The US Environmental Protection Agency (EPA) has defined 10 ecoregions within the NAWRPR (Figure 3.3). Seven of the ecoregions are in the Ozark Plateaus, and three are in the Mississippi Alluvial Plain. One of the ecoregions is associated with the Arkansas River Valley. Characteristics of all of the ecoregions in the NAWRPR are summarized in Table 3.1.

The ecoregion that developed on the Boston Mountains Plateau is considered distinct from the ecoregion that developed in the Springfield and Salem Plateaus. The Boston Mountains ecoregion is a mosaic of woodland, forest, and savanna. Oak-hickory-pine forest is the dominant natural vegetation. Higher moisture levels and cooler temperatures on north-facing slopes and in valleys support oak-hickory forest communities. Pines occur on drier west and south facing slopes over sandstone. Fish communities in Boston Mountain streams tend to be diverse and dominated by sensitive species (Woods, et al. 2004). The Boston Mountains contain habitat for a number of cave species (Anderson 2006).

The Ozark Highlands ecoregion of the Springfield and Salem Plateaus is characterized by being rich in karst features, including caves, sinkholes, and underground streams. Soils here are generally cherty. Habitat diversity and species richness are high in this ecoregion. Natural vegetation is primarily oak-hickory forest. Pines tend to grow here on steep, cherty escarpments, and on shallow soils derived from sandstone. Glades dominated by grass and cedar occur on shallow soils over dolomite. Streams in this ecoregion tend to have gravelly bottom material and are often spring-fed. Fish communities are characteristically dominated by sensitive species (Anderson 2006, Woods, et al. 2004).

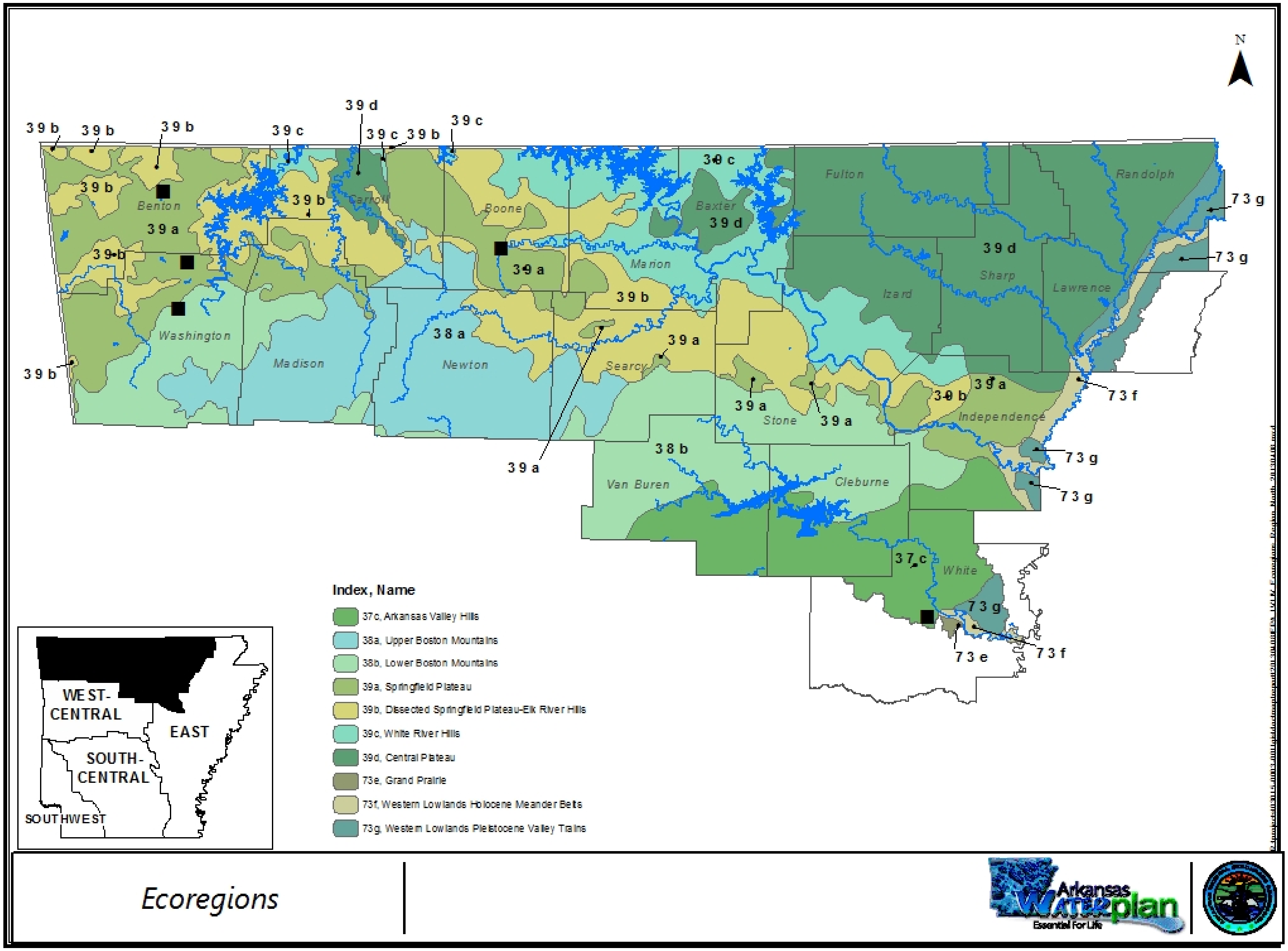

Figure 3.3. Level IV ecoregions of the NAWRPR (Woods, et al. 2004)

Table 3.1. Ecoregions in the NAWRPR (Woods, et al. 2004).

Level III Ecoregion	Level IV Ecoregion	Native Vegetation	Hydrology
Arkansas Valley	Arkansas Valley Hills	Oak-hickory forest and oak-hickory-pine	Low gradient streams
Boston Mountains	Upper Boston Mountains	Oak-hickory forest	Small streams intermittent in summer
Boston Mountains	Lower Boston Mountains	Oak-hickory-pine and oak-hickory forests	Small streams intermittent in summer
Ozark Highlands	Springfield Plateau	Oak-hickory-pine and oak-hickory forests	Perennial, spring-fed streams
Ozark Highlands	Dissected Springfield Plateau – Elk River Hills	Oak-hickory-pine and oak-hickory forests	Perennial, spring-fed streams
Ozark Highlands	White River Hills	Oak-hickory-pine and oak-hickory forests; cedar glades	Perennial, spring-fed streams and some dry valleys
Ozark Highlands	Central Plateau	Oak-hickory-pine and oak-hickory forests; barrens; cedar glades	Hilly; some karst features
Mississippi Alluvial Plain	Grand Prairie	Tall grass prairie, oak-hickory open woodland and savannah	Low gradient streams
Mississippi Alluvial Plain	Western Lowlands Holocene Meander Belts	Bottomland hardwood forest and woodland of primarily oaks	Runoff from Ozark Highlands and Boston Mountains feeds most streams, former and current river channels of White, Black, Cache Rivers, low gradient streams
Mississippi Alluvial Plain	Western Lowlands Pleistocene Valley Trains	Post oak, loblolly pine; sandpond forests primarily oak	Braided streams; little flooding in uplands

The Arkansas Valley ecoregion includes floodplains, terraces, and hills. Within the NAWRPR, oak-hickory forest and oak-hickory-pine forest are the most common forest communities in this ecoregion, within the Planning Region. Stream fish communities typically include a number of sensitive species (Woods, et al. 2004).

The ecoregion of the Mississippi Alluvial Plain, within the Planning Region, is characterized by floodplain features, including natural levees, terraces, swales, and abandoned stream channels; and poorly drained soils (Anderson 2006, Woods, et al. 2004). Soils here are sandy loam, silty loam, or clay (ASWCC 1987). Natural vegetation and habitats include southern bottomland forest and wetlands. Streams here have very low gradients and fine-grained bottom material, and they are frequently channelized or otherwise altered. Fish communities are dominated by tolerant species, with few, if any, sensitive species (Anderson 2006, Woods, et al. 2004).

3.4 Aquatic Biodiversity

The upper White River watershed in the NAWRPR includes streams with the best water quality and highest productivity in the state. Fish communities in these streams are often dominated by sensitive species. This planning region has the highest number of aquatic animal species of greatest conservation need in the state; 144 out of the 268 identified (Anderson 2006). Figure 3.4 provides a summary of the aquatic and semi-aquatic species of greatest conservation need found in the planning region. Of the over 180 aquatic and semi-aquatic plant species tracked by ANHC, over 70 occur in the NAWRPR (ANHC 2013). Of the 42 Arkansas endemic aquatic species (found nowhere else in the world), 15 occur in the planning region (Figure 3.5) (Anderson 2006). Approximately 443 miles of streams and over 20 springs and caves in the planning region have been designated by the Arkansas Department of Environmental Quality (ADEQ) as Ecologically Sensitive Waterbodies because they provide habitat for endemic, threatened, or endangered species (Figure 3.6) (APCEC 2011). Additional information on threatened and endangered species in the planning region is provided in Section 5.3.7.

3.5 Climate

The NAWRPR lies in a semi-humid region characterized by long summers, relatively short winters, and a wide range of temperatures. Temperature, precipitation, and evaporation data for the planning region were obtained from the National Weather Service, Oceanic and Atmospheric Administration National Climatic Data Center (NOAA NCDC) and the Prism Climate Group and reviewed. These data are available for each of the climate divisions in Arkansas (Figure 3.7). Data for climate divisions 1 and 2 were used to characterize climate in the NAWRPR. Summaries of these data are presented below, along with discussions of factors that influence climate in the NAWRPR and long-term climate trends in the region.

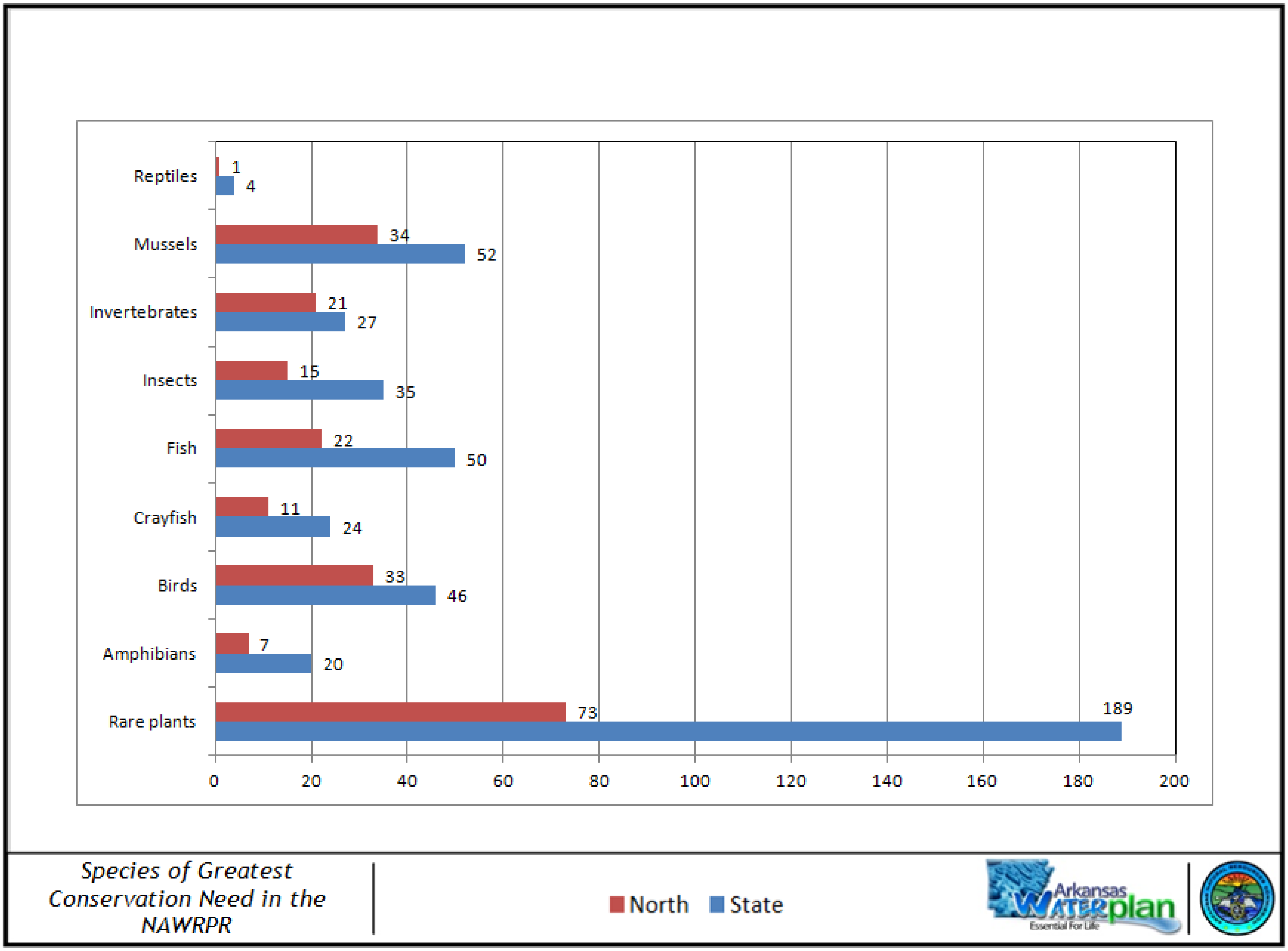

Figure 3.4. Species of greatest conservation need found in the NAWRPR (Anderson 2006, ANHC 2013).

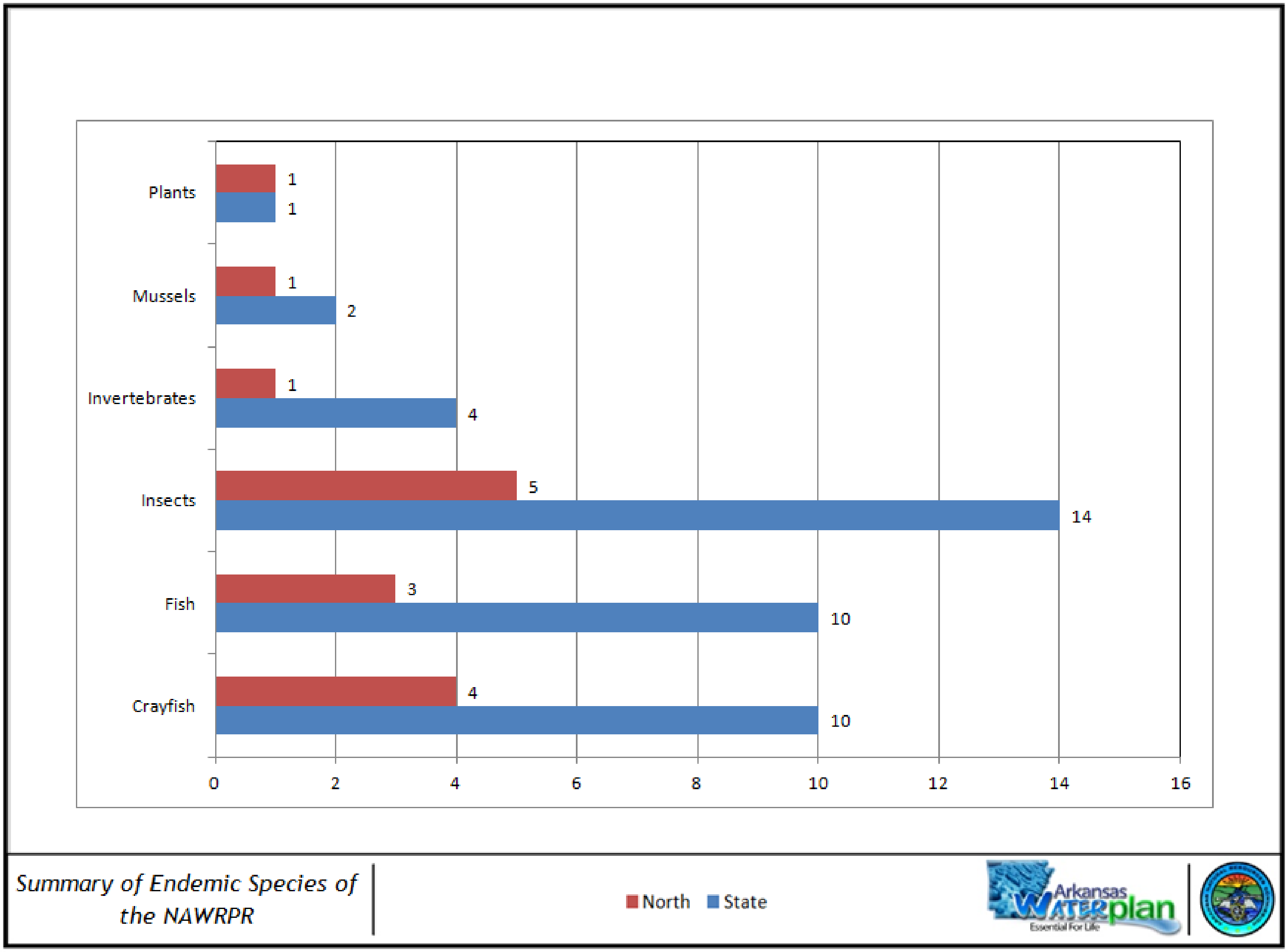

Figure 3.5. Summary of endemic species of the NAWRPR.

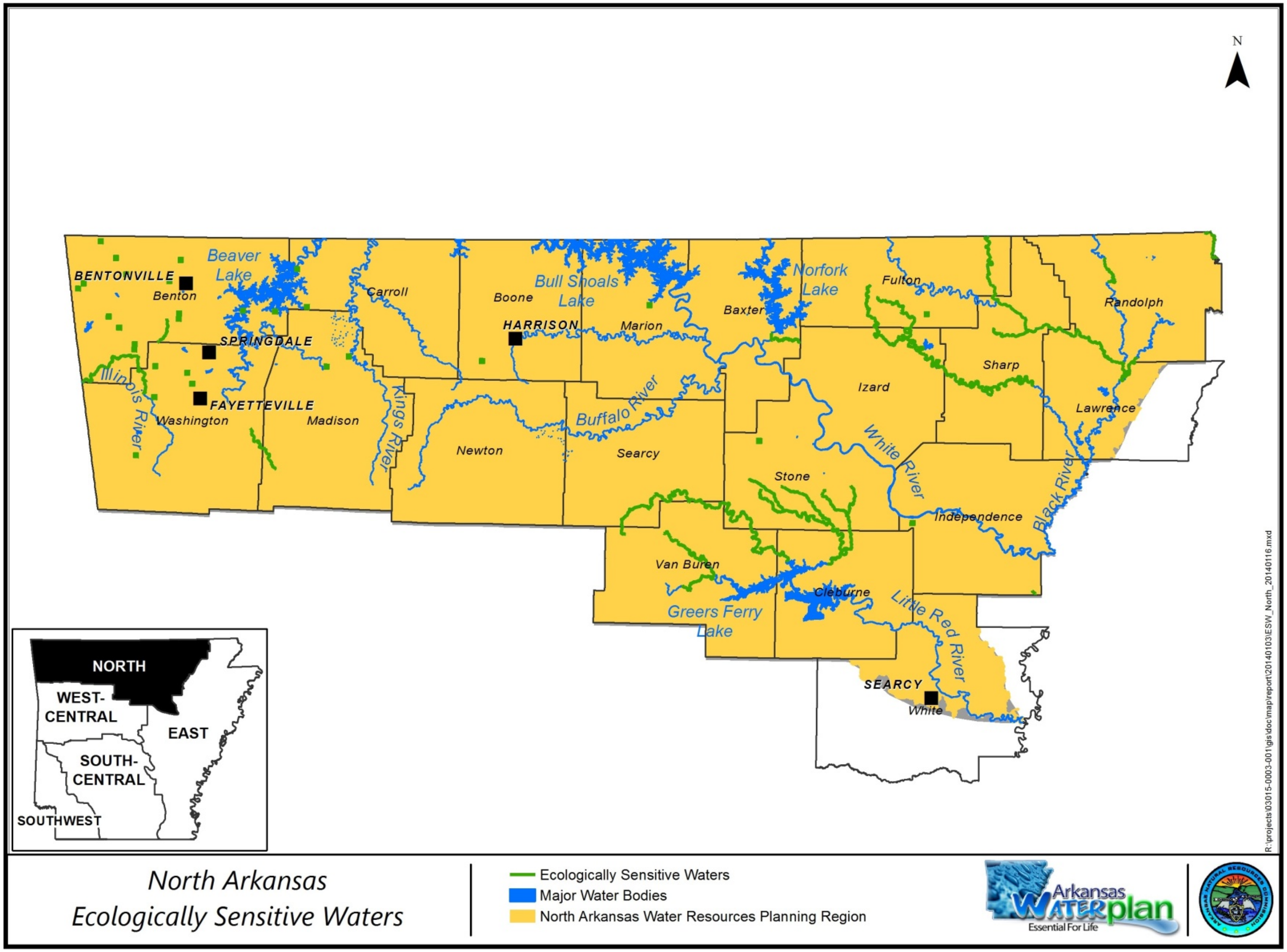

Figure 3.6. Ecologically sensitive waterbodies in the NAWRPR (APCEC 2011).

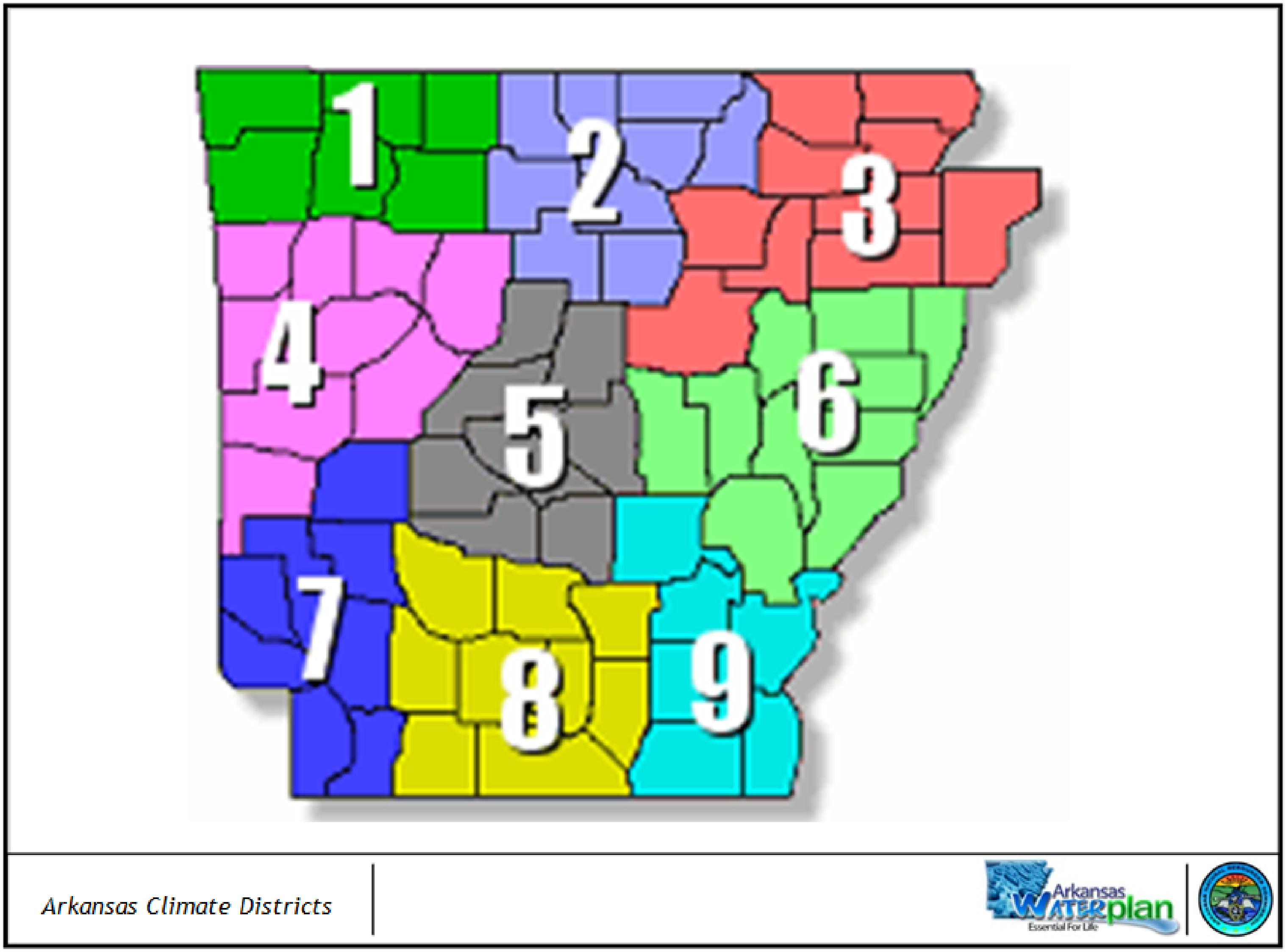

Figure 3.7. Arkansas climate divisions (NOAA NWS 2013).

3.5.1 Temperature

The average annual temperature in the NAWRPR is approximately 58°F (NOAA NCDC 2013a). Extremes in air temperatures may vary from winter lows around 0°F, usually caused by Canadian air masses, to summer highs above 100°F. Extreme temperatures may occur for short periods of time at any location within the study area (ASWCC 1987). The growing season averages around 200 days per year in the uplands, and around 220 days per year in the Mississippi River Alluvial Plain (Woods, et al. 2004). Average monthly temperatures over the period from 1981 through 2010 are shown in Figure 3.8. Variations in annual maximum daily temperatures across the planning region are shown in Figure 3.9.

3.5.2 Precipitation

According to the NOAA NCDC, the average annual precipitation for both Climate Divisions I and II was approximately 46 inches for the years 1985-2012 (NOAA NCDC 2013a).

The NAWRPR does experience snowfall as well as rainfall. Average snowfall amounts for the years 1981-2010 ranged from 1.6 inches per year in Black Rock, Arkansas, to 13.8 inches per year in Gravette, Arkansas (Golden Gate Weather Services 2011).

Average monthly precipitation over the period from 1981 through 2010 is shown in Figure 3.10. Variations in average annual precipitation across the region are displayed in Figure 3.11.

3.5.1 Evaporation

Evaporation is the process by which water changes from liquid to gaseous water vapor. When the conversion from liquid to water vapor occurs on leaves, the process is called transpiration. Evapotranspiration is the combination of these processes. The amount of evapotranspiration is controlled primarily by sunlight, but is influenced by humidity and wind (Scott, et al. 1998).

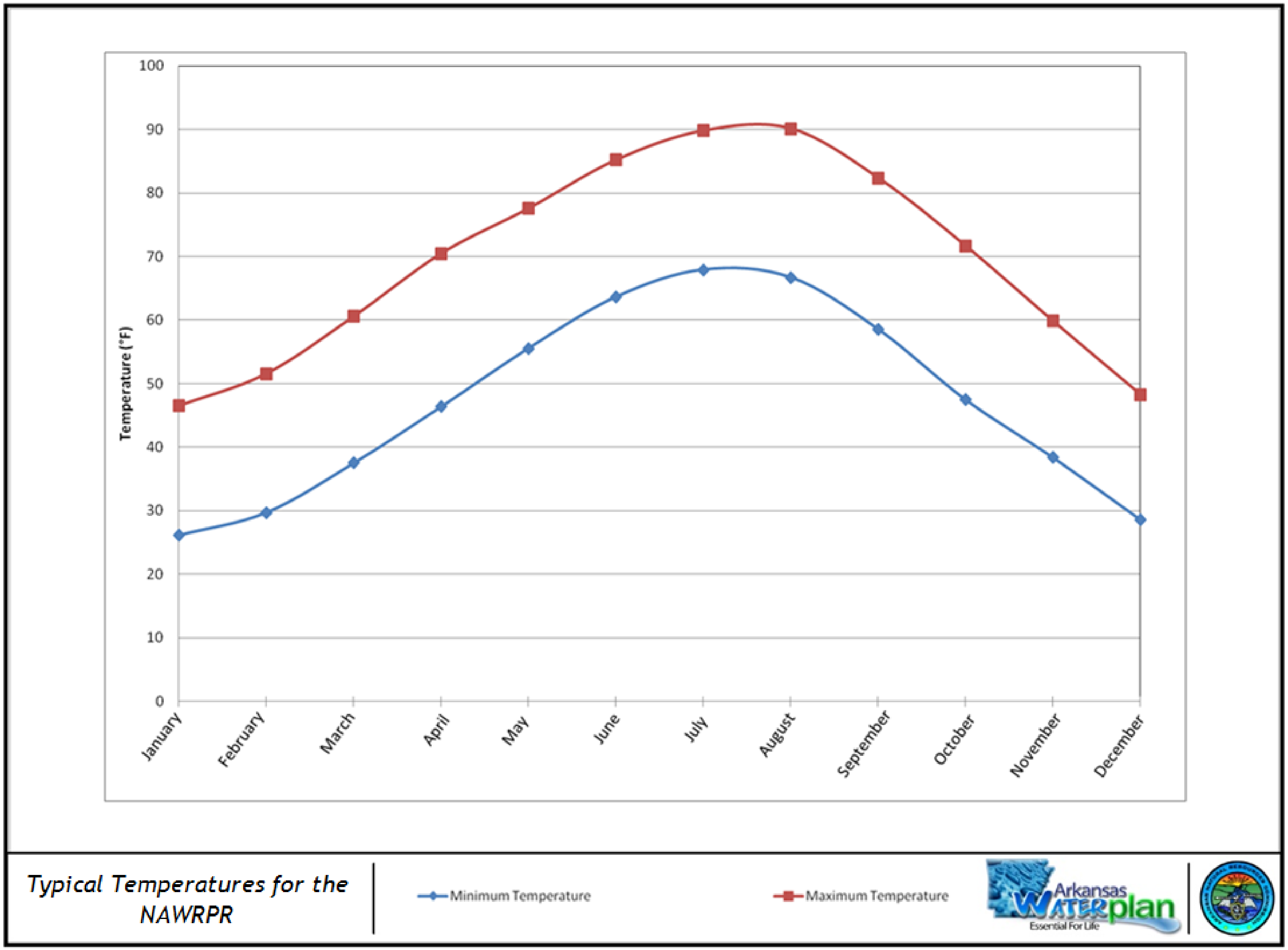

Figure 3.8. Typical temperatures for the NAWRPR (PRISM Climate Group 2012).

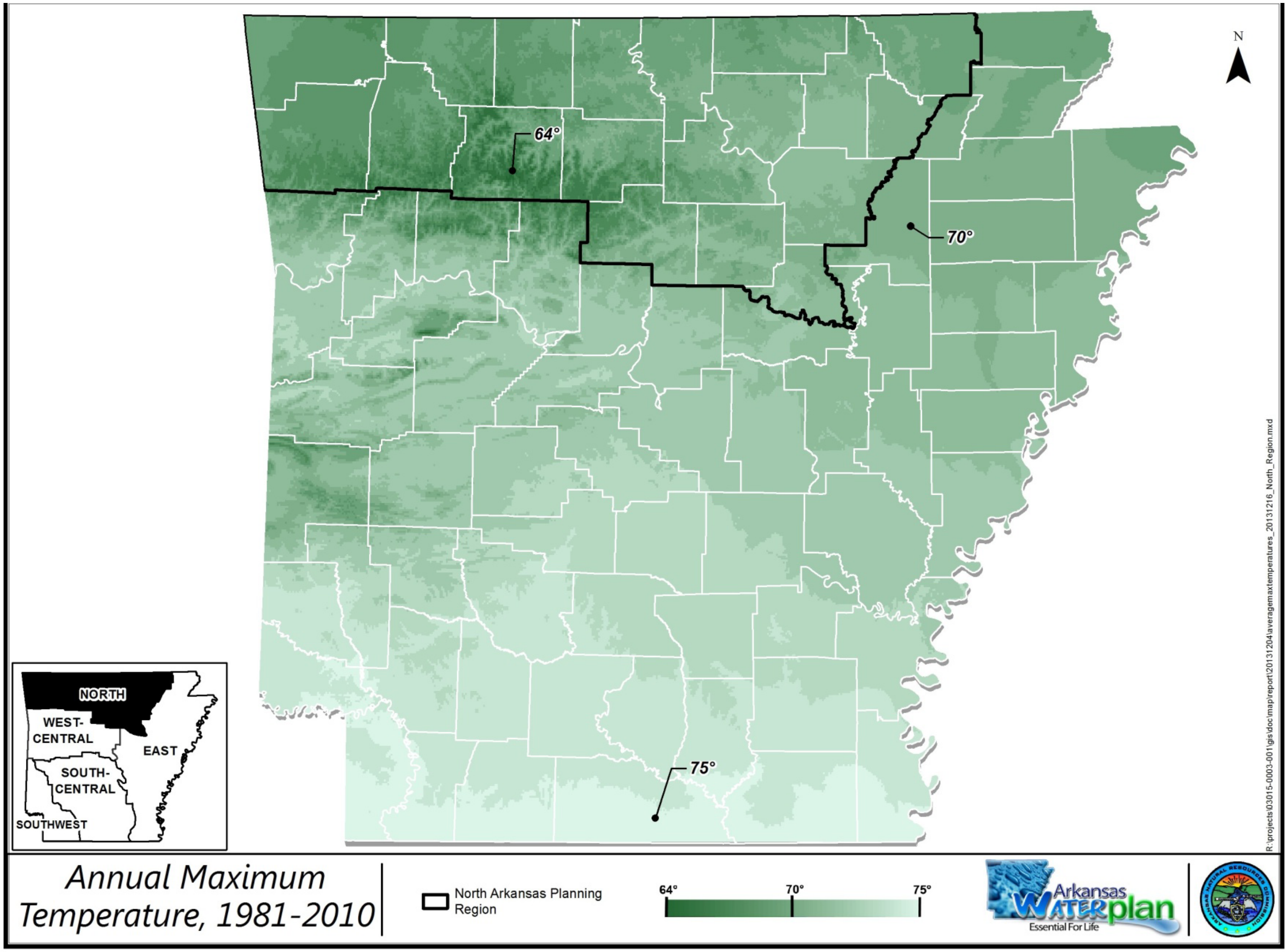

Figure 3.9. Annual maximum daily temperatures in the NAWRPR.

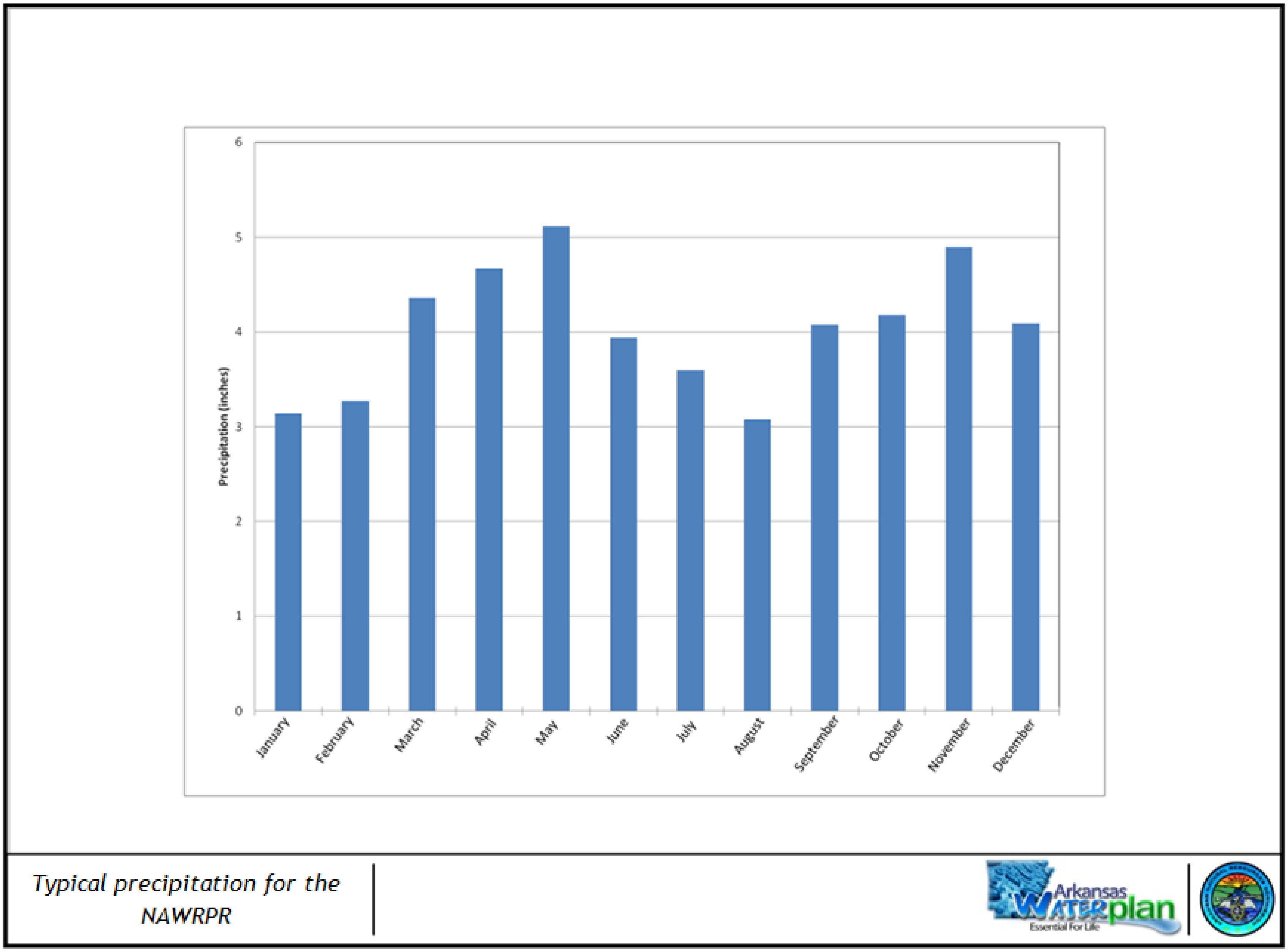

Figure 3.10. Typical precipitation for the NAWRPR (PRISM Climate Group 2012)

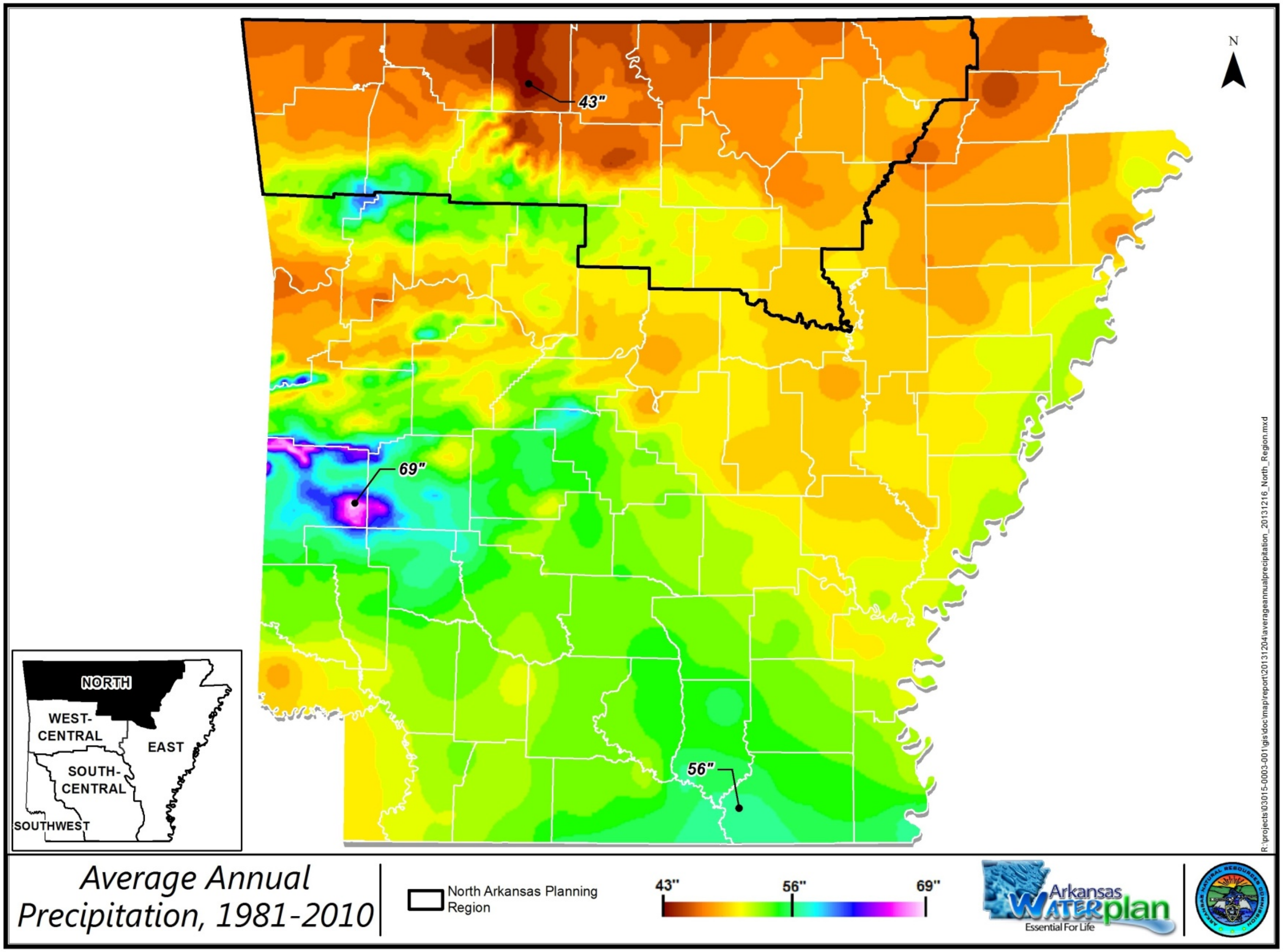

Figure 3.11. Average annual precipitation (inches) in the NAWRPR.

Potential evapotranspiration is the maximum rate at which water in soil and on plants would change to water vapor, assuming there is no shortage of water to be changed. Actual evapotranspiration is usually less than the potential. Potential evapotranspiration is difficult to measure, but can be estimated from the meteorological measurement, pan evaporation. Pan evaporation is the rate of evaporation of water from a specific style of open pan at a weather station.

Pan evaporation data taken from 1953 to 1979 in Mountain Home, Arkansas, was reported in a NOAA National Weather Service (NWS) report. It showed a sum of monthly averages of 35.85 inches evaporated in the May-October period. Annual average was not available (NOAA NWS 1982).

3.5.2 Drought

Although the NAWRPR receives precipitation throughout the year, drought conditions can occur in the region. One of the tools the NOAA uses to determine when drought conditions exist is the Palmer Drought Indices. These indices are based on the differences of precipitation and temperatures from normal. The Palmer Drought Severity Index (PDSI) also takes into account the length of time that drought conditions last. PDSI values less than zero indicate drought conditions. An index of -2 indicates moderate drought, -3 indicates severe drought, and -4 indicates extreme drought (NOAA 2012). Figures 3.12 and 3.13 show time series plots of PDSI values for Climate 1 and Climate 2 Divisions in Arkansas. Periods with multiple consecutive years of drought have occurred frequently in North Arkansas. This region is currently experiencing a period of drought that began in 2010 for Division 1 and 2011 for Division 2 (NOAA NCDC 2013b).

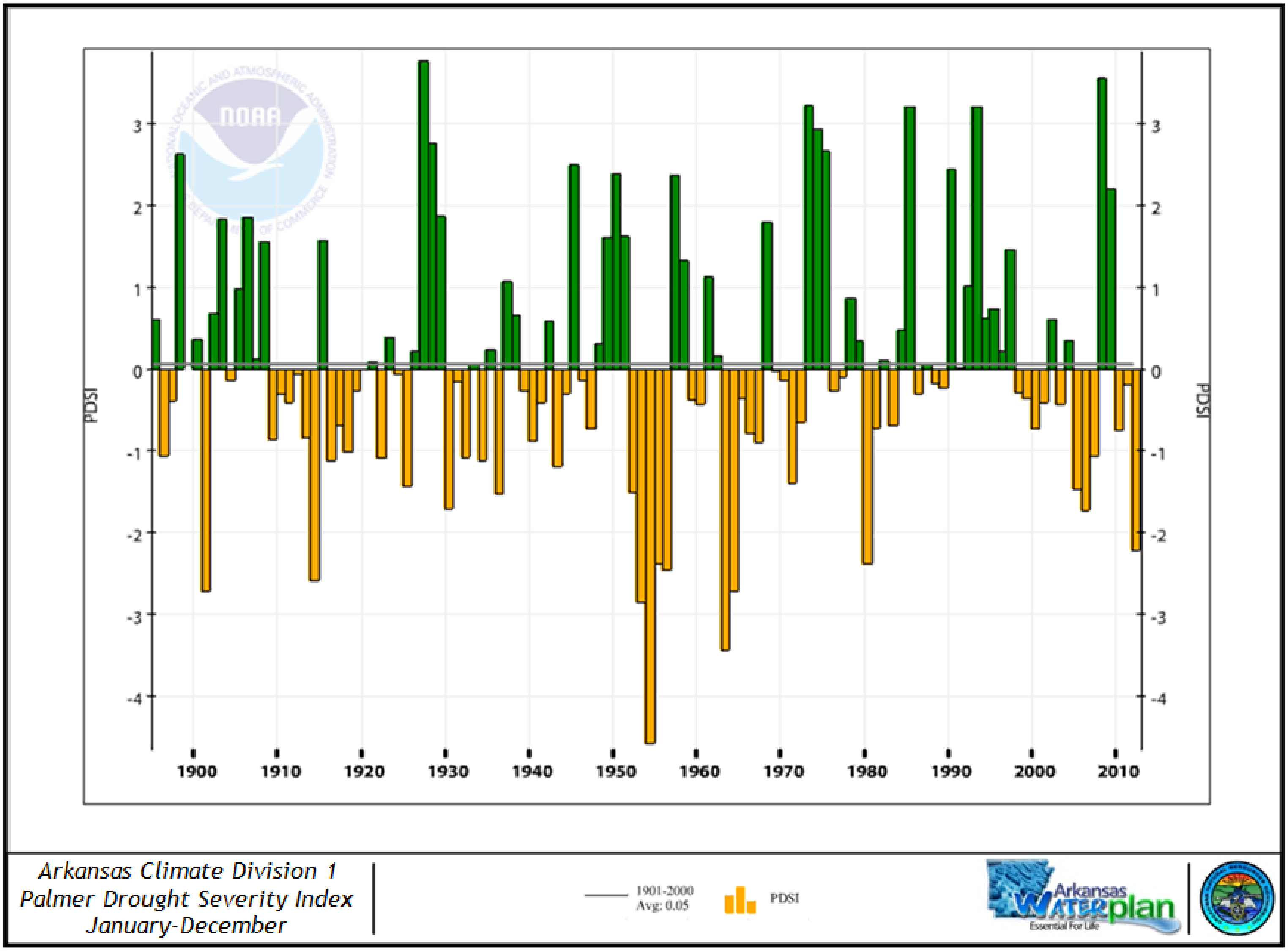

Figure 3.12. Historical values of the Palmer Drought Severity Index for the northwest climate division (1) (NOAA NCDC 2013b).

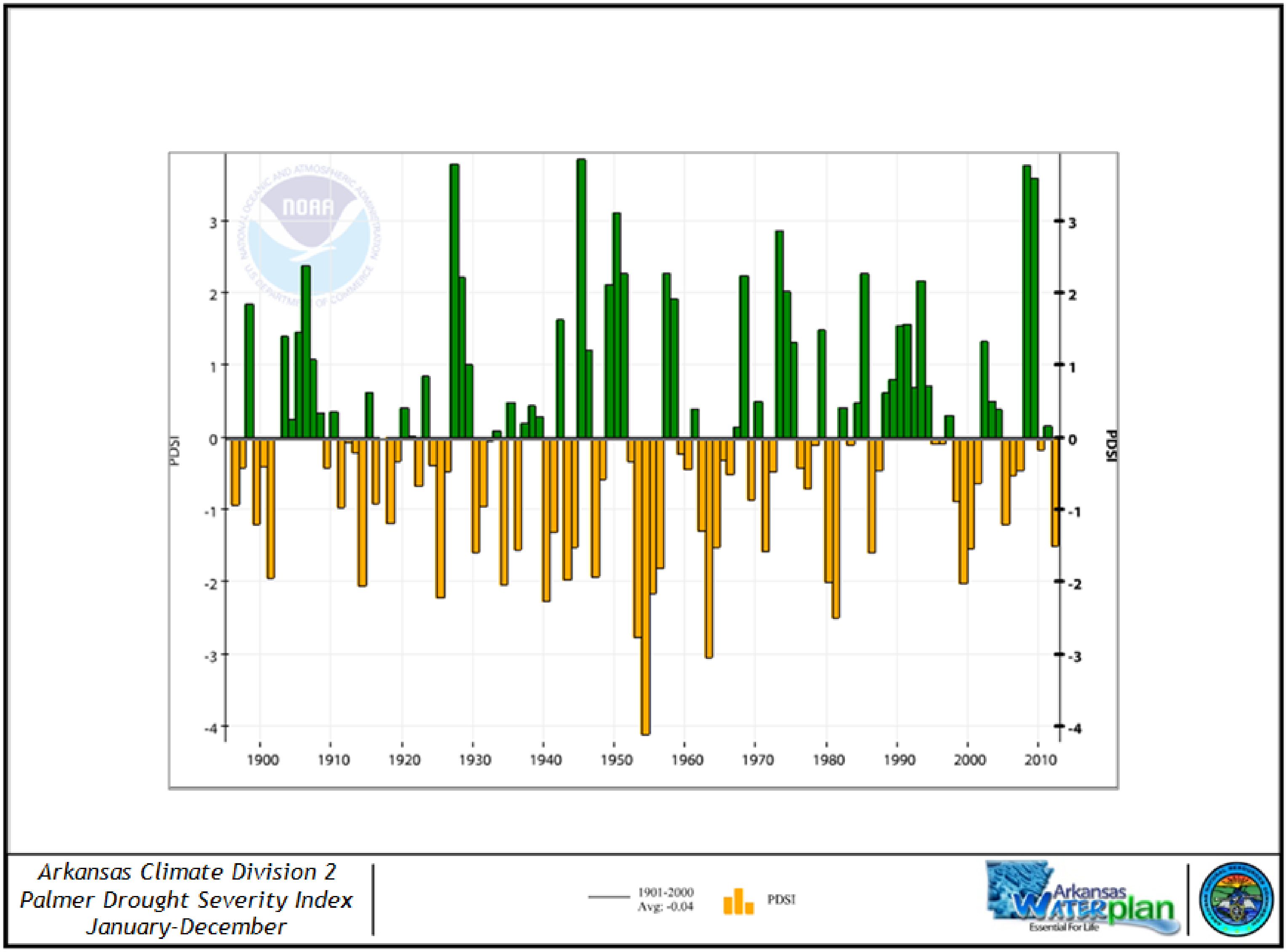

Figure 3.13. Historical values of the Palmer Drought Severity Index for the north-central climate division (2) (NOAA NCDC 2013b)

3.5.3 Climate Variability

In 2007, the Governor's Commission on Global Warming (GCGW) was established to, among other tasks, evaluate the potential impacts of global warming on the state citizens, natural resources, and economy. The GCGW's literature review conducted by the GCGW identified the following climate change effects anticipated for the state:

- Increased incidence of severe weather events,
- Increased incidence of flooding,
- Increased incidence of drought,
- Possible saltwater intrusion into aquifers resulting from sea level rise, and
- Changes in climatic zones (GCGW 2008).

Plots of annual average temperature and total annual precipitation from 1895 to 2013 for the north Arkansas climate divisions (1 and 2) are shown in Figures 3.14 and 3.15, respectively. The temperature data appear to exhibit a cycle of change, where temperatures in the first half of the 20th century were warmer than the second half, but appear to be warming again in the early 21st century (Figure 3.14). The US Department of Agriculture (USDA) modified their plant hardiness zone map in 2012. Changes in this map suggest that this Planning Region has experienced climatic changes. On the 1990 plant hardiness zone map, the Planning Region was classified as primarily zone 6b, with some areas of 7a along the southern border. On the 2012 plant hardiness zone map, the majority of the Planning Region is classifies as zone 7a, with some areas of 6b. These changes suggest that the Planning Region has become warmer, which follows the trend shown on Figure 3.14 (Clark and Karklis 2012). Precipitation totals for both climate divisions appear to exhibit a slight long-term increasing trend. A detailed analysis of long-term precipitation trends across the state is being prepared as part of the 2014 water plan update.

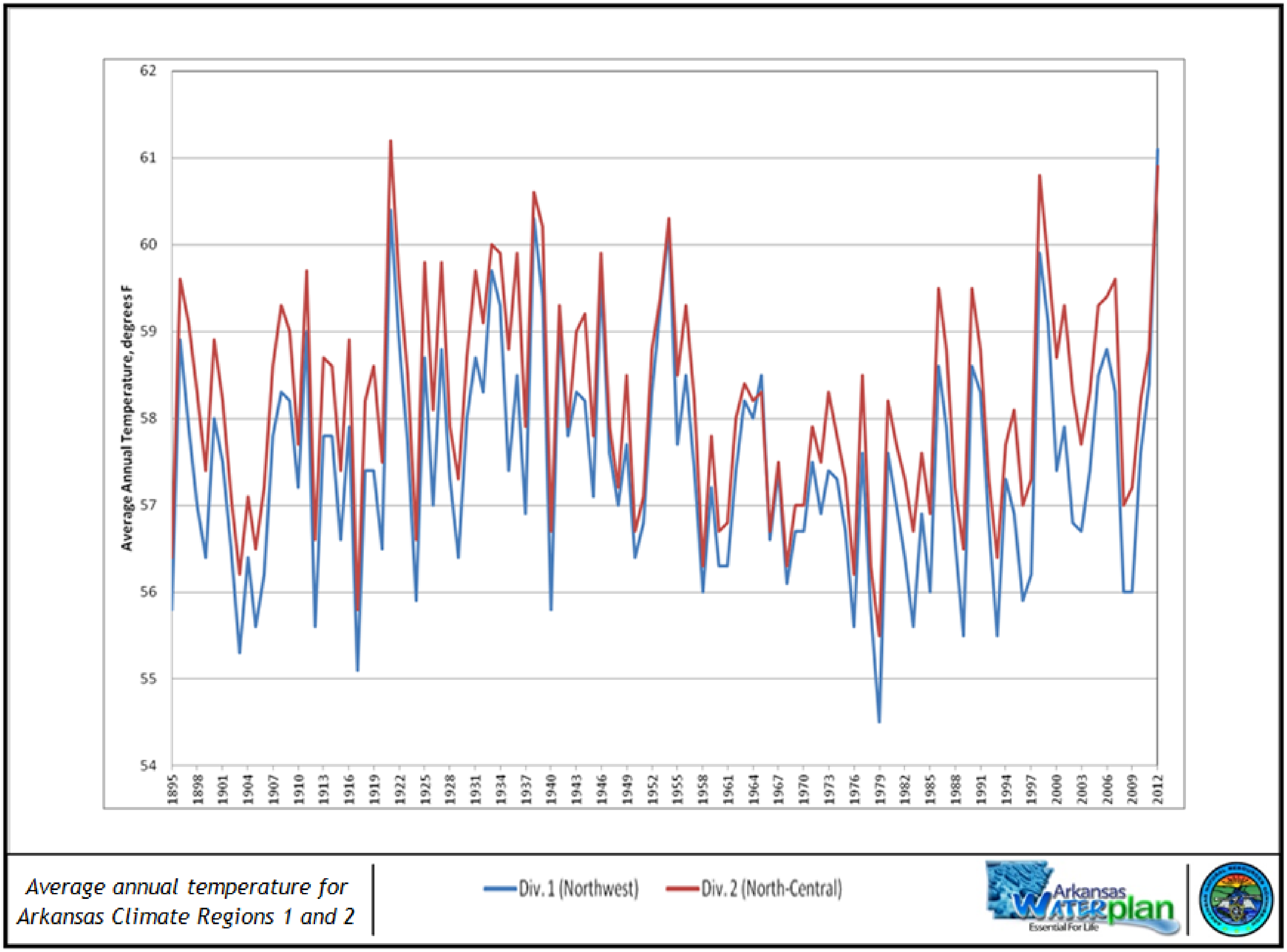

Figure 3.14. Average Annual Temperature for Arkansas Climate Regions 1 and 2.

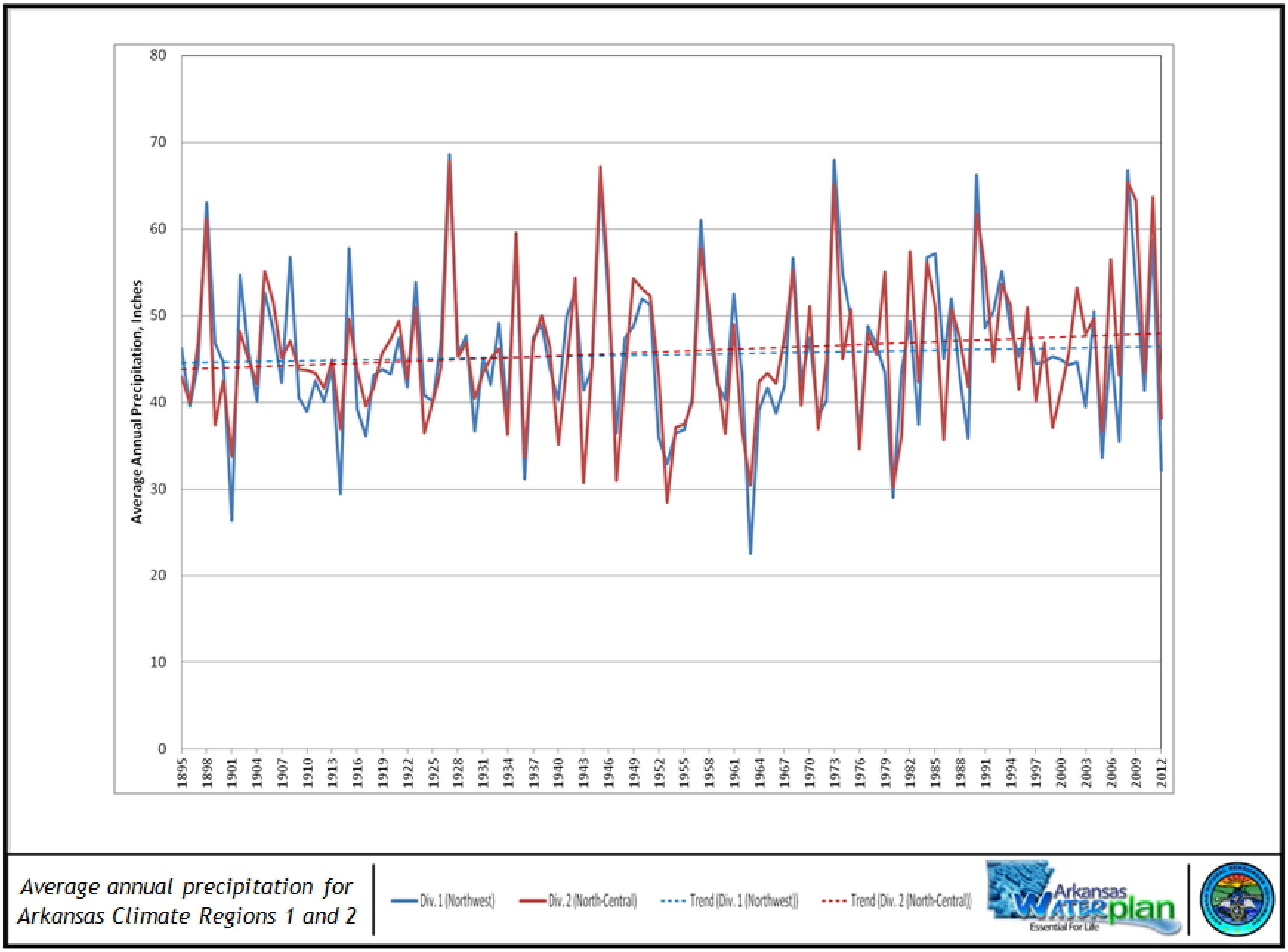

Figure 3.15. Average Annual Precipitation for Arkansas Climate Regions 1 and 2

3.6 Land Use

The types and percentages of land use for the NAWRPR as taken from data from the 2006 US land cover database (Fry, et al. 2011) are displayed in Figure 3.16. A map of land use is displayed in Figure 3.17. The majority of the land in the NAWRPR is forested, primarily with deciduous forest. Total forested area in the NAWRPR is approximately 61.2%. Pasture is the next most common land use with approximately 21.8% of land, followed by developed land with a total of approximately 6.4%.

3.6.1 Forest

There are over 4.9 million acres of forest in the NAWRPR. Table 3.2 lists the acreage of forest land per county as reported by the USDA Forest Service (USFS). Newton County has the most acreage of forest. Forested areas in the region include the Ozark National Forest, which is located in Benton, Washington, Madison, Newton, Searcy, Marion, Van Buren, Baxter, Izard, and Stone Counties. The majority of the forest land in the planning region counties (over 95%) is classified by the USFS as timberland or commercial forest land (USFS 2013). Table 3.2 also includes the forest land areas from the Resource Inventory Data System in 1977 reported by county in the 1990 AWP reports. Because these data are from different sources, their comparability is uncertain. However, the values suggest that there has been no significant change in the amount of forest land in the planning region counties during the period since the 1990 AWP update.

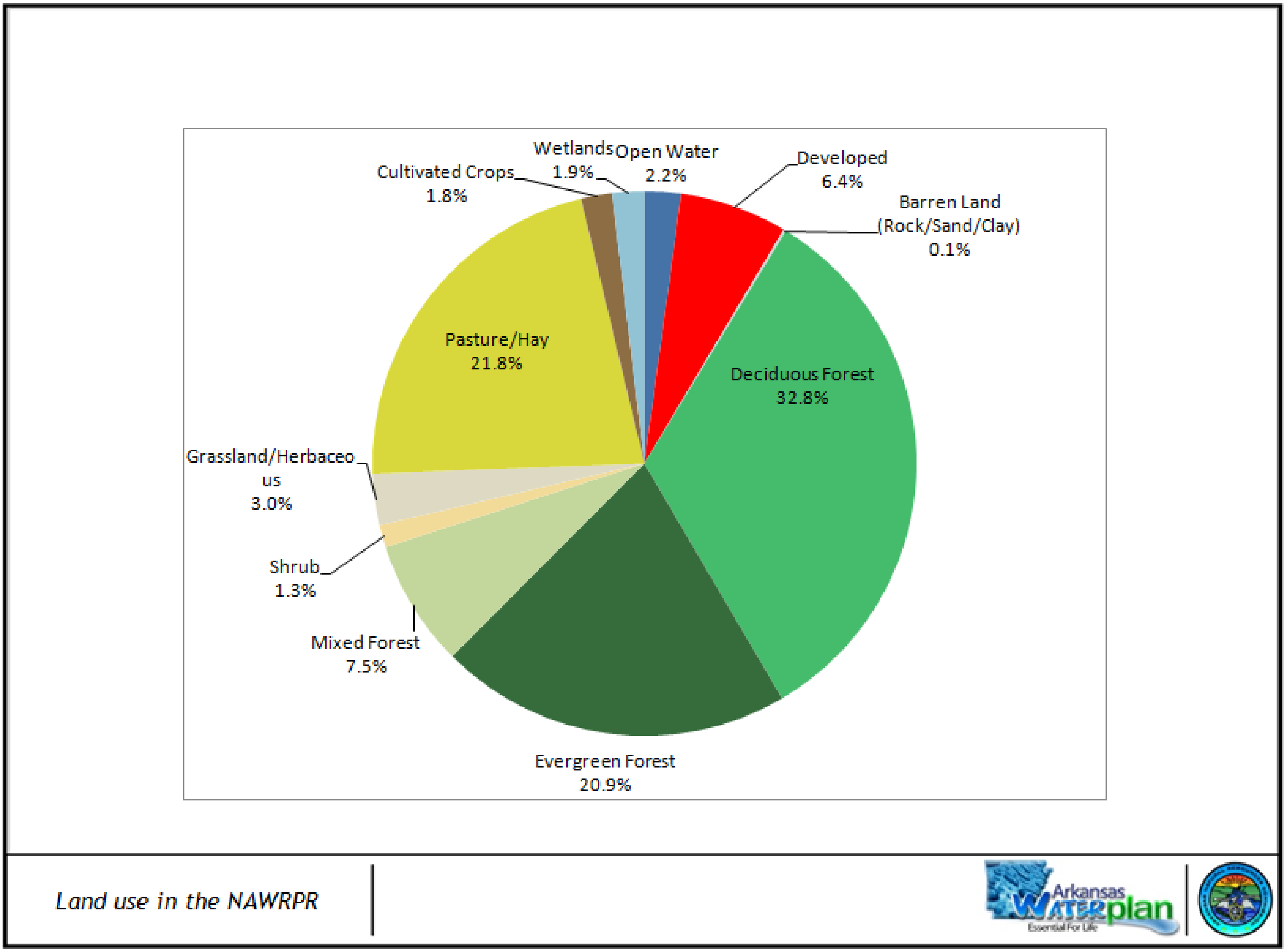

Figure 3.16. NAWRPR land use (Fry, et al. 2011).

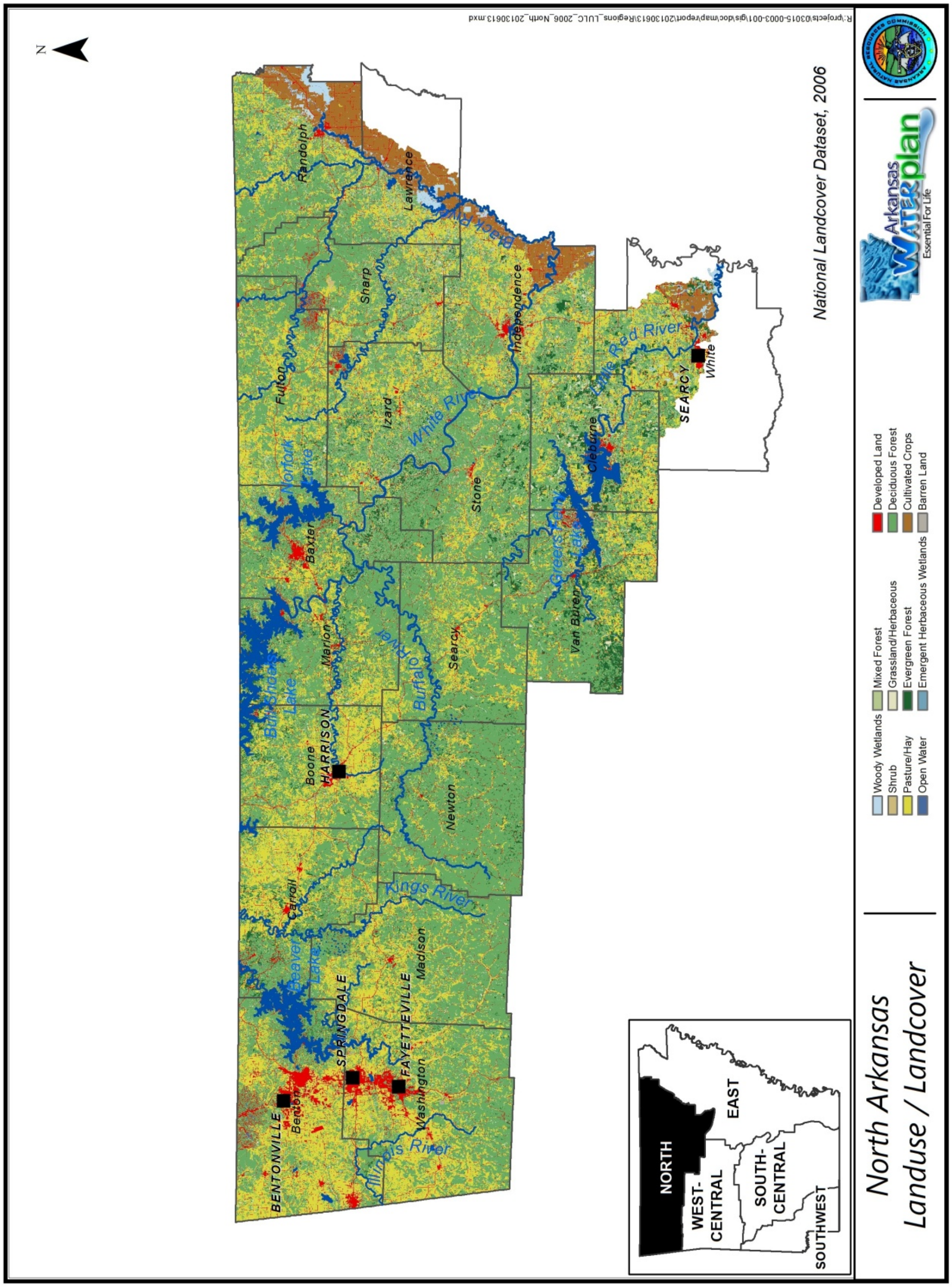

Figure 3.17. NAWRPR land use map (Fry, et al. 2011).

Table 3.2. Forest land acreage per county in the NAWRPR (USFS 2013, ASWCC 1987, USACE Little Rock District 1988)

County	1990 AWP Forest Land (acres)	2012Forest Land (acres)	Change
Baxter	251,317	231,750	-
Benton	225,310	224,350	-
Boone	183,074	167,034	-
Carroll	189,460	214,415	+
Cleburne	249,183	274,063	+
Fulton	205,464	248,883	+
Independence	241,651	228,953	-
Izard	203,427	252,589	+
Lawrence*	110,589	86,918	-
Madison	374,185	337,071	-
Marion	271,513	255,126	-
Newton	470,821	433,023	-
Randolph	196,729	188,648	-
Sharp	259,232	261,468	+
Stone	327,873	346,659	+
Searcy	289,360	293,974	+
Van Buren	318,502	359,242	+
Washington	306,674	330,528	+
White*	144,001	241,113	+
Total	**4,818,365**	**4,975,807**	+

* Note: the acreage reported is for the entire county, but part of this county is in a different planning region.

3.6.2 Agriculture

Agricultural land accounts for the next largest proportion of the planning region at approximately 23% (Figure 3.16). Pasture and haylands account for the majority of this land use category (90%). The acreage reported in the 2007 Census of Agriculture for pasture in the counties of the NAWRPR was 2.5 million with 1.0 million acres of cropland. In the 1990 AWP, the acreage reported for pasture was 2.6 million, with 0.4 million acres of cropland. Because these data are from different sources, their comparability are uncertain (see Table 3.3) Comparing pasture and cropland areas from the 1987 and 2007 Census of Agriculture indicates there has been a slight decline in pasture area, but no significant change in the amount of cropland in the counties of the NAWRPR since 1990 (Table 3.3) (US Census Bureau1989, USDA National Agricultural Statistics Service 2009).

Table 3.3. Agricultural land uses with acreage (USDA National Agricultural Statistics Service 2009, US Census Bureau 1989, ASWCC 1987).

	Cropland (acres)			Pasture (acres)		
County	1990 AWP	1987 Census of Agriculture[a]	2007 Census of Agriculture[a]	1990 AWP	1987 Census of Agriculture[b]	2007 Census of Agriculture[b]
Baxter	0	8,547	12,146	93,037	105,317	73,175
Benton	17,655	74,438	76,869	286,794	270,207	165,779
Boone	0	24,217	33,732	181,022	260,707	188,440
Carroll	0	32,179	41,452	181,908	247,918	184,497
Cleburne	7,463	18,143	28,204	93,618	108,082	80,654
Fulton	0	16,489	17,274	185,576	202,292	142,614
Independence	65,044	97,089	86,270	165,119	180,134	129,679
Izard	0	14,604	23,403	155,451	188,042	125,122
Lawrence*	157,031	209,581	190,038	50,903	81,931	62,782
Madison	0	36,069	48,711	158,295	226,942	170,768
Marion	0	11,288	12,875	105,880	145,707	107,119
Newton	0	8,958	13,514	55,259	88,707	80,418
Randolph	71,088	113,985	113,581	140,670	136,531	126,541
Searcy	0	17,775	22,818	132,936	188,358	137,847
Sharp	0	14,076	22,630	106,621	152,523	126,844
Stone	0	13,577	21,519	59,290	115,155	101,579
Van Buren	0	19,861	22,763	128,510	111,217	63,868
Washington	12,527	77,296	83,080	250,401	315,351	201,373
White*	89,039	200,237	159,002	114,688	203,280	197,977
Total	**419,847**	**1,008,409**	**1,029,881**	**2,645,978**	**3,328,401**	**2,467,076**

*Note: the acreage reported is for the entire county, but part of this county is not in the NAWRPR
a Note: sum of “harvested cropland” and “other cropland” reported in census
b Note: sum of “pastureland, all types” and “cropland used only for pasture” reported in census

The majority of cropland occurs east of the Fall Line and along the White River (Figure 3.17). Approximately 20% of the cropland in the counties of the planning region was irrigated in 2007. This is 4 times what it was in 1987 (US Census Bureau1989, USDA National Agricultural Statistics Service 2009). The crop items with the largest acreage within the planning region counties in 2007 were forage, soybeans, and rice (USDA National Agricultural Statistics Service 2009). Soybeans and rice were identified as the two crops with the most acreage in the upper White River basin 1990 AWP (ASWCC 1987). There are several counties in the planning region that grow select crops a little more unique to their area, which include field and grass seed (Benton, Boone, Fulton, Izard, Madison, and Stone Counties), and English walnuts (Searcy County) (2007 Census of Agriculture, County Profiles).

3.6.2 Developed Land

Developed land accounts for over 6% of the land area in the planning region. The Fayetteville – Springdale – Bentonville metropolitan area is located within the NAWRPR. This area, and other urban areas, has expanded since the 1990s. Table 3.4 compares areas for urban and built-up lands in the counties of the NAWRPR reported in the 1990 AWP, and from the most recent land use data set. These data indicate that developed land has increased in all of the counties of the planning region. Some of the differences in these numbers are likely the result of differences in the methodologies for classifying land use, however, population changes in these counties suggest that not all of the increase is due to differences in methodology (See Section 4.1)

Table 3.4. Comparison of urban/built-up area reported for counties in the NAWRPR (Fry, et al. 2011, USACE Little Rock District 1988, ASWCC 1987).

County	Urban/Built-up 1977 (acres)	Urban/Built-up 2006 (acres)
Baxter	0	24,774
Benton	10,101	68,465
Boone	11 ,965	20,762
Carroll	17 ,584	20,992
Cleburne	2,349	16,128
Fulton	0	18,978
Independence	5,502	25,106
Izard	10,402	17,620
Lawrence*	4,990	20,136
Madison	0	21,005
Marion	5,578	17,148
Newton	0	16,539
Randolph	234	17,744
Searcy	0	14,927
Sharp	16,867	20,038
Stone	0	14,259
Van Buren	9,948	20,148
Washington	28,292	55,215
White*	7,353	35,240
Total	**101,382**	**465,224**

3.6.3 Public Land

There are approximately 877,600 acres of public land in the NAWRPR, around 12% of the planning region total area. Table 3.5 reports the number of each type of public land as reported by the Arkansas State Highway and Transport Department (AHTD), along with the total acreage for each. The Ozark National Forest accounts for the majority of public land in the NAWRPR. There are also several wildlife management areas (WMAs), national wildlife refuges (NWRs), and two national parks. In addition, there are several city and state parks. Many of the public land types overlap in some areas of the region. For example, there are several wilderness and wildlife management areas within the Ozark National Forest.

Table 3.5. Public lands in the NAWRPR (AHTD 2006, AGFC 2009)

Public Land Type	Count	Total Acreage	Percent of Total Area in NAWRPR
City Park	159	6,361	0.08%
County Park	29	3,267	0.04%
Local Park	18	2,262	0.03%
National Forest	1	638,527	7.93%
National Park	2	97,199	1.21%
National Wildlife Refuge	2	15,127	0.19%
Natural Area	13	4,300	0.05%
Natural Area (no public access)	1	1.6	0.00%
Park & Campsite	1	0.2	0.00%
Park / Public Use Area	8	958	0.01%
Public Use Area	20	2,410	0.03%
Recreation Area	5	2.5	0.00%
State Park	9	16,398	0.20%
Wayside Park	2	4.1	0.00%
Wilderness Area	6	91,270	1.13%
Wildlife Demonstration Area	1	1,050	0.01%
Wildlife Management Area	14	272,217	3.38%

3.7 Surface Water

There are approximately 19,620 miles of rivers and streams in the NAWRPR and 25,170 acres of impounded water (USGS 2009, ASWCC 1981). The major river in the region is the White River. The largest impoundments in this region are Beaver Lake, Bull Shoals Lake, Norfork Lake, and Greers Ferry Lake. Surface water availability issues, both water quantity and water quality, are discussed in detail in Section 5.

3.7.1 Rivers and Streams

There are approximately 19,620 miles of rivers and streams in the NAWRPR. One of the state's major rivers, the White River, flows through the planning region. Additional principal streams in the planning region include the Illinois River, Kings River, Buffalo River, Black River, and Little Red River.

The White River originates in Northwest Arkansas, in the Boston Mountains. Flow is regulated by four mainstem reservoirs and two tributary reservoirs. The river flows north past Fayetteville in Washington County, into Beaver Lake, located in Benton and Carroll Counties. Downstream of Beaver Lake dam, the river continues flowing northeast and crosses the Arkansas-Missouri state line just north of Eureka Springs, Arkansas. The river then flows generally east through southern Missouri, forming Table Rock Lake and Lake Taneycomo. Downstream of the Lake Taneycomo dam, the river flows past Branson, Missouri, and then south, where it reenters Arkansas. The river meanders back and forth over the state line several times before feeding into Bull Shoals Lake. Downstream of Bull Shoals Lake, the White River continues south-southeast and joins up with the North Fork tributary near Norfork, Arkansas. The White River leaves the planning region in Jackson County, near Newport. The river eventually empties into the Mississippi River in Desha County. Tributaries of the White River in the planning region are the Kings River, Buffalo River, Black River, and Little Red River.

The Kings River originates in the Boston Mountains in Madison County. It flows north through Carroll County, Arkansas, into Missouri where it flows into Table Rock Lake. Tributaries of the Kings River are Osage Creek, Piney Creek, Keels Creek, Dry Fork Creek, Warmfork Creek, Pine Creek, Felkins Creek, and Sweden Creek (Miller 2006). All of these tributaries originate in the planning region.

The Buffalo River originates in the Boston Mountains in Newton County. It flows east from Newton County through Searcy, Marion, and Baxter County, where it empties into the White River. The headwaters of the river are formed by two of its tributaries, Big Buffalo Creek and Reeves Fork. Other tributaries include Richland Creek, Calf Creek, Bear Creek, Brush Creek, Mill Creek, Tomahawk Creek, Water Creek, and Spring Creek (National Park Service 2013). All of the tributaries originate in the planning region except Richland Creek, which originates just outside of the planning region in Pope County (USGS 2009).

The Black River is formed in southeast Missouri by three streams, and enters Arkansas flowing south near the town of Corning in Clay County (Cavaneau 2012). It enters the planning region in Randolph County near Pocohontas. The Black River flows generally south and eventually empties into the White River at Jacksonport in Jackson County, at the boundary between the North and East planning regions. Tributaries of the Black River in the NAWRPR include the Little Black River, Spring River, and Strawberry River. Of these tributaries, the Strawberry River is the only one originating in the planning region. The Little Black and Spring Rivers both originate in southeast Missouri (USGS 2009).

The Little Red River is formed by three forks, the South, Middle, and Devils Fork, all of which originate in the Ozark Mountains. These three forks feed into Greers Ferry Lake, an impoundment of the river in Cleburne County. Downstream of Greers Ferry Dam, the river flows southeast through Cleburne and White Counties, emptying into the White River north of Georgetown, at the edge of the planning region. Tributaries of the Little Red River downstream of Greers Ferry Lake are Sulphur Creek, Canoe Creek, and Big Creek (Arkansas Department of Parks and Tourism 2013b). All of these tributaries originate within the planning region.

The Illinois River is the only major river in the planning region that is not a tributary to the White River. The Illinois River is located in western Northwest Arkansas. Its headwaters begin near Hogeye in Washington County. The river then flows northwest through Washington County before turning southwest in Benton County. It flows out of Arkansas into Oklahoma about 5 miles south of Siloam Springs (IRWP 2013a). The Illinois River eventually empties into the Arkansas River near Gore, Oklahoma, upstream of where the Arkansas River enters Arkansas at Fort Smith. Tributaries of the Illinois River that originate in the planning region are Osage Creek, Flint Creek, and Baron Fork Creek. Of these tributaries, Osage Creek is the only one whose confluence with the Illinois River is in the planning region. Flint Creek and Baron Fork Creek both meet up with the river in Oklahoma.

The historical average annual surface runoff in the NAWRPR ranges from approximately 7 inches in the northeastern area of the planning region to approximately 13 inches in the south-central area of the planning region (Figure 3.18). Seasonal variation in surface runoff mirrors seasonal variation in precipitation (Pugh and Westerman 2014).

The mean monthly flows for four USGS stream gages in the NAWRPR are compared in Figure 3.19. Figure 3.20 shows the locations of these gages. Streamflow in the NAWRPR is generally highest from December through May because of the large amount of precipitation during this period (Figure 3.16). Similarly, streamflow is generally lowest during June through November due to lower precipitation and increased water use and evapotranspiration that occur during the growing season.

Long term flow records in the NAWRPR have recently been analyzed for trends. A 1992 USGS report found that no trend existed for 7-day annual low flow series at gage stations on the Buffalo River with a 50-year period of record. An analysis of stations in undisturbed watersheds showed that there were no climatic trends for the period of record and therefore it could be inferred that any increasing or decreasing flow trends could be attributed to human influences (USGS 1992). An updated state-wide analysis of long term trends in flow runoff is being conducted by the USGS and USACE as part of the 2014 AWP update.

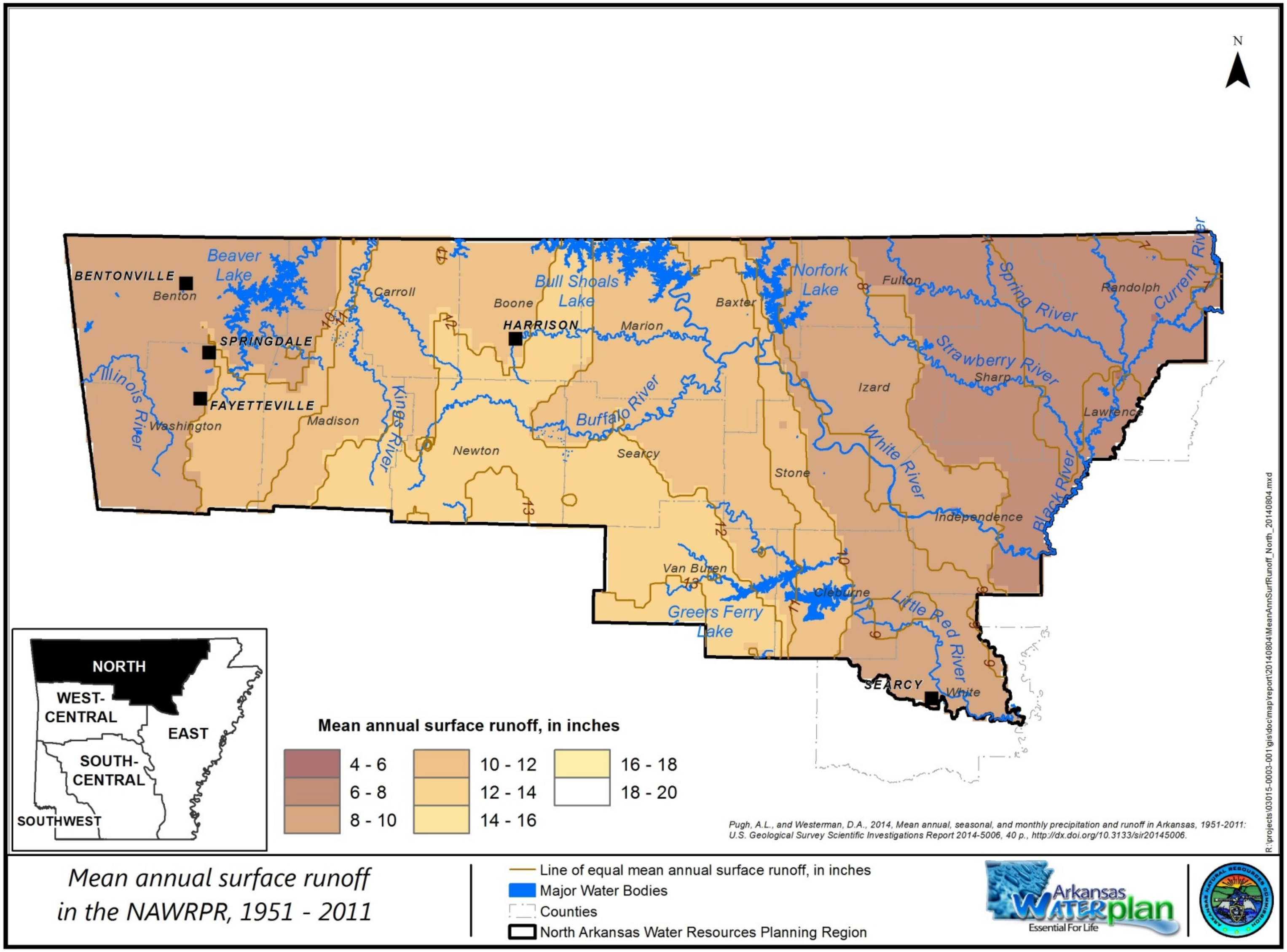

Figure 3.18. Average annual surface runoff in the NAWRPR, 1951 to 2011 (Pugh and Westerman 2014).

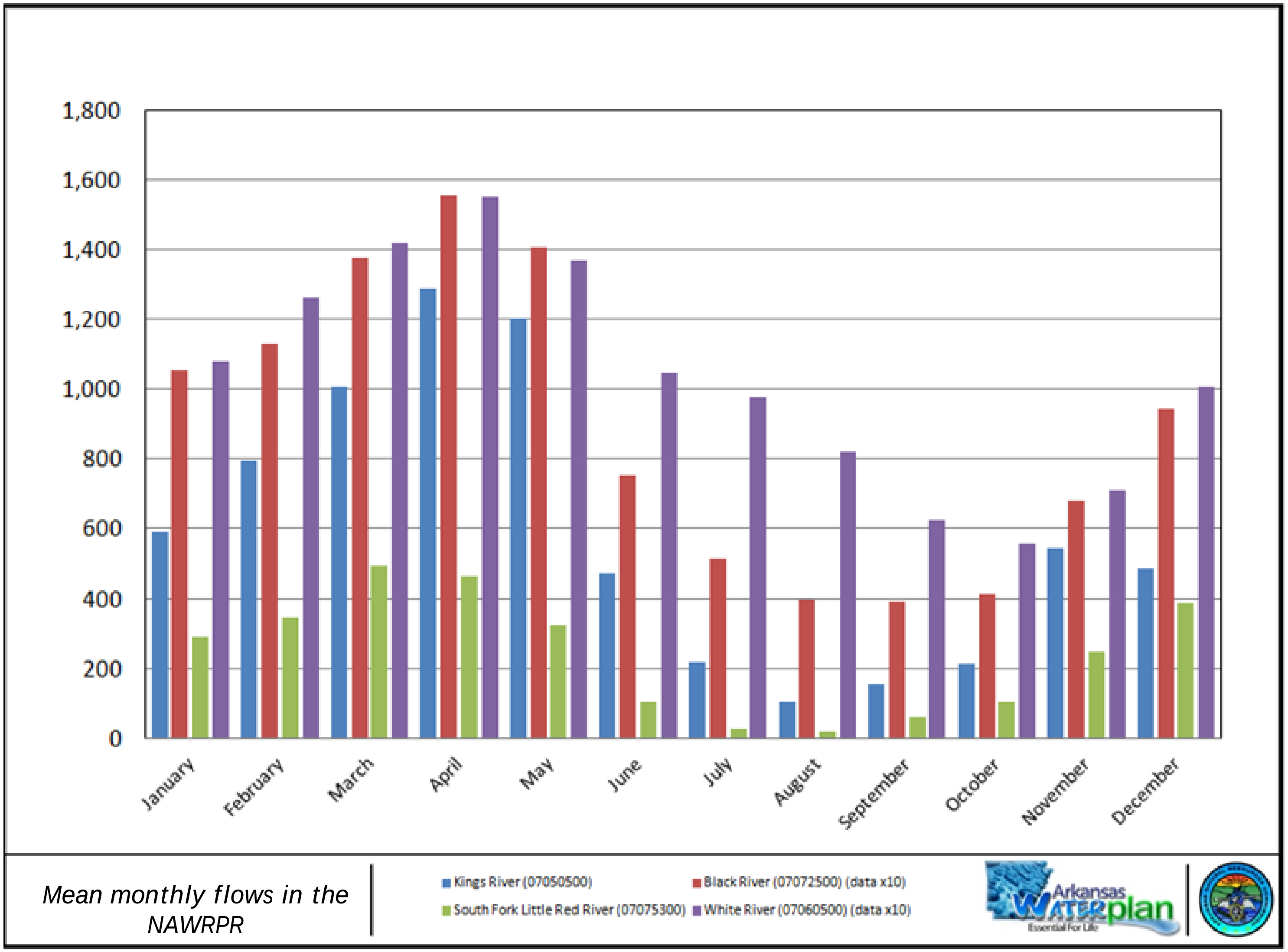

Figure 3.19. Mean monthly flows reported for USGS gaging stations on selected streams in the NAWRPR (USGS 2013c) (Data for the Black River and White River gages have been divided by 10 for easier compairison).

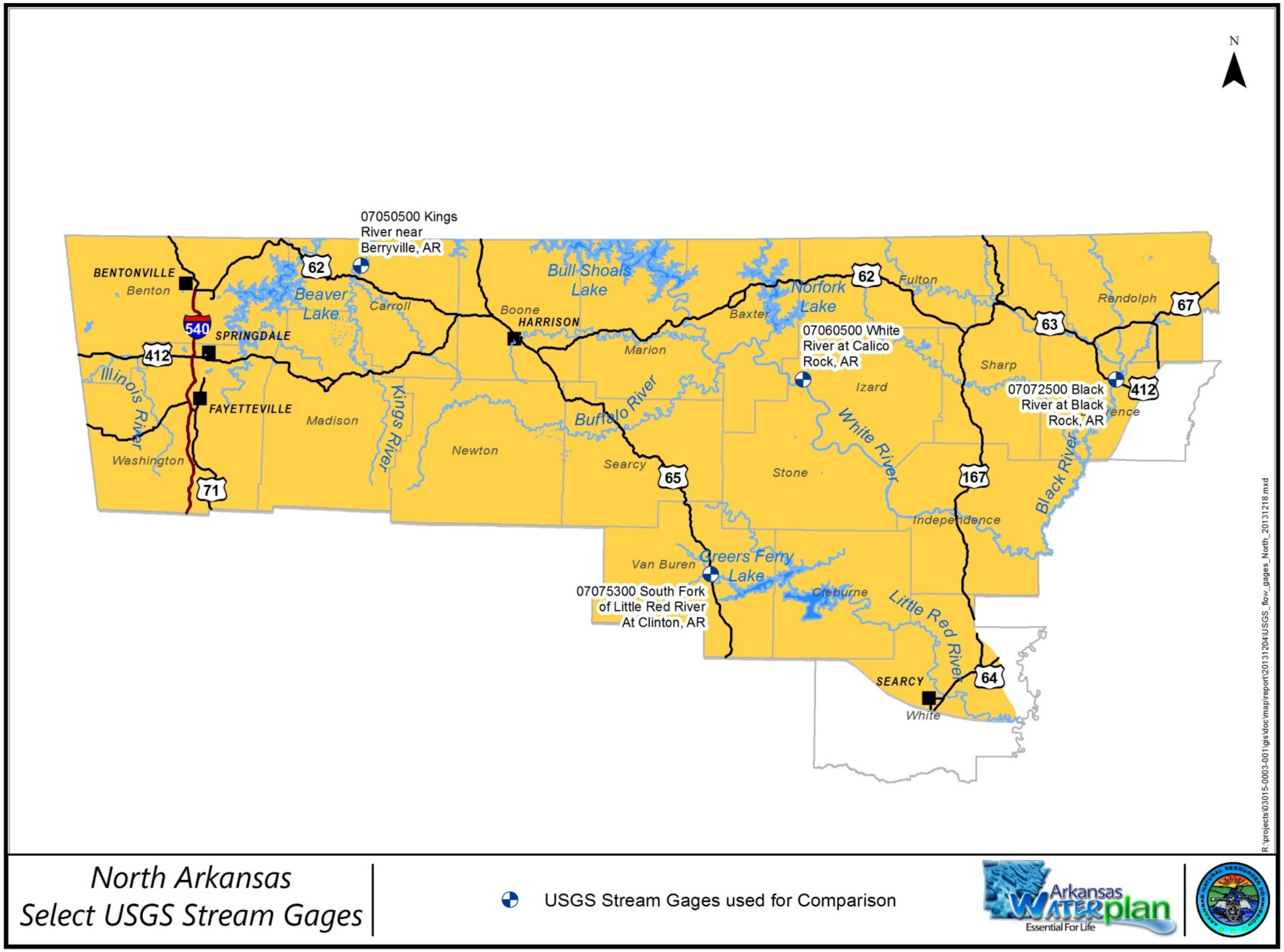

Figure 3.20. Select USGS gage stations in the NAWRPR.

3.7.2 Impoundments

In 1981 there were over 25,170 acres of impoundments in the planning region (Table 3.6). An updated state-wide inventory of impoundments is being prepared for the 2014 AWP update. ADEQ has identified 12 significant publicly owned lakes in the planning region. The Arkansas Department of Pollution Control and Ecology (ADPCE), now ADEQ, defined these as lakes that are at least 100 acres and have access designed to enhance public use (ADPCE 1990). A list of these significant publicly owned lakes is given in Table 3.7.

Table 3.6. Lakes in the NAWRPR (ASWCC 1981).

County	Number of Lakes	Area (acres)	Capacity (acres-feet)
Baxter	1,624	731	2,105
Benton	3,599	2,055	36,585
Boone	3,036	784	2,166
Carroll	2,107	979	4,938
Cleburne	2,242	1,036	3,170
Fulton	3,329	1,376	10,048
Independence	2,283	1,134	5,119
Izard	2,388	2,118	25,605
Lawrence*	910	1,015	5,838
Madison	3,202	1,020	2,623
Marion	1,400	463	832
Newton	1,362	368	1,130
Randolph	1,692	2,547	7,406
Searcy	3,034	1,091	1,975
Sharp	1,770	1,723	13,552
Stone	3,162	1,207	3,968
Van Buren	2,683	1,967	30,573
Washington	5,014	2,225	18,275
White*	2,515	1,338	7,847
USACE	5	226,370	15,649,500
USFS	1	102	1,600
Arkansas Department of Parks & Recreation	2	18	121
AGFC	16	1,652	34,424

*Part of this county is not in the NAWRPR. The number of lakes, area, and capacity of lakes were adjusted so that any lake over 5 acres that was outside of the planning region was not included. An inventory of exact locations of smaller lakes was not available.

Table 3.7. Information for significant publicly owned lakes in the NAWRPR (ADEQ 2008, 2012c; ADPCE 1990)

Name	County	Lake type	Surface area (acres)	Average Depth (feet)	Capacity (acre-feet)	Purpose
Norfork Lake	Baxter	Reservoir	22,000	57	1,983,000	Hydropower
Beaver Lake	Benton	Reservoir	28,200	58	1,952,000	Hydropower
Greers Ferry Lake	Cleburne	Reservoir	31,500	60	2,844,500	Hydropower
Bull Shoals Lake*	Marion	Reservoir	45,440	67	5,408,000	Hydropower
Crystal Lake	Benton	Reservoir	60	12	1,020	Fishing
Lake Wedington	Washington	Reservoir	102	16	1,600	Recreation
Lake Elmdale	Washington	Reservoir	180	8	180	Fishing
Lake Fayetteville	Washington	Reservoir	196	15	2,940**	Recreation
Bobb Kidd Lake	Washington	Reservoir	200	13	4,018	Fishing
Lake Sequoyah	Washington	Reservoir	500	8	4,000**	Recreation
Swepco Lake	Benton	Reservoir	531	17	9,027**	Water Supply
Lake Charles	Lawrence	Reservoir	562	8	7,740	Fishing

* Portion of lake outside planning region
** Capacity not reported; calculated as surface area (acres) x average depth (feet)

Several of the impoundments in the NAWRPR were built for the purpose of generating hydroelectric power at the dams. The federal Flood Control Acts of 1938, 1941, and 1954 led to the creation of several dams and reservoirs along the White River for flood control, water supply, and hydroelectric power generation. The dams on Beaver Lake, Table Rock Lake, Bull Shoals Lake, Norfork Lake, and Greers Ferry Lake all provide hydroelectric power (Reynolds 2012).

3.7.3 Wetlands

Several types of wetlands exist in the NAWRPR, including mountaintop depressions, which can be found along the mountaintop areas in the Ozark National Forest. Sinkholes are also present in the planning region, mainly in the terraces and uplands north of the Buffalo River (Arkansas Multi-Agency Wetland Planning Team 2001a). Some designated wetland natural areas exist in the planning region, such as the wet tallgrass prairie areas of Chesney Prairie, Searles Prairie, and Baker Prairie Natural Areas (ANHC 2010). A unique type of riverine wetland, known as a Spring Run, exists in the planning region in the Ozark Mountains (Arkansas Multi-Agency Wetland Planning Team 2001b).

3.7.4 Surface Water Quality

Surface water in the Boston Mountains region of the NAWRPR is exceptional overall, with concentrations of most biochemical and nutrient characteristics being very low. Water quality in the Ozark Highlands region differs from this in that alkalinity, total dissolved solids, and total hardness concentrations are higher due to limestone and dolomite. Developed and pasture land use also have an effect on the water quality of the area (Woods, et al. 2004). Surface water quality issues within the NAWRPR are discussed in detail in Section 5.

3.8 Groundwater

Compared to the Gulf Coastal Plain, the Interior Highlands have less reported groundwater use, which has contributed to the prevalent use of surface water, less agriculture, lower population and industry densities, lower yield from geologic formations, and lack of detailed reporting in the Interior Highlands. The aquifers of the Interior Highlands generally occur in shallow, fractured, and discontinuous bedrock that results in lower porosity, storage, and yields than the laterally extensive, coarse-grained, and unconsolidated sediments of the Gulf Coastal Plain. The dominant use of groundwater in the Interior Highlands is domestic supply, with minor industrial, small-municipal, and commercial-supply use (Kresse, et al. 2013).

3.8.1 Aquifers

There are four recognized aquifers in the NAWRPR, listed in Table 3.8 and mapped on Figure 3.21. These aquifers are designated as regional aquifers and encompass parts of several states. For a more detailed description of these formations refer to McFarland (2004). Kresse and others (2013) provide a comprehensive review of the aquifers of Arkansas to include the geologic setting, hydrologic characteristics, water levels, water use, and water quality. Much of the information presented in this section was summarized from the Kresse and others (2013) report.

Table 3.8. Nomenclature, geologic age, and use for aquifers in the NAWRPR.

Province	Section	Formation or Group of Formations	Geologic Age	Hydrogeologic Unit Name	Aquifer Use[1]
Gulf Coastal Plain	Mississippi Alluvial Plain	Coastal Plain Alluvium	Quaternary	Mississippi River Valley,	IR, PS, IN
		Nacatoch Sand	Cretaceous	Nacatoch aquifer	PS
Ozark Plateaus	Boston Mountains	Atoka Formation Bloyd Formation Hale Formation Imo Shale Pitkin Limestone Fayetteville Shale Batesville Sandstone Ruddell Formation Moorefield Formation	Mississippian and Pennsylvanian	Western Interior Confining System	D
	Springfield-Salem Plateaus	Boone Formation	Mississippian	Springfield Plateau Aquifer	D, PS
		Clifty Limestone Penters Chert Lafferty Limestone St. Clair Limestone Brassfield Limestone Cason Shale Fernvale Limestone Kimmswick Limestone Plattin Limestone Joachim Dolomite St. Peter Sandstone Everton Formation Smithville Formation Powell Dolomite Cotter Dolomite Jefferson City Dolomite Rubidoux Formation Gasconade Formation Van Buren Formation Eminence Dolomite Potosi Dolomite	Ordovician through Devonian	Ozark aquifer	PS, D

[1]IR= irrigation, PS = public supply, IN = industrial, D = domestic. Listed in order of highest use by volume. Primary use in capital letters; secondary use in small caps.

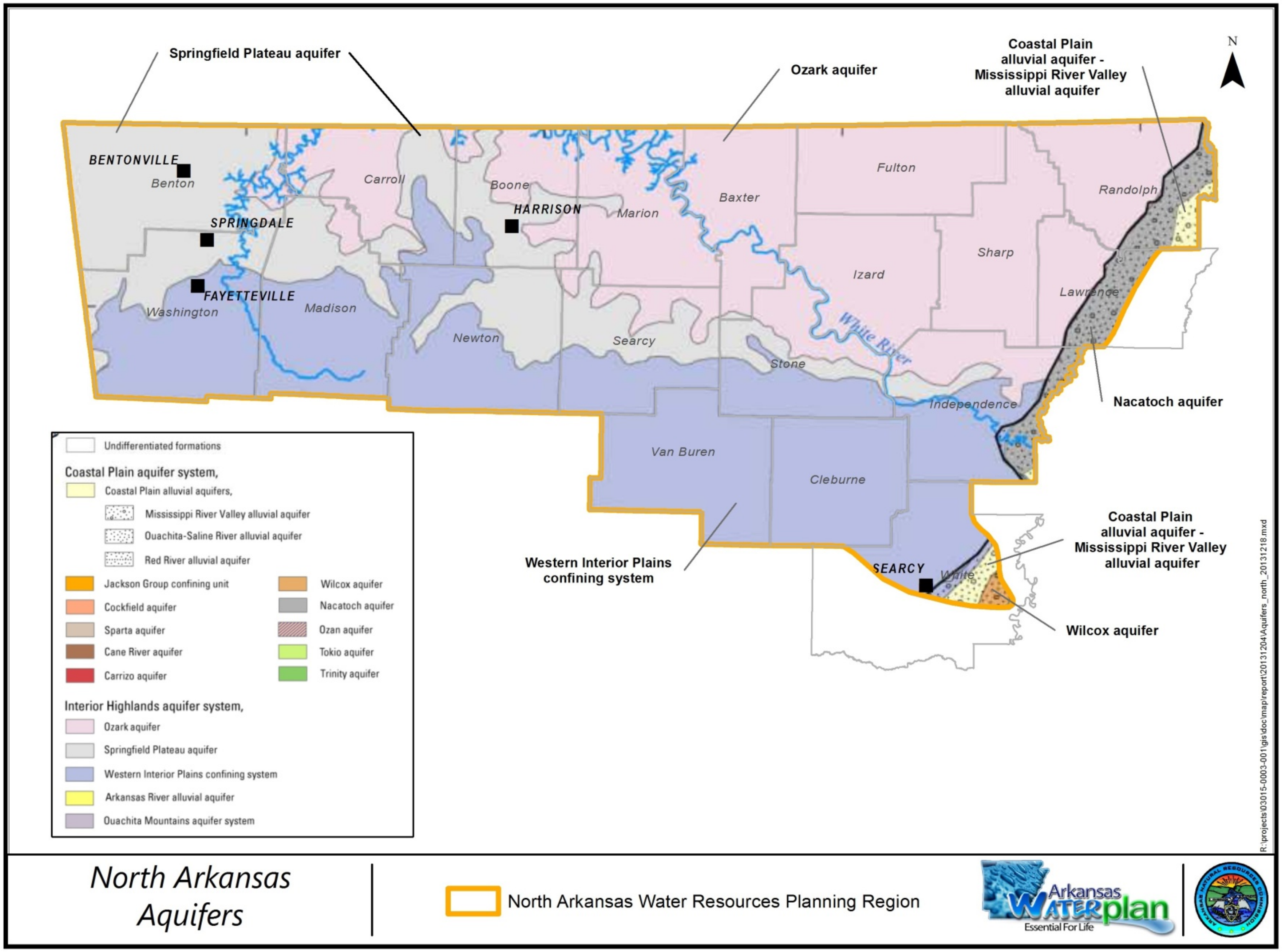

Figure 3.21. Aquifers of the NAWRPR (Kresse, et al. 2013).

Only a small area of the NAWRPR is underlain by the regional aquifers of the Mississippi Alluvial Plain, where they overlap the Ozark Plateaus. Therefore, these aquifers will not be described here. Aquifers of the Mississippi Alluvial Plain are described in detail in the background report for the Eastern Arkansas Water Resources Planning Region.

Recognized aquifers in the Ozark Plateaus include the Springfield Plateau and Ozark aquifers. The Boston Mountains Plateau and the portion of the Arkansas River Valley included in the NAWRPR belong to the Western Interior Plains (WIP) confining unit and there are no formally recognized aquifers. However, there are several shallow, undifferentiated, and saturated rocks of limited extent that serve as groundwater supply for domestic and small community purposes (Adamski, et al. 1995).

3.8.1.1 Springfield Plateau aquifer

The Springfield Plateau aquifer encompasses the Springfield Plateau and portions of the Salem Plateau in the Ozark Plateaus physiographic province. The Boone Formation comprises the Springfield Plateau aquifer and is the uppermost stratigraphic unit throughout most of the province (Imes and Emmett 1994). The Boone Formation is a limestone with abundant chert and clay, except for the base of the unit which is a relatively pure limestone known as the St. Joe Limestone Member. The porosity and permeability of the Boone Formation is very low except along fractures and bedding planes. Portions of this limestone have been dissolved to form an open network of caves, enlarged fractures, dissolutionally enhanced bedding planes, conduits, sinkholes, sinking streams, and springs creating a distinct karst topography and complex hydrological system (Brahana, et al. 1999).

The Springfield Plateau aquifer is generally unconfined across the Springfield Plateau and confined in the Boston Mountains Plateau by an interval of formations known as the Western Interior Plains Confining System. Most recharge to the aquifer occurs by infiltration of precipitation across outcrop areas of the Boone Formation. Where confined, recharge occurs as leakage through the overlying units (Adamski, et al. 1995). The nature of the primary and secondary porosity of this aquifer creates a dual flow system (diffuse and focused), which is further discussed by Kresse, and others (2013). The result is an aquifer with well yields that range from 0.01 to 1,000 gallons per minute (gpm). However, most wells throughout the extent of the aquifer yield less than 20 gpm (Adamski, et al. 1995). Water levels generally reflect the topography and exhibit a strong relation to elevation.

Groundwater movement at local scales is strongly controlled by lithology (rock type and bedding planes), structure (fractures, faults, and dip), and karst features (sinkholes and conduits). Structural features (faults and fractures) have been shown to either facilitate or impede groundwater flow (Kresse, et al. 2013; Brahana and Davis 1998). Discharge from the Springfield Plateau aquifer primarily occurs through springs, with withdrawals from wells and leakage to the underlying Ozark aquifer system playing a minor role. When present, the Chattanooga Shale serves as a lower confining unit, known as the Ozark Confining Unit, and exchange between the Springfield Plateau and Ozark aquifers is limited.

3.8.1.1 Ozark aquifer

The Ozark aquifer encompasses the Salem, Springfield and Boston Mountain Plateaus. The Ozark aquifer is separated into an upper and lower section based on differences in dominant lithologies, groundwater levels, confined or unconfined conditions, yields, and geochemistry. The upper Ozark aquifer is exposed and generally unconfined in the Salem Plateau and is confined in the Springfield and Boston Mountain Plateaus by the Springfield Plateau aquifer system. For a detailed discussion of the hydraulic properties of this aquifer refer to Imes and Emmitt (1994) and Kresse and others (2013).

The upper Ozark aquifer is primarily composed of limestones and dolostones, which consist of nine geologic formations (Table 3.8). These formations range in thickness from very thin to intervals of a 1,000 feet or more throughout Arkansas. In the unconfined upper Ozark aquifer, recharge occurs as precipitation across outcrop areas, but where the upper Ozark aquifer is overlain by the Springfield Plateau aquifer system, most recharge occurs as downgradient flow from the outcrop areas. The primary porosity and permeability of the upper Ozark aquifer is low, with well yields ranging from 5 to 10 gpm (Kresse, et al. 2013); however, in the upland areas of the Salem Plateau, where karst topography is well developed and focused flow paths exists, spring discharges commonly exceed 100 cubic feet per second (cfs) (Imes and Smith 1990).

The lower Ozark aquifer is confined throughout Arkansas and consists of the Rubidoux Formation and the Gunter Member of the Gasconade Dolomite. These units are predominately sandstones with abundant dolomite and shaly intervals (Kresse, et al. 2013). While there are additional formations comprising the lower Ozark aquifer, these units are not used in Arkansas and were precluded from this report. The Ozark aquifer is confined below by the St. Francois Confining Unit. Recharge occurs as downgradient flow from outcrop areas in southern Missouri, with some leakage from the upper Ozark aquifer. Although the formations of the lower Ozark aquifer form a complex karst hydrological system of high yield in Missouri, production from the lower Ozark aquifer in Arkansas is attributed to porous sandstone layers rather than karst features. Wells in the lower Ozark aquifer are among the most productive in the region, with well yields ranging from less than 10 to near 600 gpm (Lamonds 1972).

Water-level data for the upper and lower Ozark aquifers are limited in Arkansas. For both aquifers, groundwater flow is generally south along the regional dip. For the upper Ozark aquifer, water levels average between 700 and 1000 feet in elevation. Water levels are generally a subdued reflection of topography, where the upper Ozark aquifer is unconfined, and groundwater flow directions are outward from areas of high elevation to discharge areas (streams) occurring at lower elevations (Kresse, et al. 2013). For the lower Ozark aquifer, water levels average between 400 and 1,000 feet elevation. Water-level variations are attributed to topographic relief, changes in pumping, and regional dip (Kresse, et al. 2013).

3.8.1.2 Western Interior Plains Confining Unit

The Boston Mountains Plateau and the portion of the Arkansas River Valley included in the NAWRPR are represented by a group of formations referred to as the Western Interior Plains (WIP) Confining Unit. These formations are comprised primarily of fractured shale, sandstone, and siltstone rocks of Mississippian and Pennsylvanian age that are characterized by low porosity, permeability, and yields. While there are no formally recognized aquifers, there are numerous shallow, undifferentiated, and saturated rocks of limited extent that are used for domestic and small community supply (Kresse, et al. 2013).

For this system, recharge occurs as precipitation that infiltrates the ground in upland areas and percolates to the water table. Groundwater flow paths are defined by small-scale topographic features where flow occurs from elevated areas to valley floors terminating in small stream systems. Groundwater storage in these aquifers is limited primarily to fractures and faults. Typical well yields range from 1 to 5 gpm, and thicker sandstone units in the eastern part of the WIP system commonly yield 5 to 10 gpm. It is not uncommon for wells in the WIP system to go dry during pumping, especially during dry periods. Water levels in the WIP confining system range from near land surface to approximately 50 feet below ground surface. Seasonal fluctuations are about 10 feet, with drawdowns from pumping increasing fluctuations to as much as 45 feet (Kresse, et al. 2013).

3.8.2 Groundwater Quality

In general, the water quality of groundwater in the NAWRPR is of good quality. Some problems with groundwater quality include sedimentation and some nutrient issues. Groundwater quality is discussed in more detail in Section 5.

3.9 Groundwater-Surface Water Connections

In the Springfield Plateau and Ozark aquifers, the karst network creates a hydrologic system of great complexity with a close connection between surface watersheds and groundwater basins. Direct hydraulic connections of karst features (sinkholes and conduits) to the land surface lead to rapid recharge from surface derived runoff associated with precipitation events. Flow in these areas is typically rapid, flow directions are difficult to predict, and inter-basin transfer (groundwater diversion to adjacent basins owing to karst piracy) is common. Locally, interaction between surface and groundwater can be extensive through losing and gaining stream segments and through cave streams, springs, and seeps that serve as tributaries or directly discharge to streams. Regionally, streams serve as flow boundaries and as primary drains to groundwater basins (Brahana 1997; Kresse, et al. 2013; Brahana, et al. 1999) Owing to the more pure carbonate lithologies of the Ozark aquifer, karst features tend to be more abundant, are more concentrated, and are larger in size than the karst features of the Springfield plateau aquifer

(Adamski, et al. 1995) which allows for a greater quantity of water to be transported through the system.

In general, there is less surface water-groundwater interaction in the Boston Mountains and the northern portions of the Arkansas River Valley than in the Springfield and Salem Plateaus. In the Boston Mountains, stream flow is primarily derived from surface runoff and typically none of the streams are considered perennial (Adamski, et al. 1995).

4.0 SOCIO-ECONOMIC CHARACTERISTICS

The socio-economic characteristics of the NAWRPR include current demographics, income, employment, and industries. This section describes these characteristics and presents changes in these regional characteristics since the 1990 AWP update. In addition, the wastes generated by the communities and industries in the NAWRPR are characterized. These wastes must be properly managed to protect water quality in the NAWRPR.

4.1 Demographics

Demographic information from the 2010 US Census for the counties within the NAWRPR are presented below. Demographic data presented include population totals, the percentages of people living in urban and rural areas, above or below selected ages, and of different races. Information from the 2010 Census is compared to information from the 1990 Census to identify population changes that have occurred since the last AWP update. Although the 1990 AWP updated reported population data from the 1980 Census, the 1990 Census data better represents conditions at the time of the previous update. Population changes affect the need and demand for water resources, not just for drinking water, but also for recreation, food supply, irrigation, and aesthetics. Population demographics also affect the potential tax base to pay for water infrastructure updates, expansion, and repairs.

4.1.1 2010 Population

The population of the NAWRPR was over 800,000 in 2010, an increase of over 50% since 1990. Population data for the region is summarized in Table 4.1, and mapped in Figure 4.1. Benton County and Washington County are the second and third most populated counties in the state, respectively. These two counties are part of the Fayetteville-Springdale-Rogers Large Metropolitan Statistical Area and contain the Fayetteville-Springdale-Rogers Urbanized Area (Figure 4.2) (US Census Bureau 2012). Large Metropolitan Statistical Areas are geographic regions, defined by the US Office of Management and Budget, where an area of high population density has close economic ties. Urbanized areas have a population of at least 50,000 people at a density of 1,000 to 500 people per square mile (US Census Bureau 2011). In addition, 13 areas within the planning region were identified as Urban Clusters in the 2010 census (Figure 4.2). Urban Clusters are areas with population densities of 500 to 1,000 people per square mile, which contain a total of 25,000 to 50,000 people (US Census Bureau 2011, 2012). However, there are also two counties in the planning region with population under 10,000 inhabitants. About half of the total 2010 population in the planning region counties (51%) lived in urban areas. The percentage of people living in rural areas in 2010 varied from 100% in seven of the counties, to around 25% in Benton and Washington counties (US Census Bureau 2012).

Table 4.1 County populations in the NAWRPR (U of A at Little Rock Institute for Economic Advancement 2002, US Census Bureau 2012).

	Total population			**Percent Urban Population**		
County	**1990**	**2010**	**Change 1990 to 2010**	**1990+**	**2010**	**Change in percent urban population 1990 to 2010**
Baxter	31,186	41,513	33%	28.9%	34.2%	5.3
Benton	97,499	221,339	127%	55.6%	74.8%	19.2
Boone	28,297	36,903	30%	35.1%	37.8%	2.7
Carroll	18,654	27,446	47%	17.3%	27.2%	9.9
Cleburne	19,411	25,970	34%	28.8%	24.5%	-4.3
Fulton	10,037	12,245	22%	5.7%	7.1%	1.4
Independence	31,192	36,647	17%	29.5%	31.4%	1.9
Izard	11,364	13,696	21%	0%	0%	0.0
Lawrence*	17,457	17,415	0%	40.4%	36.4%	-4.0
Madison	11,618	15,717	35%	0.0%	0%	0.0
Marion	12,001	16,653	39%	0.0%	0%	0.0
Newton	7,666	8,330	9%	0.0%	0%	0.0
Randolph	16,558	17,969	9%	37.1%	32.6%	-4.5
Searcy	7,841	8,195	5%	0%	0%	0.0
Sharp	14,109	17,264	22%	27.0%	19.9%	-7.1
Stone	9,775	12,394	27%	0%	0%	0.0
Van Buren	14,008	17,295	23%	0%	0%	0.0
Washington	113,409	203,065	79%	65.2%	74.5%	9.3
White*	54,676	77,076	41%	40.8%	45.7%	4.9
Total	**526,758**	**827,132**	**57%**	**38.9%**	**51.0%**	**12.1**

*Part of this county is in another planning region

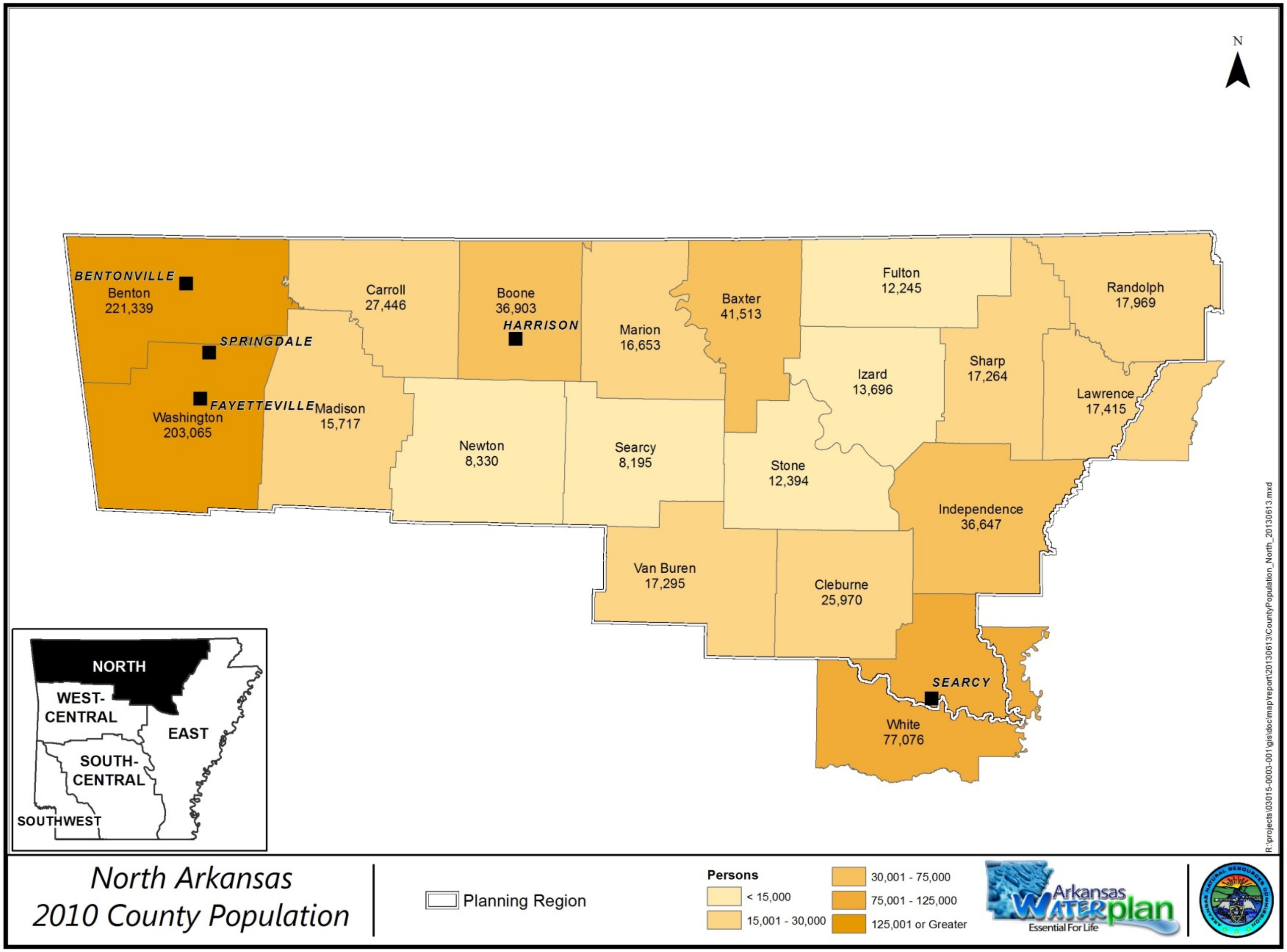

Figure 4.1. Population totals from the 2010 census for counties in the NAWRPR (US Census Bureau 2012b).

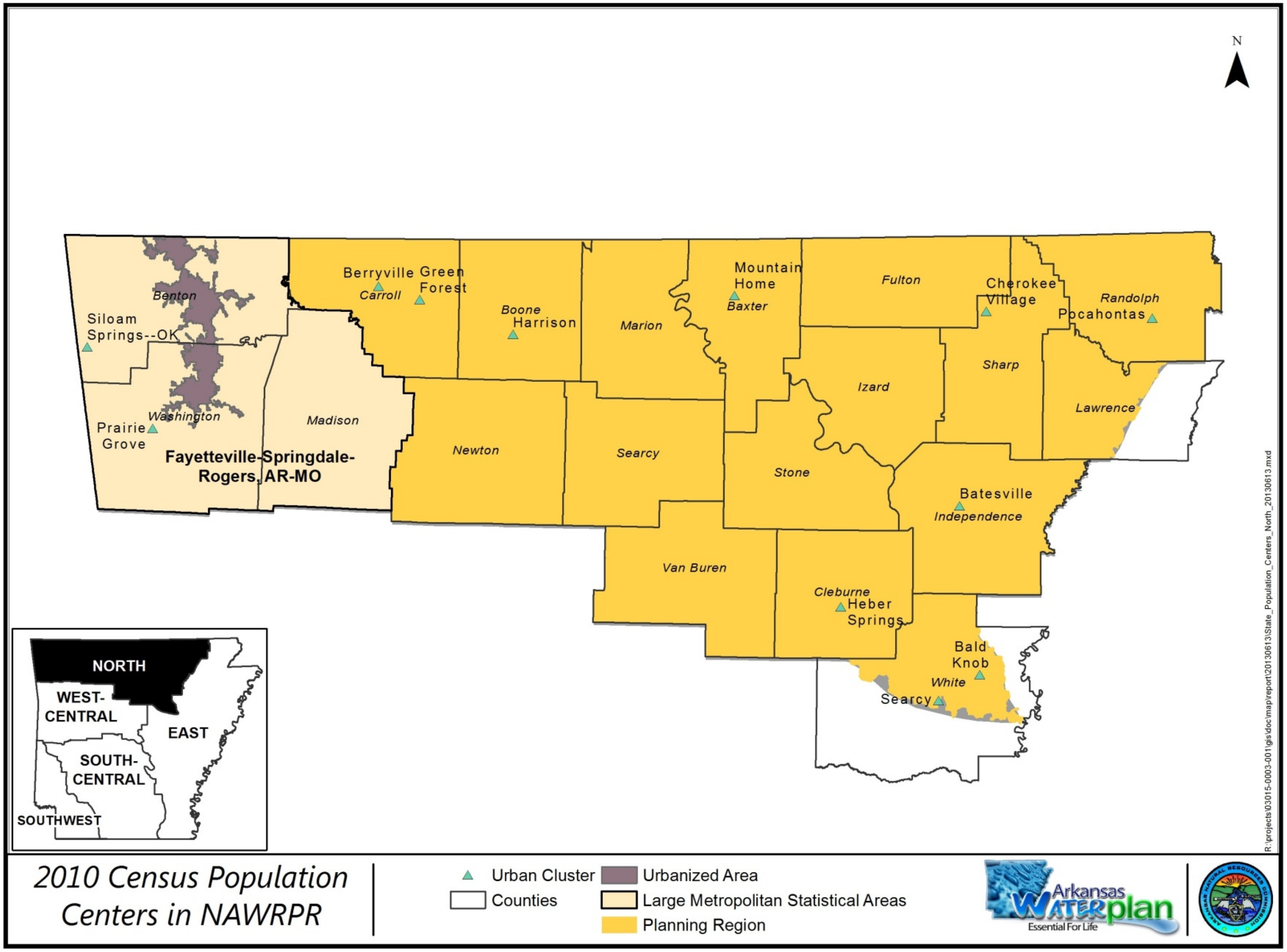

Figure 4.2. 2010 population centers located in the NAWRPR (US Census Bureau 2012a).

Demographic data on race for the counties within the NAWRPR are summarized in Table 4.2. There is a relatively large Hispanic population in a number of the counties in the region. Washington County is home to the largest population of Pacific Islanders in the state.

Table 4.2. Demographic summary for counties in the NAWRPR (US Census Bureau n.d.).

County	White Non-Hispanic	Black	Hispanic	Asian	American Indian	Pacific Islander	Other Single Race	Multiple Race
Baxter	39,837	59	688	163	217	16	14	519
Benton	169,605	2,647	34,283	6,245	3,440	634	224	4,261
Boone	35,139	64	674	153	247	21	17	588
Carroll	23,062	74	3,489	160	224	16	18	403
Cleburne	24,894	67	517	51	126	7	4	304
Fulton	11,805	39	97	28	79	1	5	191
Independence	32,914	709	2,139	276	142	19	16	432
Izard	13,006	175	208	39	102	2	3	161
Lawrence*	16,848	134	158	22	61	4	1	187
Madison	14,451	27	759	81	171	11	6	211
Marion	15,963	28	287	37	99	4	4	231
Newton	7,894	5	141	22	84	1	4	179
Randolph	17,226	128	283	28	89	4	1	210
Searcy	7,800	3	121	11	91	1	1	167
Sharp	16,399	91	290	49	164	2	4	265
Stone	11,912	11	157	45	82	3	3	181
Van Buren	16,282	65	475	56	113	2	7	295
Washington	150,546	5,828	31,458	4,372	2,154	4,100	227	4,380
White*	69,026	3,033	2,879	411	425	30	43	1,229
Total	**313,048**	**13,187**	**79,103**	**12,249**	**8,110**	**4,878**	**602**	**14,394**
Percentage	**38%**	**2%**	**10%**	**1%**	**1%**	**<1%**	**<1%**	**2%**

*Part of this county is in another planning region
+ Percentage based

Demographic data on age, sex, and education level for the counties within the NAWRPR are summarized in Table 4.3. The majority of the population in these counties (60%) is between the ages of 18 and 65. Of the total population over the age of 18, 30% are high school graduates. The highest percentage of high school graduates occurs in Sharp County, with 40% of inhabitants. An overall average of 18% of the population in the NAWRPR over the age of 18 are college graduates, with the highest percentages occurring in Benton and Washington Counties.

Table 4.3. Additional Demographic Characteristics of Counties in the NAWRPR (US Census Bureau n.d.).

County	Total female population	Total population under 18 Years	Total population over 65 Years	High School Graduates	College Graduates
Baxter	21,490	7,506	11,659	11,699	4,677
Benton	112,215	61,848	26,986	41,582	38,017
Boone	18,837	8,585	6,673	10,231	3,609
Carroll	13,915	6,183	5,131	7,000	3,271
Cleburne	13,193	5,162	6,118	6,975	3,067
Fulton	6,246	2,598	2,742	3,949	1,025
Independence	18,687	8,792	5,730	9,839	3,235
Izard	6,642	2,625	3,229	3,966	1,282
Lawrence*	8,947	3,992	3,160	4,957	1,098
Madison	7,836	3,801	2,452	4,362	1,288
Marion	8,366	2,983	3,964	4,924	1,834
Newton	4,124	1,736	1,701	2,463	754
Randolph	9,159	4,171	3,361	4,999	1,419
Searcy	4,110	1,675	1,745	2,338	504
Sharp	8,732	3,717	4,134	5,449	1,610
Stone	6,266	2,555	2,826	3,366	1,047
Van Buren	8,673	3,537	3,923	4,893	1,570
Washington	101,579	51,484	19,641	34,553	33,267
White*	39,274	18,433	10,848	18,146	8,892
Total	**418,291**	**201,383**	**126,023**	**185,691**	**111,466**
Percentage	**51%**	**24%**	**15%**	**30%+**	**18%+**

*Part of this county is in another planning region
+Percentage based on population 18 years or older

4.1.2 Changes from 1990

Table 4.3 shows population data for 1990. In 1990, Washington County had the largest population, followed closely by Benton County. At that time, Washington County was ranked as having the second largest county population the state, and Benton County was ranked fourth (U of A Little Rock Institute for Economic Advancement 2002).

Table 4.3 and Figure 4.3 show the population change for each county between 1990 and 2010. Most counties in the NAWRPR experienced population growth during this period. Overall, the population of the counties in the NAWRPR increased 57%. The greatest growth occurred in Northwest Arkansas in Benton and Washington Counties. Benton County had the greatest growth with a 127% increase in population. Population in Washington County increased 79%. Northwest Arkansas was named the 15th fastest growing region in the US by a 2010 U.S. Census Bureau Report (The City Wire 2012).Other counties in the region also experienced significant growth. Baxter, Boone, Carroll, Cleburne, Madison, Marion, Stone, and White Counties all had a population increase greater than 25%. Only Lawrence County experienced a decrease in population between 1990 and 2010, with a -0.2% change.

Most counties in the NAWRPR also experienced a growth in urban population percentage between 1990 and 2010. Benton County had the greatest growth from 55.6% to 74.8%. Some counties experienced no change in urban population, as their urban population remained 0. These counties are Izard, Madison, Marion, Newton, Searcy, Stone, and Van Buren Counties. Others had a decrease in urban population percentage. Cleburne, Lawrence, Randolph, and Sharp Counties all had a decline in the percent of population in urban areas.

4.2 Income and Employment

Income and employment data are available by county from the US Census Bureau. Recent data are presented below to characterize the current quality of life within the NAWRPR. Data from 1990 are also presented for comparison, to provide insight into changes that have occurred in the region since the 1990 AWP update.

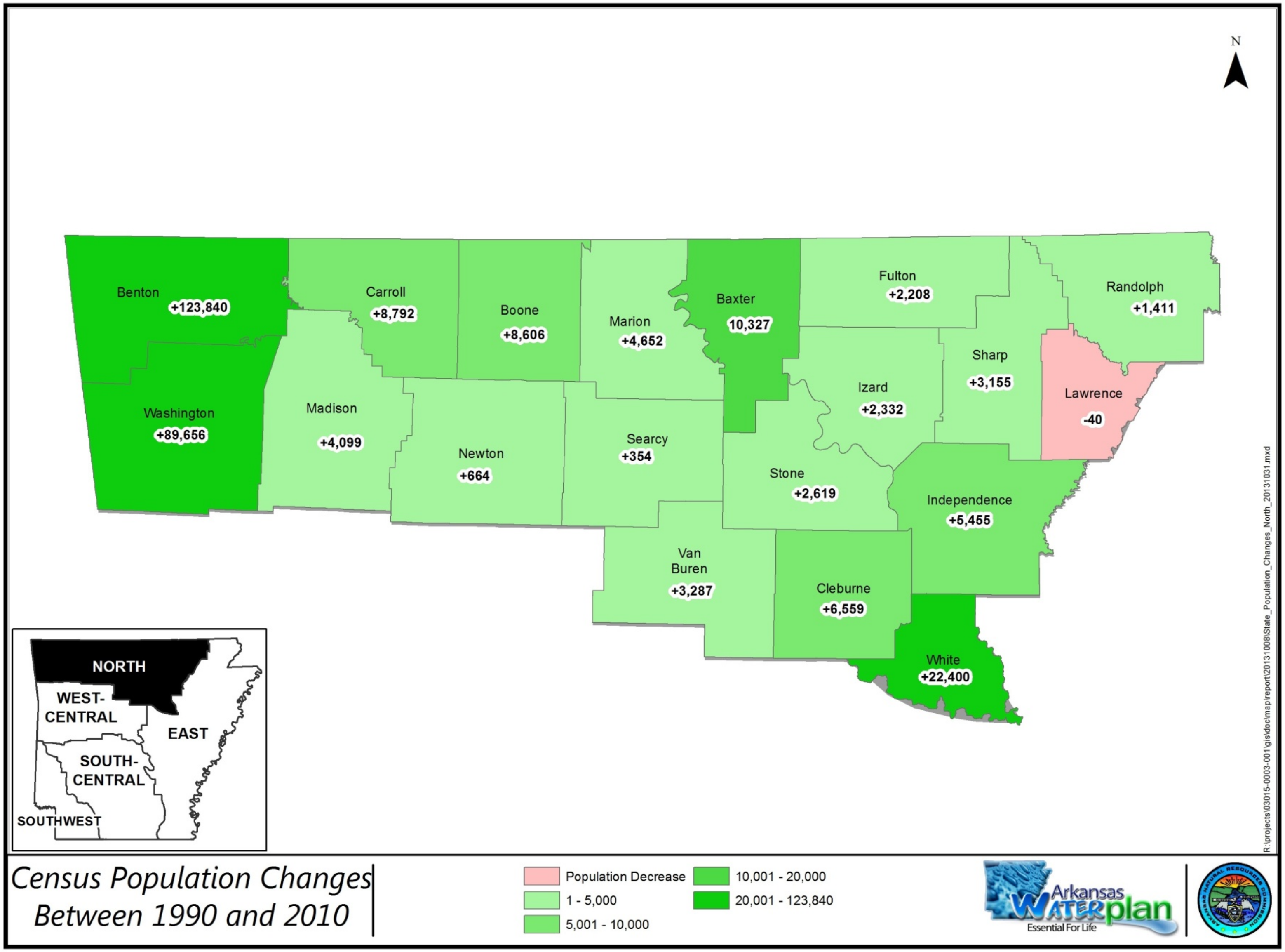

Figure 4.3. Population changes in the NAWRPR between 1990 and 2010.

4.2.1 Current Income and Employment Levels

Median household incomes reported by the US Census Bureau in the 2007-2011 Community Survey for counties in the NAWRPR are shown in Table 4.4. The average median household income in the planning region was just over $35,000. Searcy County had the lowest median household income in the planning region, $29,384. Two other counties in the planning region had median household incomes below $30,000. Benton County had the highest median household income in the region, $52,159, and the second highest in the state. Three counties - Benton, Washington, and White - had median household incomes greater than the state average of $40,149.

4.2.2 Changes in Income and Employment from 1990

Information on income and employment from the 1990 Census (1989 data) for the counties in the NAWRPR is included in Table 4.4. The average median income in the NAWRPR in 1989 was less than the state-wide median income of $21,147. The average median income in the 2010 census remained less than the state-wide median of $40,149 (US Census Bureau 2013).

Overall, the percentage of families and the percentage of population below poverty decreased from 1990 to 2010. However, the overall unemployment rate increased from 7.3% to 7.9%. All counties experienced an increase in unemployment except for Cleburne, Newton, Searcy, Sharp, Stone, and White Counties.

Table 4.4. Income and employment characteristics for counties in the NAWRPR (US Census Bureau n.d., U of A at Little Rock Institute for Economic Advancement 2002).

County	Median household income		Families with income below poverty level		Population below poverty level		Unemployment	
	1989	2007 - 2011	1990	2007 – 2011	1990	2007 – 2011	1990	2007 – 2011
Baxter	$ 18,826	$ 35,589	12.2%	10.8%	16.3%	16.0%	7.3%	8.9%
Benton	$ 26,021	$ 52,159	6.8%	8.5%	9.6%	11.8%	3.5%	5.5%
Boone	$ 20,656	$ 37,703	10.7%	10.9%	13.9%	15.8%	4.8%	6.3%
Carroll	$ 20,623	$ 36,031	12.1%	13.0%	15.2%	17.0%	5.9%	8.1%
Cleburne	$ 19,438	$ 38,510	14.0%	12.0%	17.3%	16.6%	8.8%	8.2%

Table 4.4. Income and employment characteristics for counties in the NAWRPR (continued).

County	Median household income		Families with income below poverty level		Population below poverty level		Unemployment	
	1989	2007 - 2011	1990	2007 – 2011	1990	2007 – 2011	1990	2007 – 2011
Fulton	$ 14,950	$ 33,281	22.1%	13.6%	26.3%	19.6%	8.3%	11.8%
Independence	$ 20,208	$ 34,878	13.2%	16.2%	17.1%	21.4%	6.6%	7.1%
Izard	$ 16,910	$ 31,865	16.4%	14.5%	21.1%	17.8%	7.2%	10.7%
Lawrence*	$ 15,337	$ 32,337	20.6%	19.0%	25.0%	23.3%	7.9%	9.2%
Madison	$ 18,392	$ 35,579	17.1%	16.9%	20.1%	20.8%	4.0%	6.5%
Marion	$ 17,220	$ 34,063	14.7%	13.1%	18.9%	17.0%	7.3%	8.0%
Newton	$ 18,000	$ 29,702	22.9%	18.1%	29.6%	21.6%	9.3%	3.8%
Randolph	$ 16,719	$ 33,072	15.8%	16.5%	20.4%	19.9%	7.6%	8.1%
Searcy	$ 13,221	$ 29,384	24.5%	13.7%	29.9%	22.1%	9.1%	5.8%
Sharp	$ 17,362	$ 29,590	16.9%	15.6%	21.8%	24.0%	11.4%	10.2%
Stone	$ 15,655	$ 31,364	21.0%	16.4%	26.0%	22.4%	9.3%	7.3%
Van Buren	$ 17,103	$ 32,906	17.2%	16.9%	22.2%	24.9%	8.7%	9.6%
Washington	$ 23,124	$ 41,474	9.8%	12.8%	14.6%	18.9%	3.9%	6.9%
White*	$ 19,722	$ 41,618	14.7%	12.5%	18.7%	16.4%	8.0%	7.4%
Average	**$ 18,394**	**$ 35,321**	**15.9%**	**14.3%**	**20.2%**	**19.3%**	**7.3%**	**7.9%**

*Part of this county is in another planning region

4.3 Economic Drivers

Agriculture, tourism, manufacturing, education, and retirement communities are important economic drivers in the NAWRPR (Association of Arkansas Counties 2013). The US Census Bureau conducts an economic census every 5 years. This includes information on the value of sales, and the number of people employed by the industrial sector by county. Information from the 1992 and 2007 economic census, as well as the 1990 and 2010 census, are presented below. It should be noted that US Census data withholds some information in order to avoid disclosing information for individuals and individual companies. Also, all totals include county-wide data for Lawrence and White Counties, both of which are not entirely in the NAWRPR. Therefore the reported US Census data for all years should be considered estimations.

4.3.1 Current Regional Economic Drivers

The value of sales and receipts reported for the counties within the NAWRPR in the 2007 economic census is summarized on Figure 4.4. Agriculture is not an economic sector reported in the economic census. However, agriculture contributes value to manufacturing, real estate, wholesale trade, and transportation and warehousing economic sectors (U of A Divison of Agriculture 2012). Retail trade accounts for the largest proportion of the value of sales and receipts, followed by manufacturing and services. Note that approximately 57% of the value of sales and receipts reported in 2007 were from Northwest Arkansas, with 39.2% of the total in Washington County. White County also had a significant portion, with approximately 10% of the total.

The number of people employed in the NAWRPR by economic sectors, as reported in the 2007-2011 American Community Survey (ACS) and the 2007 Economic Census, are summarized on Figure 4.5. The economic sectors for which employment is reported in these two sources are slightly different. However, both sources indicate that health care and education, retail trade, and manufacturing provide the majority of employment in the NAWRPR. Agriculture generates jobs in every economic sector, particularly manufacturing, health care, retail trade, and transportation and warehousing (included in administration on Figure 4.5) (U of A Divison of Agriculture 2012).

The majority of people employed in the NAWRPR reside in Northwest Arkansas, in Benton and Washington Counties. These two counties account for approximately 55% of employment in the region, according to the 2007-2011 ACS data. White County accounts for approximately 9% of jobs. The least number of jobs are located in Newton County (US Census Bureau n.d.).

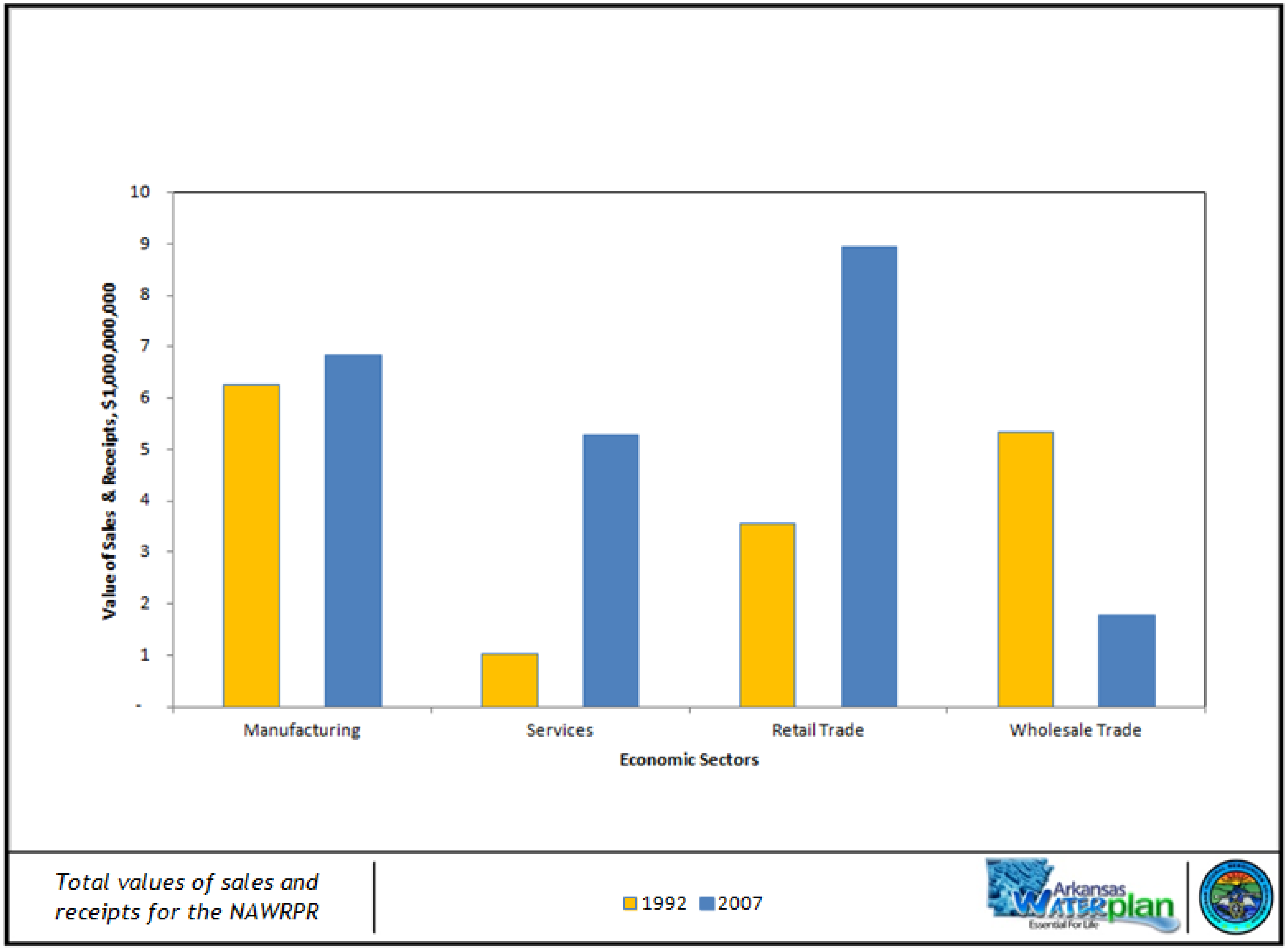

Figure 4.4. Total values of sales and receipts by economic sector for the NAWRPR (US Census Bureau 1992,2007).

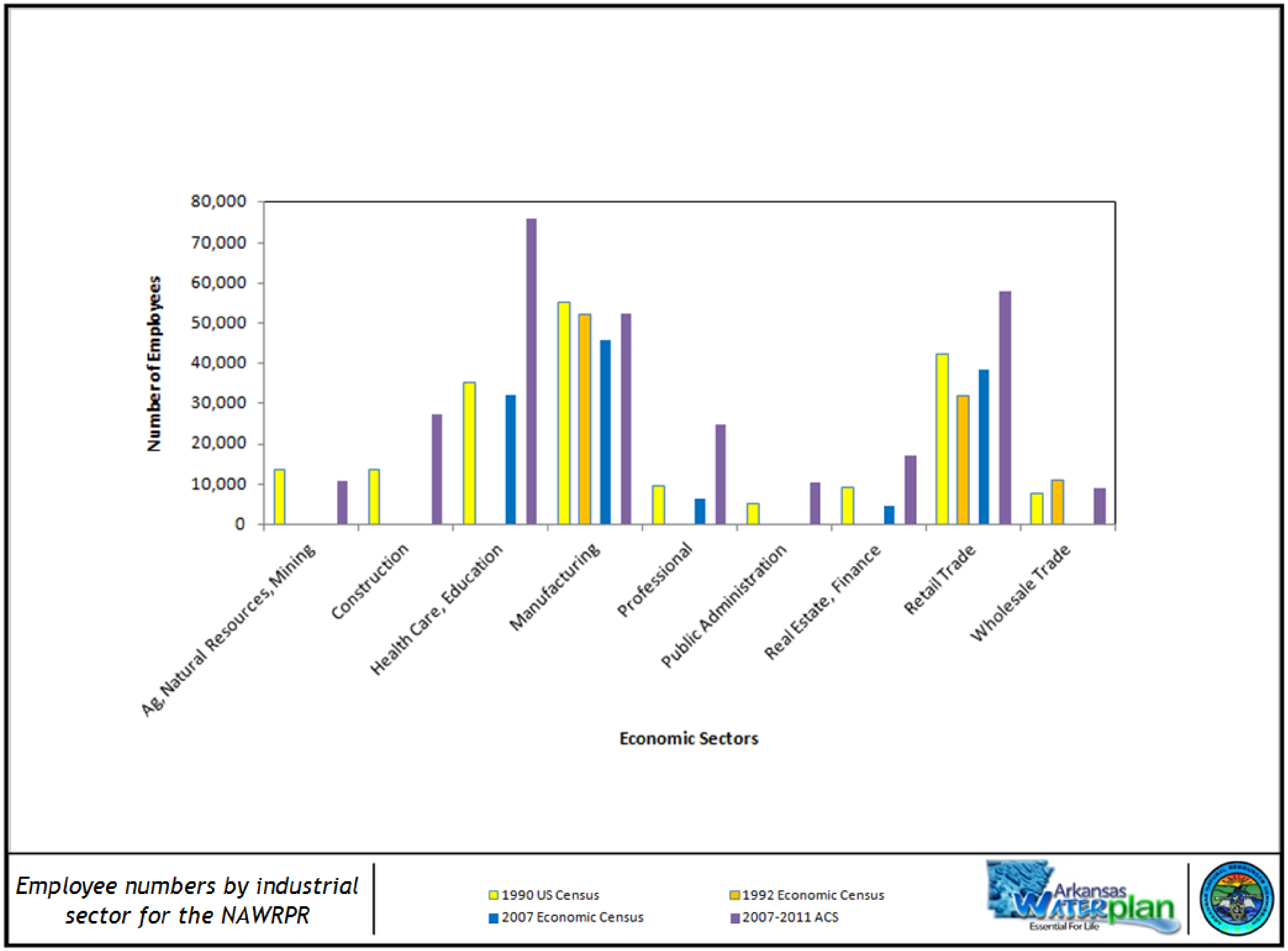

Figure 4.5. Total number of employees by economic sector for the NAWRPR (US Census Bureau n.d. 1992, 2007, 2011; U of A at Little Rock Institute for Economic Advancement 2002).

4.3.1.1 Agriculture

Agriculture is the largest industry in Arkansas. Arkansas is the second-largest broiler producer in the country (USDA 2012). Northwest Arkansas, particularly Benton and Washington Counties, produces most of the state's poultry (Riffel 2013a). Livestock sales, which includes poultry and eggs, accounted for the majority (95%) of the 2007 revenues from sale of agricultural products in the counties in the planning region. The total value for sale of livestock produced in these counties during 2007 was close to $2 billion, and poultry sales accounted for the majority of this value (Table 4.5). In most counties, the value of poultry sales was greater than the value of cattle and swine sales (USDA National Agricultural Statistics Service 2009).

Crop production also contributes to the economy of the planning region. The total value for sale of crops produced in the counties of the NAWRPR during 2007 was over $184 thousand (Table 4.5).

Table 4.5. Value of selected agricultural product sales in the counties of the NAWRPR (US Census Bureau 1989, USDA National Agricultural Statistics Service 2009).

	Poultry and eggs value ($1,000)		Cattle value ($1,000)		Swine value ($1,000)		Livestock value ($1,000)		Crop value ($1,000)	
County	**1987**	**2007**	**1987**	**2007**	**1987**	**2007**	**1987**	**2007**	**1987**	**2007**
Baxter	$8,170	$4,955	$6,203	$10,249	$150	$22	$14,661	$16,781	$186	$741
Benton	$199,986	$378,588	$20,708	$28,435	$26,726	D	$259,452	$427,015	$4,032	$6,942
Boone	$10,240	$92,109	$11,673	$24,398	$506	$21	$24,990	$117,725	$528	$2,081
Carroll	$55,312	$227,899	$16,643	$27,147	D	$47	$79,649	$258,836	$840	$2,273
Cleburne	$27,637	$42,987	$4,060	$9,901	$533	$9	$34,040	$54,505	$269	$1,618
Fulton	$1	D	$7,205	$21,393	$1,524	$36	$12,352	$25,121	$209	$649
Independence	$28,815	$73,215	$7,805	$28,312	$608	$19	$37,662	$101,877	$9,233	$21,754
Izard	$10,795	$23,563	$4,284	$10,170	$1,245	D	$17,253	$39,138	$200	$1,165
Lawrence*	D	$19,139	$2,807	$5,067	$602	$42	$3,986	$15,589	$36,815	$53,548
Madison	$57,339	$137,964	$10,226	$16,554	D	$34	$75,656	$157,340	$604	$2,787
Marion	$2,295	$25,186	$7,629	$8,143	$240	$31	$11,240	$34,048	$156	$755
Newton	D	$11,147	$2,904	$5,130	$1,034	$1,456	$4,735	$18,093	$122	$927
Randolph	D	$10,191	$4,615	$10,407	$1,243	$97	$6,316	$20,984	$14,369	$43,265
Searcy	D	D	$6,199	$8,528	$392	D	$9,468	$11,548	$273	$719
Sharp	$4,626	$43,117	$4,555	$11,903	$593	$22	$10,376	$55,860	$275	$805
Stone	$25,124	$26,243	$3,887	$16,266	$108	$4	$29,218	$42,673	$309	$1,012
Van Buren	$8,053	$4,854	$3,236	$5,980	$272	D	$16,391	$14,226	$407	$1,276
Washington	$245,398	$365,621	$19,861	$32,084	$19,501	D	$295,579	$410,061	$3,120	$7,904
White*	$22,604	$59,068	$8,577	$22,375	$328	$58	$35,025	$34,000	$18,066	$34,241
Total	**$706,395**	**$1,545,846**	**$153,077**	**$302,442**	**$55,605**	**$1,898**	**$978,049**	**$1,855,420**	**$90,013**	**$184,462**

* Part of this county is in another planning region.; D=data withheld to protect privacy

4.3.1.2 Tourism

Tourism is the second largest industry in Arkansas. Tourism, including water-based recreation, is a large contributor to the economy of the NAWRPR. According to the 2012 Annual Report Summary from the Arkansas Department of Parks and Tourism, Northwest Arkansas (Benton, Carroll, Madison, and Washington Counties) has the highest revenue from tourism in the state, as well as the greatest number of visitors (Arkansas Department of Parks and Tourism 2012).

The five large reservoirs in the NAWRPR (Beaver Lake, Bull Shoals Lake, Norfork Lake, Greers Ferry Lake, and Table Rock Lake) contribute to the economy of the region in many ways. The reservoirs are popular tourist attractions, with several state parks, marinas, campgrounds, and activities to draw tourists to the area. USACE has estimated economic impacts of recreation at the reservoirs located in the NAWRPR. Overall, the five USACE reservoirs in the planning region generate over 1,000 jobs, and over $625 million in revenue, wages, and taxes (Table 4.6). Also, Beaver Dam, Bull Shoals Dam, Norfork Dam, and Greers Ferry Dam all house hydroelectric power plants. In 1990, approximately 9% of electricity in Arkansas was produced by hydroelectric plants, but this usage dropped to 3% by 2006 (Reynolds 2012).

Table 4.6. Economic benefits from USACE reservoirs in the NAWRPR in 2012 (USACE 2013).

Reservoir	Total Sales ($1,000)	Jobs	Payroll ($1,000)	Value Added ($1,000)
Beaver Lake	$65,637	955	$25,342	$40,558
Bull Shoals Lake	$58,680	919	$21,415	$36,005
Greers Ferry Lake	$164,296	2,706	$58,986	$98,499
Norfork Lake	$29,549	520	$9,961	$17,363
Table Rock Lake+	$98,883	1,446	$35,879	$59,887
Total	**$417,045**	**6,546**	**$151,583**	**$252,312**

*Includes wages, salaries, payroll benefits, profits, rents, and indirect business taxes.
+ The majority of this reservoir and its benefits are in Missouri.

Hunting, fishing, and wildlife watching account for a significant portion of the tourism economy of the NAWRPR. In 2011, Arkansas ranked seventh in the nation in hunting-related sales. There are several WMAs in the region. Along with the large reservoirs in the region, there are also several smaller lakes, ponds, and rivers that attract anglers. The AGFC maintains 36 fishing locations in the NAWRPR (AGFC 2011a). Four of these locations are on WMAs that are maintained by the state. Three of the AGFC –listed fishing areas are also USACE-maintained lakes. Economic contributions from wildlife recreation in Arkansas are summarized in Table 4.7. Regional data are not available.

Table 4.7. Economic contributions from wildlife recreation in Arkansas (AGFC 2013a, USFWS, US Census Bureau 1993, 2013).

Activity	Total expenditures (million $)		2011 Retail sales (million $)	2011 State/local tax revenue (million $)	2011 Federal tax revenue (million $)
	1991	2011			
All hunting	$85.0	$1,018.8	$877.4	$99.2	$99.5
Waterfowl hunting	NR	$288.0	$236.7	$29.1	$23.9
Sport fishing	$216.9	$495.6	$508.0	$49.4	$49.8
Wildlife watching	NR	$216.1	NR	NR	NR

NR=Not reported

Streams in the NAWRPR are also important to the tourism and recreation economy of the planning region. ADEQ has designated Bull Shoals Lake and 1,165 miles of streams in the planning region as Extraordinary Resource Waterbodies for “scenic beauty, aesthetics, broad scope recreation potential, and intangible social values” (Figure 4.6) (APCEC 2011). Over 325 miles of streams in the planning region are designated as Natural and Scenic Waterways (Figure 4.6). The Buffalo River is the first designated National River. Forty-three miles of the Strawberry River are designated as Arkansas Natural and Scenic River, and portions of North Sylamore Creek and Richland Creek are designated as National Wild and Scenic Rivers (ANHC 2012).

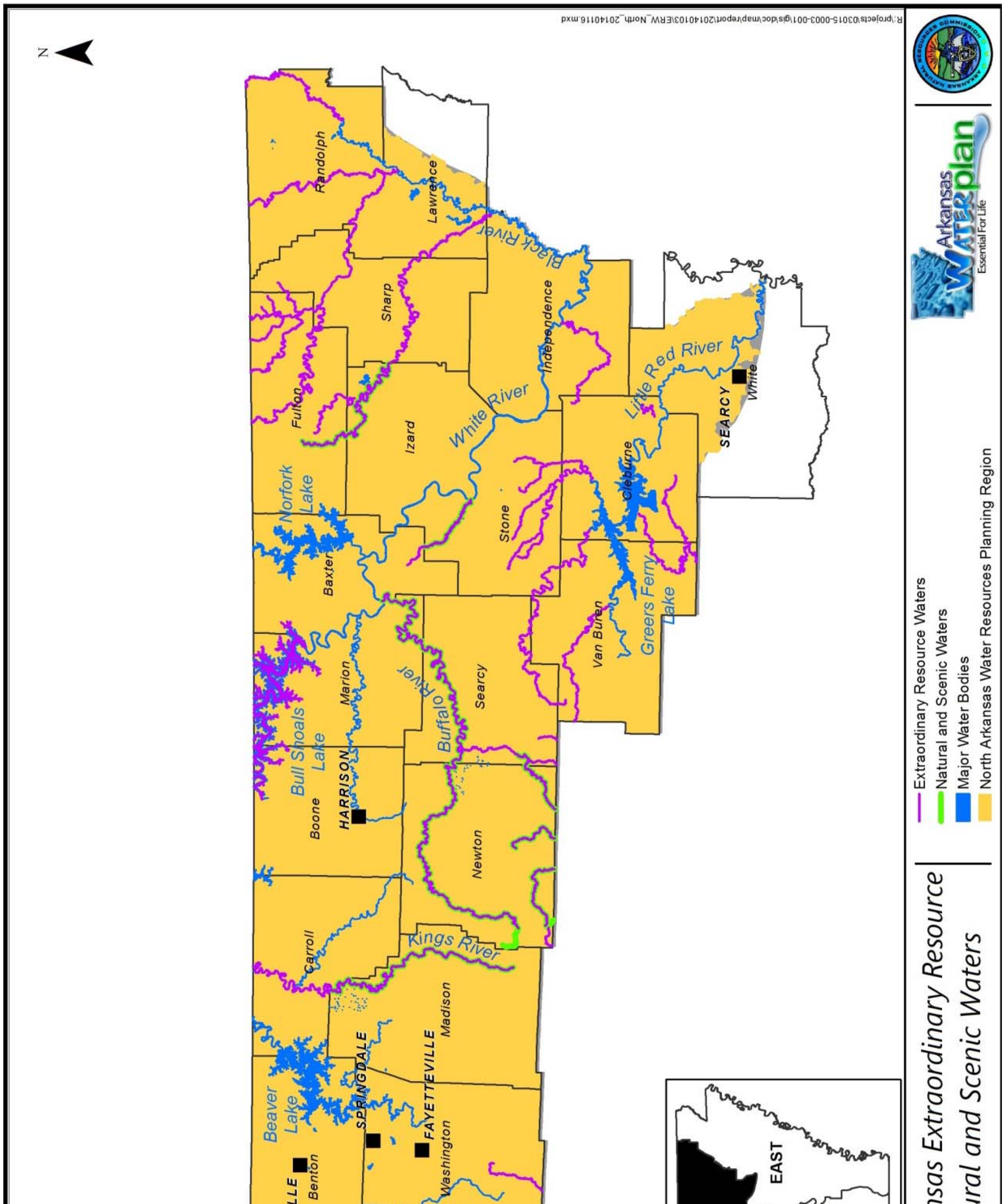

Figure 4.6 Designated extraordinary resource waters and natural and scenic waterways in the NAWRPR.

4.3.1.3 Fayetteville Shale Natural Gas Production

A new horizontal fracturing technique established in the late 1990s in the natural gas industry has made it possible to extract natural gas from shale formations. Beginning in the mid-2000s, gas production began in the Fayetteville Shale formation in Central Arkansas, including Van Buren, Independence, Cleburne, and White Counties (Figure 4.7). The introduction of this new industry in the region had a very positive impact on the economy, providing new employment opportunities and also boosting other industries in the region, including transportation, hospitality, education, and finance (Center for Business and Economic Research, U of A 2012).

4.3.1.4 Fish Hatcheries

Several fish hatcheries are located in North Arkansas. Trout hatcheries maintained by the USFWS are located downstream of Greers Ferry Dam, Bull Shoals Dam, Beaver Dam, and Norfork Dam. According to the USFWS, for every $1 spent on fish hatchery operations, more than $100 was generated for the economy (Shoults 2012).

A warm water fish hatchery is located in Centerton, in Benton County. The C.B. “Charlie” Craig State Hatchery is managed by the Arkansas Game and Fish Commission. Another warm water hatchery is located at Mammoth Spring, in Fulton County. It was established in 1903 and is maintained by the USFWS. The Mammoth Spring National Fish Hatchery works to restore various species of fish to areas in the White River basin and also is working to help recover endangered and threatened species such as freshwater mussels. The USFWS states that for every tax dollar used for the hatchery, there is a $12 net economic value, totaling over $1.5 million per year (USFWS 2010b).

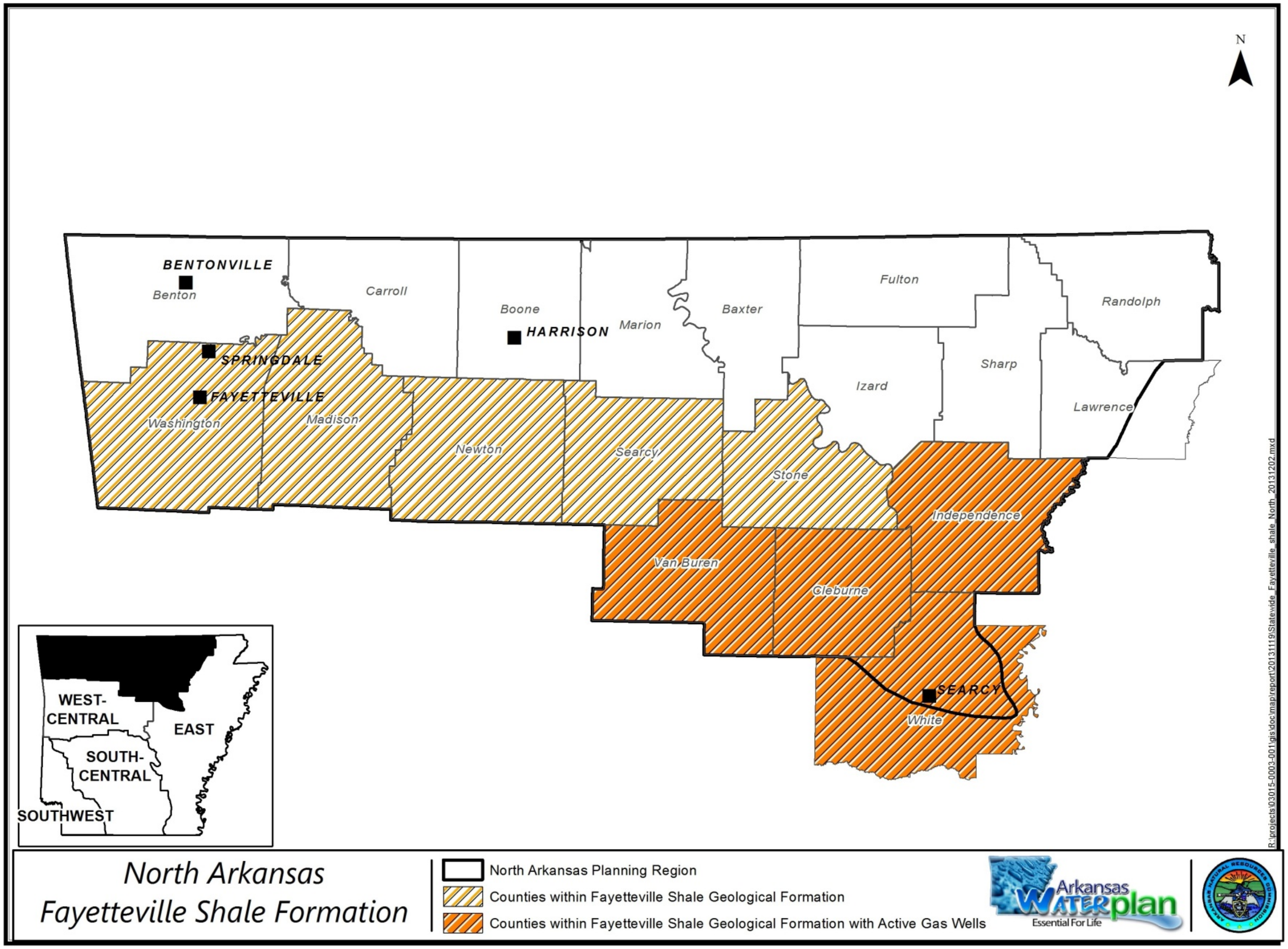

Figure 4.7. North Arkansas Fayetteville Shale formation and counties with active gas well sites.

4.3.1.5 Corporations

There are a number of large corporations based in the NAWRPR, including Tyson Foods, Wal-Mart Stores, Inc., and J.B. Hunt. The largest of these is Wal-Mart Stores, Inc. Wal-Mart is the most profitable retail outlet in the world (Riffel 2013b). It is based in Bentonville and is one of the largest employers in the United States (Wal-Mart 2014a). Wal-Mart annual revenues in 2013 were over $460 billion (Walmart 2014b).Tyson Foods, which is based in Springdale, is one of the largest producers of food in the world. In 2013, Tyson Foods annual revenue was over $34 billion (Tyson Foods, Inc. 2014). J.B. Hunt Transport Services, Inc., is based in Lowell. It is the largest trucking company in Arkansas and one of the largest transportation logistics companies in the United States (Cothren 2011). J.B. Hunt annual revenues in 2013 were greater than $5 billion (J.B. Hunt Transportation Services Inc. 2014).

4.3.2 Comparison to 1990 Regional Economy

1992 US Economic Census totals for values of sales and receipts for the NAWRPR are given in Figure 4.3 along with the 2007 data. The 1992 data does not report several economic sectors for county level, and several sectors are grouped together. From the data provided, however, it can be seen that manufacturing and retail have continued to be the dominant sales industries in the region. Wholesale trade sales have declined.

1992 US Economic Census totals and 1990 Census totals for number of employees per industrial sector are given in Figure 4.5 alongside the 2007 Economic Census and 2007-2011 ACS data. Again, some sector divisions are slightly different among the different census reports. However, it can be inferred from the given data that manufacturing, retail, and health care have continued to be the main sectors of employment since 1990. The finance and real estate, professional and administrative services, and construction sectors have shown a general increase in employment numbers from 1990 to present. The overall number of employees was significantly greater in the 2007-2011 data as compared to all other data sets.

4.3.2.1 Agriculture

Agriculture was the largest industry in the state in 1990. In 1987 and 1992, Arkansas was first in the nation in terms of broiler production (US Census Bureau 1990, US Department of Commerce 1994). As in 2012, Washington and Benton Counties were ranked highest in the state in value of poultry product sales in 1987 and 1992 (US Department of Commerce 1994). The value of both livestock sales and crop sales in 1987 was less than in 2007 (Table 4.5). Swine production appears to have declined since 1987 in most of the counties of the planning region (Table 4.5).

4.3.2.2 Tourism

Tourism trends have not changed significantly since 1990. Northwest Arkansas was the most profitable area of the NAWRPR for tourism in 1990, as it was in 2012 (Arkansas Department of Parks and Tourism 1991, 2012).

4.3.2.3 Other Changes

The development of the Fayetteville Shale natural gas is the largest change in the regional economy since 1990. Other changes include the growth of companies in the region. J.B. Hunt Transport Services, Inc. increased annual revenue from $1 billion in 1993 to over $5 billion in 2013. Wal-Mart grew as well. In 1990 Wal-Mart was the top retailer in the nation, but expanded globally throughout the world in the 1990’s and 2000’s (Walmart 2014c).

4.4 Waste Generation and Disposal

Industries and communities in the NAWRPR produce wastes that must be properly managed to protect water quality, which contributes to water availability for the water users of the NAWRPR. The ADEQ is the state agency responsible for regulating solid waste, hazardous waste, and wastewater. These three waste sources are managed through separate permitting programs overseen by the US Environmental Protection Agency (EPA). Waste management in the NAWRPR is quantified below, along with changes in waste management that have occurred since the 1990 AWP update.

4.4.1 Solid Waste

There are three regional solid waste management districts (RSWMDs), and portions of two RSWMDs, within the NAWRPR (Figure 4.8). Information on solid waste generation and disposal for each of these districts is summarized in Table 4.8. All but the Ozark Mountain RSWMD, report that their solid waste disposal facilities and collection services are sufficient to meet demand. However, illegal dumping that occurs in the districts could pose local threats to water quality.

Table 4.8. Solid waste generation and disposal information for RSWMDs in the NAWRPR (Benton County RSWMD 2011, Boston Mountain RSWMD 2011, Northeast Arkansas RSWMD 2011, Ozark Mountain RSWMD 2011, White River RSWMD 2011).

RSWMD Name	Number of counties in RSWMD	Number of Counties in planning region	Number of landfills in planning region	2010 Solid Waste Generated In-district (tons)	2010 Solid Waste Disposed In-district (tons)	Number Illegal Dump Sites Identified 2010
Benton	1	1	1	351,929	238,995	Not available
Boston Mountain	2	2	1	450,000	Not available	31
Ozark Mountain	6	6	0	Not available	71,628	Not available
White River	10	7 + 1 partial	2	127,845	101,794	12
Northeast	4	1 + 1 partial	0	70,558	70,064	Not available

There have been significant changes in the solid waste arena since 1990, driven by the need to protect water quality. In 1991, federal regulations changed, requiring improvements in the way landfills were constructed in order to protect groundwater quality. In addition, the new regulations required monitoring of groundwater quality around landfills (EPA 2012a, ADEQ 2011a). At the same time, state regulations set up programs to fund cleanup of groundwater contamination from landfills, and for collection and recycling of batteries and waste oil, both of which pose risks to surface and groundwater quality when disposed of improperly. Around 1995, the Arkansas General Assembly established a policy to eliminate illegal dumping, another threat to surface and groundwater quality. State legislation to implement this policy was passed in 1997. In 2005, state legislation was passed that resulted in the development and implementation

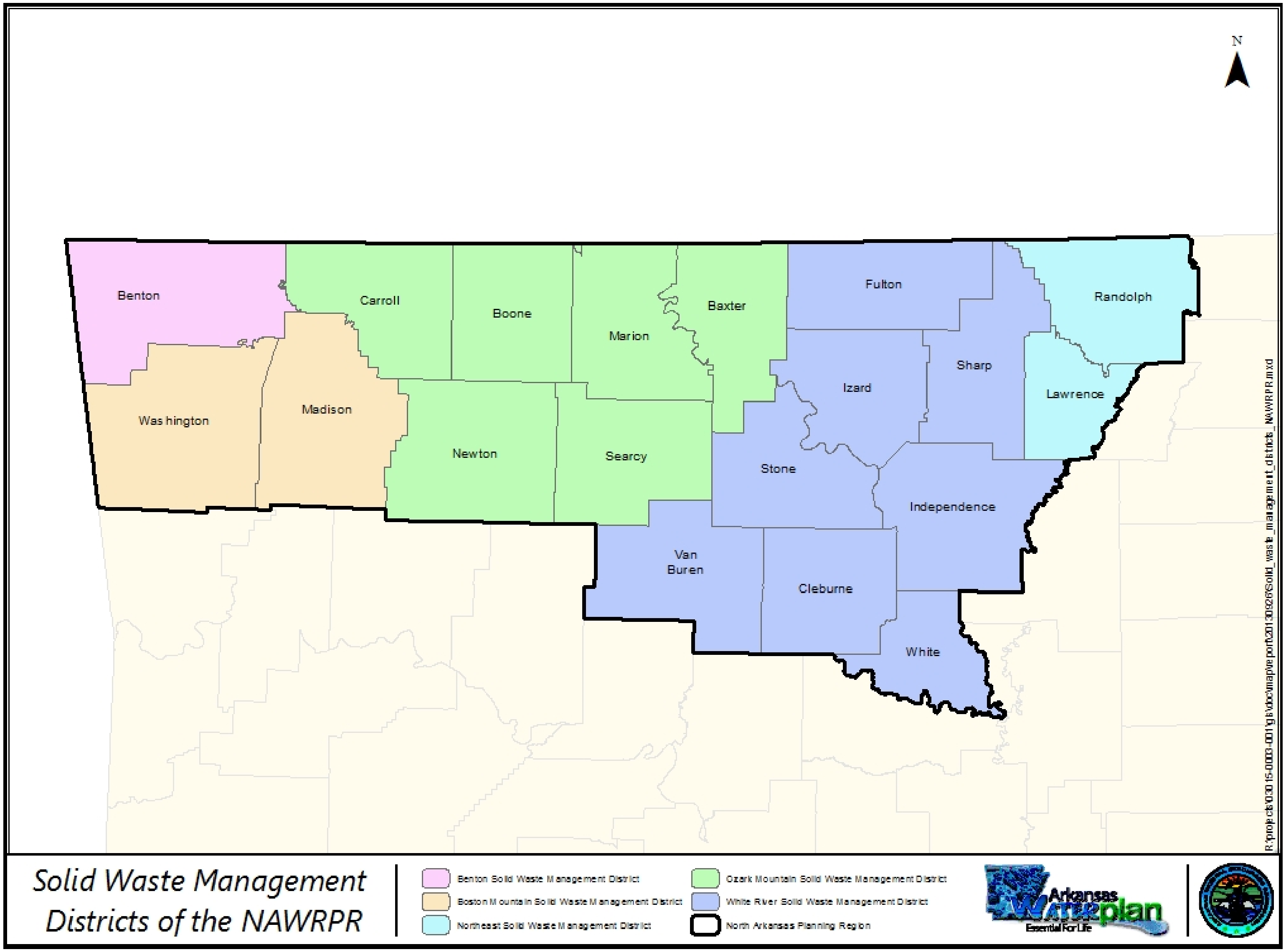

Figure 4.8. Solid waste management districts of the NAWRPR (ADEQ 2011b).

of a comprehensive mercury minimization program for the state. Mercury is a surface water quality issue throughout the state (ADEQ 2011a).State programs initiated since 1990 for the collection and recycling of electronics and collection of household hazardous wastes also protect water quality.

4.4.2 Hazardous Waste

There are 145 permitted hazardous waste generators in the counties within the NAWRPR (Table 4.9). The majority of the permitted hazardous waste generation facilities in the planning region are located in Washington County. There are 38 facilities in the counties within the NAWRPR that are classified as large quantity generators, meaning they generate at least 1,000 kilograms of hazardous waste per month (EPA 2012b). There are 107 facilities classified as small quantity generators, meaning they generate between 100 and 1,000 kilograms of hazardous waste per month (EPA 2012c).There are also two active hazardous waste treatment/storage/disposal facilities in the region; one in Independence County, and one in Izard County (ADEQ 2012a).

Hazardous waste generation data is compiled annually, but this program was not implemented in Arkansas until after 1990. Information from 1990 on the number of hazardous waste generators is also not readily available. Therefore, a comparison with 1990 conditions has not been made in this document.

Table 4.9. Hazardous Waste Generators in the NAWRPR (ADEQ 2012a).

County	Large Quantity Generator	Small Quantity Generator
Baxter	1	8
Benton	6	27
Boone	1	5
Carroll	0	1
Cleburne	1	3
Fulton	0	0
Independence	3	3
Izard	1	0
Lawrence*	0	0
Madison	0	2
Marion	1	0
Newton	0	0
Randolph	1	3
Searcy	0	0
Sharp	0	0
Stone	0	1
Van Buren	0	1
Washington	18	44
White**	5 (5)	9 (6)
Total	**38**	**107**

*Part of this county is in another planning region; values reported are for the permits located within the planning region only
** Part of White County is in another planning region; some permits were located in the City of Searcy, which is divided by the region boundary; all permits for this city were included and are shown in parentheses

4.4.3 Wastewater and Stormwater

There are around 960 point sources with active permits to discharge wastewater and stormwater in the NAWRPR (Table 4.10). These discharges are permitted by ADEQ through the federal National Pollutant Discharge Elimination System (NPDES). Industrial, municipal, and domestic wastewater discharges are permitted through NPDES as well as discharges of stormwater and runoff associated with industrial sites, municipalities (MS4s), and temporary construction sites. See Section 6 for more details on wastewater regulations and permitting in Arkansas.

Table 4.10. Active NPDES Permits in the NAWRPR (ADEQ 2013d).

County	NPDES Industrial	NPDES Municipal	NPDES Domestic	NPDES Stormwater	Construction of WWTP	NPDES Other[1]	Total
Baxter	14	3	7	21	4	2	51
Benton	25	10	5	159	6	18	223
Boone	15	3	1	25	2	1	47
Carroll	8	4	5	10	5	3	35
Cleburne	9	3	5	29	2	4	52
Fulton	6	2	0	4	0	0	12
Independence	27	4	1	34	3	6	75
Izard	8	5	1	15	5	1	35
Lawrence*	6	5	1	3	0	0	15
Madison	6	1	0	14	0	2	23
Marion	3	2	3	4	0	2	14
Newton	2	2	0	7	2	4	17
Randolph	8	5	0	6	2	2	23
Searcy	1	2	0	3	1	3	10
Sharp	1	4	1	8	0	0	14
Stone	2	1	2	7	1	2	15
Van Buren	10	2	6	13	2	2	35
Washington	36	6	3	139	3	2	189
White**	19 (14)	6 (1)	2 (1)	43 (33)	1	7 (3)	78
Total	**206**	**70**	**43**	**544**	**39**	**61**	**963**

*Part of this county is in another planning region; values reported are for the permits located within the planning region only

** Part of White County is in another planning region; some permits were located in the City of Searcy, which is divided by the region boundary. The given value for permits is for the whole region in the NAWRPR including Searcy, with the number of permits in Searcy in parentheses

[1]Includes filter backwash, process water, agricultural, cooling water, toxics, and saltwater discharges.

Approximately 95 surface water bodies in the planning region receive discharges from permitted entities. Several of these water bodies receive discharges from more than one point source (ADEQ 2008).

Table 4.11 compares the number of NPDES permits for municipal, domestic, and industrial wastewater reported for the NAWRPR in the 1990 state-wide water quality assessment, with the current numbers for the same categories of NPDES permits. The number of permitted wastewater discharges in these categories in the NAWRPR has increased approximately 165% since the 1990 AWP update. Note that the state-wide water quality assessment reports do not include permits for municipal, industrial, or construction stormwater runoff. The first industrial and construction stormwater runoff NPDES permits were issued by

ADEQ in 1992 (ADEQ 2013a, ADEQ 2013b). ADEQ did not issue permits for small municipalities' stormwater runoff until 2004 (ADEQ 2013c).

Table 4.11. Comparison of active NPDES Permits in the NAWRPR in 1990 and 2013 (ADEQ 2013d, ADPCE 1990)

Permit type	1990	2013	Change
Industrial	10	206	196
Municipal	66	70	4
Domestic	48	43	-5
Cooling water	3	2	-1
Filter backwash	3	23	20
Process water	1	23	22
Agricultural	1	2	1
Other	14	19	5
Total	**146**	**388**	**242**

5.0 WATER RESOURCES ISSUES

Water resources issues in the NAWRPR include concerns about the amount of water that is available, how the water is used, and the chemical and biological quality of water resources. In addition, there are concerns in the region about how water is managed in terms of flood control, water supply infrastructure, and wastewater treatment infrastructure. These issues are discussed and, to some extent, quantified below. Changes in regional water resources issues since the 1990 AWP update are also discussed.

5.1 Flooding

Flood control has long been an issue for the White River, the main waterway in the NAWRPR. As a result of the Flood Control Act of 1944, several dams were constructed along the river in order to control flooding, including USACE projects – Beaver Dam, Table Rock Dam (in Missouri), Greers Ferry Dam, Norfork Dam, and Bull Shoals Dam. Flooding occurs routinely throughout the planning region, but many of the floods are isolated events that affect only small areas or are limited to a few watersheds. Large, widespread disasters also occur. Since 1957, there have been 34 major disaster declarations involving flooding in Arkansas. From 2003 to 2010, some or all of the counties included in the NAWRPR were included in 15 flooding disaster declarations (Arkansas Department of Emergency Management 2010).

The most recent significant flood event in Arkansas occurred largely in the NAWRPR. Major flooding occurred during April and May of 2011 that included the White River, Kings River, and Illinois River, as well as the tributaries to these major rivers. Heavy rains during the week of April 21-27, 2011 resulted in record water levels at gages along the Illinois River and Baron Fork (NWS Weather Forcast Office 2011). A USGS report on the flood events of late April and early May of 2011 calculated the recurrence intervals for several gages in the NAWRPR. The recurrence interval of the storm events ranged from a 5-year event at the White River near Fayetteville, to a 100-year event at Osage Creek at Elm Spring. Several of the gages in the NAWRPR experienced a 50-year flood event (Westerman, et al. 2013).

Another more recent flood disaster occurred during the week of August 8-14, 2013, and led to six counties in the NAWRPR being declared as a federal disaster area (FEMA 2013a).

5.2 Water Supply

Population growth, as well as expansion of water-intensive industries in this region, such as irrigated agriculture, aquaculture, and hydrofracking, has resulted in increased demands in the NAWRPR.

5.2.1 Groundwater

Historically, the Springfield Plateau aquifer was extensively used for domestic, municipal, commercial, and industrial uses. Numerous towns were founded near large springs, which were used to power grain and lumber mills and to serve as a water supply. Today, the primary use of the aquifer is for domestic and livestock supply. Low yields limit use of the Springfield Plateau aquifer, and most commercial, municipal, and industrial water users rely on surface water supply systems (Kresse, et al. 2013).

In the WIP confining unit, water use is limited to domestic, small community, and non-irrigation agricultural supply, owing to poor well yields and limited groundwater resources. Since domestic and water supply systems producing less than 50,000 gallons per day are not required to report groundwater use, there is no way to accurately quantify the number of domestic and livestock wells in use in the WIP. As of 2010, water use from 13 wells completed in the Atoka Formation of the WIP confining unit was reported. These wells were primarily used for public supply at parks, schools, stores, and some commercial business.

As of 2010, there were 108 wells reported in the Ozark aquifer, with 79 wells completed in the lower Ozark aquifer and the remainder completed in the upper Ozark aquifer. Higher costs associated with drilling prevent many small community suppliers from using the more productive lower Ozark aquifer. As a result, there are communities in the planning regions that struggle to provide adequate water to meet their needs (ADH 2009, Grant 2013). The primary use of the Ozark aquifer is public water supply, with 76.45 million gallons per day (mgd) withdrawn in 2010. Primary users of the Ozark aquifer in Arkansas include Cherokee Village, Decatur, Holiday Island, Corning, and Mammoth Spring.

5.2.1.1 Groundwater Water Level Monitoring

Most groundwater monitoring in the NAWRPR is performed for the purpose of determining water quality, but water levels are also monitored. The USGS monitors water levels at several sites in the planning region. They maintain one real-time water level monitoring site in the planning region, in Stone County. There are also four USGS master wells located in the planning region, three in Fulton County, and one in Benton County (T. Fugitt, ANRC, personal communication 9/4/2013). The ANRC collects data on groundwater in areas where water-level problems are a known issue (Kresse, et al. 2013). ANRC is not currently collecting data on groundwater levels in the NAWRPR (ANRC 2013).

5.2.1.2 Ozark Aquifer

Ground-water withdrawals do not appear to have caused distinguishable differences in shallow groundwater levels over time in northern Arkansas (Gillip 2007). Although wells completed in the Ozark aquifer are limited, declines in water levels were noted in northwest Arkansas in the counties of Benton, Carroll and Washington. However, water level monitoring has observed recent decreases in the rates of water-level declines and water level increases in some wells. These water level changes were attributed to the expansion of rural communities and conversion to surface-water resources (Gillip, Czarnecki and Mugel 2008, Schrader 2005).

5.2.2 Surface Water

Current water supply in Northwest Arkansas is meeting needs, and projections have showed that the potable water supplied by Beaver Water District (from Beaver Lake) will be ample through at least 2055 (Wiest 2011).

Water supply in Central Arkansas is of growing concern, and recent proposals have been made to reallocate water storage from Greers Ferry Lake in order to meet water supply needs in several areas in central Arkansas (Waldon 2012). In 2010, the Little Rock District USACE issued a Finding of No Significant Impact, supporting the proposal for this water reallocation (USACE Little Rock District 2010).

Drilling in the Arkhoma Basin Fayetteville Shale, a geologic formation being heavily developed for natural gas resources in the state, extends into Van Buren, Independence, Stone, Cleburne, and White Counties. The gas is being extracted from this formation using the hydrofracking process. This process uses large volumes of surface water. Development of the Fayetteville Shale in this region has increased surface water demand and use.

Minimum streamflow criteria have been promulgated for the White River from Bull Shoals dam to the Mississippi River. These criteria protect the ability of the White River to support multiple uses. Concern about the White River trout fisheries located downstream of USACE dams resulted in the modification of operations at Bull Shoals dam on the White River and Norfork dam on the North Fork of the White River to provide minimum releases. The purpose of these minimum releases is to provide enough downstream flow to maintain dissolved oxygen (DO) and temperature levels appropriate for trout during periods of reduced power generation demand.

5.3 Water Quality Issues

Federal law requires states to assess the water quality of the waters of the state (both surface water and groundwater) and prepare a comprehensive report documenting the water quality, which is to be submitted to EPA every 2 years. ADEQ is the agency in Arkansas responsible for enforcing the water quality standards and preparing the comprehensive report for submittal to EPA. This section discusses surface water and groundwater quality issues that have been identified in the NAWRPR. These issues include non-attainment of surface water quality standards, non-attainment of drinking water standards and water quality guidelines in groundwater, fish consumption advisories, nonpoint source pollution of surface water and groundwater, and contaminants of emerging concern.

5.3.1 Water Quality Monitoring

To assess water quality, it is necessary to collect water quality data through monitoring programs. Monitoring of water quality in the NAWRPR occurs under a range of programs, including routine ambient, special project, and research-oriented monitoring. Multiple agencies are responsible for the various water quality monitoring programs, and numerous entities assist with monitoring activities. Surface water and groundwater monitoring programs in the planning region are outlined below.

5.3.1.1 Surface Water

ADEQ monitors water quality of surface waters through several programs. There are 274 ADEQ water quality monitoring station locations in the NAWRPR (ADEQ 2013e). The ambient water quality monitoring network includes 45 sites on rivers and streams in the NAWRPR that are sampled monthly for chemical analysis. The roving water quality monitoring network includes 42 stream sites in the planning region. These sites are divided into four regional groups. Each group of sites is sampled for chemical and bacterial analysis on a rotating basis, bimonthly over a 2-year period, every 6 years. Bacterial analysis is also performed on samples from the ambient water quality monitoring network within the active region of the roving water quality monitoring network. ADEQ also routinely monitors water quality in 12 significant publicly owned lakes within the planning region (ADEQ 2004, ADEQ 2012c).

In addition, ADEQ conducts water quality monitoring during “intensive surveys.” These surveys can involve water sampling for chemical and bacterial analysis, as well as biological sampling to evaluate water quality. Intensive surveys are conducted for a variety of purposes, including determination of total maximum daily loads (TMDLs), and to augment water quality information from the routine water quality monitoring networks for more accurate assessment of designated use support (ADEQ 2012c).

Through its nonpoint source management program, ANRC oversees water quality monitoring programs two watersheds in the NAWRPR, Illinois River and Upper White River. These programs involve universities, contractors, and nonprofit organizations. Parameters monitored by these programs typically include nutrients and sediment, turbidity, and/or total suspended solids.

The monitoring and reporting requirements for surface water used for human consumption are authorized by both federal and state regulations. A summary of these requirements can be found in Chapter 5 of *Arkansas Public Water System Compliance Summary*, “Microbial Disinfection By-Products Rules” (ADH 2012). There are 74 public water supply systems in the NAWRPR that use surface water (ADH n.d.). Depending on the treatment methods used and the number of customers served by the public water supply utilizing surface water, the monitoring requirements for the raw surface water, or source water, will vary and may include turbidity, *Escherichia coli* (*E. coli*), cryptosporidium, total organic carbon (TOC), and alkalinity.

The USGS also routinely monitors surface water quality data in the NAWRPR. Data from USGS monitoring stations may also be used in the biennial assessment. There are 26 active USGS water quality monitoring stations in the NAWRPR (Figure 5.1). Samples are collected at these stations monthly, bi-weekly, or quarterly (USGS 2013a). The USGS National Water Quality Assessment Program Ozark Plateaus Study Unit includes areas within the NAWRPR, including the Black River, Illinois River, and White River watersheds. The USGS and its partners conducted an intensive study of water quality in these areas over the period from 1991 through 1995 (USGS 2008).

5.3.1.2 Groundwater

In the NAWRPR, groundwater quality monitoring is performed through programs ranging from ambient to research-oriented and mandated monitoring. Multiple agencies are responsible for the various groundwater monitoring programs, and numerous entities assist with monitoring activities. Divisions of ADEQ administer mandated groundwater monitoring programs at various sites that are regulated by state and federal programs. The purpose of this monitoring is to evaluate potential and actual impacts to groundwater resulting from human activities and natural phenomenon (ADEQ 2012c).

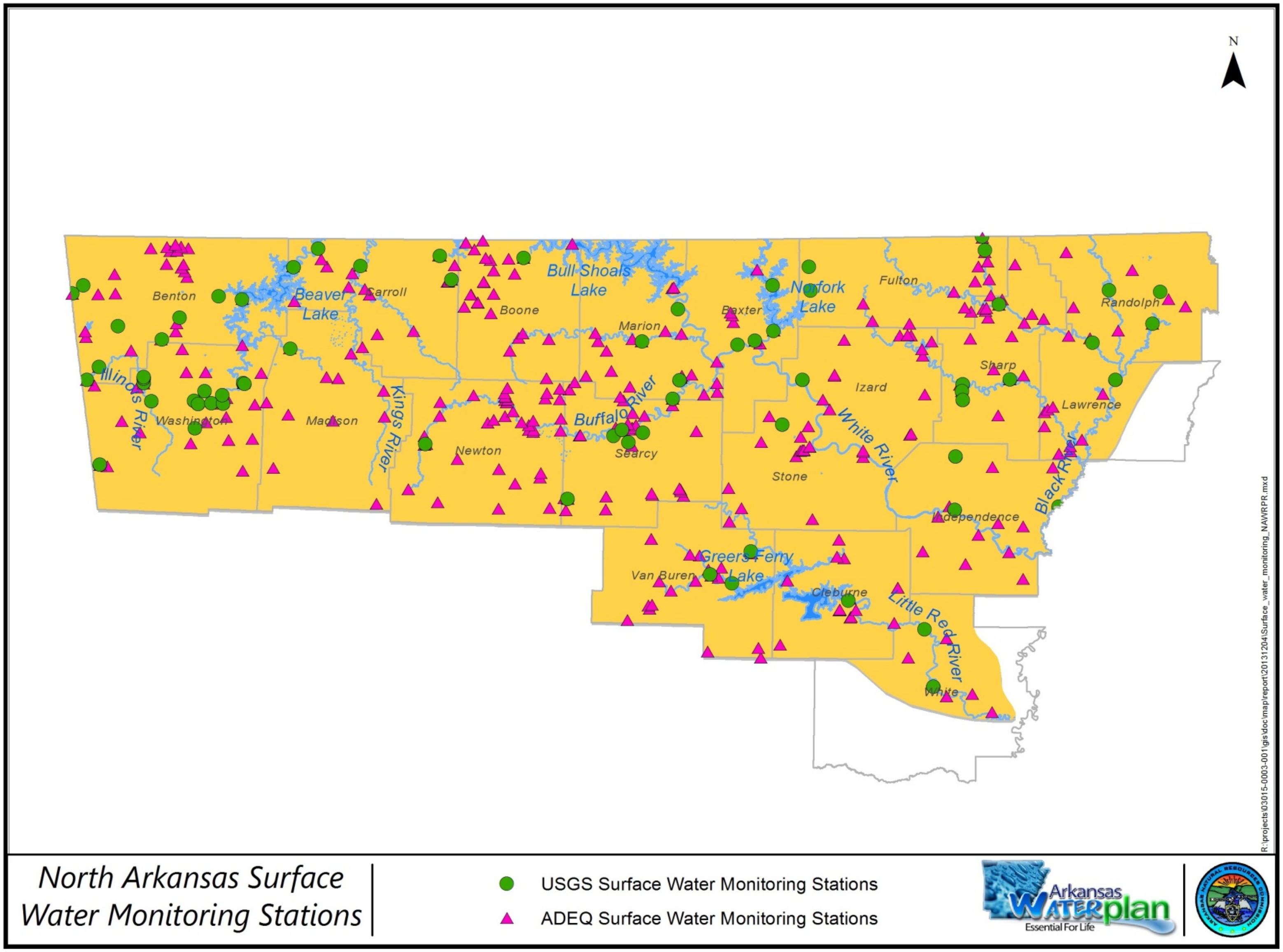

Figure 5.1. Surface water quality monitoring in the NAWRPR.

ADEQ developed the Arkansas Ambient Ground Water Monitoring Program in 1986, which currently consists of 12 monitoring areas and approximately 250 wells and springs throughout the state (Kresse, et al. 2013). Monitoring areas in NAWRPR are shown in Figure 5.2. These monitoring areas were selected to gather water-quality data from various representative aquifers and to evaluate impacts from multiple land uses. The monitoring areas are affected by agricultural, industrial, or a combination of both sources. Samples are collected on a three-year rotational basis and include a comprehensive suite of analyses. Data are presented in various ADEQ publications available on their website and in the EPA's STORET database (ADEQ 2012c).

The U of A has conducted a significant amount of groundwater research that has resulted in scientific data and information necessary to understand, manage, and protect water resources within the state (Kresse, et al. 2013). Hard-copy or digital reports, theses, dissertations, and journal articles are available at the U of A Mullin's Library, Arkansas Water Resources Center technical library, or through various online sources.

The Arkansas Department of Health (ADH) is the primary agency for implementation of the federal Safe Drinking Water Act (SDWA) and is responsible for monitoring public water-supply wells. ADH maintains a statewide database that consists of 1300 wells (Kresse, et al. 2013). Every three years, these wells are sampled for inorganic, organic (including pesticides, herbicides, synthetic organic compounds, and volatile organic compounds), and radiochemical contaminants. The Total Coliform Rule of the SDWA requires sampling on monthly basis, where the number of samples required is dependent upon the population size. Nitrate monitoring is performed on a yearly basis unless a sample greater than or equal to 50% of the maximum contaminant level (MCL) is detected and prompts the need for increased frequency. Additionally, the Disinfection Byproduct Rule of the SDWA requires monitoring of trihalomethanes and haloacetic acids (byproducts of chlorine and other disinfectants used to treat drinking water) on a quarterly or annual basis. While all of the programs above collect samples from treated drinking water, ADH also collects samples from untreated water sources (surface and groundwater) that include bacteria, particulates, algae, organics, pathogens, total organic carbon on a weekly or monthly basis as required by the SDWA (ADEQ 2008, 2012c).

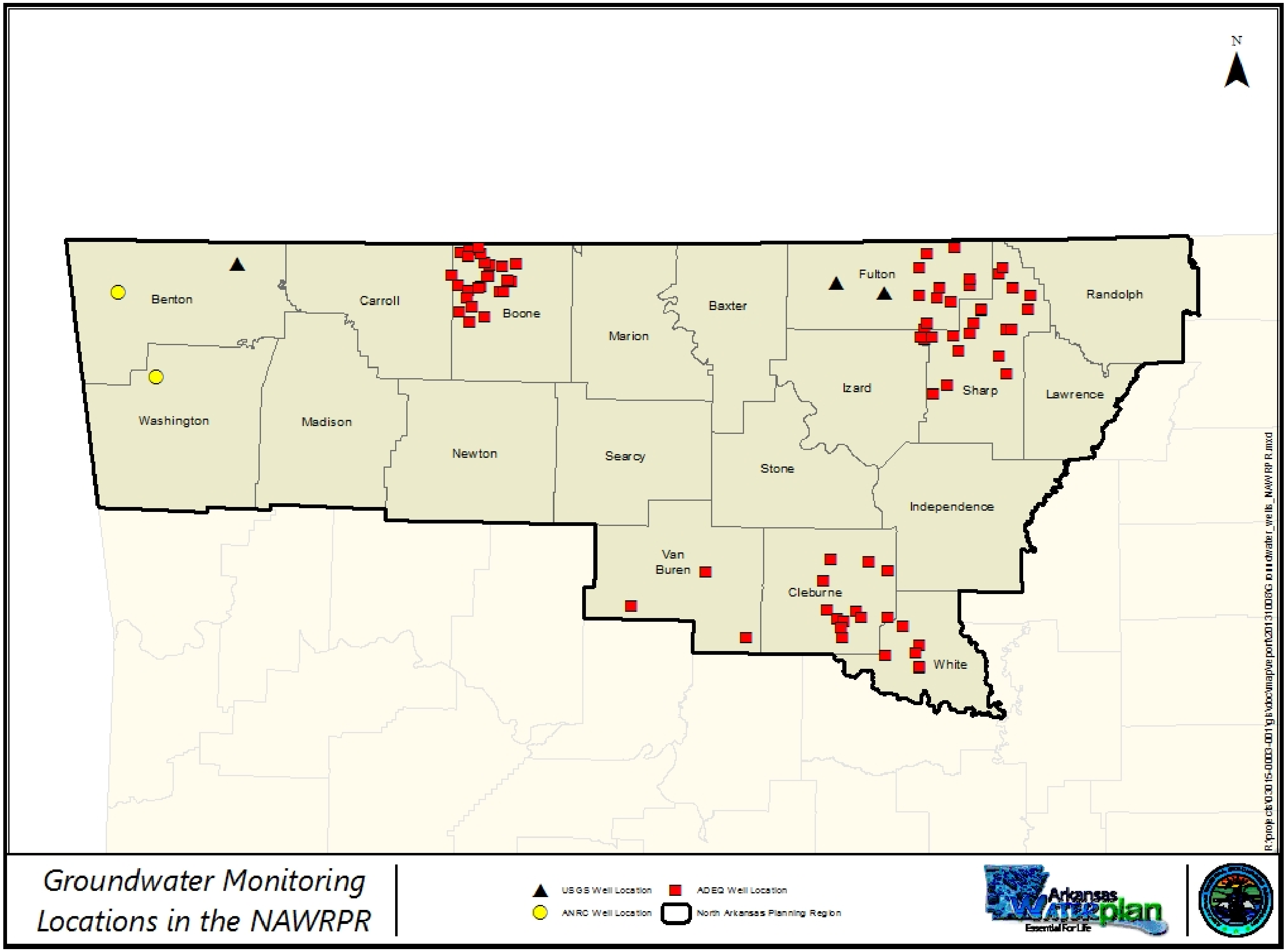

Figure 5. 2. Location of Groundwater Monitoriing Wells in the NAWRPR

Several ambient groundwater quality monitoring programs exist that involve cooperative efforts among the USGS, ANRC, and ADEQ. Figure 5.2 shows the locations where ambient groundwater monitoring is performed throughout the NAWRPR. Table 5.1 lists the monitoring areas, responsible agencies, most recent sampling event, aquifers monitored, and number of sampling sites for the various ambient groundwater monitoring programs. Groundwater-quality monitoring activities are primarily funded by USEPA grants under Sections 106 and Sections 319 of the Clean Water Act.

Table 5.1. Groundwater monitoring information for the NAWRPR (ADEQ 2012c)

Monitoring Area	Agency	Most recent sampling	Total number of wells/springs	Aquifer	Number of wells/springs
Omaha	ADEQ	2010	28	Springfield Plateau	11
				Ozark	17
Benton County	ANRC	2008	2	Springfield Plateau	1
				Ozark	1
	USGS	2012/2013*	3	Springfield Plateau	2
				Gunter Sand	1
Washington County	ANRC	2007	1	Springfield Plateau	1
North Central*	ADEQ	2010	30	Western Interior Confining Unit	30
Hardy	ADEQ	2008	24	Ozark	24
Fulton County	USGS	2011	2	Roubidoux	1
				Gunter Sand	1

* This area includes wells that are not in the planning region. Only wells within the NAWRPR were included.

ANRC collects groundwater data statewide in areas where water-level declines or water-quality degradation have been historically observed (Kresse, et al. 2013). In NAWRPR, ANRC performs groundwater monitoring at two locations in Washington (one well) and Benton (two wells) Counties. These wells were installed to evaluate the critical threat to groundwater quality in the karst terrain of northern Arkansas over an extended period of time and to assist in the establishment of groundwater quality standards. Samples are collected for the analysis of selected metals, nutrients, pesticides and other parameters (ANRC 2008). When collected, data are published in the annual Arkansas Groundwater Protection and Management Report available on the ANRC website.

The USGS has 24 groundwater wells or springs that they monitor for water quality scattered throughout the state, with three of these sites located in the NAWRPR (Figure 5.2). Samples are collected on a 5-year rotational basis for a variety of constituents to include nutrients, metals, organics, radioactivity, and selected primary and secondary drinking water standards (Kresse, et al. 2013). In addition, the USGS samples many other wells and springs for purposes of water quality and quantity investigations or as part of other monitoring programs, such as the National Water Information System. Data from these investigations and monitoring programs are presented in reports or available for download online at the Arkansas Water Science Center (http://ar.water.usgs.gov/) or similar USGS websites (Kresse, et al. 2013, ADEQ 2008, 2012c).

5.3.2 Non-attainment of Surface Water Quality Standards

Although ADEQ conducted the required statewide water quality assessments for 2010, 2012, and 2014, at the time this report was prepared, the 2008 303(d) list was the most recent state list of impaired water bodies that had been approved by EPA. Therefore, the results of the 2008 assessment are discussed here.

In 2008, approximately 2,611 miles of the 3,010 miles of streams within the NAWRPR were assessed. Of the miles assessed, about 900 miles did not meet numeric water quality criteria or did not support all of their designated uses. Pathogens, low dissolved oxygen, sediment/siltation, and minerals (chloride, sulfate, and total dissolved solids [TDS]) were the primary causes of impaired water quality in the majority of the stream miles assessed (Table 5.2) (ADEQ 2009). Mercury and sediment/siltation were the sources of impairment for lakes in the NAWRPR. The cause of impairment was unknown for 531 acres of Swepco Lake in the NAWRPR. Figures 5.3 through 5.5 show locations of impaired waterbodies in the NAWRPR. A detailed listing of water quality impairments in the planning region identified in the 2008 303(d) list is included as Appendix A.

Table 5.2. Summary of 2008 impaired waters in the NAWRPR (ADEQ 2009)

Pollutant	Miles of impaired stream	Acres of impaired lakes
Sediment/Siltation	169.3	1,500
Dissolved Oxygen	198.4	0
Chloride	42.4	0
TDS	196	0
Pathogens	411.4	0
Zinc	22.3	0
Sulfate	69.6	0
Nitrate	17.1	0
Mercury	2	50
Total Phosphorus	47.6	0
Temperature	52.3	0
Unknown	0	531

It should be noted that while a waterbody may be impaired due to sediment, there is no numeric water quality standard for sediment/siltation. Arkansas has a numeric water quality standard for turbidity but not total suspended solids (TSS); thus turbidity is the chemical parameter that is assessed to determine if sediment impairment exists. There is currently no other method that is consistently used by EPA or ADEQ to measure sediment or siltation in water.

In cases where exceedances of water quality criteria are preventing the attainment of a designated use, a TMDL must be developed. A TMDL is the maximum amount of a pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant, resulting in the waterbody being listed as impaired. A TMDL allows for the allocation of pollutant loads between point sources and nonpoint sources discharging to the waterbody, as well as a margin of safety.

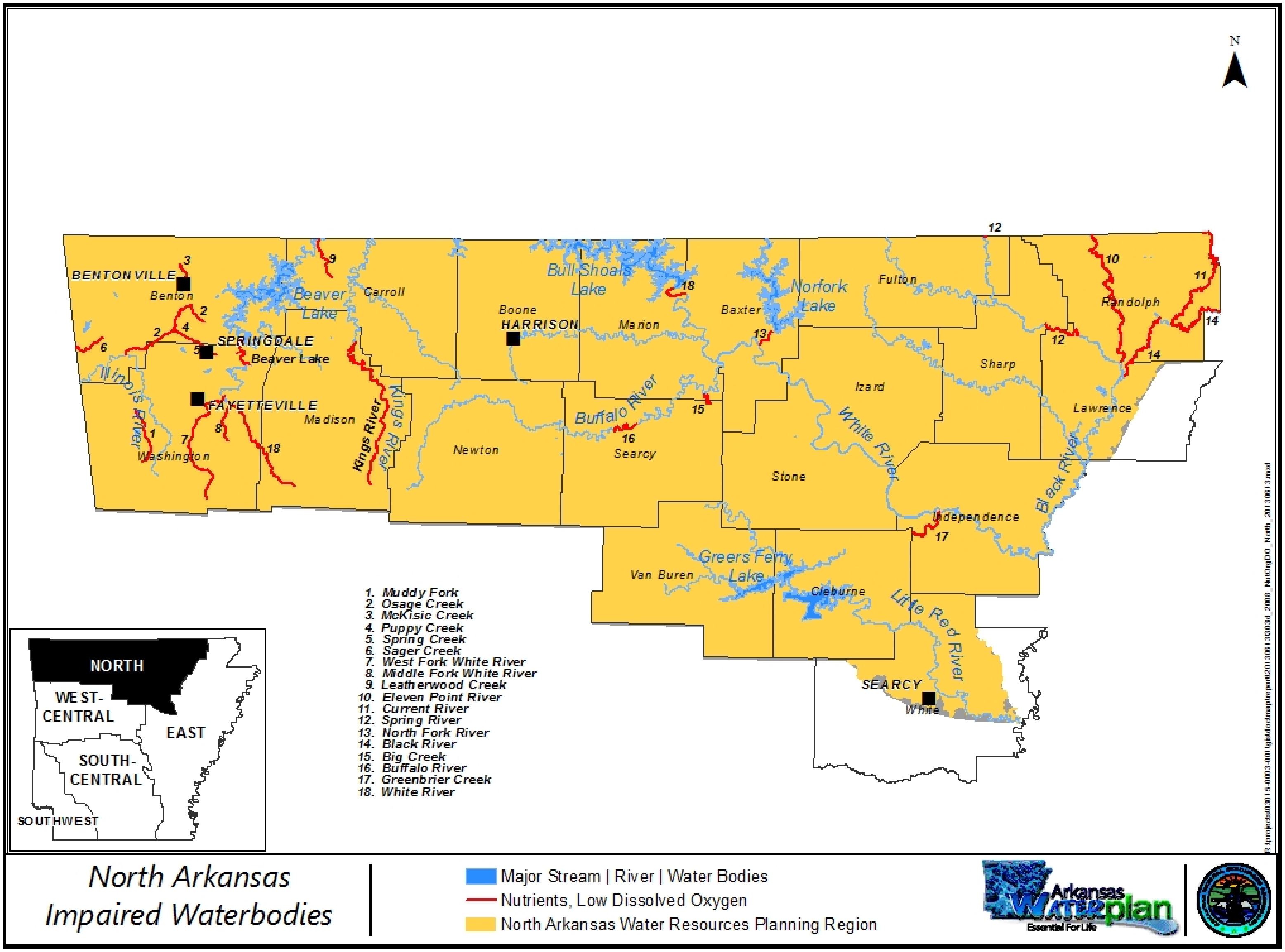

Figure 5.3. Waterbodies in the NAWRPR classified as impaired due to nutrients, and low dissolved oxygen in the 2008 303(d) list.

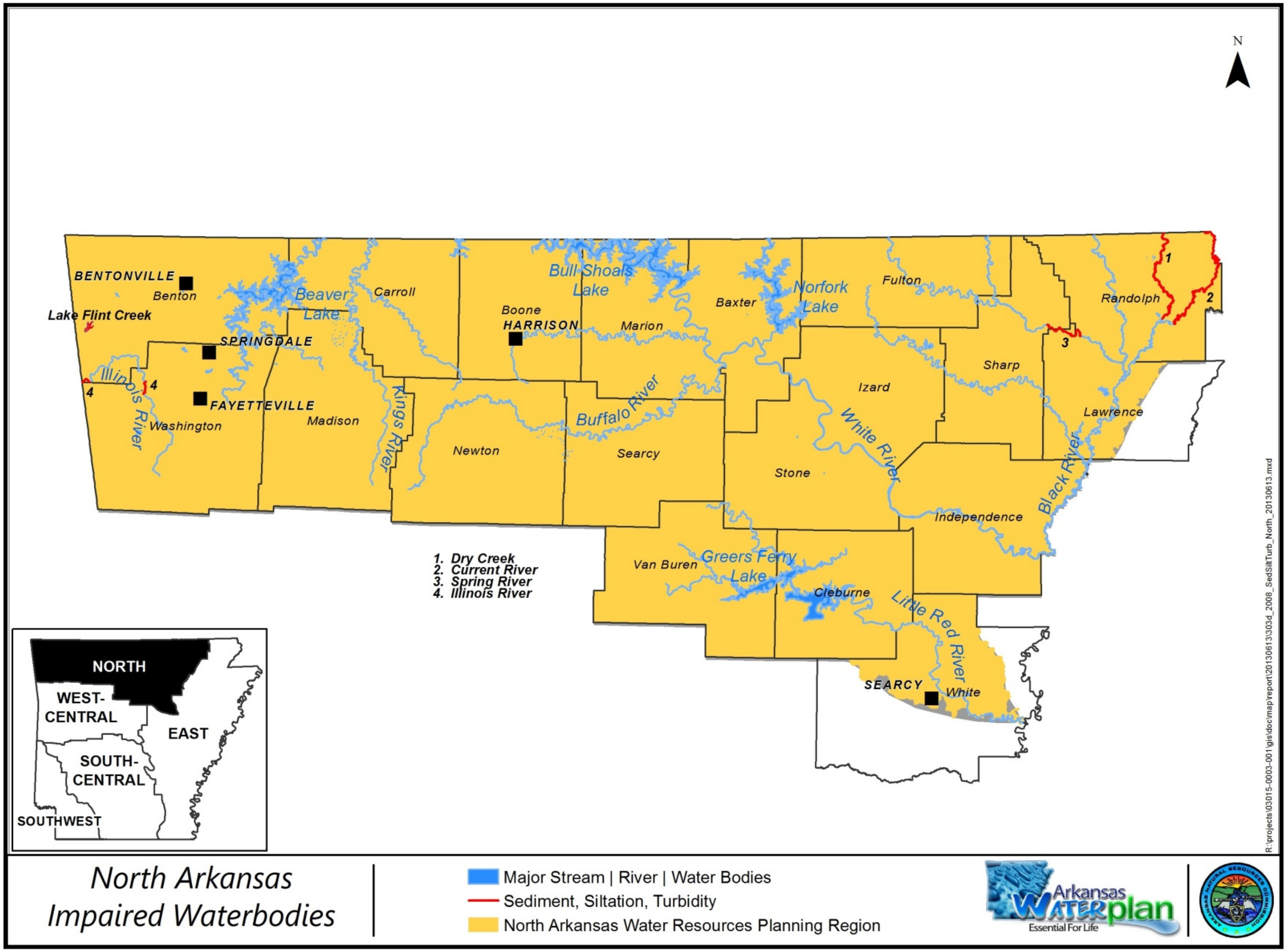

Figure 5.4. Waterbodies in the NAWRPR classified as impaired due to sedimentation, siltation, and turbidity in the 2008 303(d) list

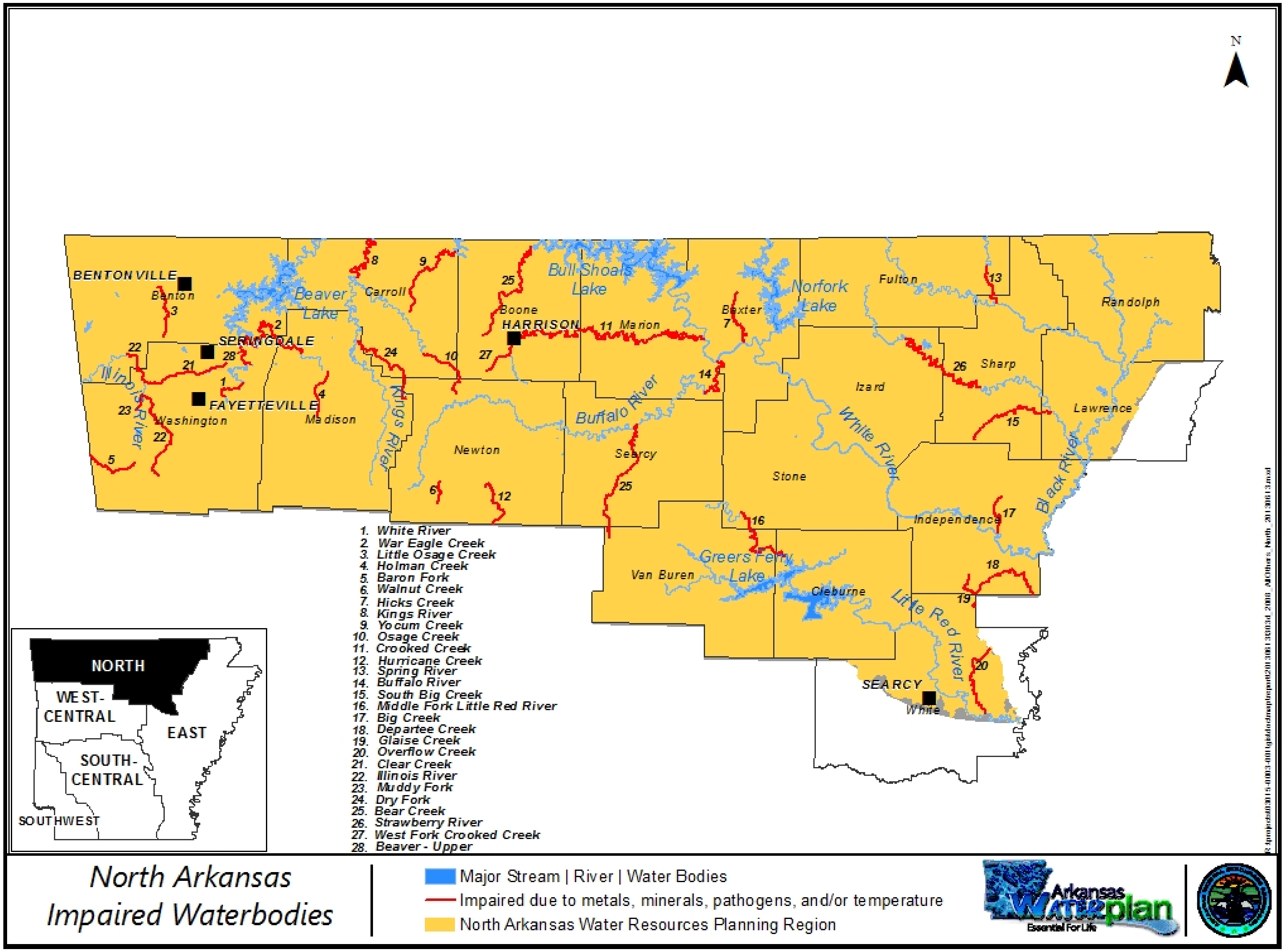

Figure 5.5. Waterbodies in the NAWRPR classified as impaired due to metals, minerals (chloride, sulfate, TDS), pathogens, and/or temperature in the 2008 303(d) list

TMDL reports have been prepared for a number of waterbodies in the NAWRPR addressing total phosphorus, pathogens, mercury, turbidity, nitrates, and dissolved oxygen (Table 5.3) (ANRC 2009).

The EPA is currently working on a TMDL for the Illinois River. Portions of the river and its tributaries in Oklahoma are included on the Oklahoma 2012 303(d) list for total phosphorus. Portions of three Illinois River tributaries in Arkansas are on the Arkansas 2008 303(d) list for phosphorus also. The TMDL project is currently in the modeling phase. Both Arkansas and Oklahoma have EPA-approved watershed management plans for the Illinois River (EPA 2013a).

Table 5.3. TMDLs for waterbodies in the NAWRPR

Waterbody	Impaired Uses	Pollutants	Status
Bull Shoals (White River) Tailwaters	Aquatic Life	Dissolved Oxygen	5/01/2009
Caney Creek	Primary contact recreation	Pathogens	6/01/2007
Clear Creek	Primary contact recreation	Pathogens	9/01/2009
Cooper Creek	Primary contact recreation	Pathogens	6/01/2007
Dota Creek	Primary contact recreation	Pathogens	6/01/2007
Hicks Creek	Drinking water use	Nitrate	12/08/2000
Holman Creek	Drinking water use	Nitrate	12/08/2000
Johnson Hole	Fish Consumption	Mercury -Fish Tissue	9/17/2002
Little Red River	Primary contact recreation	Pathogens	6/01/2007
Little Strawberry River	Primary contact recreation	Pathogens	6/01/2007
Middle Fork Little Red River	Primary contact recreation	Pathogens	6/01/2007
Mill Creek	Primary contact recreation	Pathogens	6/01/2007
Norfork (North Fork River) Tailwaters	Aquatic Life	Dissolved Oxygen	5/01/2009
Osage Creek near Berryville	Aquatic Life	Phosphorus	1/10/2006
Overflow Creek	Primary contact recreation	Pathogens	6/01/2007
Reeds' Creek	Primary contact recreation	Pathogens	6/01/2007
South Fork Little Red River	Fish Consumption	Mercury -Fish Tissue	9/17/2002
	Primary contact recreation	Pathogens	6/01/2007

Table 5.3. TMDLs for waterbodies in the NAWRPR (continued).

Waterbody	Impaired Uses	Pollutants	Status
Strawberry River	Aquatic Life	Turbidity	1/05/2006
	Primary contact recreation	Pathogens	6/01/2007
Ten Mile Creek	Aquatic Life	Turbidity	12/22/2005
	Primary contact recreation	Pathogens	6/01/2007
Town Branch	Fisheries	Total Phosphorus	Closed June 24, 2013
	Drinking water use	Nitrate	12/08/2000
West Fork White River	Aquatic Life	Turbidity	1/05/2006
White River	Aquatic Life	Turbidity	1/05/2006
Illinois River	Aquatic Life	Nutrients	On-going

5.3.3 Nutrient Surplus Areas

The 1990 AWP identified excess nutrients as a water quality issue in the upper White River basin (ASWCC 1987). During the 1990s, both point sources and manure from poultry and livestock were identified as nutrient sources in the area. A number of programs have since been implemented to reduce the impacts of these nutrient sources on water quality.

Nutrients issues in the Illinois River have become controversial because it is an interstate waterbody. The headwaters of the Illinois River are in Northwest Arkansas. From Arkansas, the river flows into Oklahoma and eventually forms Lake Tenkiller. Downstream of the lake, the river flows south and joins the Arkansas River.

The State of Oklahoma has designated the Illinois River as a scenic river, and phosphorus limits have been set at 0.037 mg/L. A U.S. Supreme Court ruling has stated that the downstream state's requirements be met at the state line. This requirement challenges the WWTP point source dischargers in the watershed in Arkansas. Many of these WWTPs dramatically reduced total phosphorus levels in their discharge between 2003 and 2010 in an effort to reduce phosphorus concentrations in the Illinois River to meet the Oklahoma standard at the state line. There are many factors contributing to phosphorus to the Illinois River including urban runoff, wild animals, fertilizer applications, poultry and cattle operations, and WWTPs. Recent agreements between the two states have led to a water quality pact that will allow Arkansas

10 years to study and implement programs in order to try to meet Oklahoma's phosphorus standards (Davis and Moritz 2013). In early 2013, the attorneys general of Arkansas and Oklahoma agreed to conduct a stressor response study of the Illinois River and other scenic rivers to determine what phosphorus levels keep algae to a minimum in these streams (Second Statement of Joint Principles 2013).

The controversy over phosphorus in the Illinois River prompted further actions to reduce nutrients in Northwest Arkansas streams, including declaring eight watersheds in Arkansas Nutrient Surplus Areas. The Illinois River, Spavinaw Creek, Little Sugar Creek, and the Upper White River (Washington, Benton, Madison, Carroll, Boone, Marion, and Baxter Counties) in the planning region have been designated as nutrient surplus areas (Figure 5.6) (Winthrop Rockefeller Foundation 2008). This designation requires that nutrient management practices be used in these areas to help to reduce nitrogen and phosphorus levels in the surface and ground water. Nutrient management training and planning is also required.

Long term monitoring of phosphorus concentrations in the Illinois River watershed shows that phosphorus loads to the Illinois River are declining (Haggard 2010). Wastewater treatment upgrades and implementation of nutrient management practices are having an effect (Haggard and Scott 2013).

5.3.4 Non-attainment of Drinking Water Quality Standards and Water Quality Guidelines by Groundwater

Most aquifers in the planning region are considered to have good to very good water quality. However, areas of poor water quality have been identified. In some areas, poor groundwater quality is a natural phenomenon. In other areas, human activities have caused contamination of the groundwater. In Arkansas, groundwater quality issues primarily occur in shallow aquifers (ADEQ 2008). For the most part, groundwater quality issues have not changed significantly since the 1990 AWP update (ADEQ 2008, Bryant, Ludwig and Morris 1985).

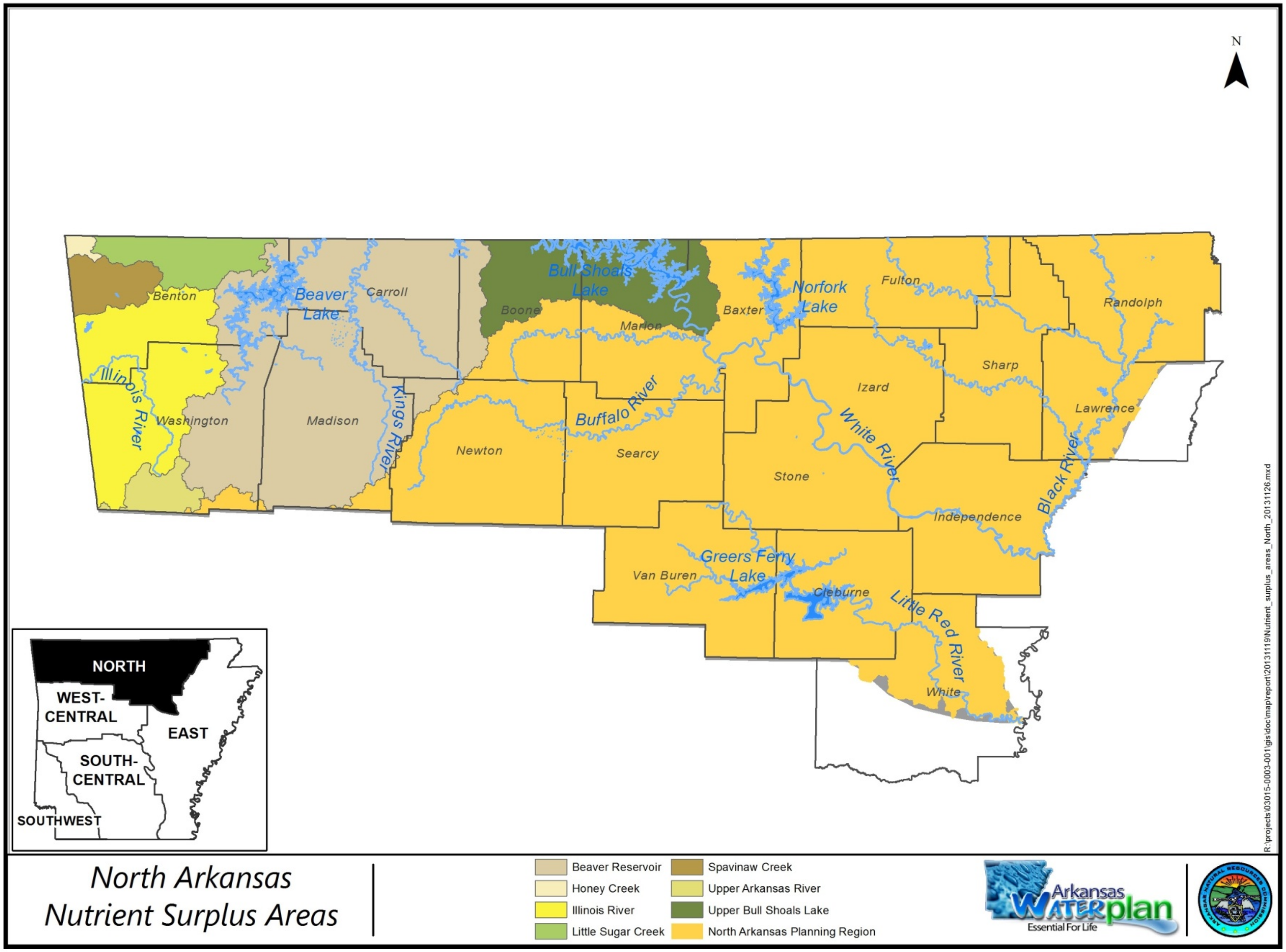

Figure 5.6. Nutrient Surplus Areas in the NAWRPR.

5.3.4.1 Springfield Plateau aquifer

Groundwater in the Springfield Plateau is generally of good quality, and the water can typically be used without treatment. The dominant water type is calcium-bicarbonate (Lamonds 1972). Published values of pH range from 6.0 to 9.1 su with a median of 7.2 su, and dissolved solids range from 58 to 515 milligrams per liter (mg/L), with a median of 193 mg/L. Analysis of pH and dissolved solids indicate that the aquifer is well buffered, which is typical of limestone aquifers (Kresse, et al. 2013). Studies have shown iron to frequently exceed Federal drinking water limits (Lamonds 1972, Steele 1981). It is postulated that mobilization of iron from the overlying regolith that contains abundant iron oxyhydroxide minerals is a likely source for the observed iron concentrations. In general, however, iron concentrations are low throughout the Springfield Plateau aquifer (Kresse, et al. 2013). Additionally, the Springfield plateau aquifer has naturally high water hardness related to the amount of carbonate minerals dissolved in the water resulting from water-rock interaction. Water hardness can present problems related to scaling of plumbing fixtures, which has been documented throughout the region (Imes and Emmett 1994, Adamski 2000).

Steep topography and poor soils result in agricultural operations (beef, swine, and poultry) as the dominant land use in Northern Arkansas. Nationally, Arkansas is ranked second in poultry production, with the top three counties for agricultural sales located in northwest Arkansas, and pollutants associated with agricultural activities are common contaminants found in the aquifer. A source of human derived contaminants is septic systems, which are the primary means of domestic waste disposal in rural and many suburban areas in the planning region. The Ozarks are characterized by thin, poorly developed soils that make installation of properly functioning septic systems difficult. Documented contaminants associated with septic systems and agricultural activities include nutrients (especially nitrate), fecal bacteria, and pesticides (Kresse, et al. 2013; Smith and Steele 1990; Steele and McCalister 1985; Davis, Brahana and Johnston 2000; Knierem, Pennington and Steele 2009).

Sediment problems are frequently found in karst environments associated with urban land-use as a result of denuding the landscape. In addition to facilitating bacterial transport, increased sediment loads can have adverse impacts on karst habitats and processes. In northwest

Arkansas, (Gillip 2007) observed large volumes of sediment move through caves near urban centers, where individual storm events deposited up to 3 feet of sediment adversely impacting cave ecosystem. Hays and others (1998) attributed fish kills at trout farms in Bella Vista, Rogers, and Springdale to increased sedimentation and resulting water quality degradation of springs (Kresse, et al. 2013).

5.3.4.2 Ozark aquifer

In general, water quality data for the Ozark aquifer in northern Arkansas are not as prevalent as data for the Springfield Plateau aquifer. The carbonate rocks of the Ozark aquifer yield a hard to very hard calcium-magnesium-bicarbonate water type. Published values of pH range from 4.8 to 8.7 su with a median of 7.3 su, and dissolved solids range from 52 to 1,735 mg/L, with a median of 285 mg/L. Analysis of pH and dissolved solids indicate that the aquifer is well buffered, which is typical of carbonate aquifers (Kresse, et al. 2013).

Like the Springfield Plateau, agricultural (beef, swine, and poultry) operations occur throughout the area. Although elevated nitrate concentrations have increased with increasing agricultural land use, similar to that for groundwater in the Springfield Plateau aquifer, mean and median nitrate concentrations are much lower in the Ozark Aquifer, and the Ozark aquifer appears to be less vulnerable to nitrate contamination. No definitive attributes have been identified to explain the higher affinity of the Springfield Plateau to nitrate contamination. It is postulated that the upper Ozark aquifer may have physical characteristics, such as lower permeability soils and regolith owing to lower chert abundance, thicker regolith, less fractures and bedding planes, which create a lower susceptibility to surface derived contaminants (Kresse, et al. 2013). Elevated nitrate concentrations found in the lower Ozark aquifer are anomalous owing to its depth, longer flow paths, and confinement. Elevated nitrate concentrations in the lower Ozark aquifer have been ascribed to the sensitivity of the karst landscape in the upper Ozark aquifer to surface derived contamination and the lack of adequate well design (Kresse, et al. 2013).

The Arkansas Department of Health has observed radium levels above the Federal maximum contaminant level of 5 picocuries per liter in public water supply systems. Currently, elevated radium levels in the lower Ozark aquifer are considered naturally occurring and are attributed to the Paleozoic shales (Kresse, et al. 2013). In addition to radium, naturally occurring iron occasionally exceeds Federal drinking water standards (0.300 mg/L), but other naturally occurring inorganic constituents are generally low throughout the lower and upper aquifer.

5.3.4.3 Western Interior Plains Confining Unit

Due to the limited groundwater resources of the area, there is little groundwater quality data available for the WIP Confining Unit. Of the few groundwater quality studies published, most focus on the WIP Confining Unit in the northern portion of the Arkansas River Valley. Recent groundwater studies by Kresse and others (2012) that were conducted to evaluate impacts of the Fayetteville Shale gas play to water quality in central Arkansas provide the most comprehensive evaluation of the WIP aquifers. These studies coincided with the portion of the Arkansas River Valley in the NAWRPR.

In general, groundwater in the undifferentiated aquifers of the WIP is of good quality. Groundwater from the undifferentiated aquifers of the WIP system is typically a strongly calcium-bicarbonate to sodium bicarbonate water type. Groundwater with elevated iron, sulfate, and chloride may be encountered in localized areas, and occasionally exceed Federal secondary drinking water standards (Kresse, et al. 2012). Constituent concentrations were attributed to the rock type, groundwater residence times (degree of water rock interaction), and microbially mediated processes.

Compared to the Springfield Plateau and Ozark aquifers, nitrate concentrations in the WIP aquifers are relatively low; however, elevated nitrate concentrations were associated with shallow sandstone aquifers overlain by sandy soils. In these areas, the soil is more permeable and aquifers are more susceptible to surface-derived contamination (Kresse, et al. 2013). Since the Boston Mountains Plateau is not considered karst terrain, less impact from surface derived contaminates would be expected due to diffuse recharge allowing for natural attenuation to occur to a greater extent in the unsaturated zone.

Hydraulic fracturing in the Fayetteville Shale has raised concerns about the potential for groundwater quality impacts. A recent study by Kresse and others (2012) found groundwater quality in domestic wells in areas of gas development to be consistent with natural process.

5.3.5 Fish Consumption Advisories

There is one active fish consumption advisory for mercury in the NAWRPR. Details of this advisory are given in Table 5.4. The location of this waterbody is shown on Figure 5.6.

Table 5.4. Fish Consumption Advisories in the NAWRPR (ADH, AGFC, ADEQ 2011; ADEQ 2012c)

Waterbody	Miles Affected	Pollutant of Concern	Restrictions for high risk groups[1]	Restrictions for general public
Johnson Hole - South Fork Little Red River	2	Mercury	Should not eat largemouth bass (16 inches or longer) from this area	Should not eat largemouth bass (16 inches or longer) from this area

[1] Pregnant or breastfeeding women, women who plan to become pregnant, and children under 7 years of age

5.3.6 Nonpoint Source Pollution

Nonpoint source pollution (NPS) was identified as a water resources issue in the 1990 AWP (ASWCC 1990). NPS still contributes significantly to surface water and groundwater quality issues in the NAWRPR. As discussed in Sections 2 and 3, in this planning region, urbanization and poultry production are two sources of nonpoint source pollution. However, hazardous waste sites and resource extraction activities in the planning region also contribute nonpoint source pollution.

5.3.6.1 Nonpoint Source Priority Watersheds

In the 2011 – 2016 NPS Pollution Management Plan, three watersheds within the NAWRPR have been identified as priority watersheds for nonpoint source pollution issues; Beaver Lake, Illinois River, and Strawberry River (Figure 5.8). This program primarily addresses nutrients and sediment in runoff. The targeted sources of nonpoint source pollutants in these watersheds are summarized in Table 5.5 (ANRC 2011b).

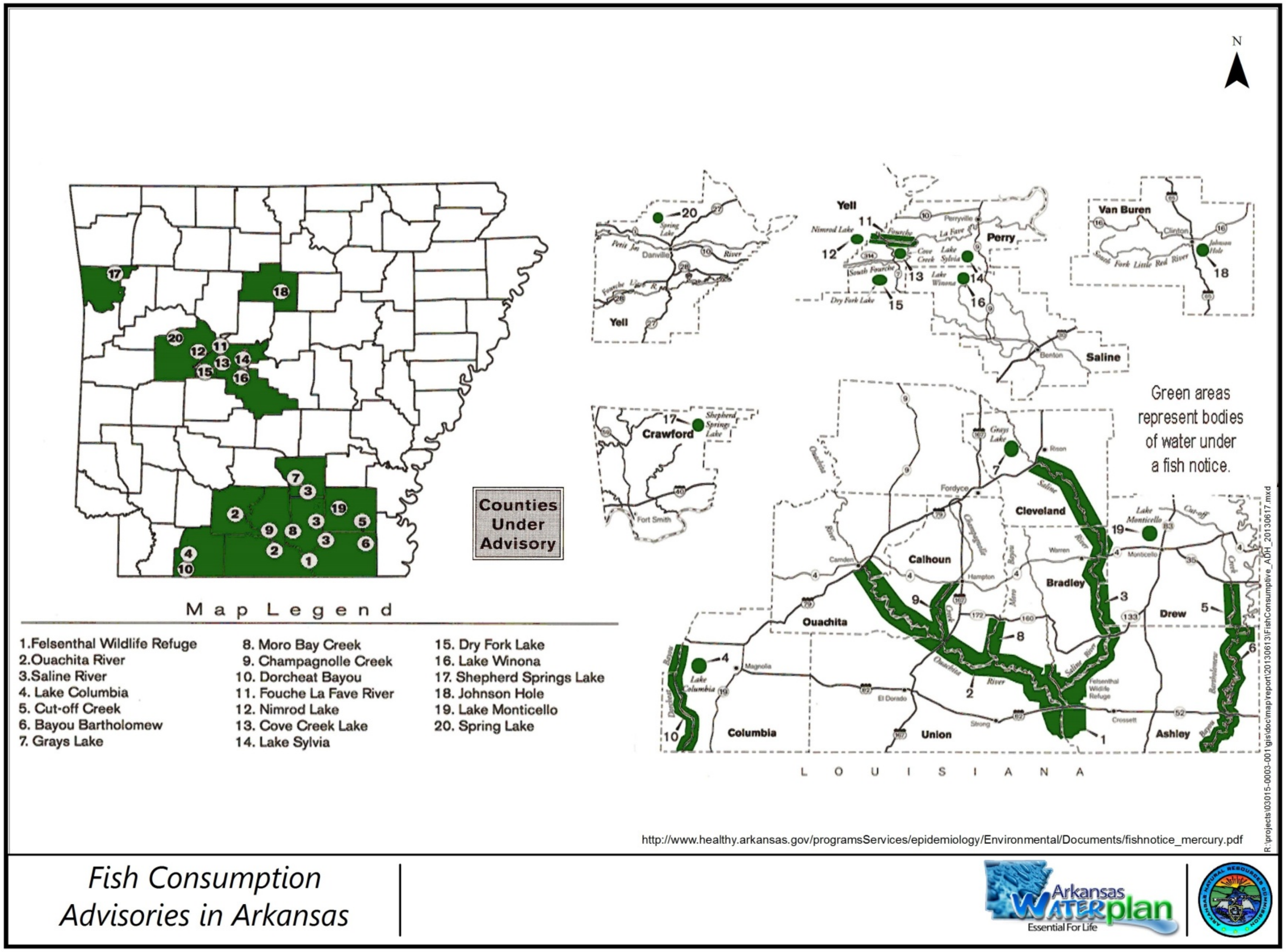

Figure 5.7. Waterbody in the NAWRPR for which fish consumption advisories have been issued (ADH, AGFC, ADEQ 2011)

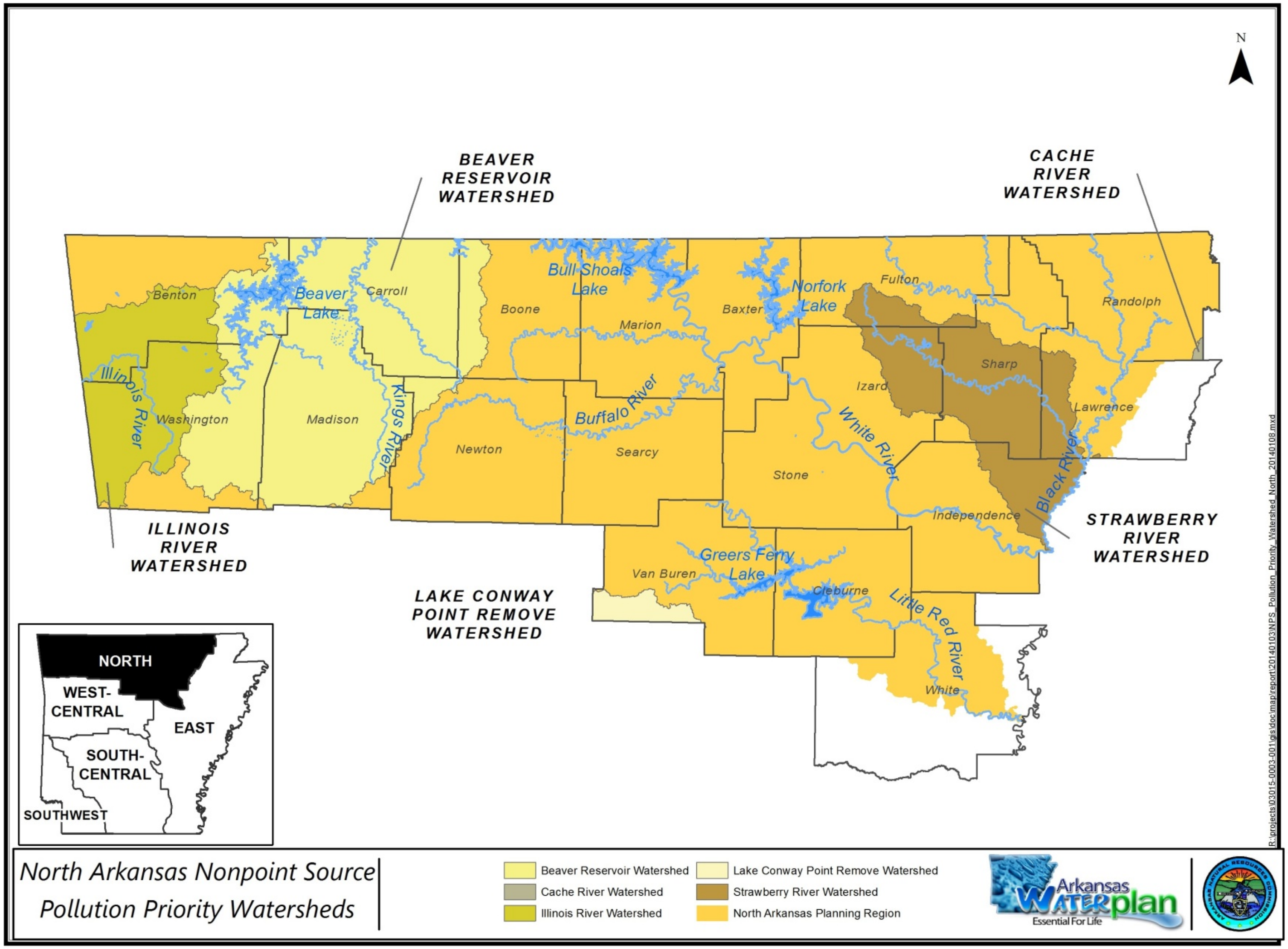

Figure 5.8. Nonpoint source pollution priority watersheds in the NAWRPR (ANRC 2011b).

Table 5.5. Targeted pollutants and sources in ANRC priority NPS watersheds (ANRC 2011b).

Watershed	Pollutant	Source
Beaver Lake	TSS, siltation/turbidity, nutrients, DO	Animal agriculture, urban areas, streambanks
Illinois River	Siltation/turbidity, nutrients, pathogens	Animal agriculture, urban areas, streambanks, surface mining
Strawberry River	Siltation/turbidity, nutrients	Unpaved roads, animal agriculture,

5.3.6.2 Hazardous Waste Remedial Action Priority Sites

There is one site in the NAWRPR identified as federal priority for hazardous waste cleanup (i.e., Superfund sites) due to contamination of water resources. The site, Arkwood, Inc., has been on the National Priority List (NPL) since 1989. Some phases of remediation have been completed, but others are still ongoing (EPA 2013b).

Three hazardous waste remediation sites in the NAWRPR are currently on the state priority list (SPL), and one has been removed from the SPL. All of these sites have had, or have, groundwater contamination issues. Surface water contamination has been an issue at four of these sites. Table 5.6 summarizes the information about these sites.

Table 5.6. Status of Superfund sites in the NAWRPR with water quality issues.

Site name	EPA ID	Site Location	Pollutants of concern	Contaminated water resources	Remediation complete	List
Arkwood, Inc.	ARD084930148	Boone County	Pentachlorophenol (PCP), creosote	New Cricket Spring; groundwater	Ongoing	NPL
Baldwin Piano & Organ	ARD006337620	Fayetteville (Washington Co)	Chlorinated, non-chlorinated organic compounds	Fawn Creek; groundwater	Ongoing	SPL
Fulton Class 3C Landfill	N/A	Rogers (Benton County)	Iron, manganese, other organic/inorganics	Springs near Beaver Lake; groundwater	Ongoing	SPL
R& P Electroplating	ARD051961829	Fayetteville (Washington County)	Various hazardous substances	West Fork White River; groundwater	Aug. 2010	SPL
Swift Chemical Co. Farm Site	ARR000011122	Rogers (Benton County)	Trichloroethene (TCE)	Groundwater	Aug. 2012	Removed from SPL

5.3.6.3 Resource Extraction

There is concern that natural gas extraction from the Fayetteville Shale Play could affect groundwater quality. However, a study conducted in 2011 did not find evidence of groundwater contamination associated with natural gas extraction in north-central Arkansas (Warner, et al. 2013, EPA 2013c).

Gravel mining occurs on several streams in the NAWRPR. Gravel mining has been found to affect stream habitat. It can be a direct cause of stream bank erosion, which can lead to both water quality and ecological problems. One study on the Illinois River, Kings River, and Crooked Creek found that biomass and density of invertebrates decreased as a result of mining. Distribution of biota was also affected (Brown, Lyttle and Brown 1998). Commercial gravel mining operations are no longer permitted along the Kings River, but are permitted to operate in its tributaries (Kings River Watershed Partnership 2009). Gravel mining had been allowed in Crooked Creek, but future permits were denied and current in-stream permits suspended in 2007 due to the placement of the entire assessed length of Crooked Creek on the 303(d) list (USGS 2010).

5.3.6.4 Buffalo National River

Concern has arisen in recent years over water quality of the Buffalo National River, particularly the potential for nonpoint source pollution from animal operations in the watershed. In 1992, there were 39 confined animal operations in the watershed. The Buffalo River Swine Waste Demonstration Project was started in 1995 by ADEQ in order to look into any issues in the watershed associated with swine production, and establish best management practices (BMPs) at several sites. A project to improve manure management on dairy farms in the Buffalo River watershed was initiated in 1997. In 1994 there were 27 dairy facilities operating in the watershed (EPA 2012d). In 2013, nine commercial animal farms were operating in the watershed, one of which was large enough to be classified as a Confined Animal Feeding Operation under the Clean Water Act. The siting of the first Confined Animal Feeding Operation in the state in the watershed of the Buffalo National River has become controversial.

5.3.1 Contaminants of Emerging Concern

There is growing interest, nationally and in Arkansas, in the occurrence of a group of chemicals called contaminants of emerging concern, which include pharmaceuticals, personal care products (e.g., soap and shampoo), natural and synthetic hormones, surfactants, pesticides, fire retardants, and plasticizers primarily in surface waters, but also starting to be measured in groundwater across the nation. The risks to human health and the environment from the majority of these chemicals are unknown, which is why they are referred to as “contaminants of emerging concern.” Contaminants of emerging concern have been detected in surface waters in the NAWRPR (Galloway, et al. 2005). Detection, however, does not indicate there is an effect.

5.4 Loss of Aquatic Biodiversity

In a 2002 report, NatureServe ranked Arkansas 13th in the nation for the level of reportedly extinct species (NatureServe 2002). In 2005, 369 animal species of greatest conservation need were identified for Arkansas by a team of specialists. These species of greatest conservation need include 144 species associated with aquatic and semi-aquatic habitats that occur in the NAWRPR (Anderson 2006, ANHC 2013). This is more than any other region of the state. Figures 5.9 through 5.12 show the number of aquatic species of greatest conservation need that are present in watersheds within the NAWRPR. The greater the number of aquatic species of greatest conservation need present in a watershed, the more important it is to protect and restore water resources and their aquatic habitats in the watershed. Critical characteristics of aquatic habitats include water levels and flow volumes, and the seasonal variation in them. The majority of the watersheds in the NAWRPR have high numbers of species of greatest conservation need. The Spring River has the highest number of species of greatest conservation need in the planning region (Figure 5.12).

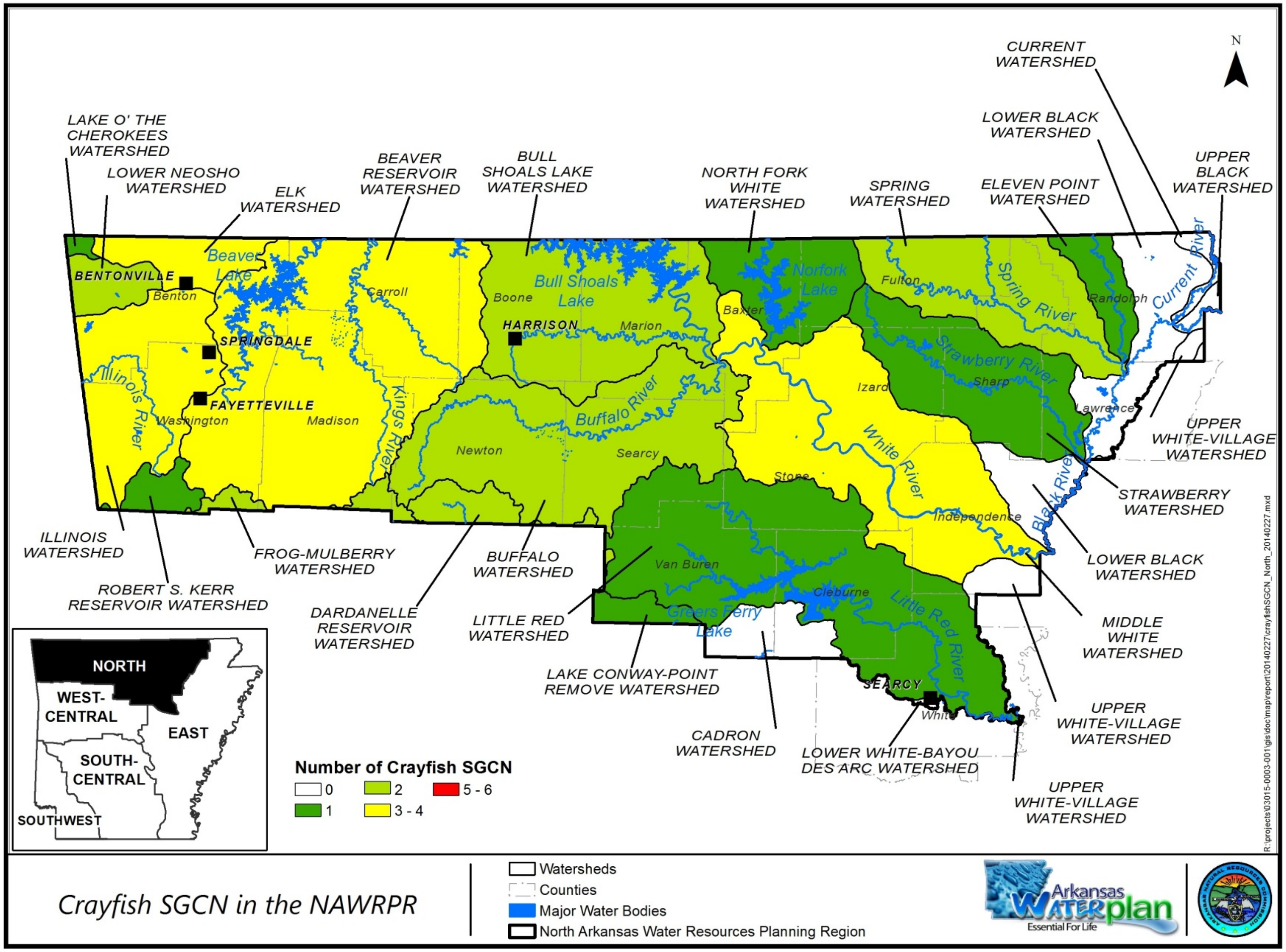

Figure 5.9. Numbers of crayfish Species of Greatest Conservation Need (SGCN) in watersheds of the NAWRPR.

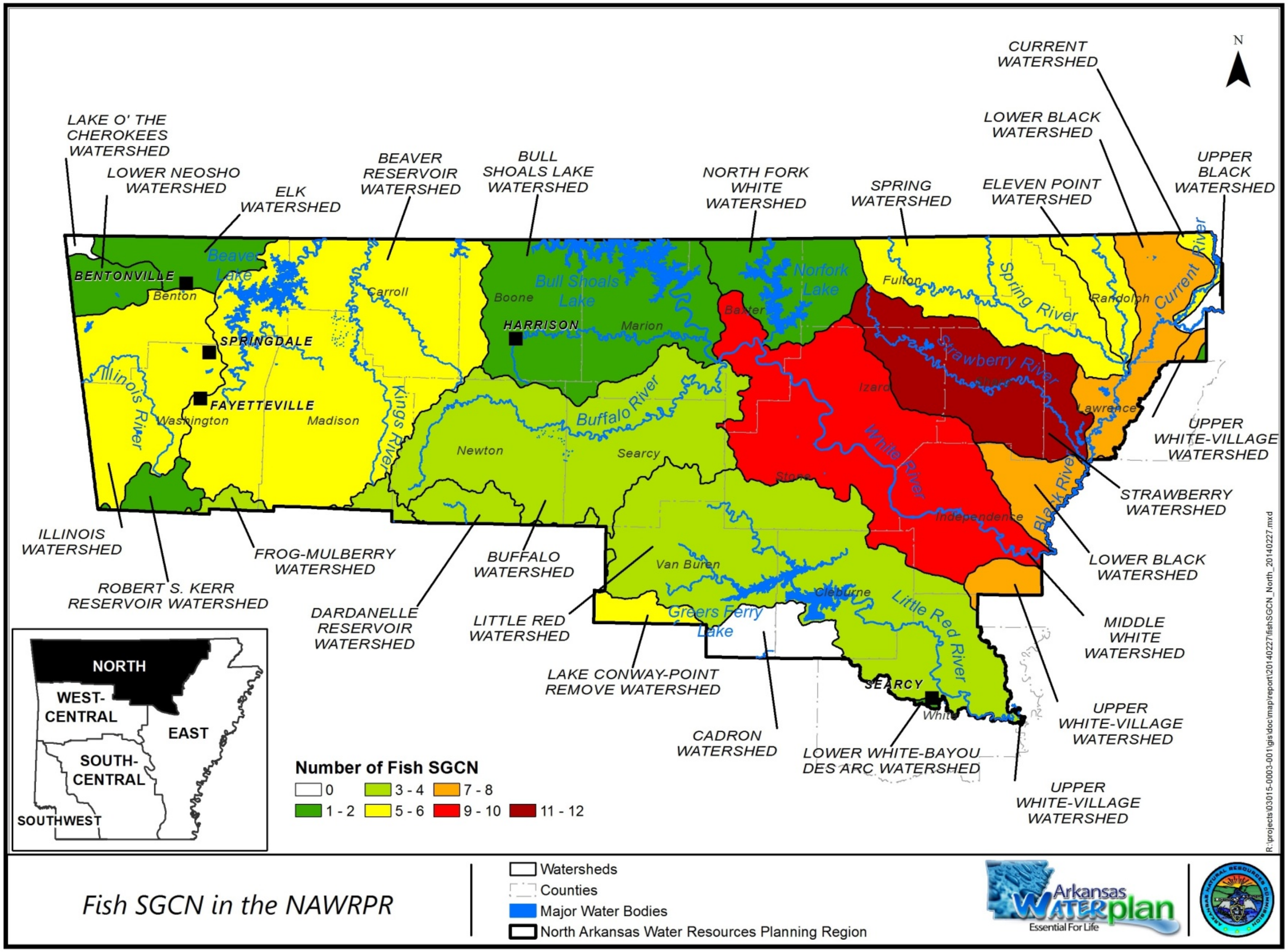

Figure 5.10. Numbers of fish SGCN in watersheds of the NAWRPR.

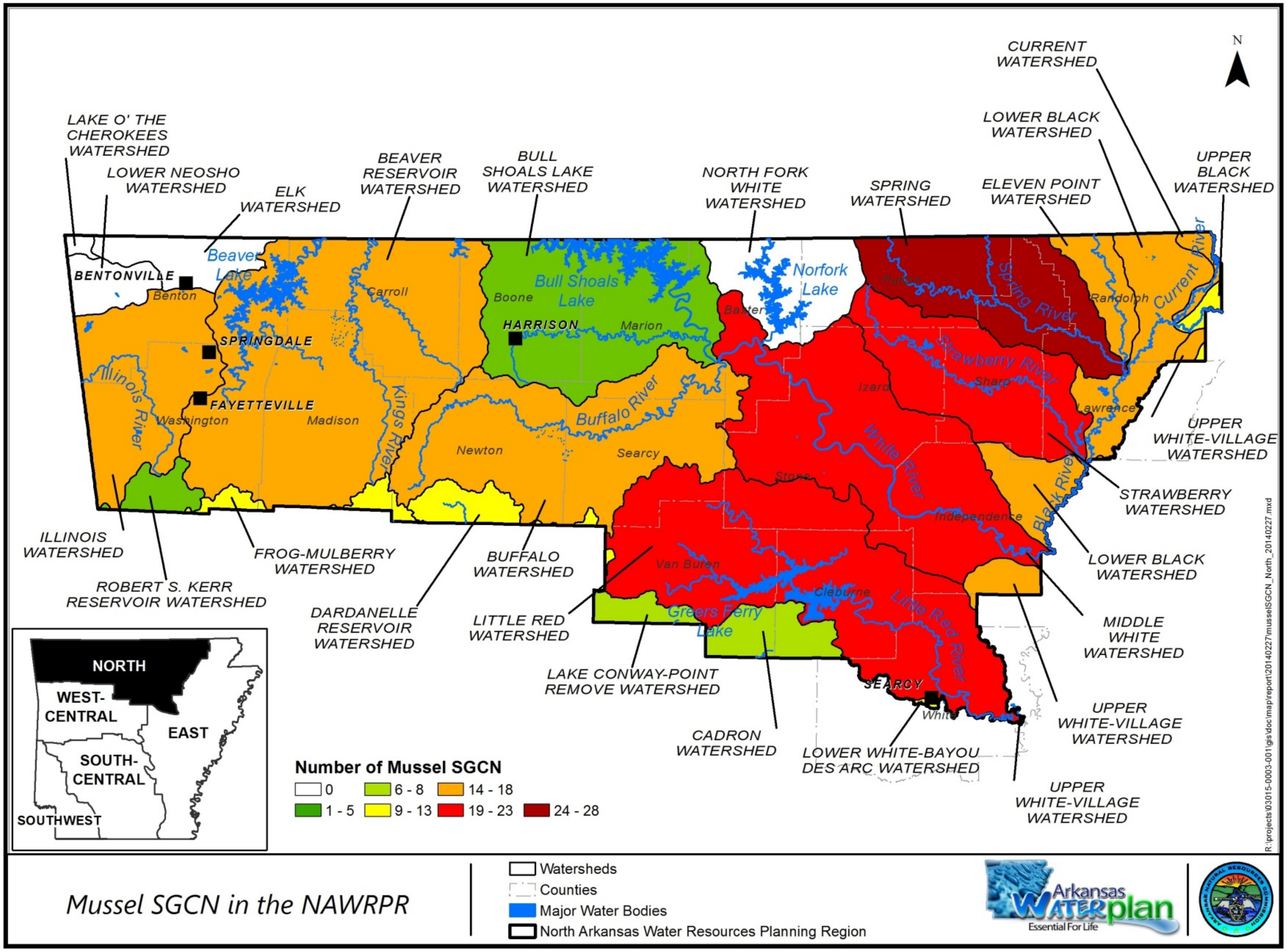

Figure 5.11. Numbers of mussel SGCN in the watersheds of the SCAWRPR.

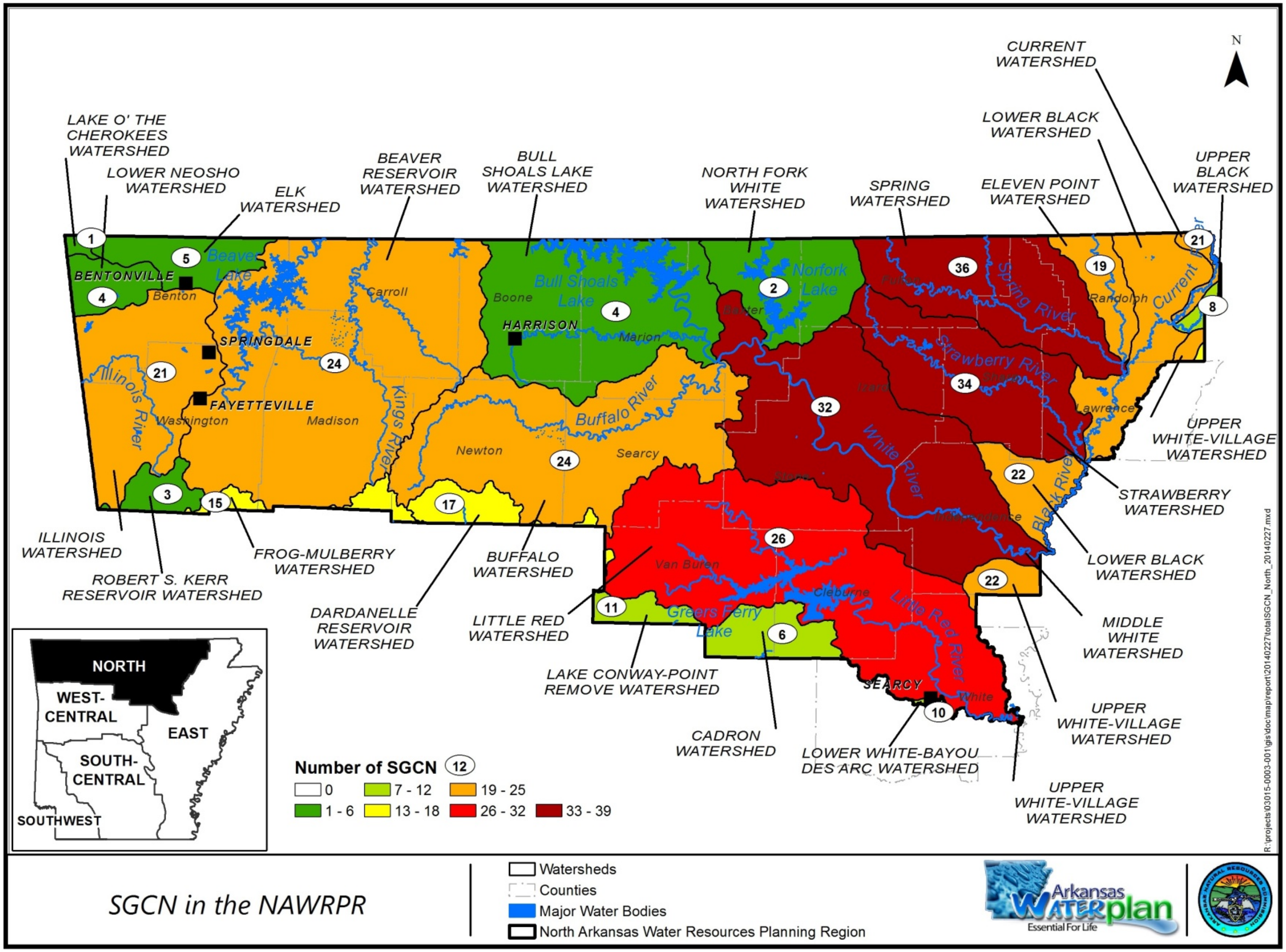

Figure 5.12. Total numbers of crayfish, fish, and mussel SGCN in the watersheds of the SCAWRPR.

In addition to these animal species of greatest conservation need, the Arkansas Natural Heritage Commission has identified 73 species of rare aquatic and semi-aquatic plants that are present in the NAWRPR. Fourteen of the aquatic and semi-aquatic species present in the planning region are on the federal list of threatened and endangered species (Table 5.7). Eleven semi-aquatic plant species present in the planning region are on the state threatened and endangered plant species list (Table 5.8). Many of the species of concern are affected by water quality, water levels, flow rates, and/or seasonal changes in water levels or flow

Table 5.7. Federally-listed threatened and endangered species occurring in aquatic and semi-aquatic habitats in the NAWRPR (ANHC 2013, AGFC 2011b, USFWS n.d., Anderson 2006)

Common Name	Species Name	Status	NAWRPR habitat
Arkansas Darter	Etheostoma cragini	Candidate Species	Neosho River drainage area of NWA
Curtis Pearlymussel	Epioblasma florentina curtisi	Endangered	Spring River at Hardy, Salem, and near confluence of Black River
Missouri bladderpod	Physaria filiformis	Endangered	Izard and Washington Counties
Neosho Mucket	Lampsilis rafinesqueana	Proposed Endangered/Proposed Critical Habitat	Illinois River
Ozark Cavefish	Amblyopsis rosae	Threatened	Ozark Mountain caves in Northwest AR
Pink Mucket	Lampsilis abrupta	Endangered	Spring and White Rivers
Pondberry	Lindera melissifolia	Endangered	Lawrence County
Rabbitsfoot	Quadrula cylindrica	Proposed Endangered/Proposed Critical Habitat	Newton, Searcy, Sharp, Van Buren, Washington, and White Counties
Running buffalo clover	Trifolium stoloniferum	Endangered	Independence County
Scaleshell	Leptodea leptodon	Endangered	Some streams in Fulton and Lawrence Counties
Snuffbox	Epioblasma triquetra	Endangered	Some streams in Baxter, Independence, Izard, Lawrence, Marion, Randolph, and Sharp Counties
Speckled Pocketbook	Lampsilis streckeri	Endangered	Middle Fork of Little Red River (six miles)
Turgid Blossom	Epioblasma turgidula	Endangered	Spring Creek, Black River, White River

Table 5.7. Federally-listed threatened and endangered species occurring in aquatic and semi-aquatic habitats in the NAWRPR (continued).

Common Name	Species Name	Status	NAWRPR habitat
Yellowcheek Darter	Etheostoma moorei	Endangered	Devils, Middle, South, and Archey forks of Little Red River

*This list is not finalized and will be updated in the future.

Table 5.8. State threatened and endangered species occurring in aquatic and semi-aquatic habitats in the NAWRPR counties (ANHC 2013).

Common Name	Species Name	Status
Sedge	Carex opaca	Endangered
Showy lady's-slipper	Cypripedium reginae	Endangered
Spinulose wood fern	Dryopteris carthusiana	Threatened
Small-headed pipewort	Eriocaulon koernikianum	Endangered
Winterberry	Ilex verticillata	Threatened
Pondberry	Lindera melissifolia	Endangered
Heart-leaf plantain	Plantago cordata	Threatened
Southern tubercled orchid	Platanthera flava	Threatened
Purple fringeless orchid	Platanthera peramoena	Threatened
Rose pogonia	Pogonia ophioglossoides	Threatened
Silky willow	Salix sericea	Endangered

In some cases, the presence of non-native aquatic species is believed to affect aquatic biodiversity. There are 35 non-native aquatic animal species known to occur in the NAWRPR (Table 5.9). The majority of the non-native fish species present in the region are sportfish species that have been introduced purposely and are regularly stocked. The impact of many of these species on native species is unknown. Some species, such as carp, are suspected to affect native species as a result of modifying aquatic habitats, e.g., removing vegetative cover and increasing turbidity. Other species, such as non-native sportfish and exotic clams, are suspected to affect native species by competing with them for food and/or habitat (USGS 2013b).

Table 5.9. Non-native aquatic species in the NAWRPR (USGS 2013b).

Species Common Name	Species Scientific Name	Origin	Location	Dates Identified	Method of Introduction	Impact
Freshwater jellyfish	Craspedacusta sowerbyi	China	Beaver Lake, Bull Shoals Lake, Greers Ferry Reservoir, Lake Norfork, rock quarry, White River	1999	Accidental	Preys on native species
Rock Bass	Ambloplites rupestris	Great Lakes, Atlantic, Missouri	Crooked Creek, Norfork Lake, White River, Illinois drainage, Little Sugar Creek, Spavinaw Creek, Elk River, Greers Ferry Lake, White River, Kigns River, War Eagle Creek, North Sylamore Creek, Buffalo River, Current River	1888, 1955, 1959, 1960, 1962, 1963, 1965, 1966, 1968, 1969, 1970, 1971, 1972, 1982, 1997	Stocked	Competition, hybridization with natives
White Catfish	Ameiurus catus	Atlantic and Gulf	Illinois Drainage	1988	Stocked	--
Goldfish	Carassius auratus	Eastern Asia	Bull Shoals Lake, Beaver Reservoir, Flint Creek, Kings River, Greers Ferry Reservoir, Black River, White River, Spring River, Illinois River, Richland Creek	1988	Accidental	--
Unidentified pacu	Colossoma or Piaractus sp.	Tropical America	Beaver Reservoir, White River	1992, 2006	Accidental	Unknown
Asian clam	Corbicula fluminea	Southern Asia, eastern Mediterranean, Africa	Beaver Lake, Little Red River, Greers Ferry Reservoir, Spring River, Strawberry River	1975, 1978, 1979, 1985	Accidental	Biofouling, diet modification
Grass Carp	Ctenopharyngodon idella	Eastern Asia	Norfork Lake, Illinois drainage, lower Neosho drainage, Little Sugar Creek, Beaver Reservoir, Bull Shoals Lake, Piney Creek, Lake Wedington	1988, 1995, 2004	Stocked	Habitat modification
Common Carp	Cyprinus carpio	Eurasia	Throughout the region	1963, 1965, 1985, 1988, 1991, 1992, 1995, 1998	Stocked	Habitat modification
Waterflea	Daphnia lumholtzi	East Africa, Australia, India	Beaver Lake	1995	Accidental	Unknown
Threadfin Shad	Dorosoma petenense	Ohio River, Mississippi River Basin, Atlantic Slope	Beaver Lake, Flint Creek, White River, Black River	1980, 1988	Stocked	Habitat modification
Zebra mussel	Dreissena polymorpha	Black, Caspian, Azov Seas	White River (Bull Shoals Lake)	2007	Accidental	Biofouling

Table 5.9. Non-native aquatic species in the NAWRPR (continued).

Species Common Name	Species Scientific Name	Origin	Location	Dates Identified	Method of Introduction	Impact
Northern Pike	Esox lucius	Atlantic, Arctic, Pacific, Great Lakes, Mississippi River basins	Norfork Lake, Beaver Reservoir, Big Creek, Illinois drainage	1976, 1988	Stocked	Competition, hybridization with natives
tiger muskellunge	Esox lucius x E. masquinongy	Great Lakes Region	Spring River	1992	Stocked	Competition, hybridization with natives
Muskellunge	Esox masquinongy	St. Lawrence River - Great Lakes	Norfork Lake, Bull Shoals Lake	1988	Stocked	Competition, habitat modification
Blue Catfish	Ictalurus furcatus	Mississippi River basin, Gulf Slope	Throughout region, especially Benton County	1988, 1997	Stocked	Hybridication with natives
Redbreast Sunfish	Lepomis auritus	Atlantic, Gulf Slope drainages	Devils Fork Little Red River, Spring River, Sylamore Creek, Upper White drainage	1962, 1964, 1966, 1980, 2002	Stocked	Competition with native species
Green Sunfish	Lepomis cyanellus	Great Lakes, Hudson Bay, Mississippi River	White River	2007	Accidental	Decline of native species
Redeye Bass	Micropterus coosae	Savannah, Chattahoochee, Mobile Bay basins	Spring River downstream from Mammoth Spring	1988	Stocked	Decline of native species
Wiper	Morone chrysops x M. saxatilis	None - artificial hybrid	Norfork Lake, Beaver Lake, Greers Ferry Reservoir, Little Red River	1981, 1988, 1992	Stocked	Hybridication with natives
Striped Bass	Morone saxatilis	Atlantic drainages	Norfork Lake, Beaver Lake, Bull Shoals, English Creek, White River	1967, 1968, 1969, 1975, 1976, 1980, 1984, 1988, 1992, 1997	Stocked	Preys on native species
Nutria	Myocastor coypus	South America	Little Red, Lower Black drainages	1978	Imported	Habitat modification
Ozark Shiner	Notropis ozarcanus	White and Black River systems	Osage Creek	1979	Unknown	Unknown
Cutthroat Trout	Oncorhynchus clarkii	Pacific Coast	North Fork, Beaver Lake, White River	1988, 1992, 1997	Stocked	Hybridication with natives
Rainbow Trout	Oncorhynchus mykiss	Pacific Slope	Throughout the region	1950, 1976, 1988, 1992, 1997, 2007	Stocked	Hybridication with natives
Gap ringed crayfish	Orconectes neglectus chaenodactylus	--	Spring River	1998, 2003, 2005, 2006	--	--

Table 5.9. Non-native aquatic species in the NAWRPR (continued).

Species Common Name	Species Scientific Name	Origin	Location	Dates Identified	Method of Introduction	Impact
Yellow Perch	Perca flavescens	Atlantic, Arctic, Great Lakes, Mississippi River basins	Black River, Bull Shoals Lake	1905, 1999	Stocked	Competition with native species
pirapatinga, red-bellied pacu	Piaractus brachypomus	Tropical America	Pond at Fairview Memorial Gardens, Fayetteville	1995	Aquarium releases	Unknown
Fathead Minnow	Pimephales promelas	North America	Greers Ferry Reservoir, South Fork Spring River, Spring River, Strawberry River	1950, 1988	Introduced as bait fish	Unknown
Brown Trout	Salmo trutta	Europe, Northern Africa	Bull Shoals, North Fork, Beaver Lake, Little Red River, White River, Spring River	1988, 1992, 1997	Stocked	Decline of native species
tiger trout	Salmo x Salvelinus trutta x fontinalis	None - artificial hybrid	Little Red River	2005	Stocked	Unknown
Brook Trout	Salvelinus fontinalis	Canada	North Fork River, White River	1988, 1992, 1997	Stocked	Decline of native species
Lake Trout	Salvelinus namaycush	Canada	Beaver Lake, Greers Ferry Reservoir, Little Red River	1986, 1988, 1997	Stocked	Decline of native species
Sauger	Sander canadensis	St. Lawrence River - Great Lakes	Greers Ferry Reservoir	1980	Stocked	Competition with native species
Saugeye	Sander canadensis x vitreus	--	Crown Lake	1992	--	Competition with native species
Walleye	Sander vitreus	St. Lawrence River - Great Lakes	Beaver Lake, Greers Ferry Reservoir, Bull Shoals Lake	1976, 1988	Stocked	Decline of native species

There are also 10 species of invasive aquatic plants known to occur in the planning region (Table 5.10) (University of Georgia - Center for Invasive Species and Ecosystem Health 2013). In addition to the species listed in Table 5.9, a nonnative algae has been identified at locations within the NAWRPR. *Didyomsphenia geminata* is a type of algae that attaches to cobble in streams and secretes fibrous stalks that can be swept downstream and accumulate as debris. This type of algae has been found in recent years in the White River below Beaver, Bull Shoals, and Norfork Dams and below the dam at Greers Ferry on the Little Red River (AGFC 2008, 2013c). A study performed by ADEQ found that the growth of this algae and its stalks below Bull Shoals Dam could cause negatively affect growth and reproduction of the trout population. The algae could make conditions unsuitable for fish spawning and could cause dissolved oxygen levels to fall below the necessary levels for maximum trout growth (Shelby 2006).

5.5 Water Infrastructure

Communities throughout the state struggle to maintain drinking water and wastewater infrastructure, including treatment plants and distribution lines. A few communities in the NAWRPR are experiencing growth that is requiring expansion of water supply and wastewater capacity. For example, new drinking water infrastructure was recently completed, providing a new supply of water to north-central Arkansas (Grant 2013, Ozark Mountain Regional Public Water Authority n.d.). In other areas within the planning region, maintaining aging infrastructure with limited financial resources is more likely an issue.

Another concern is the recent increased focus on nutrients in wastewater discharges. Historically, permitted point source discharges in Arkansas were not limited with regard to the amount of nutrients in the wastewater they discharged. Current regulations require that all point source discharges in watersheds of waterbodies included on the Arkansas list of impaired waters due to phosphorus, be limited in the amount of phosphorus that can be present in their discharge (Arkansas Regulations 2.509). Point source discharges located in the designated nutrient surplus watersheds in the NAWRPR are subject to limits for phosphorus in their discharge under this regulation. There have been a number of expensive changes made to the wastewater treatment

Table 5.10. Invasive aquatic plants of the NAWRPR (University of Georgia-Center for Invasive Species and Ecosystem Health 2013).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
Common water hyacinth	*Eichhornia crassipes*	South America	Washington	1988	Accidental	Habitat modification
Yellow iris	*Iris pseudacorus L.*	Asia, Africa, Europe	Washington	1988	Accidental	--
Purple loosestrife	*Lythrum salicaria*	Europe and Asia	Baxter, Izard, Randolph	2010	Introduced	Displacement of native species
Parrotfeather	*Myriophyllum aquaticum*	South America	Cleburne, Independence, Fulton, Benton	1988	Introduced	Competition with native species
Brittleleaf naiad	*Najas minor*	Europe	Baxter	1979	--	--
Watercress	*Nasturtium officinale*	Europe, Asia, Africa	All but Searcy, Van Buren, Cleburne, White	--	--	--
Yellow floating heart	*Nymphoides peltata*	Europe, Asia	Benton, Washington	1954, 1988, 2010	--	--
Reed canarygrass	*Phalaris arundinacea*	North America	Washington	1988	Accidental	Excludes other vegetation
Curly-leaved pondweed	*Potamogeton crispus*	Africa	Benton	1988	Accidental	--
Narrow-leaved cattail	*Typha angustifolia*	--	Carroll, Baxter	1988	--	--

infrastructure in these watersheds to reduce nutrient discharges and meet these limits. There are also a number of wastewater treatment plants in other areas of the NAWRPR that have current discharge permits with monitoring requirements for phosphorus and/or nitrate (ADEQ 2013d).

Two dam failures have occurred in recent years in the NAWRPR. In June 2000 a dam in Ponca Creek, a tributary to the Buffalo River, failed. There were no injuries and no structural damage. Washout from the dam washed into the river and national park. A second dam failure occurred in July 2004 in Decatur on a small earthen dam that did not require state regulation (Arkansas Department of Emergency Management 2010).

6.0 INSTITUTIONAL AND REGULATORY SETTING

This section provides a description of the regulatory and institutional framework for water resources management in NAWRPR. It includes general descriptions of federal and state laws, regulations, and programs that deal with water resources management in the region, as well as a listing of federal, state, and local governmental and nonprofit institutions that are involved in water resources management in the region. In addition, the interrelationships between regulations and institutions at the federal, state, and local levels in the NAWRPR are illustrated.

6.1 Legal Framework

The legal framework for management and use of water resources in Arkansas is based on court case law, laws enacted by the Arkansas General Assembly, and rules and regulations enacted by state agencies. Federal laws and regulations also influence the regulation of water resources in the state (ANRC 2011a). The discussion below identifies and summarizes the laws and regulations and associated programs that guide water management in NAWRPR, and summarizes changes that have occurred in this legal framework since the 1990 AWP update.

6.1.1 Federal Laws and Regulatory Programs

Federal policy recognizes that states have primary authority for regulation of water usage within their borders. Therefore, the federal laws, regulations, and associated programs that influence water resources management in the NAWRPR primarily relate to water quality. Federal legislation and programs also deal with other aspects of management of water resources in the region such as conservation and protection of waterbodies, flood control, and navigation.

6.1.1.1 Water Quality

The current federal laws and programs that guide management of water quality in the NAWRPR are summarized in Table 6.1. The Clean Water Act (CWA) of 1972 (most recently amended in 2002) and the Safe Drinking Water Act (SDWA) of 1974 (most recently amended in 1996) are two important pieces of federal water quality legislation that authorize a number of

Table 6.1. Federal laws and regulatory programs that affect NAWRPR water quality. Highlighted laws and programs were promulgated after the 1990 AWP update.

Federal Law	Federal Water Quality Regulatory Programs	Responsible Federal Agency
Clean Water Act	Ambient nutrient water quality standards	EPA
	Biosolids regulations	
	Impaired waters	
	Nonpoint source pollution management	
	NPDES point source permitting	
	NPDES stormwater permitting	
	NPDES pesticide application permitting	
	NPDES confined animal feeding operations permitting	
	State ambient water quality standards	
	State biennial water quality assessment	
	Total maximum daily loads (TMDL)	
	Dredge and fill permitting	USACE
Safe Drinking Water Act	Source water protection	EPA
	Underground injection wells	
Underground storage tank regulations	Underground storage tank program	EPA
Resource Conservation and Recovery Act (RCRA)	Hazardous waste management	EPA
	Solid waste management	
	Subtitle D	
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	Hazardous waste site clean up	EPA
Federal Insecticide, Fungicide, and Rodenticide Act	Endangered species protection program	EPA
	Labeling requirements	
	Registration	
Surface Mining Control and Reclamation Act	Mine reclamation	US Department of the Interior (USDI)
	Surface mining control	
Toxic Substances Control Act	Polychlorinated Biphenyls (PCB) Program	EPA
Soil and Water Resources Conservation Act	Conservation Effects Assessment Program	US Department of Agriculture
Arkansas Wilderness Act	National forests	USFS
National Forest Management Act		
Weeks Act		
Oil Pollution Act	Oil spill response planning	EPA
Pollution Prevention Act	Pollution prevention planning	EPA
National Environmental Policy Act (NEPA)	Environmental impact analysis of Federal projects, with mitigation	EPA, Council on Environmental Quality

federal water quality programs. Legislation related to forest conservation, such as the Cooperative Forestry Assistance Act, is included here because forests can protect and improve water quality. The EPA is responsible for administering the majority of these laws and programs; however, EPA has delegated some of this authority to state agencies such as ADEQ and the Arkansas Department of Health.

The CWA of 1972 established the NPDES that regulates point source discharges through a permit program. The NPDES program is managed by EPA, but ADEQ has been delegated authority to issue NPDES permits. NPDES permits are based on a combination of technology-based and water quality based standards. Technology-based standards are developed by EPA for certain categories based on the performance of pollution control technologies available to the industry without regard for the receiving water body. Water quality based standards are developed after consideration of the designated uses of the receiving water body and the water quality criteria necessary to protect those uses. In 1987, Congress amended the CWA to include nonpoint sources of pollution such as stormwater runoff from industries, construction sites, and municipalities. NPDES permits for the NAWRPR are summarized in Section 4. The 1987 amendments also addressed management of biosolids (sewage sludge). The CWA also requires permits for dredge and fill activities in wetlands, lakes, streams, rivers, and other waters of the US. These permits are issued by the USACE.

The TMDL program was established by the CWA in 1972; however, TMDLs were rarely developed for waterbodies until the 1990s, after environmental groups began suing the EPA over the lack of TMDLs being performed (EPA 2008). The CWA requires that a TMDL study be conducted for waterbodies identified as having impaired water quality. The TMDL study is conducted to determine the maximum amount of a pollutant that a waterbody can receive and still meet ambient water quality standards. This maximum load is split between point sources and nonpoint sources. These loads are then compared to the estimated existing point source and nonpoint source loads to determine the amount of reduction required for the waterbody to meet its water quality standards. The first TMDLs for waterbodies in the NAWRPR were completed in 2000. Prior to this, beginning in the 1980s, ADEQ routinely performed Wasteload Allocation Studies as part of the NPDES permitting process to determine the amount of a pollutant that could be discharged to a waterbody. Since 2001, 26 TMDLs have been completed for waterbodies in the NAWRPR (see Section 5).

In 1998, EPA initiated a program to develop ambient water quality criteria for nutrients, i.e., nitrogen and phosphorus. At the time, nutrients were identified as a leading cause of water quality issues across the nation, including such high profile events as the hypoxic zone in the Gulf of Mexico and algal blooms along the national seacoast. In 2001, EPA published recommended criteria development plans (EPA 2013d).

The drinking water source water protection program was initiated as a result of the 1996 amendment to the SWDA. The purpose of this program is to prevent the need for increased treatment of drinking water (resulting in increased treatment costs and costs to customers) due to water quality degradation, by protecting the quality of the drinking water source. In the majority of cases, the cost of protecting drinking water sources from pollution is far lower than the cost of upgrading water treatment to remove increased pollution. There are approximately 310 public water utilities in the NAWRPR that are subject to SDWA regulations (ADH n.d.). More information on source water protection in the region is included in Section 5.1.2.

Subtitle D of the 1991 amendment of the Resource Conservation and Recovery Act (RCRA) introduced specifications for how landfills were to be constructed and managed to protect water quality. This led to sweeping changes in solid waste management across the country and in Arkansas (ADEQ 2011a).

6.1.1.2 Water Resources Management

The federal regulations and programs that address non-water quality aspects of water resources management are summarized in Table 6.2. These include regulations and programs that address flood control, river navigation, wetlands tracking, or water-based recreation. Programs related to drinking water infrastructure are also included in Table 6.2 and discussed below. Some of the legislation and programs that address water quality also address other aspects of water resources management. For example, preservation of forest lands protects water quality and hydrology. As a result, there is some duplication in Tables 6.1 and 6.2. Federally appropriated water, such as the water required to maintain navigation on the McClellan-Kerr

Table 6.2. Federal laws and programs that affect aspects of NAWRPR water resources other than water quality.

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Clean Water Act	Wetland and stream mitigation	USACE	Physical protection of waterbodies, including wetlands
Safe Drinking Water Act	Consumer confidence reports	EPA	Protects/improves public water supply
	Finished water criteria	EPA	Protects human health
	Operator certification	EPA	Informs the public
Endangered Species Act	Freshwater species protection	USFWS	Mechanism for physical protection of waterbodies that are habitats for endangered species
	Waterfowl protection		
Soil and Water Resources Conservation Act	Census of Agriculture	USDA	Irrigation and agriculture
	Conservation Effects Assessment Program	USDA	Water resources protection/improvement
	Natural Resources Inventory	USDA	Characterize water resources
National Environmental Policy Act	Environmental Impact Statements and Mitigation	EPA, Council on Environmental Quality	Water resources protection/mitigation
Flood Control Act/Water Resources Development Act	Dam safety	USACE	Water storage, water supply, flood reduction, flow management, restoration of physical aquatic habitat
	Flood control reservoirs		
	Levees		
	Navigation systems		
Arkansas Wilderness Act	National forests	USFS	Well managed forestlands improve and protect water resources
National Forest Management Act			
Weeks Act			
Rivers and Harbors Act	Navigation	USACE	Federal navigation systems in Arkansas
	Section 10	USACE	Protects waterbodies, including wetlands
Migratory Bird Hunting and Conservation Stamp Act	Small wetland acquisition program	USFWS	Protects wetlands
Emergency Wetlands Resources Act	National Wetlands Inventory	USFWS	Track wetland resources
Dam Safety and Security Act	National Dam Safety Program	Federal Emergency Management Agency (FEMA)	Protection of lives and property
Wild and Scenic Rivers Act	National Wild and Scenic Rivers	USFS	Preservation of water resources for recreation
National Parks Acts	National Parks	USDI National Park Service	Protection of water resources associated with national parks

Table 6.2. Federal laws and programs that affect aspects of NAWRPR water resources other than water quality (continued).

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Migratory Bird Conservation Act	Acquisition of lands for wildlife refuges	Migratory Bird Conservation Commission	Preservation of water resources for bird habitat
National Wildlife Refuge System Improvement Act	National Wildlife Refuges	USFWS	Preservation of water resources for habitat
Pittman-Robertson Wildlife Restoration Act	Wildlife and sport fish restoration	USFWS	Preservation of water resources for fish and wildlife habitat
National Flood Insurance Act	National Flood Insurance Program	FEMA	Insurance against flood losses
	Floodplain management	FEMA	Reduction of flood damage
	Flood hazard mapping	FEMA	Identification of flood hazard areas
None	Climate monitoring	NOAA	Tracking precipitation and evaporation – water availability
	Climate prediction	NOAA	Future water availability
	Drought status	NOAA	Enactment of water shortage specific management

Highlighted programs were initiated after the 1990 AWP update.

Arkansas River Navigation System, is not available for other uses. Federal water appropriations preempt other beneficial water uses, such as irrigation.

An important federal program for mitigating impacts to wetlands and streams is part of the dredge and fill permitting program of the CWA (Section 404), overseen by the USACE. This mitigation program was initiated in 1990, when the EPA and the USACE signed a memorandum of agreement establishing a process for determining the need for mitigation of impacts to wetlands, streams, and other water resources under the CWA Dredge and Fill Permitting program. This program provides a means for dredge and fill permit applicants to compensate for unavoidable destruction of aquatic habitat by either restoring or creating similar habitat either on site or at another location (EPA 2013e). There are five sites within the NAWRPR that have been designated as commercial mitigation banks for CWA dredge and fill permitting (Table 6.3) (USACE n.d.). The program is a mechanism for implementing the federal policy of no-net-loss of wetlands (EPA 2013e). Revised regulations governing this mitigation program were issued in 2008.

Table 6.3. Commercial mitigation banks within and serving areas within the NAWRPR.

Name of site	Location	Year Established	Area (acres)	Primary service area	Secondary service area	Sponsor	Credits
Little Horse Creek	Benton County	2011	70	Benton, Crawford, Washington Counties		Natural State Streams LLC	20106.5 stream
Kings River Mitigation Bank	Madison County	2008	274	Benton, Washington, Carroll, Boone, Marion, Madison Counties	Newton, Marion, Searcy, Stone, Izard, Fulton, Independence Counties	Natural Resources Investment Group	29736.25 stream
Davis Creek Mitigation Bank	Searcy County	2010	319	Newton, Searcy, Stone, Marion, Izard, Baxter, Independence	Baxter, Marion, Boone, Fulton, Van Buren, Cleburne, White, Independence, Jackson	Mitigation Solutions LLC	93778.7 stream
Hartsugg Creek	Searcy County	2010		Stone, Searcy, Newton, Johnson, Pope, Van Buren, Cleburne, White	Baxter, Stone, Izard, Independence	Advanced Ecology, Ltd	
Little Red River	White County	1999	50	Stone, Searcy, Van Buren, Cleburne, White	none		0.74 bottomland hardwood

The 1996 amendments to the SDWA directed EPA and the states to develop requirements for certification of water treatment system operators (EPA 2012e). These amendments also initiated a program that required public water suppliers that operate community water systems to provide annual reports to drinking water utility customers on the quality of their drinking water (EPA 2013c).

The Endangered Species Act provides for protection and recovery of imperiled terrestrial, freshwater, and marine plant and animal species (except pest insects) (USFWS 2013b). The NAWRPR contains aquatic and semi-aquatic habitat important for a number of endangered species (See Tables 5.4 and 5.5).

The upper Buffalo River and North Sylamore Creek are included in the National Wild and Scenic Rivers system. The purpose of this program is to preserve free-flowing rivers with outstanding natural, cultural, or recreational characteristics. The designated portion of the Buffalo River extends from the headwaters to the boundary of the Ozark National Forest. The designated portion of the North Sylamore Creek extends from the boundary of the Clifty Canyon Botanical Area to the confluence with the White River. These designated stream reaches are managed by the USFS (ANHC 2012, Interagency Wild and Scenic Rivers Council n.d.).

Under the National Flood Insurance Act, flood hazard maps have been completed for the entire NAWRPR, and half of the mapping has been, or is in the process of being, modernized, within the last 8 years. The counties that have not been modernized are Madison, Newton, Marion, Searcy, Van Buren, Stone, Cleburne, Izard, and Fulton (Figure 6.1). Flood hazard maps for these counties are more than 25-years old. Modernized flood hazard maps typically include updated Special Flood Hazard Areas (SFHAs), and are created in a digital countywide format. For the communities participating in the National Flood Insurance Program (NFIP), the flood hazard maps identify the regulatory SFHA whereby the community floodplain administrator applies the locally adopted and enforced floodplain management ordinance. Participation the NFIP is voluntary, however non-participation results in federal flood insurance not being available to residents and limits post-disaster financial assistance. All of the counties included in the NAWRPR except Baxter, Boone, Carroll, Cleveland, Marion, and Stone are participating in the program (FEMA 2013b). Though these counties do not participate, some of the communities within the counties do. These communities are listed in Table 6.4.

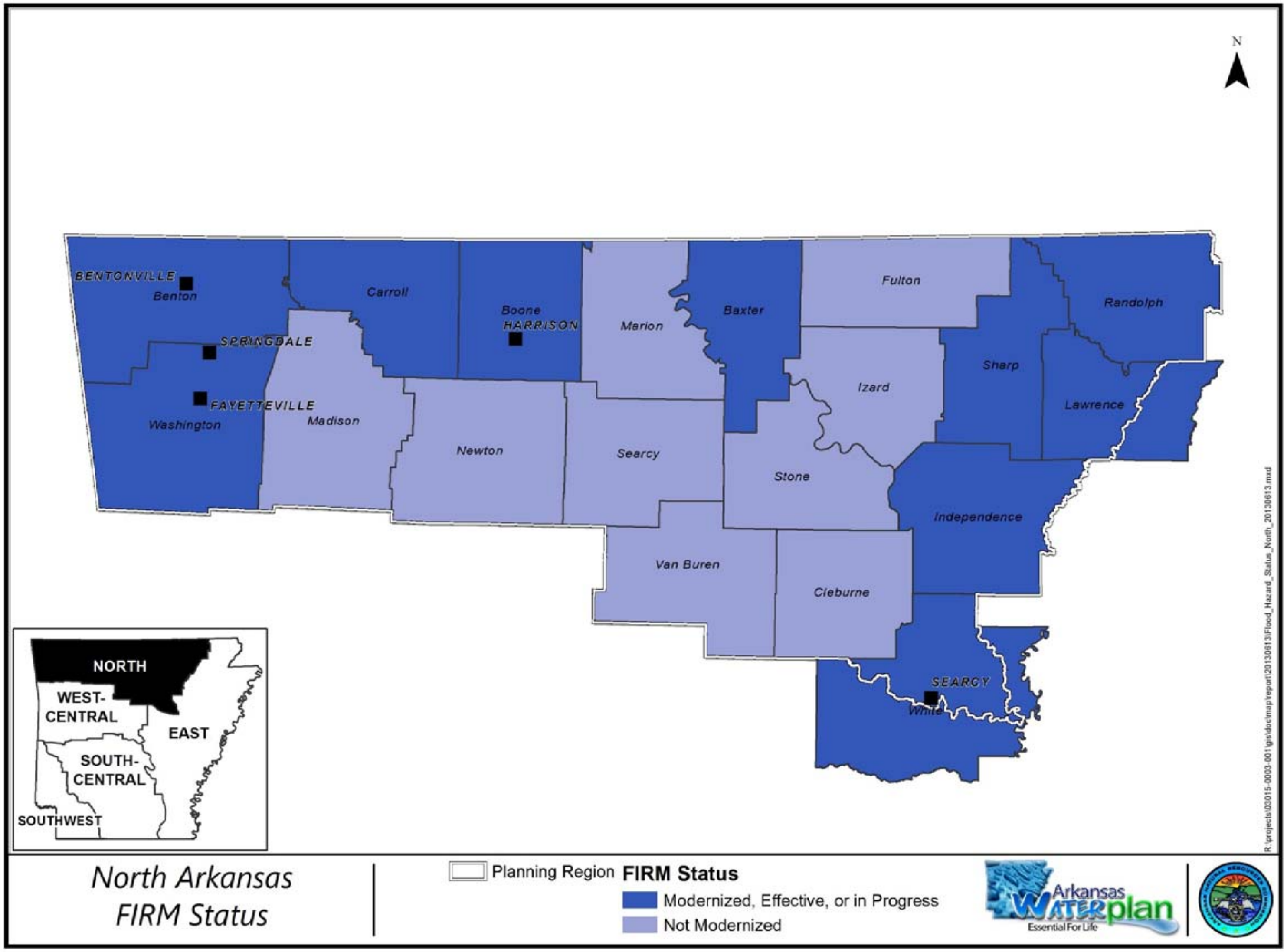

Figure 6.1. Status of flood hazard mapping in the NAWRPR.

Table 6.4. Communities participating in the NFIP not located in a participating county.

County	Participating Community
Baxter	Gassville
	Mountain Home
	Norfork
	Salesville
Boone	Bellefonte
	Bergman
	Harrison
Carroll	Beaver
	Eureka Springs
Cleveland	Kingsland
Marion	Bull Shoals
	Flippin
	Yellville
Stone	Mountain View

Federally appropriated water, such as the water allocated for hydropower at the dams along the White River, is not available for other uses. Surface waters in the NAWRPR that are under some degree of federal management include the White and Little Red Rivers (Beaver, Bull Shoals, TableRock, Greers Ferry, and Norfork Lakes), the Black River (Clearwater Lake in Missouri), and the Buffalo River (National River, National Wild and Scenic River) and North Sylamore Creek (National Wild and Scenic River).

6.1.2 Federal Laws and Assistance Programs

Federal laws have also established a number of programs to provide technical and financial assistance for water resources management, that are available in Arkansas. Assistance programs for management of water quality and other aspects of water resources are discussed in the following sections.

6.1.2.1 Water Quality

Table 6.4 summarizes current federal assistance programs available in the NAWRPR and the associated federal laws. The majority of the federal assistance programs listed in Table 6.5 originated through the Farm Bill. The Farm Bill has been amended four times since 1990, most recently in 2013 (National Agricultural Law Center 2012). New conservation programs that are intended to assist farmers in protecting and restoring water quality have been added with each amendment. In 2012, over 166,300 acres in the counties of the NAWRPR were enrolled in Farm Bill programs, and over $18.7 million in funding provided to those counties for water quality practices (Table 6.6) (NRCS 2012).

The Illinois River Sub-Basin and Eucha-Spavinaw Lake Watershed Initiative is a program funded by the USDA NRCS with the purpose of improving water quality in the Illinois River and Eucha-Spavinaw Lake Watersheds while maintaining food production in the area. 43.8% of the included land area in Northwest Arkansas, with the remaining area in Oklahoma. Conservation practices in the area are planned to aid in the water quality improvement efforts, including land treatments and addition of structures (NRCS 2013).

The CWA authorizes EPA to provide federal funding assistance to states and local entities through three funding programs. Through the Clean Water State Revolving Fund, federal funds are provided to ANRC to fund a low interest loan program for wastewater treatment, nonpoint source pollution control, and watershed management projects in the state. Grants for nonpoint source pollution control projects are authorized under Section 319 of the CWA. Finally, Section 106 of the CWA authorizes federal funding assistance to states and interstate agencies through grants for pollution control programs such as discharge permitting and water quality monitoring.

Table 6.5 Federal water quality assistance programs available in the NAWRPR.

Federal Law	Federal Water Quality Funding Assistance Programs	Responsible Federal Agency
CWA	Clean water state revolving fund	EPA
	Nonpoint source pollution management grants	
	Water pollution control program grants	
Comprehensive Environmental Response, Compensation, and Liability Act	Hazardous waste site clean up	EPA
Cooperative Forestry Assistance Act	Forest Stewardship Program	USFS
	Forest Legacy Program	
	Urban and Community Forestry Program	
Housing and Community Development Act	Community development block grants programs	US Department Housing and Urban Development (HUD)
Consolidated Farm and Rural Development Act	Water and waste disposal systems for rural communities	USDA Rural Utilities Service
	Water and Waste Disposal Loans and Grants	
	Solid Waste Management Grants	
	Grant Program to Establish a Fund for Financing Water and Wastewater Projects	
Farm Bill	Agricultural Water Enhancement Program	NRCS
	Conservation Reserve Program (CRP)	USDA Farm Services Agency
	Conservation Innovation Grants Program	NRCS
	Conservation Stewardship Program (CSP)	
	Cooperative Conservation Partnership Initiative	
	Environmental Quality Incentives Program (EQIP)	
	Farm and Ranch Land Protection Program	
	Grassland Reserve Program	
	Grazing Lands Conservation Initiative	
	Mississippi River Basin Healthy Watersheds Initiative	
	Illinois River Sub-Basin and Eucha-Spavinaw Lake Watershed Initiative	
	National Water Management Center	
	National Water Quality Initiative	
	Organic Initiative	
	Wetlands Reserve Program	
	Wildlife Habitat Incentives Program	
American Recovery and Reinvestment Act	Clean water state revolving fund, clean up of leaking underground storage tanks	Recovery Accountability and Transparency Board
Clean Vessel Act	Funding for pumpout stations and waste reception facilities for recreational boaters	USFWS

Note: Highlighted laws and programs were promulgated after the 1990 AWP update.

Table 6.6. NRCS conservation programs summary for 2012 (NRCS 2012).

County	Conservation Stewardship Program			Environmental Quality Incentives			Wildlife Habitat Incentive Program			Emergency Watershed Protection Program		Environmental Quality Incentives Program		
	Contracts	Acres	FY12 Obligations	Contracts	Acres	FY12 Obligations	Contracts	Acres	FY12 Obligations	FY12 Obligations	Project Type	Contracts	Acres	FY12 Obligations
Baxter	--	--	--	--	--	--	9	1,170	$129,047	--	--	10	1,588	$110,546
Benton	--	--	--	--	--	--	--	--	--	$111,623	Stream Bank Restoration	94	7,560.3	$2,232,264
Boone	--	--	--	--	--	--	--	--	--	--	--	11	534.3	$117,323
Carroll	--	--	--	--	--	--	1	65	$5,690	--	--	25	828.3	$518,892
Cleburne	--	--	--	1	54.5	$7,146	12	876.7	$80,531	--	--	25	1,626.3	$505,106
Fulton	--	--	--	--	--	--	25	2,950.1	$457,055	--	--	74	12,311.9	$1,204,130
Independence	14	22,535.1	$496,506	--	--	--	4	615.0	$48,113	$36,995	Debris Removal	36	8,297.3	$136,179
Izard	2	598.9	$ 8,781	--	--	--	5	356.4	$31,532	--	--	39	6,917.8	$759,393
Lawrence*	68	52,330.3	$2,326,961	--	--	--	1	200	$48,628	$59,287	Stream Bank Stabilization	8	6,559	$149,718
Madison	--	--	--	--	--	--	--	--	--	--	--	27	1,835.9	$405,230
Marion	4	1094	$13,648	--	--	--	6	1,247	$136,971	--	--	--	--	--
Newton	--	--	--	7	392.3	$60,430	3	86	$17,541	--	--	--	--	--
Randolph	4	2,687.0	$80,125	--	--	--	1	750	$ 28,001	$23,153	Auxiliary Spillway Repair (PL-566 dam)	--	--	--
Searcy	9	3,525.1	$22,833	4	719.9	$78,591	20	2,038	$424,462	--	--	--	--	--
Sharp	4	1,697.2	$18,934	--	--	--	--	--	--	--	--	--	--	--
Stone	1	39.3	$688	--	--	--	13	923.4	$258,744	--	--	--	--	--
Van Buren	1	524.5	$6,741	9	901.1	$166,823	11	936.4	$68,784	$52,000	Landslide Stabilization	--	--	--
Washington	--	--	--	--	--	--	--	--	--	--	--	--	--	--
White*	2	1,964.3	$50,600	--	--	--	1	880	$29,326	--	--	--	--	--
Totals	**109**	**84,308.7**	**$3,025,817**	**21**	**2,067.8**	**$312,990**	**109**	**12,479**	**$1,715,797**	**$283,058**		**349**	**48,059.1**	**$5,243,209**

* Part of this county is in another planning region; value reported is for the entire county and may not reflect what is in the planning region

Table 6.6. NRCS conservation programs summary for 2012 (NRCS 2012) (continued).

County	Little Red River Irrigation District AWEP project			Illinois River/Eucha Spavinaw Watershed Initiative			Point Remove Wetlands Reclamation and Irrigation District			The Nature Conservancy Cache/White River			Strike Force Initiative			Wetlands Reserve Program		
	Contracts	Acres	FY12 Obligations	Contracts	Acres	FY12 Obligations	Contracts	Acres	FY12 Obligations	Contracts	Acres	FY12 Obligations	Easements	Acres	FY12 Obligations	Easements	Acres	FY12 Obligations
Baxter	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benton	--	--	--	72	5,548	$1,795,389	--	--	--	--	--	--	--	--	--	--	--	--
Boone	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Carroll	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cleburne	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fulton	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Independence	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	578.8	$698,590
Izard	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lawrence*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Madison	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Marion	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Newton	--	--	--	--	--	--	--	--	--	--	--	--	1	243	$14,938	--	--	--
Randolph	--	--	--	--	--	--	--	--	--	--	--	--	10	1,099	$182,041	--	--	--
Searcy	--	--	--	--	--	--	--	--	--	--	--	--	21	2,455	$778,710	--	--	--
Sharp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Stone	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Van Buren	--	--	--	--	--	--	4	171	$26,178	--	--	--	--	--	--	--	--	--
Washington	--	--	--	61	5,294.4	$2,384,654	--	--	--	--	--	--	--	--	--	--	--	--
White*	28	2,559.6	$818,519	--	--	--	--	--	--	2	131	$118,490	--	--	--	5	1,310.4	$1,680,140
Totals	**28**	**2,559.6**	**$818,519**	**133**	**10,842.4**	**$4,180,043**	**4**	**171**	**$26,178**	**2**	**131**	**$118,490**	**32**	**3,797**	**$975,689**	**6**	**1,889.2**	**$2,378,730**

*Part of this county is in another planning region; value reported is for the entire county and may not reflect what is in the planning region

There are additional federal laws that authorize programs that provide assistance for community waste treatment and management to protect water quality. HUD grants for construction and upgrading of wastewater infrastructure were also authorized by the Housing and Community Development Act. Several programs to provide financial assistance for wastewater systems and solid waste programs in rural areas were authorized by the Consolidated Farm and Rural Development Act.

The American Recovery and Reinvestment Act was promulgated in 2009 to save and create jobs during the recession that began in 2008. This act initiated several programs that provide money to states for a range of activities, including improvements to wastewater treatment systems and clean up of leaking underground storage tanks and hazardous waste sites (EPA 2013f). Over $25 million of recovery money was awarded to the Arkansas State Clean Water Revolving Loan Fund, and $1.6 million was awarded to the ADEQ Leaking Underground Storage Tank Program. Recovery money was awarded to three wastewater projects and three leaking underground storage tank remediation projects in the planning region (EPA n.d.).

The Clean Vessel Act was promulgated in 1992. This act established a program to provide grants to states to pay for construction, maintenance, operation, or renovation of boat pumpout stations and waste reception facilities (US Congress 1992). Money from this program was used to install fixed pumpout facilities at an Arkansas River marina near Pine Bluff (ADH 2011).

Forestry assistance programs are included in Table 6.5 because forest improvement can improve water quality.

6.1.2.2 Water Resources Management

The federal assistance programs that address non-water quality aspects of water resources management are summarized in Table 6.7. These include programs that address flood control, water conservation, water supply systems, fisheries, and aquatic habitat for wildlife. Some of the programs that provide assistance for addressing water quality, also address other aspects of water resources management. For example, some Farm Bill programs support practices that conserve water, as well as practices that protect water quality. As a result, there is some duplication in Tables 6.5 and 6.7.

Table 6.7 Federal assistance programs for aspects of water resources other than water quality that are active in the NAWRPR.

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Safe Drinking Water Act	Drinking water state revolving fund	EPA	Protects human health
Farm Bill	Agricultural Water Enhancement Program	NRCS	Water conservation
	Cooperative Conservation Partnership Initiative	NRCS	Water conservation
	Conservation Innovation Grants Program	NRCS	Water conservation
	Emergency Watershed Protection	NRCS	Flooding reduction, recovery
	National Water Management Center	NRCS	Waterbody protection/restoration
	On-farm Energy Initiative	NRCS	Water conservation
	Watershed protection and flood prevention	NRCS	Flooding management
	Wetlands Reserve Program	NRCS	Physical waterbody protection/restoration
	Wildlife Habitat Incentives Program	NRCS	Physical waterbody protection/restoration
Cooperative Forestry Assistance Act	Urban and Community Forestry Program	USFS	Trees in communities reduce stormwater runoff, improving hydrology
	Forest Stewardship Program Forest Legacy Program	USFS	Well-managed forestlands improve and protect water resources
Flood Control Act/Water Resources Development Act	Habitat restoration White River Studies	USACE	Water storage, water supply, flood reduction, flow management, restoration of physical aquatic habitat
Housing and Community Development Act	Community development block grants programs	HUD	Protects/improves public water supply
American Recovery and Reinvestment Act	Funding for drinking water state revolving fund	Recovery Accountability and Transparency Board	Protects/improves public water supply
Consolidated Farm and Rural Development Act	Water and wastewater disposal systems for rural communities, Water and wastewater disposal loans and grants, Household water well system grant program, Grant program to establish a fund for financing water and wastewater projects, Emergency community water assistance grants	USDA Rural Development	Protects/improves public water supply

Table 6.7 Federal assistance programs for aspects of water resources other than water quality that are active in the NAWRPR (continued).

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Land and Water Conservation Fund Act	Matching grants for acquisition and development of public recreation areas and facilities	USDI National Park Service	Preservation of water resources for recreation
Pittman-Robertson Wildlife Restoration Act	Wildlife restoration grant program	USFWS	Preservation of water resources for fish and wildlife habitat
Sport Fish Restoration Act	Boating infrastructure grants	USFWS	Recreational boating and fishing
	Multistate conservation grants	USFWS	Aquatic habitat research and education
	Sports fish restoration grants	USFWS	Preservation of water resources for fish and wildlife habitat

Note: Highlighted laws and programs were initiated after the 1990 AWP update.

The 1996 amendment of the Safe Drinking Water Act established the Drinking Water State Revolving Fund to assist drinking water utilities in financing infrastructure improvements. Using this fund, states can offer utilities low-cost loans and other types of assistance. Funds available through the American Recovery and Reinvestment Act were awarded to the Arkansas Drinking Water State Revolving Fund (EPA n.d.).

Farm Bill amendments and associated assistance programs, as well as the Conservation Effects Assessment Program, the assistance programs associated with the Consolidated Farm and Rural Development Act, and the HUD Community Development Block Grant Program, were discussed in Section 6.1.2.1. Farm Bill programs address water conservation (e.g., Groundwater Decline Initiative), flood control (e.g., Watershed protection and Flood prevention), and conservation and restoration of aquatic habitat (e.g., Wetlands Reserve Program, Wildlife Habitat Incentives Program).

Several water resources projects have been authorized in Arkansas since 1990 under the Water Resources Development Act (WRDA). The White River Comprehensive Study includes the entire White River, and was started in 1986 with updates in 2000 and 2007. This study includes identifying water resources needs and opportunities for water supply, flood control, navigation, recreation, power generation, wastewater management, and environment. The White

River Minimum Flow Reallocation Study was authorized by the 1999 and 2000 WRDA, and finalized in 2009. This study evaluated potential effects of reallocating storage from Beaver, Table Rock, Bull Shoals, Norfork, and Greers Ferry lakes to maintain minimum flows downstream of the dams to sustain the introduced trout fisheries. Reallocation was authorized only for Bull Shoals Lake and Norfork Lake (USACE Little Rock District 2009). Bull Shoals Dam has a target minimum release of 800 cfs. Norfork Dam has a target minimum release of 300 cfs (USACE Little Rock District n.d.). Other WRDA projects in the region include several Arkansas Highway and Transportation Department projects and other structure and bank updates. These projects are located in Washington, Benton, Stone, Van Buren, and Lawrence Counties.

6.1.3 State Laws and Regulatory Programs

Arkansas has primary authority for regulation of water usage within the state. Many of the state laws and agency regulations related to water quality implement federal laws. The federal government has delegated authority to the state for a number of regulatory administrative activities of both the Clean Water Act and the Safe Drinking Water Act.

6.1.3.1 Water Use Regulations

State water use law is based on a policy where riparian land owners, i.e., persons owning land that abuts a waterbody, have the right to reasonable use of the water within that waterbody. The reasonable use policy means that all landowners along a stream have the right to free and unrestricted use of the stream flow, provided that their use does not negatively affect the availability of water for other riparian users. Similarly, landowners have the right to reasonable use of groundwater under their property, as long as that use does not adversely affect the ability of other landowners to use the groundwater. In addition to water rights related to water withdrawals and consumptive use, Arkansas regulations address water rights related to public recreational uses of surface water such as boating and fishing (ANRC 2011a).

In Arkansas, at the state level, regulations and programs authorized by the General Assembly that are related to water use are generally administered by ANRC. In addition, the

Arkansas Water Well Construction Commission promulgates rules for construction of water supply wells, and the Arkansas Public Services Commission regulates private water utility fees. State incentive programs for water conservation, as well as funding for water resources development projects, have also been legislated. Table 6.8 summarizes selected Arkansas water use regulations that apply in the NAWRPR.

Table 6.8. State regulations related to water use.

State Water Use Regulations	Subjects Addressed by Regulations	Related State Legislation
Title 3: Rules for the Utilization of Surface Water[1]	Registration of surface water withdrawals	Arkansas Code §15-22-215
	Minimum streamflows	Arkansas Code §15-22-222
	Surface water transfers to non-riparian users	Arkansas Code §15-22-304
	Regulation of dam construction	Arkansas Code §15-22-210 - 214
	Allocation during periods of water shortage	Arkansas Code §15-22-217
Title 4: Rules for the Protection and Management of Groundwater[1]	Registration of groundwater withdrawals	Arkansas Code §15-22-302
	Groundwater protection program	Arkansas Groundwater Protection and Management Act (Arkansas Code §15-22-901 et seq.)
Arkansas Water Well Construction Commission Rules and Regulations[2]	Licensing of water well contractors	Arkansas Code §17-50-201 et seq.
	Construction requirements	
	Well reporting requirements	
Affiliate Transaction Rules[3]	Requirements for utility rates	Arkansas Code §23-2-101 et seq.
General Service Rules[3]	Standards of service for utilities	
Special Rules Water[3]	Standards of service for water utilities	

1 Enforcement by ANRC
2 Enforcement by Arkansas Water Well Construction Commission
3 Enforcement by Arkansas Public Service Commission
Note: Highlighted legislation was promulgated after the 1990 AWP update.

State law requires ANRC to "establish and enforce minimum stream flows for the protection of instream water needs" (Arkansas Code § 15-22-222). Minimum streamflow is defined by Arkansas Code §15-22-202(6) as "…the quantity of water required to meet the largest of [specified] instream flow needs as determined on a case-by-case basis." The needs to be met that are specified in the statute are interstate compacts, navigation, fish and wildlife, water quality, and aquifer recharge. This definition is used to set minimum streamflows by rulemaking under Arkansas Code §15-22-222. Where no minimum flow is set by rule, these factors are used to make a case-by-case determination of minimum flow. ANRC has adopted minimum streamflow by rule for the main stem of the White River (2009).

The minimum streamflow, set by rule or determined on a case-by-case basis, represents the trigger point for a "shortage" requiring allocation of water use. Because of the critical low flow conditions which may exist at the minimum streamflow level, the 1990 AWP recommended taking steps to reduce water withdrawals before water levels drop to minimum streamflow levels. The ANRC may allocate water among uses during a shortage.

Prior to adoption of Act 593 of 2013, minimum streamflows were classified as a "reserved" use when allocating water during a shortage, along with drinking water use and federal water rights. The legislation removed this reserved status and demoted minimum streamflows to a position below agriculture and industry in the allocation hierarchy, and ahead of hydropower and recreation. The intent was to ensure that agricultural and industrial surface water use is not curtailed during a shortage in an effort to protect instream flow needs (interstate compacts, navigation, fish and wildlife, water quality, and aquifer recharge). This change, especially as it applies a state law limitation on federal interests in navigation, interstate compacts and water quality, including wastewater discharge permits for sewer systems and industries, has not been tested.

In 1985, the Arkansas General Assembly adopted a departure from traditional riparian law by allowing transfer of water for use on non-riparian land. Prior to determining how much water is available to transfer, ANRC must first calculate the amount of water that must remain in the stream. The amount of water that must remain in the stream must be enough to cover: (1) existing riparian water rights as of June 28, 1985; (2) water needs of federal water projects as they existed on June 28, 1985; (3) firm yield of all reservoirs in existence on June 28, 1985; (4) maintenance of instream flows for fish and wildlife, water quality, aquifer recharge requirements, and navigation; and (5) future water needs of the basin of origin as projected in the AWP. The General Assembly limited the amount of excess surface water that may be permitted for non-riparian transfer to 25% of the average annual yield from the watershed after the greatest of the instream needs listed above is met. In the White River Basin, Arkansas Code§15-22-304(e) further limits excess to an amount not to "exceed on a monthly basis an amount which is 50% of the monthly average of each individual month of excess surface water."

Minimum streamflow is often mistakenly equated with fish and wildlife flow requirements. Fish and wildlife flows are one of the 5 elements of minimum streamflow, which also includes interstate compacts, navigation, water quality, and aquifer recharge. Two different methods are used to calculate fish and wildlife flows for different situations. For case-by-case determinations of minimum flow for use in characterizing shortage and allocating water during a shortage, fish and wildlife flow requirements are estimated using a modified Tennant Method (ASWCC 1988). To calculate fish and wildlife flow requirements when determining the amount of excess water available for transfer to nonriparian users, the "Arkansas Method" (Filipek, Keith and Giese 1987) is used.

In 1991, the Arkansas Ground Water Protection and Management Act (Arkansas Code §15-22-901 et seq.) was signed into law, providing ANRC with authority to designate critical groundwater areas. This law also mandated that ANRC evaluate the condition of the state's aquifers on a biennial basis, and make recommendations concerning safe yield and the designation of critical groundwater areas (ANRC 2011a). ANRC publishes annual reports on the condition of the state's groundwater resources, including recommendations concerning aquifer safe yield and designation of critical groundwater areas. There are no critical groundwater areas designated in the NAWRPR, however, legislation passed in 2001 requires the use of water meters on all non-domestic wells withdrawing water from sustaining aquifers, which include the Roubidoux and Gunter aquifers, beginning in 2006.

6.1.3.2 Water Quality Regulations

Water quality regulations are promulgated by the General Assembly, Arkansas Pollution Control and Ecology Commission (APCEC), the State Board of Health, and ANRC. Table 6.9 identifies state regulations and laws, along with associated federal laws, that address water quality.

Table 6.9. State regulations that protect water quality.

State Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Regulation 1: Prevention of Pollution by Salt Water and Other Oil Field Wastes Produced by Wells in All Fields or Pools[1]	Environmental protection during oil drilling	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 2: Water Quality Standards for Surface Waters of the State of Arkansas[1]	Water quality standards (designated uses and numeric criteria)	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 3: Licensing of Wastewater Treatment Operators[1]	Licensing program for wastewater treatment operators	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 4: Disposal Permits for Real Estate Subdivisions in Proximity to Lakes and Streams[1]	State wastewater permit	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 5: Liquid Animal Waste Systems[1]	State wastewater permit	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 6: Regulations for State Administration of the NPDES Program[1]	Federal wastewater permits (NPDES)	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)t	Clean Water Act
Regulation 15: Open-Cut Mining and Land Reclamation Code[1]	Environmental protection during non-coal mining activities, restoration of non-coal mining sites	Arkansas Open Cut Land Reclamation Act (Arkansas Code §15-57-301 et seq.) Arkansas Quarry Operation, Reclamation, and Safe Closure Act (Arkansas Code §15-57-401 et seq.)	None
Regulation 17: Underground Injection Control Code[1]	Underground injection of wastewater	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Safe Drinking Water Act
Regulation 22: Solid Waste Management[1]	Landfill construction specifications, acceptable materials for landfill disposal, regional solid waste management districts, pollution prevention	Arkansas Solid Waste Management Act (Arkansas Code § 8-6-201 et seq.), Arkansas Pollution Prevention Act (Arkansas Code § 8-10-201 et seq.)	Resource Conservation and Recovery Act, Pollution Prevention Act

Table 6.9. State regulations that protect water quality (continued).

State Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Regulation 23: Hazardous Waste Management[1]	Hazardous waste management, pollution prevention	Arkansas Hazardous Waste Act (Arkansas Code § 8-7-201 et seq.), Arkansas Hazardous Materials Transportation Act (Arkansas Code § 27-2-101 et seq.), Arkansas Pollution Prevention Act (Arkansas Code § 8-10-201 et seq.)	Resource Conservation and Recovery Act, Pollution Prevention Act
Regulation 27: Licensing of Landfill Operators and Illegal Dumps Control Officers[1]	Licensing of landfill operators, licensing of illegal dumps control officers	Arkansas Code § 8-6-901 et seq., Illegal Dump Eradication and Corrective Action Program Act (Arkansas Code § 8-6-501 et seq.)	Resource Conservation and Recovery Act
Regulation 29: Brownfields Redevelopment[1]	Clean-up and redevelopment of contaminated sites	Arkansas Hazardous Waste Act (Arkansas Code § 8-7-201 et seq.), Remedial Action Trust Fund Act, Arkansas Voluntary Clean-up Act (Arkansas Code § 8-7-1101 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Regulation 32: Environmental Professional Certification[1]	Certification program for professionals involved in clean-up of contaminated sites	Phase I Environmental Site Assessment Consultant Act (Arkansas Code § 8-7-1301 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Regulation 34: State water permit regulation[1]	Regulation of systems with the potential to pollute water resources, that are not otherwise regulated	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Title 19: Rules Governing the Poultry Feeding Operations Registration Program[2]	Registration of poultry feeding operations	Arkansas Poultry Feeding Operations Registration Act (Arkansas Code § 15-20-901 et seq.)	Clean Water Act
Title 20: Rules Governing the Arkansas Nutrient Management Planner Certification Program[2]	Training and certification of nutrient management planners	Arkansas Soil Nutrient Management Planner and Applicator Certification Act (Arkansas Code § 15-20-1001 et seq.)	Clean Water Act

Table 6.9. State regulations that protect water quality (continued).

State Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Title 21: Rules Governing the Arkansas Nutrient Management Applicator Certification Program[2]	Training and certification of nutrient applicators	Arkansas Soil Nutrient Management Planner and Applicator Certification Act (Arkansas Code § 15-20-1001 et seq.)	Clean Water Act
Title 22: Rules Governing the Arkansas Soil Nutrient and Poultry Litter Application and Management Program[2]	Nutrient surplus areas, nutrient management plans, poultry litter management plans, poultry litter transport	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.), Arkansas Poultry Feeding Operations Registration Act (Arkansas Code § 15-20-901 et seq.), Arkansas Soil Nutrient Management Planner and Applicator Certification Act (Arkansas Code § 15-20-1001 et seq.), Arkansas Soil Nutrient Application and Poultry Litter Utilization Act (Arkansas Code § 15-20-1101 et seq.)	Clean Water Act
Rules and regulations pertaining to general sanitation[3]	Groundwater pollution, surface water pollution, sewage treatment	Arkansas Sewage Disposal Systems Act (Arkansas Code § 14-236-101 et seq.)	Clean Water Act
Rules and regulations pertaining to public water systems[3]	Safety of drinking water supplied by public water systems	Arkansas Code § 20-7-101 et seq.	Safe Drinking Water Act
Rules and regulations pertaining to semi-public water systems[3]	Safety of drinking water supplied by semi-public water systems	Arkansas Code § 20-7-101 et seq.	Safe Drinking Water Act
Rules and regulations pertaining to water operator licensing[3]	Licensing for drinking water treatment systems	Arkansas Code § 17-51-101 et seq.	Safe Drinking Water Act
Rules and regulations pertaining to onsite wastewater systems, designated representative, and installers[3]	Permitting of onsite wastewater treatment systems (septic systems), licensing of designated representatives for onsite wastewater treatment systems, licensing of installers of onsite wastewater treatment systems	Arkansas Sewage Disposal Systems Act (Arkansas Code § 14-236-101 et seq.)	Clean Water Act

Table 6.9. State regulations that protect water quality (continued).

State Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Rules and regulations pertaining to mobile home and recreational vehicle parks[3]	Water supply, wastewater disposal, solid waste management	Arkansas Code § 20-7-101 et seq.	Clean Water Act, Safe Drinking Water Act, Resource Conservation and Recovery Act
Arkansas regulations on pesticide classification[4]	Pesticide classification	Arkansas Pesticide Control Act (Arkansas Code § 2-16-401 et seq.), Arkansas Pesticide Use and Application Act (Arkansas Code § 20-20-201 et seq.)	Federal Insecticide, Fungicide, and Rodenticide Act
Arkansas regulations on pesticide applicator licensing[4]	Licensing of pesticide applicators	Arkansas Pesticide Use and Application Act (Arkansas Code § 20-20-201 et seq.)	Federal Insecticide, Fungicide, and Rodenticide Act
Arkansas Water Well Construction Commission Rules and Regulations	Specifications for construction of water wells to provide safe drinking water	Water Well Construction Act (Arkansas Code § 17-50-101 et seq.)	Safe Drinking Water Act
Rules and Regulations pertaining to outdoor bathing places[3]	Swim beach water quality	Arkansas Code § 20-7-101 et seq.	Clean Water Act
Marine sanitation[3]	Marine sanitation	Arkansas Code § 27-101-401 et seq.	Clean Vessel Act

Note: Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update.
1 Responsible state agency is ADEQ-2 Responsible state agency is ANRC
3 Responsible state agency is Arkansas Department of Health 4 Responsible state agency is Arkansas State Plant Board

Table 6.9 illustrates that there are myriad state regulations, covering a range of activities, that address water quality. The most basic of these are the regulations that set criteria for the quality of state surface waters and groundwater. These regulations identify the uses that state waterbodies should support, and specify narrative and numeric criteria for water quality to ensure the identified uses can be supported. In Arkansas, numeric water quality criteria for dissolved oxygen, turbidity, temperature, and minerals are ecoregion-based (APCEC 2011). Arkansas is in the process of developing numeric criteria for nutrients in surface water to meet federal requirements (ADEQ 2012b). State numeric water quality criteria for groundwater are in development.

As specified in the CWA, state water quality standards consist of designation of uses for water bodies, narrative or numeric criteria for selected parameters to ensure the designated uses are supported, and an anti-degradation policy to protect water bodies with water quality that is better than the standards. The state water quality standards are reviewed every three years. A summary of the designated uses assigned to surface waterbodies in the NAWRPR under Regulation 2 is provided in Table 6.10. Numeric surface water quality criteria for the water bodies in the planning region are listed in Tables 6.11 through 6.13. Ozark Highlands and Boston Mountain numeric water quality criteria apply in the NAWRPR. Figure 6.2 shows the ADEQ Water Quality Planning Segments that are located in the planning region.

Table 6.10. State designated uses for surface waters in the NAWRPR (APCEC 2011).

Designated Use	Waterbodies
Extraordinary Resource Waters	Current River Eleven Point River Strawberry River Spring River South Fork Spring River Buffalo River Kings River Devils Fork and Middle Fork of Little Red River Bull Shoals Reservoir North Sylamore River Archey River Lee River Salado Creek Richland Creek
Natural and Scenic Waterways	Strawberry River Kings River Buffalo River North Sylamore Creek Richland Creek
Ecologically Sensitive Waterbodies	Numerous springs Strawberry River Spring River Eleven Point River Current River Illinois River Devils River Middle and South Forks of Little Red River Upper White River Foshee Cave
Primary Contact Recreation	All streams with watersheds of greater than 10 square miles All lakes/reservoirs

Table 6.10. State designated uses for surface waters in the NAWRPR (APCEC 2011).

Designated Use	Waterbodies
Secondary Contact Recreation	All waters
Domestic, Industrial, and Agricultural Water Supply	All waters
Fishery	All Lakes/reservoirs White River North Fork River Spring River Upper White River Little Red River (portions of)
Seasonal Fishery	Boston Mountain and Ozark Highlands seasonal streams
Perennial Fishery	Boston Mountain and Ozark Highlands perennial streams

Table 6.11. Temperature and turbidity numeric criteria that apply in the NAWRPR.

Water body	Temperature (F^o)	Turbidity – base flow (NTU)	Turbidity – all flows (NTU)
Ozark Highlands	84.2	10	17
Boston Mountains	87.8	10	19
Lakes and Reservoirs	89.6	25	45
Trout Waters	68.0	10	15

Table 6.12. Dissolved oxygen numeric water quality criteria that apply in the NAWRPR.

Water body	DO Primary (mg/L)	DO Critical (mg/L)
Streams with watershed < 10 square miles	6	2
Ozark Highland streams with watershed 10 – 100 square miles	6	5
Boston Mountain streams with watershed 10 – 100 square miles	6	6
Streams with watershed > 100 square miles	6	6
Lakes and reservoirs	5	-
Trout Waters	6	6

Table 6.13. Numeric water quality criteria for minerals that apply in the NAWRPR.

Water body	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
Black and Strawberry Rivers	20	30	270
Spring River – Eleven Point River, South Fork Spring River, Myatt Creek	20	30	270
Stennitt Creek	ER[1]	ER[1]	456[2]
White River (Dam #3 to Missouri Line – includes Bull Shoals Reservoir)	20	20	180
Buffalo River	20	20	200
Crooked Creek	20	20	200
White River (Missouri line to headwaters, includes Beaver Resrvoir)	20	20	160
Kings River	20	20	150
West Fork White River	20	20	150
Illinois River	20	20	300

1. ER – Ecoregion Standard
2. Based on critical background flow of 4 cfs

To protect surface water and groundwater quality, there are state regulations and laws that regulate discharge of wastewater, discharge of stormwater, underground storage tanks, underground injection of fluids, management of livestock, and disposal of solid waste.

The state source water and wellhead protection programs address protection of the quality of surface waters and aquifers used as public drinking water supplies. There are just over 200 active public water supply utilities in the NAWRPR. Approximately 100 of these utilities use groundwater from their own wells, and are subject to the state wellhead protection program. Seventeen use surface water and are subject to the state source water protection program. The remainder of the water utilities in the planning region purchase groundwater and/or surface water to supply to their customers (ADH n.d.).

6.1.3.3 Floodplain Management Regulations

Arkansas Code provides that it is the policy of the state to encourage and support actions to prevent and lessen flood hazards and losses. The state has the authority to adopt measures that will discourage development in flood-prone land, assist in reducing damage caused by floods, and improve long-range land management in flood-prone areas (Arkansas Code §14-268-101 et seq.).

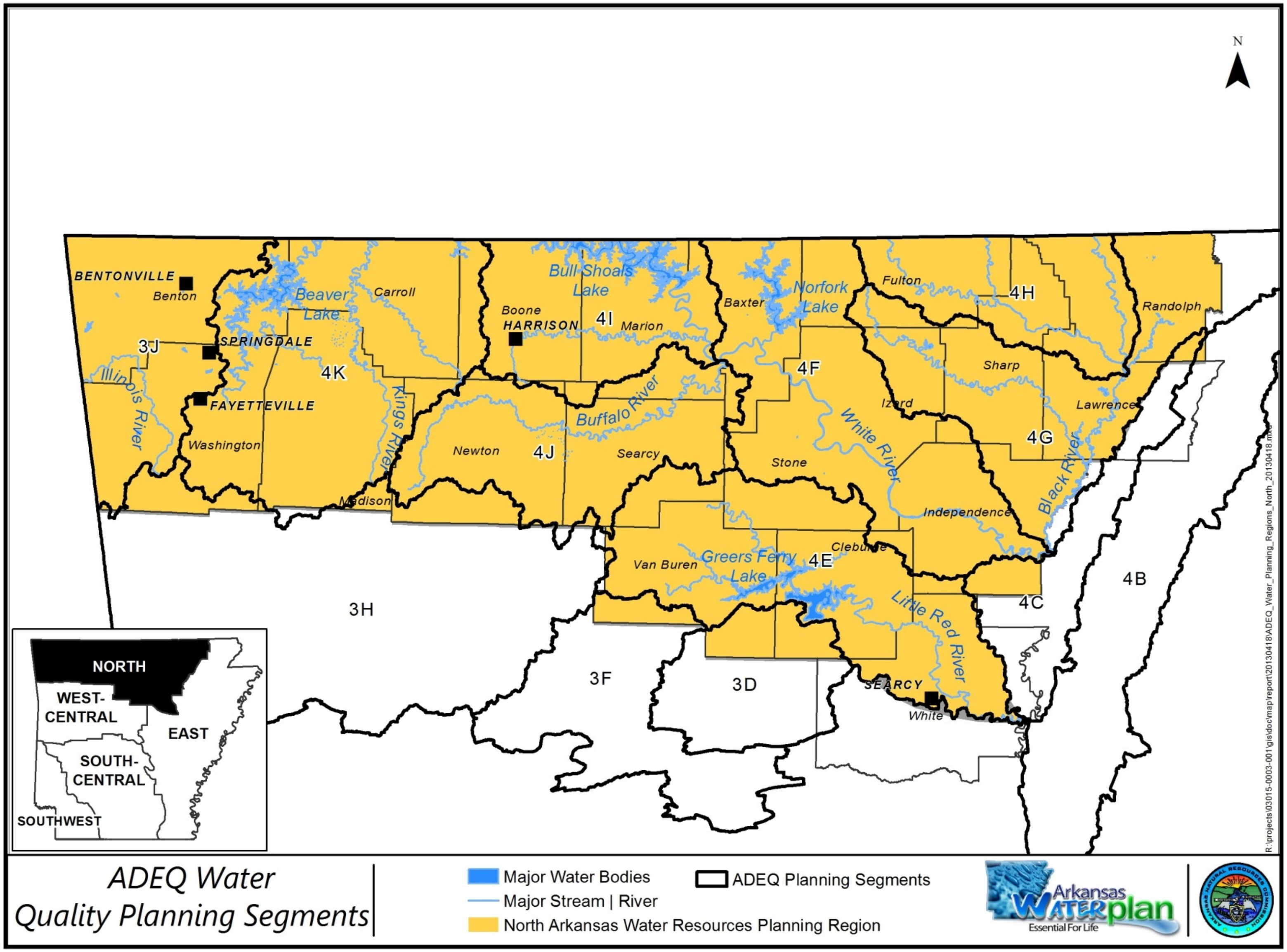

Figure 6.2. ADEQ water quality planning segments included in the NAWRPR

Arkansas statute also requires each county, city, or town that is participating in the National Flood Insurance Program to designate a "person to serve as the floodplain administrator to administer and implement the ordinance and any local codes and regulations relating the management of flood-prone areas." The designated floodplain administrator must also be accredited by ANRC under the commission's authority regarding flood control. State accreditation of floodplain administrators is regulated under ANRC Title 18 rules. Continuing education for the floodplain administrator is an especially important component of the state's accreditation program (Arkansas Code §14-268-106, §15-24-102, and §15-24-109).

6.1.3.4 Water Management Regulations

Other state regulations and programs address additional aspects of water resources and their management. Table 6.14 summarizes these regulations, and the associated federal legislation.

Table 6.14 State regulations relating to water management.

State Water Resources Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Title 6: Water plan compliance review procedures[1]	AWP	Arkansas Code § 15-22-503 and 504	None
Title 7: Rules governing design and operation of dams[1]	Dam safety	Arkansas Code § 15-22-201 et seq.	Water Resources Development Act/Dam Safety and Security Act
Title 12: Rules governing the Arkansas wetland mitigation bank program[1]	Wetland mitigation bank	Arkansas Wetlands Mitigation Bank Act (Arkansas Code § 15-22-1001 et seq.)	Rivers and Harbors Act, Clean Water Act
Rules and regulations of the Arkansas Natural Heritage Commission	Arkansas Natural and Scenic Rivers System	Arkansas Natural and Scenic Rivers System Act (Arkansas Code § 15-23-301 et seq.)	Wild and Scenic Rivers Act
Arkansas Wildlife Resources Regulations[2]	Allowance for fish passage at dams.	Arkansas Code § 15-44-110	
	Screens required on surface water intakes to protect fish	Arkansas Code § 15-44-111	

1 Responsible state agency is ANRC
2 Responsible agency is AGFC
Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update

The Arkansas Wetland Mitigation Banking Program (Arkansas Code §15-22-1002), authorized in 1995, is a state-sponsored initiative that promotes, in cooperation with federal, state, non-profit, and other interested entities, the restoration, creation, enhancement, and conservation of aquatic resources, including wetlands, streams, and deep-water aquatic habitat. This legislation authorizes ANRC to operate wetland and stream mitigation banks and to sell mitigation "credits" to private, nonprofit, and public entities required to provide mitigation for dredge and fill activities under the Clean Water Act. The "credits" represent the accrual or attainment of aquatic resource function at the mitigation bank site which results from restoration, creation, enhancement, or conservation efforts. The state wetland mitigation bank provides a cost-effective alternative for mitigating impacts. The USACE regulates both public and private mitigation banking and is responsible for approving the number of "credits" available within any individual bank. When an individual or entity is required to provide compensatory mitigation for unavoidable loss of function, the USACE can approve the purchase of "credits" from the state mitigation bank to satisfy all regulatory mitigation requirements. In 2013, there were no Arkansas Wetland Mitigation Banking Program sites within the NAWRPR (USACE n.d.).

6.1.4 State Financial Assistance Programs

Arkansas has several state programs that provide financial incentives and assistance for water resources management. The federal government has also delegated authority to the state to administer federal assistance programs of the Clean Water Act, and the Safe Drinking Water Act.

6.1.4.1 Financial Assistance for Public Water and Wastewater Projects

ANRC is responsible for managing and distributing monies from several federal assistance programs intended to assist communities in constructing and maintaining drinking water and wastewater systems (Table 6.15). There are also state-funded programs that provide financial assistance for drinking water and wastewater systems (Table 6.16). Programs shown in both Table 6.14 and 6.15 utilize both federal and state funds.

Table 6.15. Federal assistance programs for public water projects that are administered by ANRC.

Federal Program	Federal funding source	State Program
Community Development Block Grant Program	Housing and Urban Development	Arkansas Community and Economic Development Program
Drinking water state revolving fund, Clean water state revolving fund	EPA	Water resources cost share revolving fund program, Construction assistance revolving loan fund

Table 6.16 State programs for public water system assistance (administered by ANRC).

State Water Use Regulations	State Assistance Programs	Related State Legislation
Title 5: Administrative rules and regulations for financial assistance	Water resources development general obligation bond fund; Water development fund program; Water resources cost share revolving fund program; Water, sewer, and solid waste management systems program; and Water, waste disposal, and pollution abatement facilities general obligation bond fund program	Arkansas Water Resources Cost Share Finance Act (Arkansas Code § 15-22-801 et seq.), Arkansas Water, Waste Disposal, and Pollution Abatement Facilities Financing Act (Arkansas Code § 15-20-1301 et seq.)
Title 15: Rules governing loans from the safe drinking water revolving loan fund	Safe drinking water revolving loan fund program, Construction assistance revolving loan fund	Arkansas Code § 15-5-901 et seq., 15-22-1101 et seq.
Title 16: Rules governing the Arkansas clean water revolving loan fund program	Clean water revolving loan fund, Construction assistance revolving loan fund	Arkansas Code §15-5-901 et seq.
Title 23: Rules governing water and wastewater project funding through the Arkansas community and economic development program	Funding for construction or improvement of community treatment facilities for drinking water and wastewater treatment	Arkansas Code § 15-5-901 et seq.

6.1.4.2 State Financial Incentive and Assistance Programs for Promoting Water Quality and Water Resources Management

ADEQ and ANRC administer a number of incentive and assistance programs related to water resources management (Table 6.17). These include programs to assist with clean-up of hazardous waste contamination, reduction of nonpoint source pollution, and management of solid wastes to protect water quality. In addition, there are state programs to encourage water conservation and preservation of wetlands. All but one of the programs listed in Table 6.16 are funded by state sources. The state nonpoint source pollution management grant program is federally funded under the authority of the Clean Water Act Section 319.

Table 6.17 State incentive and assistance programs that protect water quality.

State Regulation	State Assistance Programs	Related State Legislation	Related Federal Legislation
Regulation 11: Solid Waste Disposal Fees, Landfill Post-Closure Trust Fund, and Recycling Grants Programs[1]	Recycling Fund	Solid Waste Management Recycling Fund Act (Arkansas Code §8-6-601 et seq.)	Resource Conservation and Recovery Act
Regulation 12: Storage Tank Regulations[1]	Petroleum storage tank trust fund	Petroleum Storage Tank Trust Fund Act (Arkansas Code § 8-7-901 et seq.)	Clean Water Act, Underground Storage Tank Regulations, including Energy Policy Act of 2005
Regulation 29: Brownfields Redevelopment[1]	Clean-up funding	Arkansas Hazardous Waste Management Act (Arkansas Code § 8-7-201 et seq.), Remedial Action Trust Fund Act (Arkansas Code § 8-7-501 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Regulation 30: Remedial Action Trust Fund, Site Priority List[1]	Clean-up funding, prioritization of contaminated sites for clean-up	Remedial Action Trust Fund Act (Arkansas Code § 8-7-501 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Title 5: Administrative rules and regulations for financial assistance[2]	Sewer and solid waste management systems program; Waste disposal and pollution abatement facilities general obligation bond program; Water, waste disposal and pollution abatement facilities general obligation fund program	Arkansas Code § 14-230-101 et seq., § 15-22-601 et seq., § 15-22-701 et seq.	None
Title 10: Rules governing the Arkansas water resource agricultural cost-share program[2]	Arkansas water resources agricultural cost-share program	Arkansas Code § 15-22-913 through 914, § 15-22-507	None
Title 11: Surplus Poultry Litter Removal Incentives Cost-Share Program[2]	Transport of poultry litter from nutrient surplus areas	Surplus Nutrient Removal Incentives Act (Arkansas Code § 15-20-1201 et seq.)	Clean Water Act

Table 6.17 State incentive and assistance programs that protect water quality (continued).

State Regulation	State Assistance Programs	Related State Legislation	Related Federal Legislation
Title 13 – Rules governing the tax credit program for the creation and restoration of private wetland and riparian zones[2]	Wetlands and Riparian Zone Tax Credit Program	Arkansas Private Wetland Riparian Zone Creation and Restoration Incentive Act (Arkansas Code § 26-51-1501 et seq.)	None
Title 14:Rules for implementing the Water Resources Conservation and Development Incentives Act[2]	Groundwater conservation tax incentives	Water Resource Conservation and Development Incentives Act (Arkansas Code § 26-51-1001 et seq.)	None
None	Nonpoint source pollution grant program[2]	None	Clean Water Act (Section 319)

Note: Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update.
1 Responsible state agency is ADEQ
2 Responsible state agency is ANRC

6.1.5 State Non-regulatory Water Resources Management Programs

There are state agency programs for natural resources protection and management that apply to water resources. These include planning, guidance, and incentive programs. These programs do not necessarily have regulations associated with them. However, they guide the activities of state agencies related to water resources. The AWP is one such program. Others are described below.

6.1.5.1 Arkansas Wildlife Action Plan

A state wildlife action plan was prepared by the AGFC, and approved by USFWS in 2007. This plan prioritizes activities to protect species of concern and their habitats throughout the state. This plan addresses amphibians, birds, fish, crayfish, insects, mammals, mussels, and reptiles. There are 231species of greatest conservation need identified for Arkansas in this plan that are found in the NAWRPR. The biggest problems faced by these species in the NAWRPR are urban development, grazing, dam locations, road construction, resource extraction, and forestry activities, among others. The most highly recommended conservation activity for this planning region is habitat restoration and improvement (Anderson 2006).

6.1.5.2 Arkansas State Wetland Strategy

A state wetland strategy was ed in 1995 by a team of Arkansas agencies. This strategy consisted of 10 elements that addressed conservation and restoration of wetlands, and improving understanding of wetlands, both by the scientific and natural resources community and by the public. Implementation of this strategy resulted in legislation that created the Arkansas Mitigation Banking Program, and the Arkansas Riparian Zone and Wetland Creation Tax Credit Program.

6.1.5.3 Arkansas Nonpoint Source Pollution Management Plan

ANRC regularly prepares a state nonpoint source pollution management plan. The purpose of this plan to provide a guide and focus for public agencies, nonprofit organizations, interest groups, and other stakeholders to work together to “develop, coordinate, and implement programs to reduce, manage or abate” nonpoint source pollution. The plan is updated every 5 years. The current plan was updated in 2010.

6.1.5.4 Arkansas Forestry Best Management Practices

The Arkansas Forestry Commission has prepared a booklet of approved guidelines for conducting forest management practices in a way that minimizes water quality impacts. Implementation of these best management practices is voluntary. These management practices are applicable to commercial and private timber operations on public or private land.

6.1.6 Local Regulations

There are also local regulations that influence management of water resources. These can include zoning laws; regulations promulgated by municipalities, counties, water and wastewater utilities; and regulations promulgated by irrigation, drainage, water, and sewer districts.

6.1.7 Regional Water Resources Management

Several agencies and organizations have developed management or restoration programs for areas within the NAWRPR. The purpose of some of these programs is to implement a state or federal regulation or policy, such as ambient water quality standards, no net loss of wetlands, or conservation of wildlife. These programs constitute a framework that provides opportunities for leveraging resources (personnel and funding) to accomplish water resources management goals.

Nine-element Watershed Plans

Watershed plans are required by the CWA to guide activities for reducing pollution in waterbodies for which TMDLs have been developed. EPA has prepared guidance describing the nine elements that should be included in watershed plans to achieve TMDLs calculated for impaired waterbodies. A nine-element watershed plan must be completed and approved by EPA before restoration projects in the watershed can receive funding from the CWA Nonpoint Source Program (Section 319 funding). There are two watersheds in the planning region for which nine-element watershed management plans have been approved by EPA. The Illinois River Watershed Management Strategy and the Upper White River update were both completed in 2004. Both were completed in order to provide a strategy for controlling nonpoint source pollution (Arkansas Water 2013).

6.1.7.1 Arkansas River Basin Compact

The State of Arkansas and State of Oklahoma signed the Arkansas River Basin Compact in 1970. This compact is an agreement concerning the waters of the Arkansas River and its tributaries. In the compact, the states outline water apportionment and cooperative efforts regarding pollution and water resource maintenance in these waters. As part of the apportionment agreement, water rights for each tributary and the main river are given as a percentage of the annual yield, which is defined in the compact as the computed annual gross runoff. Part of two sub-basins included in the compact are within the NAWRPR (Figure 6.3). According to the compact, the State of Arkansas has the right to “develop and use” waters of the Spavinaw Creek Sub-Basin as long as the annual yield is not depleted more than 50%. The State of Arkansas also has the rights to “develop and use” waters of the Illinois River Sub-Basin as

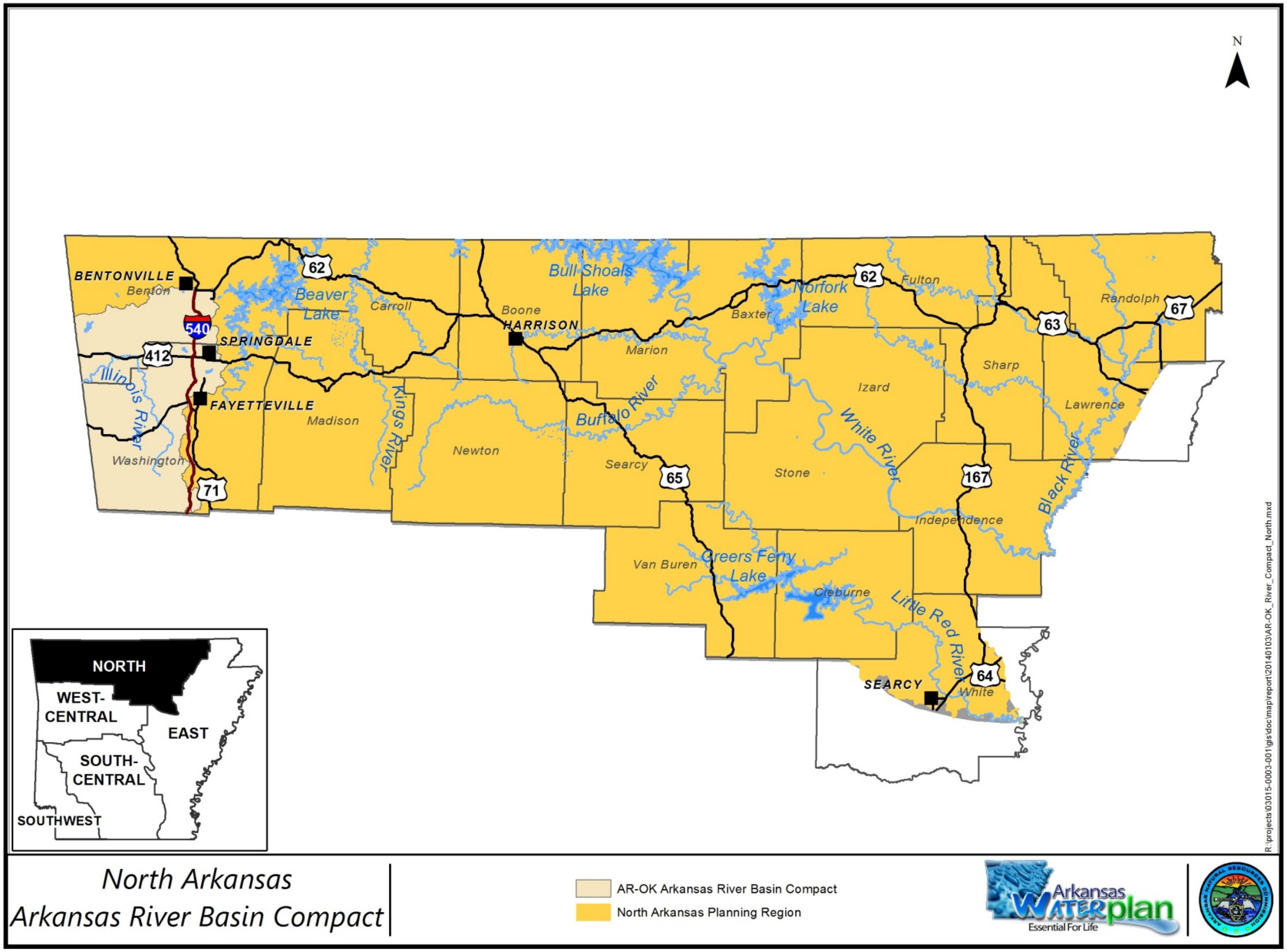

Figure 6.3. Sub-basins of the Arkansas River Basin Compact within the NAWRPR

long as the annual yield is not depleted more than 60% (Arkansas River Compact Committee 1970).

6.1.7.2 Fayetteville Shale Best Management Practices

A team consisting of multiple agencies has developed BMPs for natural gas activities in the Fayetteville Shale area intended to protect natural resources, including water quality (USFWS 2007).

6.1.7.3 Non-Profit Organizations

There are several non-profit organizations that have active programs within the NAWRPR. These include The Nature Conservancy, The Illinois River Watershed Partnership, and the Walton Family Foundation.

The Nature Conservancy has been working since 1978 on their Ozark Highlands Karst Program. They have worked to clean up and protect caves as well as the creatures within them, specifically endangered bats and cavefish. They also have an Ozark Rivers Program that involves conservation work along the Little Red and Kings Rivers. They manage preserves along the Kings River and Crooked Creek, and at Bear Hollow Cave near Bella Vista and Baker Prairie near Harrison (The Nature Conservancy 2013).

The Illinois River Watershed Partnership (IRWP) is a group of individuals and local programs that works to better the Illinois River and its watershed. It has conservation, restoration, and water quality monitoring programs, and has partnered with other organizations such as the Walton Foundation to perform research as well as obtain and restore areas of land in the watershed. For example, the Walton Foundation gave a challenge grant to help create a watershed sanctuary at Cave Springs (IRWP 2013b).

Audubon Arkansas is a chapter of the National Abandon Society and works on conservation and restoration projects. It is helping to plan and implement a NPS pollution management program along the West Fork of the White River (Audubon Arkansas 2013, ANRC 2011b).

There are also a host of other groups that support conservation in the White and Illinois River Watersheds, including the Friends of the North Fork and White Rivers (Friends of the Rivers 2013) and the Arkansas Sierra Club (Arkansas Sierra Club 2011).

6.2 Institutional Framework

Governmental responsibility for water resources management in the NAWRPR is split among many agencies on three levels (federal, state, and local). As a result, management of water resources in the NAWRPR can require coordination among a number of government entities. In addition, there are a number of Non-profit organizations that participate in water resources management in the planning region.

6.2.1 Federal Agencies

There are 16 federal agencies involved in water resources management in the NAWRPR. These federal agencies are listed in Table 6.18, along with their respective activities in this planning region.

Table 6.18. Federal agencies with water resources-related responsibilities in the NAWRPR.

Federal Agency	Responsibility in Arkansas
EPA	• Oversees state agencies in implementation of management and funding programs under o Clean Water Act, o Safe Drinking Water Act, o RCRA, o Superfund, o Federal Insecticide, Fungicide, and Rodenticide Act, and o Surface Mining Control and Reclamation Act • Conducts TMDL studies and other water quality studies in the NAWRPR • Implements programs under the Toxic Substances Control Act
Federal Energy Regulatory Commission	Oversees environmental matters related to natural gas and hydropower projects in the NAWRPR
FEMA	Prepares flood hazard maps for the region and encourages local governments to guide development decisions away from defined flood hazard risk areas through participation in the National Flood Insurance Program
HUD	Provides funding for water and wastewater infrastructure improvements
NOAA	Participates in monitoring precipitation and climate in the NAWRPR

Table 6.18. Federal agencies with water resources-related responsibilities in the NAWRPR (continued).

Federal Agency	Responsibility in Arkansas

NRCS National Water Management Center	• Located in Little Rock
	• Serves as a water resources information exchange
	• Provides support and training related to
	  ○ environmental compliance,
	  ○ hydrology and hydraulics,
	  ○ stream geomorphology and restoration,
	  ○ water quality and quantity,
	  ○ watershed and dam rehabilitation, and
	  ○ technology outreach

Southwestern Power Administration	Markets and delivers hydroelectric power produced at USACE hydropower projects in the NAWRPR
USACE	• Manages federal water, flood control, and hydropower projects in the NAWRPR • Implements sections of the Clean Water Act related to impacts to navigable waters and wetlands • Constructs flood control, irrigation, and water supply projects authorized by the Water Resources Development Act • Conducts water resources studies • Oversees dam safety for federal dams
USDA	• Conducts the Census of Agriculture • Conducts the Natural Resources Inventory • Manages Conservation Effects Assessment Projects (watershed and regional)
USDA Farm Services Agency	Implements the Conservation Reserve Program for erosion control and habitat restoration in the NAWRPR
USFS	• Manages the Ozark National Forest and associated surface waters • Forest management incentive programs • Participates in forest inventory • Manages Urban and Community Forestry Program
NRCS	• Implements over 20 Farm Bill erosion control and habitat restoration funding and technical assistance programs in the NAWRPR • Appraises the status and trends of soil, water, and related resources on non-federal land in the state and assesses their capability to meet present and future demands
USDA Rural Development	• Implements USDA rural utilities financial assistance programs
USDI National Park Service	• Manages the two national parks within the NAWRPR (Buffalo National River and Pea Ridge National Military Park), and their associated water resources • Provides funds for land and water conservation projects

USFWS	• Implements the Endangered Species Act and programs to
	  ○ Promote management of ecosystems,
	  ○ Promote conservation of migratory birds,
	  ○ Promote preservation of wildlife habitat,
	  ○ Promote restoration of fisheries,
	  ○ Combat invasive species, and
	  ○ Promote international wildlife conservation
	• Manages two national wildlife refuges in the NAWRPR
	• Conducts the National Wetland Inventory
	• Oversees state wildlife planning through the State Wildlife Grant Program

Table 6.18. Federal agencies with water resources-related responsibilities in the NAWRPR (continued).

Federal Agency	Responsibility in Arkansas
USGS	• Flow and stage monitoring of rivers and streams • Groundwater level monitoring • Water quality monitoring • Groundwater modeling • Water quality modeling • National Water Quality Assessment Program • Water data storage and management

6.2.2 Arkansas Agencies

There are over 20 Arkansas agencies involved in water resources management in the NAWRPR. These state agencies are listed in Table 6.19, along with a description of their water resources management responsibilities within the planning region.

Table 6.19. Arkansas agencies and entities with responsibilities related to water resources in the NAWRPR.

State Entity	Responsibility
ADEQ	Implements state water quality policy and the Clean Water Act NPDES program Develops and enforces water quality standards Investigates citizen complaints regarding water pollution Oversees solid waste management Operates the hazardous waste management program Manages contaminated site clean-up and redevelopment programs Develops and enforces mining and mine site reclamation regulations Manages the storage tank regulation program Permits no-discharge facilities and underground injection operations Water quality monitoring and assessment

Table 6.19. Arkansas agencies and entities with responsibilities related to water resources in the NAWRPR (continued).

State Entity	Responsibility
ANRC	• Regulates, permits, and tracks water use and dam construction • Monitors climate • Administers federal water resources funding programs • Prepares water resources and nonpoint source pollution management plans • Develops and maintains mitigation banking and restoration incentive programs for aquatic resources • Supports conservation districts • Registers poultry feeding operations • Certifies nutrient management planners and applicators • Promotes public health and safety and minimize flood losses through o training, o education, o technical assistance in floodplain management, and o accrediting floodplain administrators
Arkansas Department of Health (ADH)	• Regulates public water supply systems • Implements the Safe Drinking Water Act source water protection programs • Issues fish consumption advisories • Implements state health rules and regulations that apply to water resources • Regulates septic tanks and licenses septic tank cleaners • outdoor bathing and swimming • Implements state marine sanitation program
Arkansas Department of Parks and Tourism	• Manages the 9 state parks and associated water resources • Prepares comprehensive outdoor recreation plan • Manages outdoor recreation grant program
Arkansas Forestry Commission	• Provides guidelines for protection of water resources in forestry operations • Monitors use of forestry BMPs • Participates in forest inventory • Implements forest management incentive programs • Implements Urban and Community Forestry program • Designates and manages state forests for a variety of purposes, including o watershed protection o erosion and flood control

Table 6.19. Arkansas agencies and entities with responsibilities related to water resources in the NAWRPR (continued).

State Entity	Responsibility

Arkansas Game and Fish Commission (AGFC)	• Manages protection, conservation and preservation of various species of fish and wildlife in Arkansas through
	  ○ habitat management,
	  ○ wildlife management areas,
	  ○ fish stocking,
	  ○ hunting and fishing regulations, and
	  ○ education and outreach programs
	• Prepares state Wildlife Action Plan
	• Implements conservation grant program
	• Manages 16 lakes in the NAWRPR

Arkansas Geological Survey	• Participates in research of, and provides information and education about, state water resources • Mapping • Water well construction records
Arkansas Livestock and Poultry Commission	Regulates disposal of livestock carcasses
Arkansas Multi-agency Wetland Planning Team	Developed the State Wetland Strategy and is the lead for developing state numeric nutrient criteria for wetlands
Military Department Arkansas National Guard	Manages land and surface water resources within the boundaries of Camp Robinson
Arkansas Natural Heritage Commission (ANHC)	• Surveys and conducts research on natural communities in the state • Acquires natural areas for preservation • Manages the Arkansas Natural and Scenic Rivers system

Arkansas Oil and Gas Commission	• Provides technical assistance related to protection of water resources from wastes associated with production of
	  ○ oil,
	  ○ natural gas, and
	  ○ brine
	• Issues permits for drilling and operation of
	  ○ oil, natural gas, and brine production wells
	  ○ injection and disposal wells

Table 6.19. Arkansas agencies and entities with responsibilities related to water resources in the NAWRPR (continued).

State Entity	Responsibility
Arkansas Pollution Control and Ecology Commission (APCEC)	Environmental policy-making body for the state
Arkansas Public Service Commission	Regulates rates and services of private water utilities, as well as utilities water crossings
Arkansas State Board of Health	Promulgates health rules and regulations for the state
Arkansas State Highway and Transportation Department (AHTD)	• Hazardous waste transportation permits • Stormwater management • Develops and implements construction BMPs

Arkansas State Plant Board	Implements
	• Insecticide, Fungicide, and Rodenticide Act programs,
	  ○ pesticide registration
	  ○ user and applicator training
	  ○ dealer licensing
	• state pesticide management plan for groundwater protection,
	• groundwater quality monitoring, and
	• climate/weather monitoring

Arkansas Water Well Construction Commission	• Regulates development of groundwater through licensing water well contractors and registering drillers and pump installers • Regulates specifications for construction of water wells • Maintains water well construction records
Arkansas Waterways Commission	Studies and promotes navigable waterways for transportation and economic development
U of A Cooperative Extension Service	Provides technical assistance to Arkansans related to water conservation, and protection and restoration of water quality
U of A Water Resources Center	Participates in research related to water resources, and in water resources management projects

6.2.3 Federal-State Organizations

There are at least three federal-state organizations involved in water resources management in the NAWRPR:

- Arkansas-Oklahoma Arkansas River Compact Commission,
- Arkansas Conservation Partnership, and
- Arkansas Watershed Advisory Group.

The Arkansas-Oklahoma Arkansas River Compact Commission administers the Arkansas-Oklahoma Arkansas River Compact, which applies to Spavinaw Creek and Illinois River (see Section 6.1.7.1). The commission is made up of three representatives each from Arkansas and Oklahoma, the director of the state water agency and two residents appointed by the state governor, as well as one federal representative, appointed by the US president (Arkansas River Compact Committee 1970).

The Arkansas Conservation Partnership supports locally-led natural resources conservation through coordination of education, financial, and technical assistance to landowners. Water resources and implementation of Farm Bill programs are two of the six natural resource issues that are the focus of the partnership. Members of the partnership include the NCRS and other federal agencies, as well as ANRC, Arkansas Association of Conservation Districts, U of A Cooperative Extension, U of A at Pine Bluff, and Arkansas Forestry Commission. This partnership was formed in 1992 (ANRC 2011b, Cooperative Conservation America n.d.).

The Arkansas Watershed Advisory Group (AWAG) provides technical assistance to form local watershed groups, hosts an annual water quality conference, and facilitates quarterly discussions of voluntary water quality management approaches. AWAG is a consortium of federal and state agencies with private citizens (ANRC 2011b).

6.2.4 Regional and Local Entities

There are numerous regional and local entities in the NAWRPR that are involved in activities related to water resources management. Examples of the types of local and regional entities present in this planning region are shown in Table 6.20, along with descriptions of their activities related to water resources management.

Table 6.20. Some of the regional and local entities involved in water resources management in the NAWRPR.

Regional or Local Entity	Water Resources Involvement
Local Conservation Districts	Work with state and federal agencies to implements measures for the control of erosion and flooding, and conservation of soil and water resources
County Government	Responsible for unincorporated areas, sometimes including floodplain management and zoning
Drainage Districts	Usually created by circuit court order to plan, construct, and maintain a system to drain lands
Improvement Districts	Created by circuit court order to implement federal projects for improvement of any river, tributary, or stream bordering the state
Irrigation Districts	Created by circuit court order to distribute water resources
Regional Planning and Economic Development Districts	• Water supply and wastewater infrastructure improvements • Assist Regional Solid Waste Management Districts
Regional Solid Waste Management Districts	Manage collection, disposal, and recycling of solid waste
Regional Water Distribution Districts (e.g. Beaver Water District)	Public nonprofit organizations for distribution of water from USACE water projects (e.g. Beaver Lake)
Northwest Arkansas Regional Planning Commission	Stormwater management education and outreach
Universities	Water resources and management research, education, and outreach
Water districts and associations	• Water supply planning and management • Supply water and wastewater services

6.2.5 Non-Profit Organizations

There are several non-profit organizations that conduct activities in the NAWRPR that are related to water resources management. Examples of these organizations are listed in Table 6.21 with a description of their water resources related activities in the planning region.

Table 6.21. Non-profit organizations involved in water resources management in the NAWRPR.

Non-profit Organization	Water Resources Involvement
The Nature Conservancy	Ozark Highlands Karst Program Ozark Rivers Program Kings River Preserve Crooked Creek Preserve Bear Hollow Cave Preserve
Audubon Arkansas	West Fork-White River NPS Management Program
Ducks Unlimited	Conservation and restoration of aquatic habitat for waterfowl
Stream teams	Water quality monitoring, stream bank rehab, restoration of fish habitat
Watershed organizations	Water resources planning, Sponsor for water quality and quantity projects
Arkansas Wildlife Federation	Conservation of aquatic habitat for fish and wildlife
Arkansas Farm Bureau	Advocate for agriculture
Arkansas Environmental Federation	Advocate for Industry

6.2.6 Institutional Interactions in Water Resources Management

As noted at the beginning of this section, water resources management in the NAWRPR involves numerous entities at multiple scales. Examples of the interactions among federal, state, and local entities that occur in water resources management in the NAWRPR are presented in Table 6.22.

Table 6.22. Examples of interactions of federal, state, and local entities in water resources management within the NAWRPR.

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
Water use registration	USGS (houses registration database)	ANRC (program lead)	Water utilities, irrigation districts (water withdrawers)
Dam safety	USACE (federal dams) FEMA (oversight)	ANRC (program lead), AGFC (dam builder), Arkansas Department of Parks and Tourism (dam builder)	Water utilities, municipalities, counties (dam builders)

Table 6.22. Examples of interactions of federal, state, and local entities in water resources management within the NAWRPR (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	**State Entities**	**Regional or Local Entities**
State climate monitoring	NOAA National Weather Service, NOAA National Climatic Data Center, USGS (precipitation monitoring), USACE (climate monitoring)	ANRC (state climatologist), Arkansas State Plant Board (monitoring)	Community Collaborative Rain, Hail & Snow Network
Safe Drinking Water Act funding	EPA (funding)	ANRC (program lead)	Water utilities, municipalities/ communities, water districts
Water Resources Conservation Tax Incentives	NRCS	ANRC (program lead), U of A Cooperative Extension Service	Conservation districts
Conservation district grants program	None	ANRC (program lead)	Conservation districts
Community development block water and wastewater grants	HUD (funding)	ANRC (program lead), Arkansas Economic Development Commission	Water utilities, wastewater utilities, water districts, sewer districts
Floodplain management	FEMA	ANRC (certification)	Levee districts, counties, and municipalities
Nonpoint source pollution management	EPA (funding), NRCS (conservation programs), USFS(BMPs), The Nature Conservancy (projects), USDA Farm Services Agency (conservation program)	ANRC (program lead), Universities, Arkansas Water Resources Center, Audubon Arkansas, U of A Cooperative Extension Service, Arkansas Farm Bureau, ADEQ (TMDLs)	Watershed organizations, Conservative districts, Water districts, Stream teams, Nonprofit organizations
Clean Water Act funding program (including nonpoint source and clean water revolving loan fund)	EPA (funding)	ANRC (program lead)	Watershed organizations, sewer districts, municipalities, Nonprofit organizations
Wetland and riparian zone tax credit program	None	ANRC (program lead)	Watershed organizations
Wetland and stream mitigation	USACE (lead)	ANRC (state mitigation bank), AHTD, AGFC, ADEQ, ANHC	Local conservation districts, Nonprofit organizations, Watershed organizations
Non-riparian water use permitting	None	ANRC (program lead)	Water utilities
Arkansas Recovery Act water and wastewater funding	Recovery Accountability and Transparency Board	ANRC (program lead)	Water utilities, wastewater utilities, water districts, sewer districts
State water utility funding	None	ANRC (program lead)	Water utilities, water districts
State wastewater utility funding	None	ANRC (program lead)	Wastewater utilities, sewer districts
NPDES discharge permits	EPA (oversight, guidance)	ADEQ (program lead)	Dischargers

Table 6.22. Examples of interactions of federal, state, and local entities in water resources management within the NAWRPR (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	**State Entities**	**Regional or Local Entities**
Underground injection control	EPA	ADEQ (program lead), Arkansas Oil and Gas Commission (program lead)	Dischargers
Wastewater pretreatment program	EPA	ADEQ (program lead)	Dischargers
Water quality standards	EPA	APCEC (regulations), ADEQ (implementation, enforcement), ANRC (groundwater standards), Multi-agency Wetland Planning Team (nutrient criteria for wetlands)	Local governments, regulated entities, interest groups
Water quality assessment	EPA (oversight, guidance), USGS (data), USACE (data)	ADEQ (implementation)	None
TMDLs	EPA (oversight, guidance), USGS (data), USACE (data)	ADEQ (program lead)	None
Storage tank regulation	EPA	ADEQ (program lead)	None
Solid waste management	EPA (oversight)	ADEQ (program lead)	Regional solid waste management districts
Landfill post-closure trust fund	None	ADEQ (program lead)	Regional solid waste management districts
Hazardous waste management	EPA	ADEQ (program lead), AHTD (transport)	Interest groups
Remedial action trust fund	None	ADEQ	Interest groups
Brownfields	EPA	ADEQ	Municipalities
Superfund	EPA	ADEQ	Interest groups
Mining reclamation	US Department of the Interior	ADEQ	Interest groups
Water quality monitoring	EPA (oversight, studies), USGS (monitoring, studies), USACE (monitoring, studies)	ADEQ, ANRC, U of A Arkansas Water Resources Center (studies), AGFC (stream teams), Arkansas State Plant Board (groundwater monitoring)	Stream teams (monitoring), water utilities (monitoring)
Fish tissue sampling	None	ADEQ (program lead), ADH (consumption advisories), AGFC (sampling)	None
Stormwater management	EPA	ADEQ, U of A Cooperative Extension Service	Counties, municipalities
Spill prevention	EPA	ADEQ	None
Finished drinking water criteria	EPA	ADH	Water utilities, water districts
Source Water Protection	EPA	ADH, Arkansas Water Well Construction Commission	Water utilities (planning)
Consumer Information	EPA	ADH	Water utilities

Table 6.22. Examples of interactions of federal, state, and local entities in water resources management within the NAWRPR (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	**State Entities**	**Regional or Local Entities**
Regulation of drinking water utilities	EPA	ADH, Arkansas Public Service Commission	Water utilities
Pesticide registration, labeling and classification	EPA	Arkansas State Plant Board	Pesticide distributors and users
Community Forestry	USFS	Arkansas Forestry Commission, Arkansas Urban Forestry Council	Municipalities
Forest stewardship	USFS, USDA Farm Services Agency, NRCS	Arkansas Forestry Commission, AGFC, ANRC, Arkansas Historic Preservation Program, U of A Cooperative Extension Service, Arkansas Natural Heritage Commission	Landowners
Forest Legacy	USFS(funding), Land Trust Alliance	Arkansas Forestry Commission	Landowners
State parks	USACE, National Park Service (funding)	Arkansas Department of Parks and Tourism	Northeast chapter Arkansas Master Naturalists
Stream teams	None	AGFC	North Central and Northwest chapters Arkansas Master Naturalists, IRWP, stream teams
Wildlife management areas, refuges	USFWS	AGFC	Volunteers, nonprofit organizations
Fishing and boating programs	USACE, USFWS	AGFC, Arkansas Department of Parks and Tourism	None
Pollution prevention program	EPA	ADEQ	None
Federal irrigation projects	USACE Little Rock District, NRCS	ANRC	Irrigation Districts, Regional Water Distribution Districts
Wild/natural and scenic rivers systems	USFS, USDI National Park Service	Arkansas Natural and Scenic Rivers Commission, ANHC, ADEQ	Nonprofit organizations

7.0 REFERENCES

Adamski, J. C. 2000. *Geochemistry of the Springfield Plateau aquifer of the Ozarks Plateaus Province in Arkansas, Kansas, Missouri, and Oklahoma, USA.* Hydrogeological Processes,: 849-866.

Adamski, J. C., J. C. Petersen, D. A. Freiwald, and J. V. Davis. 1995. *Environmental and hydrologic setting of the Ozark Plateaus study unit, Arkansas, Kansas, Missouri, and Oklahoma.* U.S. Geological Survey Water-Resources Investigations 94-4022, USGS.

ADEQ. 2004. *2004 Integrated Water Quality Monitoring and Assessment Report.* Little Rock, AR: ADEQ.

ADEQ. 2008. *Integrated Water Quality Monitoring and Assessment Report - 2008.* Prepared pursuant to Sections 305(b) and 303(d) of the Federal Water Pollution Control Act, Little Rock: ADEQ.

ADEQ. 2009. *2008 List of Impaired Waterbodies (303(d) List).* Little Rock, AR: Arkansas Department of Environmental Quality, Water Division.

ADEQ. 2011a. *Timeline of Historical Events of Arkansas Solid Waste Management, 1971 - 2011.* Little Rock: Arkansas Department of Environmental Quality.

ADEQ.2011b. *Regional Solid Waste Management Boards (RSWMB).* http://www.adeq.state.ar.us/solwaste/regional_boards_sql.asp (accessed September 27, 2013).

ADEQ. 2012a. *Arkansas Hazardous Waste Generators Facility Summary.* http://www.adeq.state.ar.us/hazwaste/rcra2/facil_sum.aspx (accessed September 27, 2013).

ADEQ. 2012b. *State of Arkansas Nutrient Criteria Development Plan.* Little Rock, AR: ADEQ.

ADEQ. 2012c. *Integrated Water Quality Monitoring and Assessment Report 2012.* Little Rock: ADEQ,

ADEQ.2013a. *NPDES Industrial Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/industrial/npdes_industrial_permit_tracking.asp (accessed July 10, 2013).

ADEQ. 2013b. *NPDES Construction Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/construction/npdes_constructionstormwater_permit_tracking.asp (accessed July 2, 2013).

ADEQ. 2013c. *NPDES MS4 Small Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/ms4/npdes_ms4_stormwater_permit_tracking.asp (accessed July 2, 2013).

ADEQ. 2013d. "ADEQ Facility and Permit Summary (PDS)." *Arkansas Department of Environmental Quality.* http://www.adeq.state.ar.us/home/pdssql/pds.aspx (accessed September 27, 2013).

ADEQ. 2013e. *Surface Water Quality Monitoring Station Data Search Page.* http://www.adeq.state.ar.us/techsvs/water_quality/water_quality_station.asp (accessed October 1, 2013).

ADEQ, ANRC, Oklahoma Department of Environmental Quality, Oklahoma Water Resources Board. 2013. "Second Statement of Joint Principles and Actions." *American College of Environmental Lawyers Blog.* http://www.acoel.org/file.axd?file=2013%2F4%2Fscan_attachment249.pdf (accessed December 2013).

ADH. 2009. Proposed Ozark regional water supplier scores big with stimulus funding. Arkansas Drinking Water Update. 22(4):1.

ADH. 2011. *Arkansas Marine Sanitation Program*. Marine Sanitation. http://www.healthy.arkansas.gov/programsServices/environmentalHealth/MarineSanitation/Pages/MarineSanitation.aspx (accessed July 26, 2013).

ADH. 2012. *Arkansas Public Water System Compliance Summary*. Arkansas Department of Health, Environmental Health, Engineering, Reports and Forms. http://www.healthy.arkansas.gov/programsServices/environmentalHealth/Engineering/Documents/Reports/Compliance/ComplianceSummary.pdf (accessed July 30, 2013).

ADH. n.d. *Drinking Water Information for Arkansans.* http://www.healthy.arkansas.gov/eng/autoupdates/pwslist0.htm (accessed March 20, 2013).

ADH, AGFC, ADEQ. 2011. *Fish Consumption Notice - Mercury in Fish.* Little Rock, AR: Department of Health.

ADPCE. 1990. *Arkansas Water Quality Inventory Report.* Little Rock, AR: Arkansas Department of Pollution Control and Ecology.

AGFC. 2008. *Bull Shoals and Norfork Tailwaters Management Plan 2008-2013.* Little Rock:AGFC.

AGFC. 2009.*Wildlife Management Area Boundary (polygon), Arkansas*. Geocommons. http://geocommons.com/overlays/18197 (accessed April 25, 2013).

AGFC. 2011a. *Where to Fish.* http://www.agfc.com/fishing/Pages/FishingWheretofish.aspx (accessed December 17, 2013).

AGFC. 2011b. *Species and Habitats - Endangered Species.* http://www.agfc.com/species/Pages/SpeciesEndangered.aspx (accessed December 18, 2013).

AGFC. 2013a. *The Great Outdoors, A $1.8 Billion Business in Arkansas.* brochure, Little Rock: Arkansas Game and Fish Commission.

AGFC. 2013b. *The Handbook of Arkansas Boating Laws and Responsibilities.* Dallas, TX: Boat Ed.

AGFC. 2013c. *Arkansas Trout Fishing Guidebook 2013*. Little Rock: AGFC.

AHTD. 2006. *Public Land Boundaries Database*. Little Rock, AR: AHTD.

Anderson, J.E. (ed.). 2006. *Arkansas Wildlife Action Plan.* Little Rock: Arkansas Game and Fish Commission.

ANHC. 2010. *Natural Areas.* http://www.naturalheritage.com/natural-area/map.aspx (accessed September 19, 2013).

ANHC. 2012. *River Designations*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2623 (accessed October 2013).

ANHC. 2013. *Rare Species Search Engine: Find Arkansas Endangered Species.* http://www.naturalheritage.com/research-data/rarespecies-search.aspx (accessed July 2013).

ANRC. 2008. *Arkansas ground water protection and management report for 2008, a supplement to the Arkansas Water Plan.* ANRC.

ANRC. 2009. *Rules for Utilization of Surface Water, Title 3.* Little Rock: Arkansas Natural Resources Commission.

ANRC. 2011a. *Water Law in Arkansas.* Little Rock: Arkansas Natural Resources Commission.

ANRC. 2011b. *Arkansas 2011-2016 NPS Pollution Management Plan.* Little Rock, AR: ANRC.

ANRC. 2013. *Arkansas Ground-Water Protection and Management Report for 2012.* Little Rock: Arkansas Natural Resources Commission.

APCEC. 2011. *Regulation No. 2, Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas.* Little Rock: Arkansas Pollution Control and Ecology Commission.

Arkansas Department of Emergency Management. 2010. *All Hazard Mitigation Plan, State of Arkansas.* North Little Rock, AR: Arkansas Department of Emergency Management.

Arkansas Department of Parks and Tourism. 1991. *1990 Arkansas Travel and Tourism Report.* Little Rock, AR: Arkansas Department of Parks and Tourism.

Arkansas Department of Parks and Tourism. 2012. *Annual Report Executive Summary 2012.* Arkansas.com - Resarch and Information Services. http://www.arkansas.com/!userfiles/editor/docs/apt-annual-report-financials-2012.pdf (accessed December 2, 2013).

Arkansas Department of Parks and Tourism 2013a. *Arkansas Heritage Trail, Trail of Tears.* http://www.arkansasheritagetrails.com/tears/ (accessed April 30, 2013).

Arkansas Department of Parks and Tourism. 2013b. *Little Red River.* http://www.arkansas.com/outdoors/canoeing-rafting-kayaking/little-red-river.aspx (accessed September 18, 2013).

Arkansas Multi-Agency Wetland Planning Team. 2001a. *Clasification of Arkansas Wetlands.* http://www.mawpt.org/wetlands/classification/classes.asp (accessed September 19, 2013).

Arkansas Multi-Agency Wetland Planning Team. 2001b. *Wetlands in Arkansas.* http://www.mawpt.org/wetlands/ (accessed September 19, 2013).

Arkansas River Compact Committee. 1970. *Arkansas River Basin Compact, Arkansas-Oklahoma, 1970.* Austin, TX: Office of Representaive, United States.

Arkansas Sierra Club. 2011. *Arkansas Sierra Club.* http://arkansas.sierraclub.org/Default.htm (accessed October 4, 2013).

Arkansas Water. 2013. *ArkansasWater.org.* http://arkansaswater.org/index.php?option=com_content&view=article&id=29&Itemid=2 (accessed June 25, 2013).

Arkansas Waterways Commission. 2012. *Arkansas Waterways Commission - White River.* http://waterways.arkansas.gov/rivers/Pages/whiteRiver.aspx (accessed September 12, 2013).

Association of Arkansas Counties. 2013. *Association of Arkansas Counties.* http://www.arcounties.org/ (accessed October 16, 2013).

ASWCC. 1981.*Arkansas State Water Plan, Lakes of Arkansas.* Little Rock: Arkansas Soil and Water Conservation Commission.

ASWCC. 1987. *Arkansas State Water Plan, Upper White River Basin.* Little Rock, AR: Little Rock District USACE.

ASWCC. 1988. *Arkansas State Water Plan, Eastern Arkansas Basin.* Little Rock: Arkansas Soil and Water Conservation Commission

ASWCC. 1990. *Arkansas Water Plan Executive Summary.* Little Rock: Arkansas Soil and Water Conservation Commission.

Audubon Arkansas. 2013. *About Audobon Arkansas.* http://ar.audubon.org/about-audubon-arkansas (accessed September 30, 2013).

Benton County RSWMD. 2011. *Regional Solid Waste Management Plan.* Bentonville, AR: Benton County Regional Solid Waste Management District.

Berry, Earl. 1977. *The History of Marion County, Chapter 3, Early Trails and Roads.* http://www.argenweb.net/marion/history/history-marion-co-ar-03-roads.html (accessed April 30, 2013).

Bolton, S. Charles. 2012. *Louisiana Purchase through Early Statehood, 1803 through 1860.* http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Boston Mountain RSWMD. 2011. *Minimum Requirements for Regional Solid Waste Management Plans 2011 Revision.* Prairie Grove, AR: Boston Mountain Regional Solid Waste Management District.

Brahana, J. V. 1997. *Rationale and methodology for approximating spring-basin boundaries in the mantled karst of the Springfield Plateau, northwestern Arkansas*. The Engineering Geology and Hydrogeology of Karst Terranes. Springfield, MO, 77-82.

Brahana, J. V., and R. K. Davis. 1998. *Methodology for delineating ground-water recharge areas of springs in the carbonate-rock terrane of northwest Arkansas, and application to five separate spring basins within the region.* Final report for tasks 94-300 and 95-300 to

Arkansas Soil and Water Conservation Commission for USEPA, Project # C9996103-02 and C9996102-03, EPA.

Brahana, J. V., P. D. Hays, T. M. Kresse, T. J. Sauer, and G. P. Stanton. 1999. *The Savoy experimental watershed; early lessons for hydrogeologic modeling from a well-characterized karst research siteThe Savoy experimental watershed; early lessons for hydrogeologic modeling from a well-characterized karst research site.* Karst Waters Institute Special Publication 5. Charlottesville, VA: Karst Waters Institute, 247-254.

Branyan, Scott. 2013. *Encyclopedia of Arkansas History & Culture - Beaver Dam and lake.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=5877 (accessed July 29, 2013).

Brown, Arthur V., Madeleine M. Lyttle, and Kristine B. Brown. 1998. *Impacts of Gravel Mining on Gravel Bed Streams.* Transactions of the American Fisheries Society: 979-994.

Bryant, C. T., A. H. Ludwig, and E. E. Morris. 1985. *Ground-water Problems in Arkansas.* Water Resources Investigations Report 85-4010, Little Rock, AR: US Geological Survey.

Cavaneau, Jerry. 2012. *Encyclopedia of Arkansas History & Culture - Black River.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=4120 (accessed September 18, 2013).

Center for Business and Economic Research, U of A. 2012. *Revisiting the Economic Impact of the Natural Gas Activity in the Fayetteville Shale: 2008-2012.* Fayetteville, AR: University of Arkansas.

Clark, B. R., R. M. Hart, and J. J. Gurdak. 2011. *Groundwater availability of the Mississippi Embayment.* U.S. Geological Survey Scientific Investigations Report 2012-5258, USGS.

Clark, Caven. 2013. *National Park Service - Buffalo National River Tourism Creates $38,000,000 in Local Economic Benefit.* http://www.nps.gov/buff/parknews/buffalo-national-river-tourism.htm (accessed September 12, 2013).

Clark, Patterson, and Laris Karklis. 2012. *USDA Upgrades Plant Hardiness Zone Map.* Washington Post. http://www.washingtonpost.com/wp-srv/special/local/planthardinesszones/index.html (accessed March 2013).

Cooperative Conservation America. n.d. *Cooperative Conservation Case Study, Arkansas Conservation Partnership.* http://www.cooperativeconservation.org/viewproject.asp?pid=103 (accessed July 29, 2013).

Cothren, Zac. 2011. *J.B. Hunt Transport Services, Inc.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=2138 (accessed December 17, 2013).

Cothren, Zackery A. 2013. *The Encylopedia of Arkansas History & Culture - Greers Ferry Dam and Lake.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2320 (accessed September 12, 2013).

Davis, R. K., J. V. Brahana, and J. S. Johnston. 2000. *Ground water in northwest Arkansas; minimizing nutrient contamination from non-point sources in karst terrane.* no. MSC-288, Fayetteville, AR: Arkansas Water Resources Center.

Davis, Scott F., and Rob Moritz. 2013. *Impasse is over Arkansas, Oklahoma agree to sign water quality pact.* The Morning News.

DeBlack, Thomas A. 2012. *Civil War through Reconstruction, 1861 through 1874.* http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Department of Arkansas Heritage. 2013. *Discover Arkansas History: Regions - Ozark Mountains.* http://www.arkansasheritage.com/discover/natural_environments/regions/ozarks.aspx (accessed July 24, 2013).

EPA. 2008.*Handbook for Developing Watershed TMDLs.* Washington, D.C.: USEPA Office of Wetlands, Oceans, & Watersheds.

EPA. 2010. *Ecoregion Maps and GIS Resources.* http://www.epa.gov/wed/pages/ecoregions/ecoregions.htm (accessed September 16, 2013).

EPA. 2012a. *Landfills.* http://www.epa.gov/osw/nonhaz/municipal/landfill.htm (accessed June 3, 2013).

EPA. 2012b. *Large Quantity Generators.* http://www.epa.gov/osw/hazard/generation/lqg.htm (accessed July 9, 2013).

EPA. 2012c. *Small Quantity Generators.* http://www.epa.gov/osw/hazard/generation/sqg/index.htm (accessed July 9, 2013).

EPA. 2012d. *Arkansas: Buffalo National River Watershed Partnerships: Partners Improve Swine Waste Management.* http://water.epa.gov/polwaste/nps/success319/Section319III_AR.cfm (accessed October 22, 2013).

EPA. 2012e. *Basic Information.* http://water.epa.gov/scitech/swguidance/standards/about_index.cfm (accessed June 11, 2013).

EPA. 2013a. *Illinois River Watershed.* http://www.epa.gov/region6/water/npdes/illinoisriverwatershed/ (accessed October 22, 2013).

EPA. 2013b. *Arkwood, Inc. - Arkansas*. Arkasnas Site Status Summaries. http://www.epa.gov/earth1r6/6sf/pdffiles/arkwood-ar.pdf (accessed October 4, 2013).

EPA. 2013c. *Consumer Confidence Reports.* http://water.epa.gov/lawsregs/rulesregs/sdwa/ccr/index.cfm (accessed June 11, 2013).

EPA. 2013d. *Nutrient Policy Data, What EPA is Doing.* http://www2.epa.gov/nutrient-policy-data/what-epa-doing (accessed July 12, 2013).

EPA. 2013e. *Compensatory Mitigation.* http://water.epa.gov/lawsregs/guidance/wetlands/wetlandsmitigation_index.cfm (accessed June 17, 2013).

EPA. 2013f. "EPA Information Related to the American Recovery and Reinvestment Act of 2009." EPA. July 12, 2013. http://www.epa.gov/recovery/basic.html (accessed April 1, 2014).

EPA. n.d. EPA Recovery Mapper. http://epamap17.epa.gov/arra/# (accessed April 2014).

Fanning, B. J. 1994. *Geospeleologic analysis of cave and karst development within the Boone-St. Joe Formations of Benton and Madison Counties.* MS Thesis, Fayetteville, AR: University of Arkansas.

FEMA. 2013a. "Arkansas Severe Storms and Flooding (DR-4143)." Federal Emergency Management Agency. September 4, 2013. http://www.fema.gov/disaster/4143 (accessed March 31, 2014).

FEMA. 2013b. *Federal Emergency Management Agency Community Status Book Report - Arkansas.* The National Flood Insurance Program Community Status Book. http://www.fema.gov/cis/AR.pdf (accessed October 4, 2013).

Filipek, Steve, William E. Keith, and John Giese. 1987. *The Status of the Instream Flow Issue in Arkansas*. Proceedings Arkansas Academy of Science Vol. 41: 43-48.

Friends of the Rivers. 2013. *Friends of the North Fork & White Rivers.* http://www.friendsoftherivers.org/ (accessed October 4, 2013).

Fry, J., et al. 2011. *Completion of the 2006 national land cover database for the conterminous United States.* PE&RS, Vol.77(9), 858-864.

Galloway, JM, BE Haggard, MT Meyers, and WR Green. 2005. *Occurence of Pharmaceuticals and Other Organic Wastewater Constituents in Selected Streams in Northern Arkansas, Scientific Investigations Report 2005-5140.* Reston, Va: USGS.

GCGW. 2008. *Arkansas Governor's Commission on Global Warning Final Report.* Little Rock: Arkansas Governor's Commission on Global Warming.

Gillip, J. A. 2007.*The effects of land-use change on water quality and speleogenesis in Ozark cave systems – a paired cave study of Civil War and Copperhead Caves, northwestern Arkansas.* MS Thesis, Fayetteville, AR: University of Arkansas.

Gillip, JA, JB Czarnecki, and DN Mugel. 2008. *Potentiometric Surfaces in the Springfield Plateau and Ozark Aquifers in Northwest Arkansas, Southeastern Kansas, Southwestern Missiour, and Northeastern Oklahoma, 2006, Scientific Investigations Report 2007-5253.* Reston, VA: USGS.

Golden Gate Weather Services. 2011. *Snowfall Monthly Normals (1981-2010); Source: National Climatic Data Center.* http://ggweather.com/normals/snow.html (accessed August 2, 2013).

Grant, Steve. 2013. *Tap Opens: Bull Shoals water now flows to 4 counties in north Arkansas.* KY3.

Haggard, Brian E. 2010. "Phosphorus concentrations, loads, and sources within the Illinois River drainage area, northwest Arkansas, 1997 - 2008." Journal of Environmental Quality 39(6), 2010: 2113-2120.

Haggard, Brian E, and J. Thad Scott. 2013. "Phosphorus concentrations have been declining in the Illinois River: Was it point sources, farm-level nutrient management, or what?" Waste to Worth: Spreading Science and Solutions. Denver, CO: Extension.

Hays, P. D., G. Stanton, and J. V. Brahana. 1998.*Unpublished report for Trout Spring Trout Farm.* Bella Vista.

Huddleston, Duane, Sammie Cantrell Rose, and Pat Taylor Wood. 1998. *Steamboats and Ferries on teh White River: A Heritage Revisited.* Fayetteville, AR: University of Arkansas Press.

Hutto, R. S., and D. S. Rains. 2011. *Geologic map of the Clinton Quadrangle, Van Buren County*. Arkansas Geological Commission: Maps & Data - Geological Maps - 1:24,000 Scale Quadrangleshttp://www.geology.ar.gov/maps_pdf/geologic/24k_maps/Clinton.pdf (accessed October 7, 2013).

Imes, J. L., and B. J. Smith. 1990. *Areal extent, stratigraphic relation, and geohydrologic properties of regional geohydrologic units in southern Missouri*. U.S. Geological Survey Hydrologic Investigations Atlas HA-711-I. USGS.

Imes, J. L., and L. F. Emmett. 1994. *Geohydrology of the Ozark Plateaus aquifer system in parts of Missouri, Arkansas, Oklahoma, and Kansas.* U.S. Geological Professional Paper 1414-D, USGS.

Interagency Wild and Scenic Rivers Council. n.d. *National Wild and Scenic Rivers Program Arkansas.* http://www.rivers.gov/arkansas.php (accessed October 2013).

IRWP. 2013a. *Watershed Map.* http://www.irwp.org/about-irwp/watershed-map/ (accessed September 18, 2013).

IRWP. 2013b. *About IRWP.* http://www.irwp.org/ (accessed 30 2013, September).

J.B. Hunt Transportation Services Inc. 2014. 2013 Notice of Annual Meeting, Proxy Statement and Annual Report. Lowell, Arkansas: J.B. Hunt Transportation Services, Inc.

Key, Joseph Patrick. 2012. *European Exploration and Settlement, 1541 through 1802*. The Ecyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2916&type=Time+Period&item=European+Exploration+and+Settlement+%281541+-+1802%29&parent=&grandparent= (accessed March 25, 2013).

Kings River Watershed Partnership. 2009. *The Landowever's Guide to Streamside Living*. Kings River Watershed Partnership: Publications. http://www.kingsriverwatershed.org/default_images/publications/KRWP_Landowner'sGuidetoStreamsideLiving3-13-09.pdf (accessed October 22, 2013).

Knierem, K., D. W. Pennington, and K. F. Steele. 2009. *Addendum to report: Ground water in northwest Arkansas; minimizing nutrient contamination from non-point sources in karst terrane.* Arkansas Natural Resources Commission.

Kresse, T. M, N. R Warner, P. D Hays, A. Down, A. Vengosh, and R. B Jackson. 2012. *Shallow groundwater quality and geochemistry in the Fayetteville Shale gas-production area, north-central Arkansas.* Scientific Investigations Report 2012-5273, Reston: USGS.

Kresse, T. M., et al. 2013. *Aquifers of Arkansas: protection, management, and hydrologic and geochemical characteristics of Arkansas' groundwater resources. USGS In Review* (USGS).

Kresse, Timothy M., Nathaniel R. Warner, Phillip D. Hays, Adrian Down, Avner Vengosh, and Robert B. Jackson. 2012. *Shallow Groundwater Quality and Geochemistry in the Fayetteville Shale Gas-production Area, North-central Arkansas, 2011*. Scientific Investigations Report 2012-5273, Reston: USGS.

Lamonds, A. G. 1972. *resources reconnaissance of the Ozark Plateaus Province, northern Arkansas.* U.S. Geological Survey Hydrologic Atlas: 383.

Lankford, George E. 2013. Batesville (Independence County). *Encyclopedia of Arkansas History and Culture.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=900 (accessed April 26, 2013).

Manger, W. L., and J. Lloyd. 2008. *An introduction to the geology of northwestern Arkansas*. University of Arkansas Department of Geosciences Icebreaker Field Trip Guide, 55.

Manger, W. L., D. L. Zachry, and M. L. Garrigan. 1988. *An introduction to the geology of northwestern Arkansas*. *The Compass*, 242-257.

McFarland, J. D. 2004. *Stratigraphic summary of Arkansas*. Arkansas Geological Commission Information Circular, 36-38.

McLeod, W.E. 1978. *Old Roads in North Arkansas.* http://www.couchgenweb.com/lawrence/military.htm (accessed April 30, 2013).

Miller, Shawna. 2006. *Water Management Plan for the Kings River Watershed, Northwest Arkansas & Southwest Missouri*, HUC: 1101001.

National Agricultural Law Center. 2012. *United States Farm Bills.* http://www.nationalaglawcenter.org/farmbills/ (accessed June 11, 2013).

National Park Service. 2013. *Buffalo National River - Direction.* http://www.nps.gov/buff/planyourvisit/directions.htm (accessed September 18, 2013).

NatureServe. 2002. *Number of Extince Species in Each State.* http://www.natureserve.org/consIssues/ivoryBilled_table1.htm (accessed December 19, 2013).

NOAA. 2012. *NOAA's Drought Information Center, the Palmer Drought Severity Index.* http://www.drought.noaa.gov/palmer.html (accessed June 12, 2013).

NOAA NCDC. 2013a. *Climate at a Glance.* http://www.ncdc.noaa.gov/cag/ (accessed August 2, 2013).

NOAA NCDC. 2013b. *Historical Palmer Drought Indices.* http://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers.php (accessed May 15, 2013).

NOAA NWS. 1982. *Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States.* NOAA Technical Report NWS 34, Washington D.C.: Unites States Department of Commerce.

NOAA NWS. 2013. *Little Rock, AR - Daily Climate Data.* http://www.srh.noaa.gov/lzk/?n=wxcntl3.htm (accessed December 19, 2013).

Northeast Arkansas RSWMD. 2011. *January1, 2011 Annual Update of the Year 2004 Solid Waste Management Plan.* Paragould, AR: Northeast Arkansas Regional Solid Waste Management District.

NRCS. 2010. *Migratory Bird Habitat Initiative.* http://www.nrcs.usda.gov/wps/portal/nrcs/detail/ar/programs/?cid=nrcs142p2_035196 (accessed December 10, 2013).

NRCS. 2012. *Arkansas Annual Report 2012*. NRCS Arkansas. http://www.ar.nrcs.usda.gov/news/annual_report_2012.html (accessed September 30, 2013).

NRCS. 2013. *Illinois River Sub-Basin and Eucha-Spavinaw Lake Watershed Initiative.* http://www.nrcs.usda.gov/wps/portal/nrcs/detail/ar/programs/?cid=nrcs142p2_034905 (accessed December 10, 2013).

NSTATE, LLC. 2013. *Arkansas Base and Elevation Maps.* http://www.netstate.com/states/geography/mapcom/ar_mapscom.htm (accessed September 16, 2013).

NWS Weather Forcast Office. 2011. *Event Summary - April 21-27, 2011, Heavy Rain, Record Flooding, and Severe Weather.* http://www.srh.noaa.gov/tsa/?n=weather-event_2011apr25 (accessed September 30, 2013).

Ogilvie, Craig. 1997. *Arkansas Media Room - Lakes Play Key Role in Arkansas Recreation.* http://www.arkansasmediaroom.com/news-releases/listings/display.aspx?id=239 (accessed September 12, 2013).

Ozark Mountain Regional Public Water Authority. n.d. *How the Project Came About.* http://www.ozarkmountainregionalpwa.org/project-history.html (accessed October 1, 2013).

Ozark Mountain RSWMD. 2011. *2011 Update to Ten Year Solid Waste Management District Plan for the Ozark Mountain Solid Waste District.* Harrison, AR: Ozark Mountain Regional Solid Waste Management District.

PRISM Climate Group. 2012. *United States Average Monthly or Annual Maximum and Minimum Temperatures, 1981-2010.* Corvallis, OR: Oregon State University.

Pugh, A.L., D.A. Westerman. 2014. *Mean Annual, Seasonal, and Monthly Precipitation and Runoff in Arkansas, 1951-2011*. Scientific Investigations Report 2014-5006. Reston, VA: USGS.

Reynolds, Jerry. 2012. *The Encyclopedia of Arkansas History & Culture - Hydroelectricity.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=5527 (accessed 9 12, 2013).

Riffel, Brent E. 2013a. *Poultry Industry.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2102 (accessed December 17, 2013).

Riffel. 2013b. *Wal-Mart Stores, Inc.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=2135 (accessed December 17, 2013).

Rogers, W. B. 1987. *The Appalachian-Ouachita Orogenic Belt*. Episodes, 260-266.

Schrader, T.P. 2005. *Potentiometric Surface of the Ozark Aquifer in Northern Arkansas, 2004.* Scientific Investigations Report 2005-5208, Reston, VA: USGS.

Scott, H. Don, James A. Ferguson, Linda Hanson, Todd Fugitt, and Earl Smith. 1998. *Agricultural Water Management in the Mississippi Delta Region of Arkansas. Research Bulletin 959.* Fayetteville: University of Arkansas.

Shelby, Erica L. 2006. *An Assessment and Analysis of Benthic Macroinvertebrate Communities Associated with the Appearance of Didymosphenia geminata in the White River Below Bull Shoals Dam.* Little Rock, AR: Arkansas Department of Environmental Quality.

Shoults, Lenore. 2011. *Encyclopedia of Arkansas History and Culture - Pearl Rush.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=6576 (accessed March 18, 2013).

Shoults, Sherri. 2012. *Greers Ferry National Fish Hatchery - About Us.* http://www.fws.gov/greersferry/aboutus.html (accessed September 12, 2013).

Smith, C. R., and K. F. Steele. 1990. *Nitrate concentrations of ground water Benton County, Arkansas:.* no. MSC-073, Fayetteville, AR: Arkansas Water Resources Center.

Steele, K. F. 1981. *Groundwater quality and mineral deposits relationships in the Ozark Mountains.* no. PUB-077, Fayetteville, AR: Water Resources Research Center.

Steele, K. F., and W. K. McCalister. 1985. *Potential nitrate pollution of ground water in limestone terrain by poultry litter, Ozark region, U.S.A.* Nirate Contamination: Exposure, Consequence, and Control (Water Resources Research Center), 209-218.

Stewart-Abernathy, Leslie. 2011a. *Cherokee.* http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Stewart-Abernathy, Leslie. 2011b. *Encyclopedia of Arkansas History and Culture - Steamboats.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=4466&type=Category&item=Water&parent=Transportation&grandparent= (accessed July 29, 2013).

The City Wire. 2012. *NWA 15th fastest growing region in U.S.* TheCityWire.com.

The Nature Conservancy. 2013. *Arkansas Places We Protect.* http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/arkansas/placesweprotect/index.htm (accessed March 22, 2013).

Tyson Foods, Inc. 2014. Fiscal 2013 Fact Book. Springdal, Arkansas: Tyson Foods, Inc.

U of A Divison of Agriculture. 2012. *Economic Contribution of Arkansas Agriculture.* Little Rock: University of Arkansas Division of Agriculture,.

U of A at Little Rock Institute for Economic Advancement. 2002. *Index for Arkansas State and Counties Population and Social/Economic CHaractersitics by County 1990 Census of Population and Housing.* http://iea.ualr.edu/arkansas-census-data.html?id=174:index-for-arkansas-state-and-counties&catid=1 (accessed September 25, 2013).

University of Georgia - Center for Invasive Species and Ecosystem Health. 2013. *Invasive Plant Atlas of the United States.* www.invasiveplantatlas.org (accessed December 20, 2013).

USACE. 2013. *Value to the Nation State Level Report - Arkansas.* http://www.corpsresults.us/recreation/fastfacts/stateReport.cfml?State=12 (accessed February 2014).

USACE. n.d. *RIBITS: Regulatory In-lieu Fee and Bank Information Tracking System.* https://rsgisias.crrel.usace.army.mil/ribits/f?p=107:2:2616212477753 (accessed December 19, 2013).

USACE Little Rock District. 1988. *Arkansas State Water Plan, Arkansas River Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

USACE Little Rock District. 2009. *Final Environmental Impact Statement White River Basin, Arkansas, Minimum Flows.* Little Rock: USACE Little Rock District.

USACE Little Rock District. 2010. *Finding of No Significant Impact.* http://www.swl.usace.army.mil/Portals/50/docs/planningandenvironmental/MAWA%20FONSI%2020100505.pdf (accessed October 1, 2013).

USACE Little Rock District. n.d. *White River Minimum Flows.* http://www.swl.usace.army.mil/Missions/CivilWorks/ProgramandProjectManagement/WhiteRiverMinimumFlows.aspx (accessed October 4, 2013).

US Census Bureau. n.d. *DP03 - Selected Economic Characteristics, 2007-2011 American Community Survey 5-year Estimates.* http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_11_5YR_DP03 (accessed March 18, 2013).

US Census Bureau. 1989. *1987 Census of Agriculture Volume 1 Geographic Area Series Part 4 Arkansas State and County Data.* Washington, DC: US Government Printing Office.

US Census Bureau. 1990. *1987 Census of Agriculture, Volume 2 Subject Series, Part 3 Ranking of States and Counties.* Washington DC: US Department of Commerce.

US Census Bureau. 1992. *1992 Economic Census Area Profiles - Arkansas.* http://www.census.gov/epcd/www/92profiles/www/EC92AR.HTM (accessed September 26, 2013).

US Census Bureau. 1994. *1992 Census of Agriculture, Volume 2 Subject Series, Part 3 Ranking of States and Counties.* Washington, DC: US Department of Commerce.

US Census Bureau. 2007. *American FactFinder.* http://factfinder2.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t (accessed September 25, 2013).

US Census Bureau. 2011. *Urban Area Criteria for the 2010 Census*. Federal Register, 76 (164): 53033-53043.

US Census Bureau. 2012a. *Arkansas 2010: Population and Housing Unit Counts.* Washington, DC: US Department of Commerce.

US Census Bureau. 2013. *State and County QuickFacts - Arkansas.* http://quickfacts.census.gov/qfd/states/05000.html (accessed September 25, 2013).

US Congress. 1992. *Clean Vessel Act of 1992.* Digest of Federal Laws of Interest to the U.S. Fish and Wildlife Service. http://www.fws.gov/laws/lawsdigest/clenves.html (accessed July 12, 2013).

USDA National Agricultural Statistics Service. 2009. *2007 Census of Agriculture Arkansas State and County Data Volume 1 Geographic Area Series Part 4.* Washington, D.C.: USDA.

USDA. 2012. *Poultry and Eggs - Background.* http://www.ers.usda.gov/topics/animal-products/poultry-eggs/background.aspx (accessed December 17, 2013).

USFS. 2013. *Area, in acres, by county and forest-type group - 2012.* Forest Inventory Data Online (FIDO). http://apps.fs.fed.us/fido/standardrpt.html (accessed September 18, 2013).

USFWS. 2007. *Best Management Practices for Fayetteville Shale Natural Gas Activities.* Conway: US Fish and Wildlife Service,.

USFWS. 2009. *Logan Cave National Wildlife Refuge.* http://www.fws.gov/hollabend/logancave/ (accessed December 10, 2013).

USFWS. 2010a. *Norfork National Fish Hatchery.* http://www.fws.gov/norfork/ (accessed December 10, 2013).

USFWS. 2010b. *Mammoth Spring National Fish Hatchery.* http://www.fws.gov/mammothspring/ (accessed December 10, 2013).

USFWS. 2012. *Bald Knob National Wildlife Refuge.* http://www.fws.gov/baldknob/ (accessed December 10, 2013).

USFWS. 2013a. *Greers Ferry National Fish Hatchery.* http://www.fws.gov/greersferry/ (accessed December 10, 2013).

USFWS. 2013b. *Endangered Species Act: Overview.* http://www.fws.gov/endangered/laws-policies/index.html (accessed March 13, 2013).

USFWS. n.d. *Environmental Conservation Online System - Listings and occureences for Arkansas.* http://ecos.fws.gov/tess_public/pub/stateListingAndOccurrenceIndividual.jsp?state=AR&s8fid=112761032792&s8fid=112762573902 (accessed December 18, 2013).

USFWS, US Department of Commerce Bureau of the Census. 1993. *1991 National Survey of Fishing, Hunting, and Wildlife-associated Recreation, Arkansas.* Washington, DC: US Government Printing Office.

USFWS, US Department of Commerce Census Bureau. 2013. *2011 National Survey of Hunting, Fishing, and Wildlife-associated Recreation - Arkansas.* Washington, DC: US Fish and Wildlife Service.

USGS. 1992. *Flow Duration and Low-Flow Characteristics of Selected Arkansas Streams.* Water-Resources Investigations Report 92-4026, Little Rock, AR: USGS.

USGS. 2008. *National Water Quality Assessment Program (NAWQA) Ozark Plateaus Study Unit.* http://ar.water.usgs.gov/nawqa/ozark/nawqa.html (accessed February 24, 2014).

USGS. 2009. *National Hydrography Dataset.* Reston, VA: U.S. Geological Survey.

USGS. 2010. *2007 Minerals Yearbook - Arkansas (Advance Release).* US Geological Survey.

USGS. 2013a. *USGS Water-Quality Data for Arkansas.* http://waterdata.usgs.gov/ar/nwis/qw (accessed October 1, 2013).

USGS. 2013b. *NAS - Non Aquatic Species.* http://nas.er.usgs.gov/default.aspx (accessed December 19, 2013).

Waldon, George. 2012. *Central Arkansas Water Looks to Drink from Lake.* http://www.arkansasbusiness.com/print/article/57189 (accessed October 1, 2013).

Wal-Mart.2014a. "Corporate and Financial Facts." Walmart. February 2014. http://news.walmart.com/walmart-facts/corporate-financial-fact-sheet (accessed March 2014).

Walmart. 2014b.Walmart reports Q4 EPS of $1.67. Bentonville: Walmart.

Walmart. 2014c."History Timeline." Walmart. http://corporate.walmart.com/our-story/history/history-timeline (accessed March 31, 2014).

Warner, Nathaniel R., et al. 2013. *Geochemical and isotopic variations in shallow groundwater in areas of the Fayetteville shale development, north-central Arkansas.* Applied Geochemistry. http://dx.doi.org/10.1016/j.apgeochem.2013.04.013 (accessed May 31, 2013).

Westerman, Drew A., Katherine R. Merriman, Jeanne L. De Lanois, and Charles Berenbrock. 2013. *Analysis and Inundataion Mapping of the April-May 2011 Flood at Selected Locations in Northern and Eastern Arkansas and Southern Missouri.* Scientific Investigations Report 2013-5148, USGS.

White River RSWMD. 2011. *2011 Regional Soild Waste Management Plan.* Batesville, AR: WRRSWMD.

Wiest, Jason. 2011. *Does the Future Hold Water for Arkansas?* http://www.inarkansas.com/23666/does-the-future-hold-water-for-arkansas (accessed October 1, 2013).

Winthrop Rockefeller Foundation. 2008. *Water Issues in Arkansas: A Companion Report to "Water Issues in Arkansas - An Unfinished Story" Summary Report.* Little Rock, AR: Winthrop Rockefeller Foundation.

Woods, Alan J., T. Foti, S. Chapman, J. Omernic, J. Wise, E. Murray, W. Prior, J. Pagan Jr., J. Comstock, M. Radford. 2004. *Ecoregions of Arkansas (color poster with map, descriptive text, summary tables, and photographs).* Reston, VA: US Geological Survey.

APPENDIX A

2008 303(d) List of Impaired Waterbodies in the NAWRPR

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
3C reaches 10-22	86.9	86.9	none	0			
3D reaches 14,15	41.2	41.2	none	0			
3F reaches 18,20,21	27.6	27.6	none	0			
3H reaches 11110202-22,23,902; 11110104-9-11	86.9	86.9	none	0			
3J – Grand Neosho Basin	223.2	209	Aquatic life	51.7	Sediment/siltation	4.1	Erosion
					Total phosphorus	47.6	Unknown
			Primary contact	293.3	Pathogens	293.3	Unknown, urban runoff
			Drinking water supply	8	Nitrate	8	Municipal WWTP
			Total	319.4			
4E – Little Red River	440.2	269.9	Fish consumption	2	Mercury	2	Unknown
			Aquatic life	22.3	Zinc	22.3	Agriculture
			total	24.3			
4F – White River between Black River and Buffalo River	334.3	277.1	Aquatic life	14.8	DO	14.8	Unknown, hydropower
			Primary contact	29.1	Pathogens	29.1	Unknown, municipal WWTP
			Total	33.3			
4G – Black River, Strawberry River & tributaries (partial)	459.9	393.6	Aquatic life	139.9	DO	53.1	Unknown
					Sediment/siltation	122.4	Erosion
			Primary contact	47.7	Pathogens	47.7	Unknown
			Total	187.6			
4H – Spring River, South Fork Spring River, and Eleven Point River	238.1	216.9	Aquatic life	54.9	DO	45.6	Unknown
					Sediment/siltation	9.4	Erosion
					Temperature	9.3	Unknown
			Agriculture & industrial water supply	3.1	TDS	3.1	unknown
			Total	54.9			
4I – White River from Crooked Creek to Long Creek	160.8	124.8	Aquatic life	70.9	DO	3	Hydropower
					Temperature	31.7	Resource extraction
			Agriculture & industrial water supply	67.9	TDS	67.9	Unknown
					Sulfate & chloride	36.2	Unknown
			Total	70.9			
4J – Buffalo River &	339.8	317.1	Aquatic life	20.8	DO	9.5	Unknown
					Temperature	11.3	Unknown

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
tributaries			Agriculture & industrial water supply	23.9	TDS	23.9	Municipal WWTP
			Total	44.7			
4K – Upper White River and Kings River	484.3	473.6	Aquatic life	105.8	Sediment/siltation	33.4	Erosion
					DO	72.4	Unknown
			Drinking water supply	9.1	Nitrate	9.1	Municipal WWTP
			Agriculture & industrial water supply	101.1	TDS	101.1	Unknown, municipal WWTP
					Chloride	6.2	Unknown
					Sulfate	33.4	Unknown
			Total	140.3			
3H – Arkansas River and tributaries: State line to river mile 210	86.9	86.9	Primary contact recreation	20.5	Pathogens	20.5	Unknown
Total	3010.1	2611.5		895.9			

FTN Associates Ltd.
water resources / environmental consultants

Arkansas Water Plan
Essential For Life

ARKANSAS WATER PLAN UPDATE
TASK NO. 6-EAST ARKANSAS
WATER RESOURCES PLANNING REGION

AUGUST 6, 2014

ARKANSAS WATER PLAN UPDATE
TASK NO. 6-EAST ARKANSAS
WATER RESOURCES PLANNING REGION

Prepared for

Arkansas Natural Resources Commission
101 East Capitol Avenue, Suite 350
Little Rock, AR 72201-3813

Prepared by

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, Arkansas 72211

FTN No. 03015-0003-001

AUGUST 6, 2014

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF APPENDICES

LIST OF FIGURES

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF ACRONYMS

ACS	American Community Survey
ADEQ	Arkansas Department of Environmental Quality
ADPCE	Arkansas Department of Pollution Control and Ecology (now ADEQ)
ADH	Arkansas Department of Health
AGFC	Arkansas Game and Fish Commission
AHTD	Arkansas State Highway and Transportation Department
ANHC	Arkansas Natural Heritage Commission
ANRC	Arkansas Natural Resources Commission
APCEC	Arkansas Pollution Control and Ecology Commission
ASPB	Arkansas State Plant Board
ASWCC	Arkansas Soil and Water Conservation Commission (now the ANRC)
AWAG	Arkansas Watershed Advisory Group
AWP	Arkansas Water Plan
BCE	Before the common era
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	Cubic Feet Per Second
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
CWA	Clean Water Act
EAWRPR	East Arkansas Water Resources Planning Region
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentive Program
FEMA	Federal Emergency Management Agency
GCGW	Governor’s Commission on Global Warming
gpm	Gallons per minute
HUD	United States Department of Housing and Urban Development
MCL	Maximum Containment Level
MERAS	Mississippi Embayment Regional Aquifer Study
mg/L	Milligrams per liter
mgd	Million gallons per day
MKARNS	McClellan-Kerr Arkansas River Navigation System
MRV	Mississippi River Valley
MS4	Municipal Separate Storm Sewer System
n.d.	No date
NCDC	National Climatic Data Center
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRCS	United Stated Department of Agriculture Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
NWR	National wildlife refuge
NWIS	National Water Information System

TABLE OF CONTENTS (CONTINUED)

PCB	Polychlorinated biphenyl
PDSI	Palmer Drought Severity Index
RCRA	Resource Conservation and Recovery Act
RSWMD	Regional Solid Waste Management District
SDWA	Safe Drinking Water Act
SFHA	Special Flood Hazard Area
SGCN	Species of Greatest Conservation Need
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
U of A	University of Arkansas
US	United States
USACE	United States Army Corps of Engineers
USDA	United Stated Department of Agriculture
USDI	United States Department of the Interior
USFS	United States (USDA) Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WMA	Wildlife management area
WRDA	Water Resources Development Act

1.0 INTRODUCTION

The Arkansas Natural Resources Commission (ANRC) is responsible for preparing, and periodically updating, a statewide water resources planning document. The previous update of the Arkansas Water Plan (AWP) was completed in 1990. In 2012, ANRC initiated an update of the 1990 AWP to be completed in 2014.

This document was prepared as part of the 2014 update of the AWP (Project Task 6). This document provides background information about the East Arkansas Water Resources Planning Region (EAWRPR) that will be used in the 2014 AWP update. The EAWRPR is one of five state water resources planning regions being addressed in the 2014 AWP update. The information in this document will serve as background for updated discussion and analysis of state water supplies, water demand, and alternatives for meeting the water resources needs in the EAWRPR. This background information includes a description of the history of the planning region, its physical characteristics, natural resources, water resources, demographics, and economy. Finally, the regulatory and institutional framework for water resources management in this planning region is outlined.

2.0 GEOGRAPHY AND HISTORY

This section provides a general description of the geography of the EAWRPR, a brief history of the regional culture, and an overview of historical water resources management.

2.1 Geography

The EAWRPR encompasses approximately 15,900 square miles in eastern Arkansas (Figure 2.1). This region is bounded on the north by Missouri, to the south by Louisiana, and to the east by Mississippi. The western boundary of the EAWRPR north of Little Rock roughly corresponds to the geologic boundary between the Gulf Coastal Plain and the Interior Highlands physiographic regions. South of Little Rock, this boundary roughly corresponds to the hydrologic boundary between the Saline River, and Bayou Bartholomew or the White River. All or part of 25 counties are included in this planning region. Table 2.1 lists these counties, the area of each county that is in the planning region, and the corresponding percentage of the county in the planning region. Major cities in the planning region include Jonesboro, Paragould, Pine Bluff, Forrest City, West Memphis, Blytheville, Stuttgart, and Helena.

2.2 History

Water resources have influenced the history of this region, and the current condition of water resources in the region is a product of human activities throughout its history. The cultural history of the region is outlined below. The history of water resources development in the planning region is summarized separately.

2.2.1 Cultural

Native Americans settled the EAWRPR prior to European exploration and settlement. There is archeological evidence in the region of the presence of sophisticated native cultures beginning around 500 BCE. From this time until the first Europeans came to the region in the 1500s, the mound-building Plum Bayou Culture was active in the region (Early 2011).

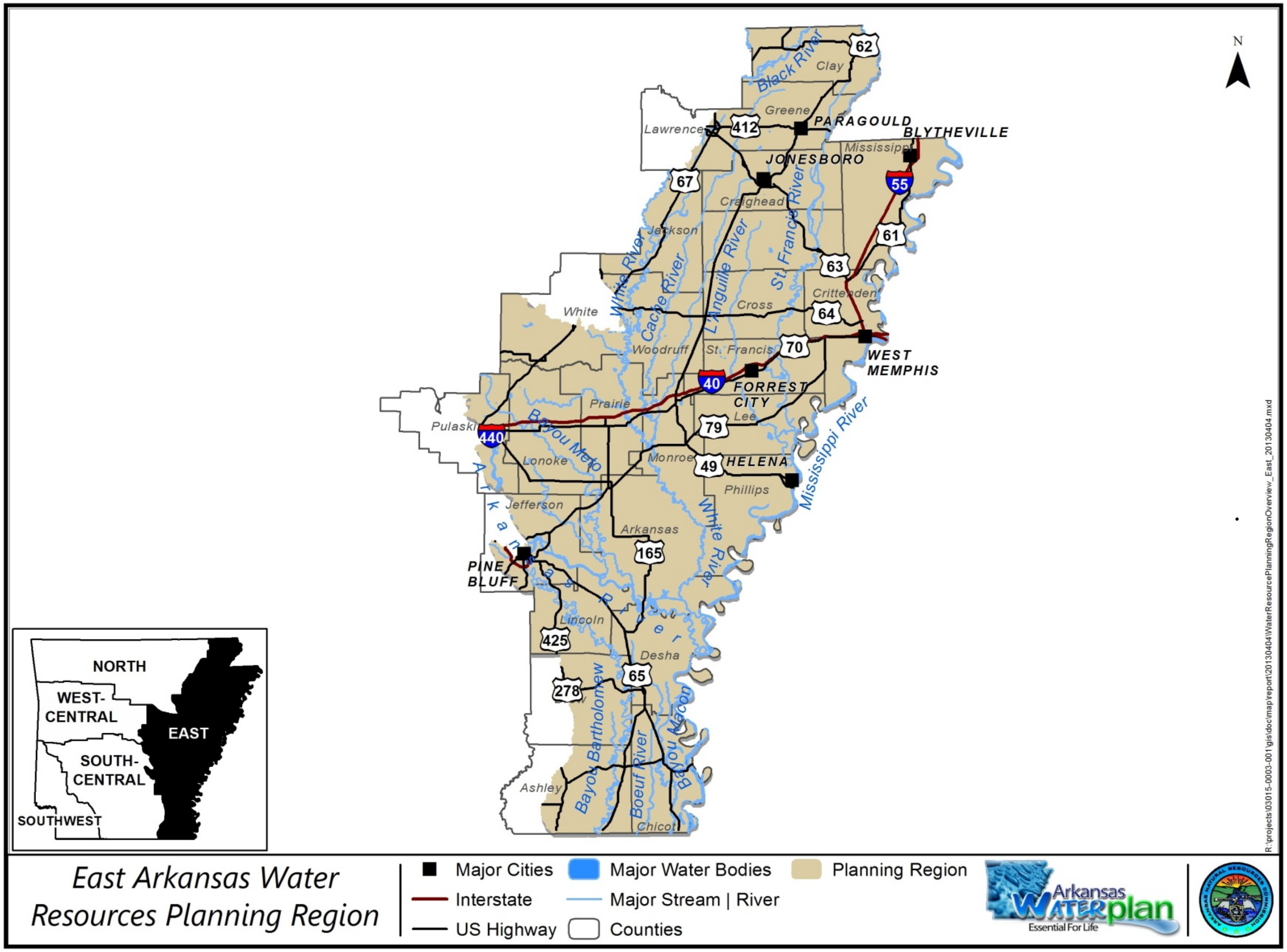

Figure 2.1. East Arkansas Water Resources Planning Region.

Table 2.1. Counties in the EAWRPR.

County	County Area in Planning Region (square miles) (US Census Bureau 2012a)	Percentage of County Area in Planning Region
Arkansas	988.77	100%
Ashley	624.81	68%
Chicot	644.30	100%
Clay	639.47	100%
Craighead	707.21	100%
Crittenden	609.76	100%
Cross	616.38	100%
Desha	768.15	100%
Drew	520.27	63%
Greene	577.70	100%
Jackson	633.94	100%
Jefferson	663.65	76%
Lawrence	217.13	37%
Lee	602.62	100%
Lincoln	561.52	100%
Lonoke	770.73	100%
Mississippi	900.57	100%
Monroe	607.12	100%
Phillips	695.66	100%
Poinsett	758.39	100%
Prairie	647.96	100%
Pulaski	337.48	44%
St. Francis	634.77	100%
White	624.69	60%
Woodruff	586.79	100%
Total	**15939.84**	

Because early European exploration and settlement utilized the Mississippi River, early explorers, missionaries, and settlers entered Arkansas via the EAWRPR. Hernando de Soto's Spanish expeditionary force were the first Europeans in the region, arriving in 1541. At this time, the region was heavily populated by natives who farmed extensively. De Soto died in 1542, in Chicot County. The Spanish then left the region in 1543 (Key 2012).

Over 100 years later, in 1673, French explorers came to the region. By this time, the native culture of the region was the Quapaw, and the native population was sparser than when the Spanish expedition traveled here. A French explorer established the first settlement west of the Mississippi River, Arkansas Post, in 1686 on the Arkansas River in what is now Arkansas County, although it was abandoned approximately 10 years later. In the 1700s, Arkansas Post was re-established by the French as a military outpost. The European focus, prior to the Louisiana Purchase in 1803, was primarily on exploitation of the abundant wild game in the region for trade, rather than immigration.

During the 1700s the Quapaw population of the region was decimated by smallpox epidemics (Key 2012). Cherokee migrated from the eastern United States (US) and established settlements along the St. Francis River beginning around 1780 (Stewart-Abernathy 2011a). The Cherokee left the region in 1817 (Bolton 2012).

American settlement of the EAWRPR did not begin in earnest until after the War of 1812. Arkansas Post, located in the region, was the territorial capital until 1821. In the 1830s, population in the region increased rapidly. The bottomland forests were cleared, swamps drained, and large-scale, southern-style, cotton plantations developed, making this region the center of Arkansas wealth and power (Bolton 2012, DeBlack 2012). Cotton thrived in the deep, rich soils of the region, and the proximity to river transportation contributed to the economic strength of the region (Hawkins 2011). Many of the early settlers in the region lived on Crowley's Ridge, while owning and operating farms in the lowlands (Turner 2001, Foti 2008).

After the Civil War, cotton plantations in the EAWRPR were converted to tenant farms, or were operated using paid labor. However, cotton prices fell after the war, remaining low through the 1890s. As a result, many cotton operations were forced to shut down. In the 1930s, cotton production in the region declined, and soybean and rice production began to increase (Hawkins 2011). Agricultural production remains the foundation of the economy of the EAWRPR.

2.2.2 Water Resources Development

A range of water resources development activities have occurred in this region throughout its history, as attitudes and policies have changed. Historically, human activities that have affected water resources in this planning region have included draining and clearing of wetlands, channelization of rivers and streams, levee building, river transportation and navigation, development of surface water and ground water for irrigation, changes in cropping, development of aquaculture, wildlife habitat and wetland conservation, and development of the recreation industry in the region.

2.2.2.1 Flood Control and Drainage

Early settlers in the EAWRPR constructed systems of canals to drain the wetlands for agriculture, and levees to protect this reclaimed land from flooding, These levees were not very tall, nor very effective (Jackson 2011). By 1958 a system of levees had been constructed by local interests along the Mississippi River in Arkansas (Mississippi River Commission 2007). However, this levee system did not adequately protect the region from flooding.

In 1879, the US Congress created the Mississippi River Commission to oversee flood control along the entire Mississippi River. Levee and drainage districts in Arkansas were formed shortly thereafter (Table 2.2). Between 1905 and 1915, the Arkansas General Assembly passed laws creating a flood control program for the Mississippi River Valley region of the state, i.e., the EAWRPR (Jackson 2011, Mississippi River Commission 2007).

Table 2.2 Levee and drainage districts in the EAWRPR (Jackson 2011).

Organization date	District Name	Counties included
1883	Chicot	Chicot
1887	Clay and Greene	Clay, Greene
1891	Laconia	Desha, Phillips
1891	Red Fork	Desha
1893	St. Francis	Crittenden, Cross, Lee, Mississippi, Phillips, Poinsett, St. Francis
1905	Linwood and Auburn	Lincoln
1905	Plum Bayou	Jefferson, Lonoke, Pulaski
1905	French Town	Jefferson
1905	Tucker Lake	Jefferson

The 1928 Flood Control Act, passed in response to the widespread damage caused by the 1927 Mississippi River flood, authorized the federal Mississippi River and Tributaries Project. This project consisted of a unified and coordinated system of flood protection structures in the lower Mississippi River Valley. This system includes levees along the Mississippi River, Arkansas River, and St. Francis River. In addition, backwater storage areas at the mouth of the St. Francis River and the White River are part of the Mississippi River flood protection system (Mississippi River Commission 2007, 2008).

Despite the work undertaken by levee and drainage districts in the EAWRPR, and the Corps of Engineers along the Mississippi River, over half of the region was still undeveloped in 1940. Machinery improvements that occurred during World War II made it possible to drain, dredge, and clear swampland at a much faster rate after the war than previously. Crop diversification also occurred at this time and spurred the increased rate of land drainage and conversion, as soybeans and rice could be grown on lands not suitable for cotton (Williams 2012).

In the late 1950s, after passage of the 1954 Watershed Protection and Flood Prevention Act, 11 watershed districts were formed in the EAWRPR to implement flood control projects. Through these projects, over 400 miles of streams in the EAWRPR were channelized and 4.7 million acres of land drained by 1970 (Williams 2012).

2.2.2.2 Wetland Loss

Prior to European settlement, there were approximately 8 million acres of wetlands in the EAWRPR (Dahl 1990). In 1849 and 1850, the US Congress passed the Swamp Land Acts, to encourage settlement of the lowlands along the Mississippi River, including eastern Arkansas. Through these Acts, land in eastern Arkansas was sold for pennies to settlers so the land could be developed. After the Civil War, timber clearing and wetland draining in eastern Arkansas increased as the timber industry and agriculture expanded in this region. Completion of the Cotton Belt railroad from St. Louis to Pine Bluff in 1883 increased the rate of the expansion of the timber industry and agriculture in the region (Balogh 2012, Zbinden 2011).

By 1920, most of the virgin timber in Arkansas had been cut, and 3.5 million acres of east Arkansas land had been organized into drainage districts. By the mid 1930s approximately 40% of the wetlands in eastern Arkansas had been drained and developed (Arkansas Multi-agency Wetland Planning Team 2001). However, in 1935, the White River National Wildlife Refuge was established in Monroe, Arkansas, Phillips, and Desha counties, preserving 160,000 acres of bottomland hardwood forested wetlands (Rogers 2013).

After World Water II, the rate of wetland loss in eastern Arkansas increased as a result of the use of mechanized equipment (Arkansas Multi-agency Wetland Planning Team 2001). The rate of wetland loss in eastern Arkansas began to decrease in the late 1970s, as awareness of the importance of wetlands for migratory bird habitat and other important environmental functions increased, and national legislation, policies, and programs were enacted that encourage conservation and restoration of wetlands (Dahl 1990).

2.2.2.3 Irrigation

The early development and expansion of irrigation in the EAWRPR is closely tied to the introduction and expansion of rice production. From 1900 to 1950, 96.6 to 99.9 % of the irrigated land in Arkansas was irrigated rice. Irrigated rice produce began in Arkansas, Prairie, and Lonoke counties in 1900. Between 1900 and 1910 irrigated rice acreage in Arkansas increased from 25 acres to almost 60,000 acres. By 1920, 180,000 acres of irrigated cropland (rice) were in production in the EAWRPR (Green 1986). Groundwater from the Mississippi River Valley alluvial aquifer was used for rice irrigation (Scott, et al. 1998). After this initial period of expansion, the amount of irrigated cropland in the region stayed fairly constant until 1940 (Green 1986).

The period from 1940 through 1954 was one of expansion of irrigated rice production in the EAWRPR. During this period, the amount of irrigated cropland in the region increased by 430 %, to over 850,000 acres. While some of the additional irrigated land was in rice production, the use of irrigation for other crops began during this period. During this time, irrigation began to be used in production of cotton, soybeans, corn, and vegetables in the EAWRPR (Green 1986).

Expansion of irrigated land slowed dramatically during the period between 1954 and 1974, increasing by only 9.5 %. During this period, modern irrigation technology became common in the region. In 1960, 87.5 % of irrigated cropland was irrigated using groundwater. Eighty-seven % of the 1960 irrigated cropland was irrigated using furrow irrigation, and 12.5 % was irrigated using sprinklers (Green 1986).

Further advancements in irrigation technology, including pumps and sprinkler pipe, in the 1970s contributed to another period of expansion of irrigated land in the EAWRPR (Green 1986). Between 1974 and 1978, the amount of irrigated cropland in Arkansas increased by 32 % (301,700 acres), primarily as a result of expansion of rice production (Scott, et al. 1998). Between 1978 and 1982, the area of irrigated cropland in Arkansas increased by 345,811 acres, a 21 % increase (US Department of Commerce Bureau of the Census 1984). This increase was primarily due to increased irrigation of soybeans and cotton (Scott, et al. 1998). Irrigated acreage in the EAWRPR has continued to increase, through 2007, when 4,295,000 acres was irrigated in this region.

Groundwater is used for the majority of the irrigation in the EAWRPR. However, concern about the ability of the aquifers in the EAWRPR to sustain the high water volumes used for irrigation has led to the development of large-scale surface water irrigation projects. In 2013 there are three irrigation projects under development in the EAWRPR, and one completed, that supply surface water for irrigation. Three additional surface water irrigation projects located in the EAWRPR are under study (US Department of Agriculture Natural Resources Conservation Service [NRCS] 2011). Information about these projects is summarized in Table 2.3.

Table 2.3. Surface water irrigation projects in the EAWRPR (NRCS 2011).

Project Name	**Counties**	**Cropland Area (acres)**	**Water Source**	**Status**
Grand Prairie	Arkansas	246,000	White River	Incomplete
Bayou Meto	Arkansas, Jefferson, Lonoke, Prairie, Pulaski	268,000	Arkansas River	Incomplete
Boeuf-Tensas	Ashley, Chicot, Desha, Drew, Jefferson, Lincoln	800,000	Arkansas River	Incomplete
Plum Bayou	Lonoke, Pulaski	14,200	Arkansas River	Complete
Bayou DeView	Craighead, Poinsett	105,500	White River?	Under study
Upper L'Anguille	Craighead, Poinsett	123,498	White River?	Under study
North Prairie	Prairie	111,080	White River?	Under study

2.2.2.4 Navigation

During the early years of European settlement in eastern Arkansas, rivers in the region were important transportation corridors, because travel overland in this region was difficult. In the 1820s, steamboats began operating on the Arkansas River and White River. By the 1830s, steamboats were active also on the Cache River and Black River. By 1875, steamboats were also navigating the St. Francis River and Bayou Bartholomew (Stewart-Abernathy 2011b, Cavaneau 2012). The Arkansas River and the White River are the only two rivers in the EAWRPR still used for commercial transportation (Figure 2.2) (Arkansas Waterways Commission 2012a). In the 1960s, the McClellan-Kerr Arkansas River Navigation System (MKARNS) was constructed on the Arkansas River and White River (Goss 2012).

2.2.2.5 Hydropower

The Arkansas Electric Cooperative Corporation operates a hydropower project located at Wilbur D. Mills Dam on the Arkansas River in the EAWRPR (part of the MKARNS). This hydropower plant is a low-head, run-of-the-river project and releases are controlled by the USACE. Construction of this power plant was begun in 1994 and completed in 1999. The plant is capable of generating power at flows between 4,000 cubic feet per second (cfs) and 200,000 cfs. The maximum discharge capacity of the plant is 53,400 cfs (Arkansas Electric Cooperative Corporation n.d.).

2.2.2.6 Aquaculture

Warm water aquaculture in the US originated in the EAWRPR. The first commercial fish farms began production here in the 1940s, raising goldfish (Engle 2012). In the mid 1940s, fish farms began producing baitfish. In 1952, there were 536 acres of fish farms in the EAWRPR (Stone, Dorman and Thomforde 2010). In the late 1950s catfish production began in the EAWRPR. Trout and tropical fish (i.e., goldfish) production were reported in the 1978 census of agriculture, when there were 24,996 acres of fish farms in Arkansas, primarily in the EAWRPR (US Department of Commerce Bureau of the Census 1977).

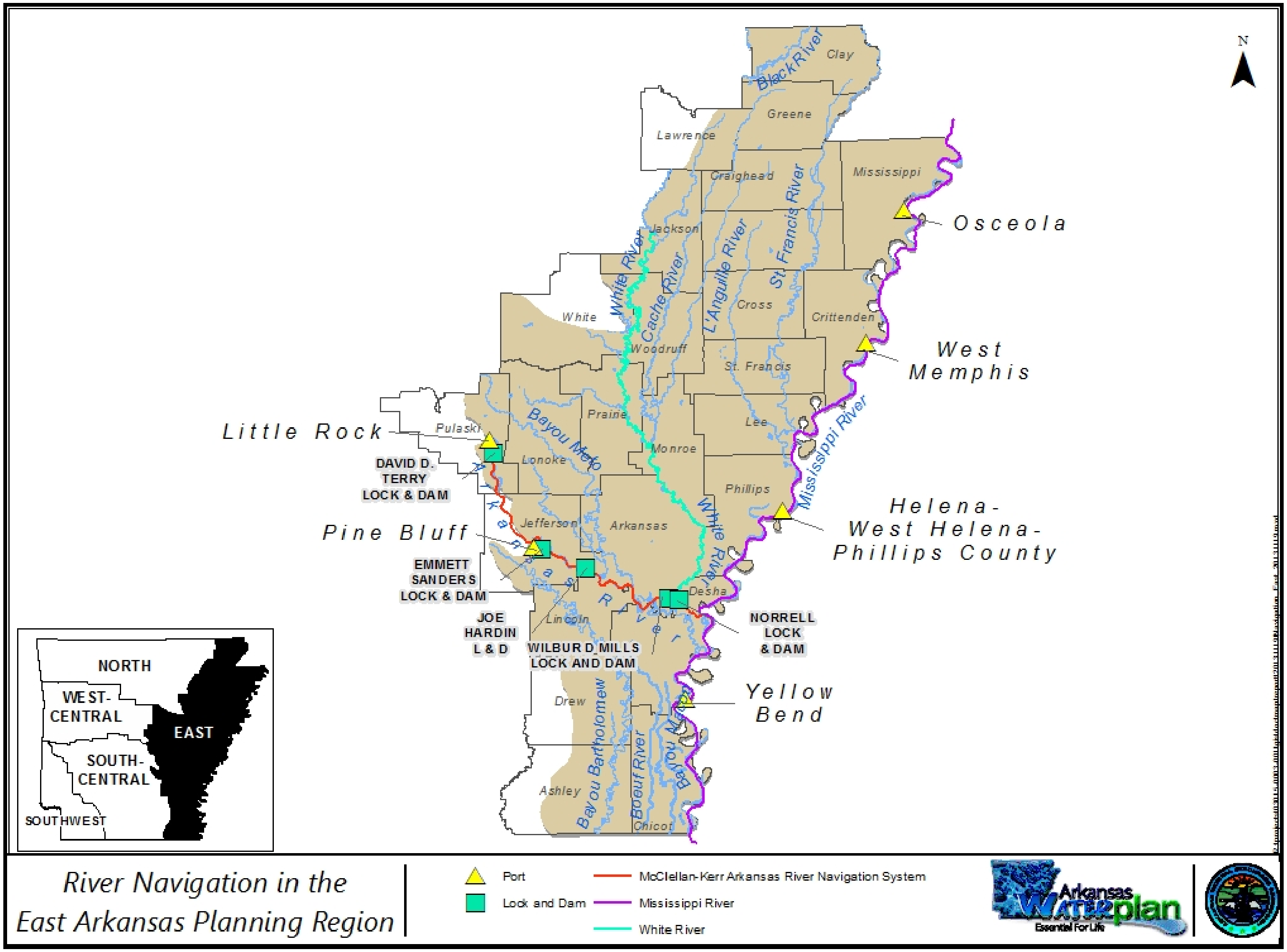

Figure 2.2. Navigation systems in the EAWRPR for water borne commodity transport.

In 2005, there were 61,135 acres of fish farms in Arkansas, with the majority in the EAWRPR. Groundwater is the primary source of water used for aquaculture ponds (USDA National Agricultural Statistical Service 2006). In 2005, 241 million gallons of groundwater and 10 million gallons of surface water were used for aquaculture (US Geological Survey 2005). Best management practices for aquaculture are focused on reducing water use and minimizing discharges from ponds (Stone, Dorman and Thomforde 2010).

2.2.2.7 Pearl Industry

Freshwater pearls found in both the White River and Black River set off a “pearl rush” in northeast Arkansas in the late 1880s (Shoults 2011). A pearl button factory was established in northeast Arkansas around 1900 to take advantage of the large freshwater mussel populations in the White River and Black River. This was a thriving industry in the area until the late 1940s (Cavaneau 2012).

2.2.2.8 Waterfowl and Aquatic Habitat Conservation

Even while large tracts of land in the EAWRPR were being cleared and drained, individuals and federal and state agencies realized the importance of the wetlands and forests in this region for support of wildlife, especially migrating waterfowl. Just after the turn of the Twentieth Century, preservation of migratory waterfowl game birds became a national priority. At this time, eastern Arkansas was already a popular hunting destination, and the region was dotted with hunting clubs where members hunted waterfowl, primarily ducks, and/or deer. The quality of the waterfowl habitat in this region was well known regionally and nationally. The enthusiasts that hunted in eastern Arkansas also recognized the threat this prime habitat faced due to the agricultural development taking place in the region. The first wildlife refuges in Arkansas were designated in this region in the early Twentieth Century by the federal government (Table 2.4) (Morrow n.d.). The Arkansas Game and Fish Commission (AGFC) began establishing wildlife management areas in the region after World War II, the majority in the 1950s. Many of these management areas were originally hunting clubs. National wildlife refuges and state wildlife management areas continued to be established in the EAWRPR throughout the Twentieth Century (Table 2.4).

Table 2.4. History of refuges and management areas for waterfowl and wet habitats in the EAWRPR (USFWS 2013a).

Name	Type[a]	Area (acres)	Counties	Year Established	Management[b]	Purpose	Other Info
Big Lake	NWR	11,038	Mississippi	1915	USFWS	Habitat	2013 National Blueway, one of the largest bottomland forests in Mississippi River valley
White River	NWR	95 million	Arkansas, Monroe, Phillips, Desha	1935	USFWS		
Bayou Meto	WMA	33,832	Arkansas, Jefferson	1948	AGFC	Waterfowl habitat and hunting, fishing	
Big Lake	WMA	12,320	Mississippi	1950	AGFC	Habitat	
Dr. Lester Sitzes III Bois D'Arc	WMA	13,626	Hempstead	1950s	AGFC	Waterfowl habitat and hunting	
Shirley Bay Rainey Brake	WMA	10,711	Lawrence	1950s	AGFC	Waterfowl hunting, fishing, habitat	
Sheffield Nelson Dagmar	WMA	7,976	Monroe	1952	AGFC	Waterfowl refuge	
Seven Devils	WMA	512	Drew	1954	AGFC	Fishing, waterfowl habitat and hunting	
St. Francis River Sunken Lands	WMA	26,000	Craighead, Greene, Poinsette	1955	AGFC	Waterfowl hunting, habitat	
Dave Donaldson Black River	WMA	25,000	Clay, Greene, Randolph	1957	AGFC	Waterfowl hunting, bottomland habitat	
Earl Buss Bayou Deview	WMA	4,254	Poinsett	1958	AGFC	Waterfowl habitat, fishing	
Wapanocca	NWR	5,486	Crittenden	1961	USFWS	Habitat	
Rex Hancock Black Swamp	WMA	6,394	Woodruff	1971	AGFC	Waterfowl hunting, fishing, habitat	
Trusten Holder	WMA	4,406	Arkansas, Desha	1973	AGFC, USFWS, USACE	Habitat	
Singer Forest	Natural Area	519	Poinsett	1973	ANHC, AGFC	Habitat	
Smoke Hole	Natural Area	455	Lonoke, Prairie	1976	ANHC	Habitat	
Chalk Bluff	Natural Area	54.9	Clay	1977	ANHC	Habitat	
Louisiana Purchase	Natural Area	35	Lee, Monroe, Phillips	1977	ANHC, Arkansas State Parks	Habitat, history	
Holloway Memorial	Natural Area	75	Prairie	1978	ANHC	Habitat	
Konecny Grove	Natural Area	22	Prairie	1979	ANHC	Habitat	
Striplin Woods	Natural Area	30	Arkansas	1979	ANHC, USFWS	Habitat	Part of White River NWR
Overflow	NWR	13,000	Ashley	1980	USFWS	Habitat	

Table 2.4. History of refuges and management areas for waterfowl and wet habitats in the EAWRPR (USFWS 2013a) (continued).

Name	Type[a]	Area (acres)	Counties	Year Established	Management[b]	Purpose	Other Info
Wittsburg	Natural Area	168	Cross	1980	ANHC	Habitat	
Cache River	Natural Area	937	Woodruff	1983	ANHC, AGFC	Habitat	Part of Rex Hancock Black Swamp WMA
Holland Bottoms	WMA	5,558	Lonoke	1985	ANHC, AGFC	Habitat, fishing, waterfowl hunting	
Cache River	NWR	56,000	Jackson, Woodruff, Monroe, Prairie	1986	USFWS	Habitat	Ramsar Wetlands of International Importance
Holland Bottoms	Natural Area	632	Lonoke	1986	ANHC, AGFC	Habitat	Part of Holland Bottoms WMA
Cypress Bayou	WMA	1503	Lonoke, White	1989	AGFC	Waterfowl habitat, fishing	
Little Bayou	WMA		Ashley	1991	AGFC	Habitat, fishing	
Big Creek	WMA	240	Lee	1992	AGFC	Habitat, fishing	
Benson Creek	WMA	610	Monroe	1993	ANHC	Habitat	
Benson Creek	Natural Area	1,459	Monroe, Woodruff	1993	ANHC, The Nature Conservancy	Habitat	
Stateline Sand Ponds	Natural Area	140	Clay	1994	ANHC	Habitat for endangered Pondberry	
Departee Creek	WMA	448	White	1998	AGFC	Habitat	
Swifton Sand Ponds	Natural Area	60	Jackson	2008	ANHC	Habitat for endangered Pondberry	
St. Francis Sunken Lands	Natural Area	80	Poinsett	2009	ANHC	Habitat for endangered Pondberry	
Cattail Marsh	WMA	78	Greene		AGFC	Waterfowl habitat, fishing, hunting	
Ethel	WMA	176	Arkansas		AGFC	Habitat, hunting	
Ring Slough	WMA	86	Clay		AGFC	Waterfowl habitat and hunting, fishing	
White Hall	WMA	111	Poinsett		AGFC	Waterfowl habitat and hunting, fishing	
Brushy Creek	WMA	220	Cross		AGFC	Habitat	
Lee County	WMA	221	Lee		AGFC	Habitat	
Cut-off Creek	WMA	8,728	Drew		AGFC	Waterfowl habitat and hunting	

a NWR = National Wildlife Refuge, WMA = Wildlife Management Area
b AGFC = Arkansas Game and Fish Commission, ANHC = Arkansas Natural Heritage Commission, US FWS = US Fish and Wildlife Service

Some areas of the EAWRPR have long supported the combination of agriculture and waterfowl habitat. The town of Stuttgart, in Arkansas County, brands itself the “Rice and Duck Capital of the World,” and held its first Wings Over the Prairie duck hunting festival in 1936 (Shrum 2012). Today, support of migratory waterfowl has widespread support from the agricultural community in the EAWRPR and nationally. A number of recent Farm Bill programs encourage conservation and enhancement of waterfowl habitat in the region with economic incentives for activities such as setting up wetland conservation easements, and flooding fields in the winter (NRCS 2013a).

2.2.2.9 Commercial Fishing

Commercial fishing was an important activity during early settlement and development in the EAWRPR (Lochmann 2013). By the 1800s, commercial fishing was widespread on the White River. Fish from the White River were shipped by railroad throughout the US (Arkansas Department of Parks and Tourism 2005a). In the 1890s, the Iron Mountain Railway transported commercial game and fish out of the region in refrigerated railcars. In the early Twentieth Century, hundreds of families in the planning region made their living from commercial fishing (Morrow n.d.).

Construction of dams on the White River in the middle of the Twentieth Century changed the fish populations, resulting in a decline in commercial fishing on that river (Arkansas Department of Parks and Tourism 2005a). Despite this, over the period from 1975 through 1985, the amount of fish taken commercially from the White River and Arkansas River approximately doubled (Robison and Buchanan 1988). In the present, commercial fishing is greatly reduced. Regulations prevent the sale of most wild caught game fish in the state. One exception is paddlefish, which are commercially fished for their eggs for caviar (Lochmann 2013). Other fish that may still be caught in the wild and sold include buffalo, catfish, carp, drum, gar, suckers, and shovelnose sturgeon (AGFC 2013a).

2.2.2.10 Red River Compact

In 1955, the US Congress authorized Texas, Oklahoma, Arkansas, and Louisiana to begin negotiating a compact to resolve disputes over rights to water in the Red River and its tributaries, as well as preventing future disputes. In 1978, after 23 years of negotiations, representatives of Texas, Oklahoma, Arkansas, and Louisiana signed the Red River Compact (Lancaster 2011). The purpose of the compact is to provide for equitable apportionment of the waters of the Red River and its tributaries among the four states to ensure conservation and protection of this shared resource.

3.0 PHYSICAL CHARACTERISTICS

This section summarizes the physical and biological characteristics of the EAWRPR. This includes the physiography, geology, climate, and land use, as well as descriptions of the ecological, surface water, and groundwater resources within the planning region.

3.1 Physiography

Arkansas is typically divided into two major physiographic regions; the Interior Highlands in the north and the Gulf Coastal Plain in the south and east. These regions are further subdivided into smaller physiographic provinces based on topography and geology. The "fall line" is where these two physiographic regions meet.

The EAWRPR is located primarily in the Gulf Coastal Plain physiographic region, with small areas of the Interior Highlands included along the northwestern boundary of the planning region. Physiographic provinces of the Gulf Coastal Plain that occur in the planning region include the Mississippi Alluvial Plain, including Grand Prairie and Crowley's Ridge, and a small part of the western edge of the southeastern West Gulf Coastal Plain (Figure 3.1) (Arkansas Geological Survey n.d.).

The physiographic province of the Interior Highlands that occurs in the planning region is the Ouachita Mountain physiographic province. This province includes part of the western edge of the planning region (Figure 3.1) (Arkansas Geological Survey n.d., Woods, et al. 2004). As it comprises such a small part of the planning region, the physiography of the Ouachita Mountain province will not be described in this document. Descriptions of this physiographic province can be found in the background reports for other planning regions.

The Mississippi Alluvial Plain accounts for the largest portion of the planning region. This physiographic region is characterized as having primarily flat to irregular terrain with a uniform slope. The West Gulf Coastal Plain has similar physiography, characterized as a south sloping plain with gently rolling hills and broad, level to nearly level stream valleys (Arkansas Geological Survey 2012, NRCS n.d.). The principal topographic features in the planning region include abandoned stream channels, natural levees, and backswamp areas. Elevations in the flatlands range from the 90 to 320 feet above sea level, decreasing southward.

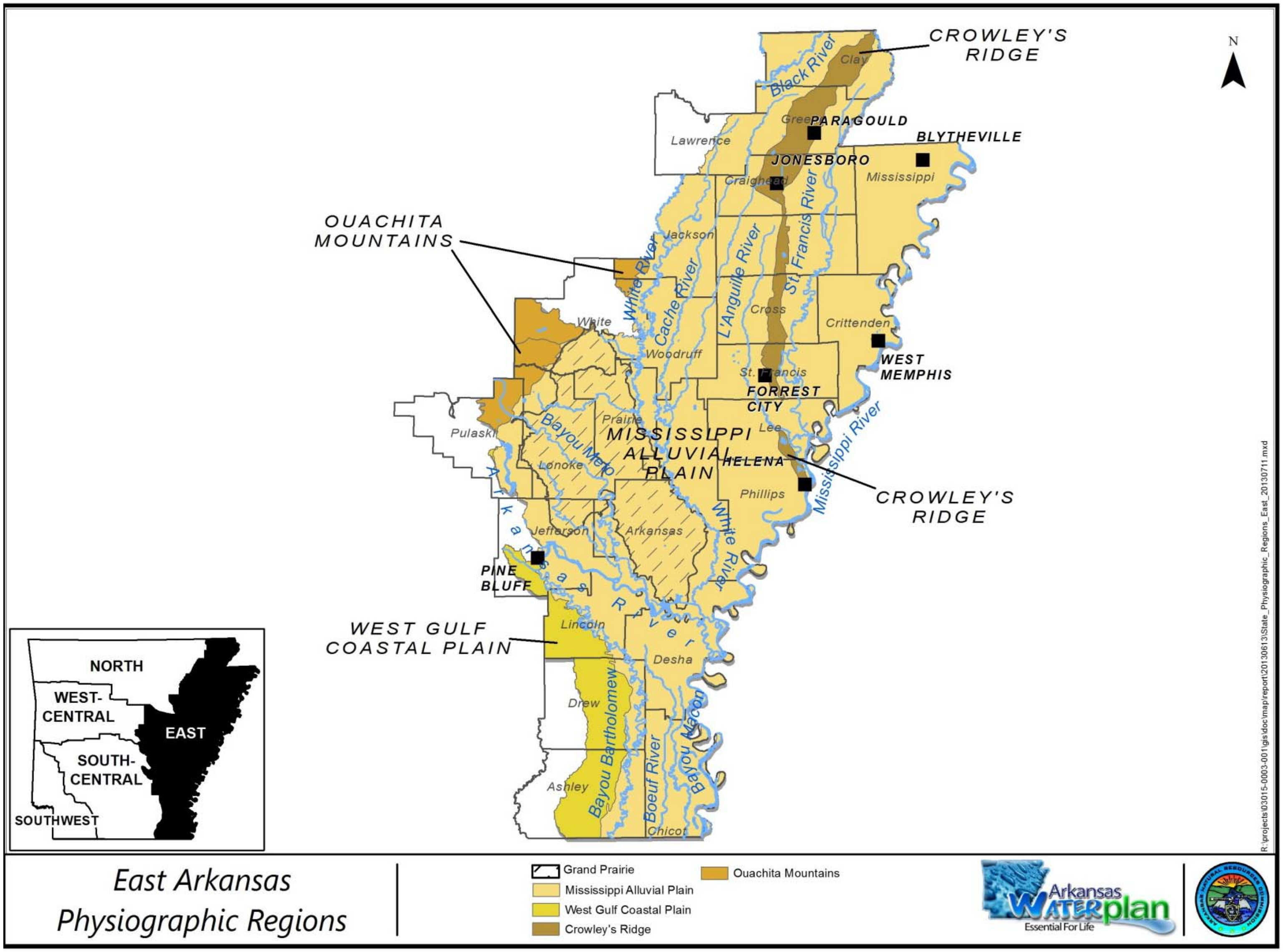

Figure 3.1. Physiographic regions within the EAWRPR (C. Kelley, ANRC, personal communication, April 25, 2013).

3.2 Geologic Setting

Geologic formations underlying the EAWRPR range in stratigraphic order from the earliest deposited layers of the Cretaceous Period to Quaternary Alluvium and Loess. Figure 3.2 displays the surface geology of the planning region.

The Mississippi Alluvial Plain province is characterized by largely unconsolidated formations. Geologic formations comprising the Mississippi Alluvial Plain in Arkansas are contained within the Mississippi Embayment which is a low lying basin that is filled with Cretaceous age to recent sediments. The Mississippi Embayment is a geosyncline (trough) formed from downwarping and rifting related to the Ouachita orogeny. This activity resulted in a deep catch basin for sediment deposition. The axis of this syncline plunges southward, with the axis roughly parallel to the Mississippi River (Clark, Hart and Gurdak 2011). The Mississippi Alluvial Plain is a predominantly Quaternary outcrop belt of the Mississippi Embayment (Manger, Zachry and Garrigan 1988). The Cretaceous-age deposits represent shallow, marginal, and usually restricted marine environments. The Tertiary-age sediments represent marginal marine and alluvial deposits. The Quaternary-age alluvial deposits consist of alternating layers of water-washed gravel, sands, silts, and clays (McFarland 2004, Clark, Hart and Gurdak 2011). For a complete description of the geologic formations in the planning region, refer to McFarland (2004).

The formation of the Mississippi Alluvial Plain is related to the structural geology and the erosional history of the area. The boundary between unconsolidated sediments of the Mississippi River Alluvial Plain and sedimentary rocks of the Interior Highlands (also known as the "fall line") is formed by faults. These faults have allowed for the older sedimentary rocks underlying the Mississippi River Alluvial Plain to subside over time and for thick sequences of unconsolidated sediments to be deposited on top (Adamski, et al. 1995). Cycles of rising and falling sea levels from the Cretaceous through the Tertiary periods resulted in older deposits cropping out on the periphery of the embayment, which is a diagnostic feature of synclinal structures (Clark, Hart and Gurdak 2011). Subsequent erosion by the Mississippi River and its tributaries has formed occasional bluffs and ridges in the area (Adamski, et al. 1995).

A surface geology feature of the planning region that has received much attention is the north-south, linear ridge known as Crowley's Ridge. This erosional remnant of the ancestral Mississippi and Ohio Rivers is generally capped by Quaternary-age loess (wind-blown dust), with minor exposures of Tertiary-age deposits along the margins (McFarland 2004). For a comprehensive review of the geography, regional geologic framework, and stratigraphy of the Lower Mississippi Valley, refer to Saucier (1994).

Small areas of the Ouachita Mountain geological province are located in White, Lonoke, and Pulaski Counties in the EAWRPR. Due to limited occurrence of this geologic province in this planning region, it is not described in this report. Descriptions of the Ouachita Mountain geological province are provided in the background reports for the other planning regions.

Industrial minerals available in the EAWRPR include clay, sand, and gravel (Mayfield 2001, USGS 2012).

The hydrogeology of the Mississippi Aluvial Plain in the planning region can be described as layers of unconsolidated silt, sand, and gravel which function as aquifers, yielding large quantities of water to wells. These aquifers are separated by clays which store greater volumes of water but have relatively low hydraulic conductivity, and therefore do not yield adequate volumes of water to wells. The tertiary formations of Crowley's Ridge act as a barrier to flow in shallow aquifers from the east of the ridge to the west. Ground water resources of the planning region are discussed in detail in Section 3.8.

Much of the surface geology of the planning region consists of Pleistocene alluvial terrace deposits (Figure 3.2). Generally, these deposits consist of fine clays with low hydraulic conductivity near the surface, with water-bearing sands and gravels underneath. This geology has contributed to some of the groundwater quantity issues in the planning region, particularly in the Grand Prairie area (USACE Vicksburg District 1984). This is discussed in greater detail in sections 3.8, 3.9, and 5.4.1.

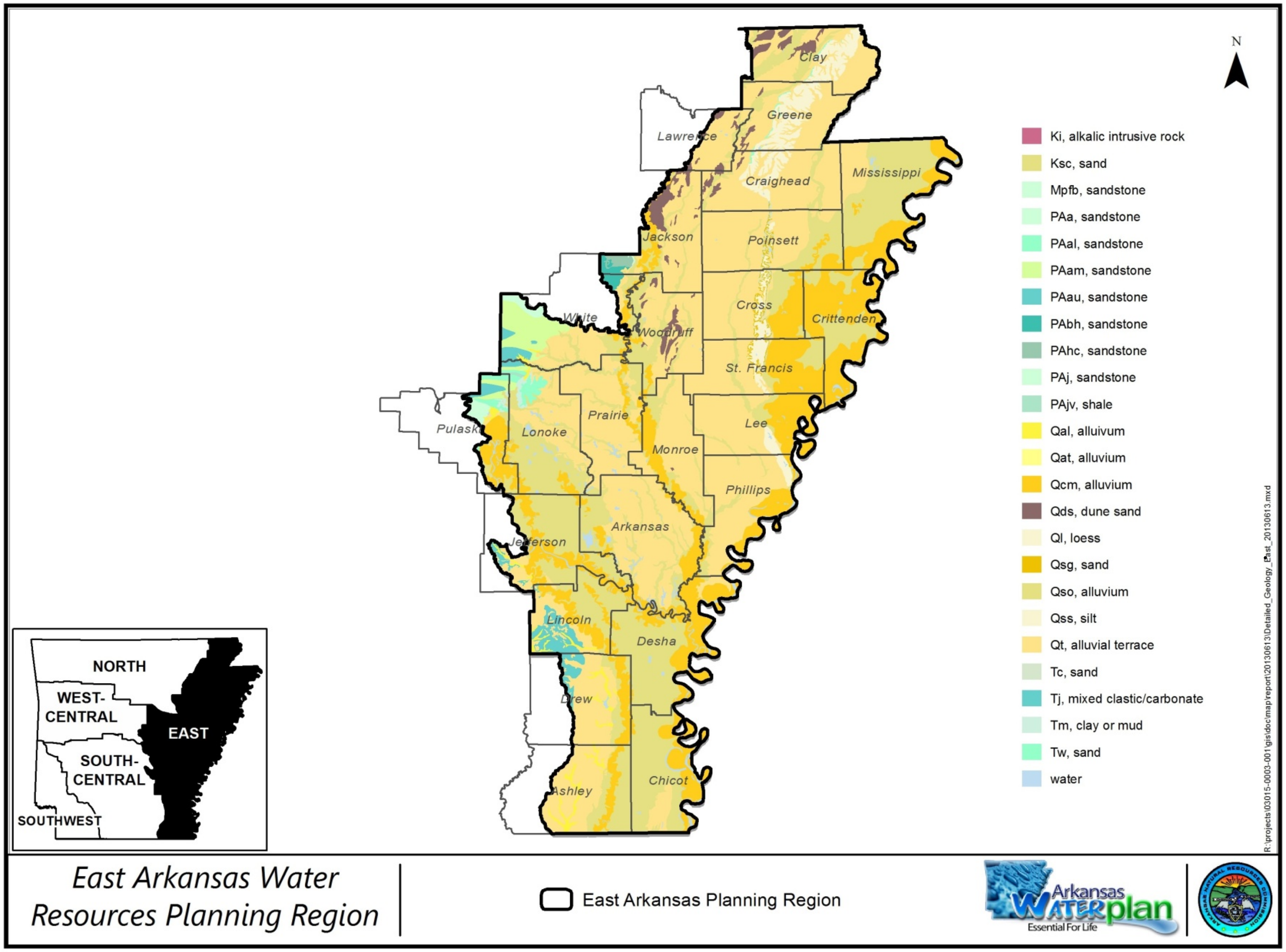

Figure 3.2. Surface geology of the EAWRPR (Haley et al. 1993).

3.3 Ecoregions

Ecoregions are areas within which ecosystems and the type, quality, and quantity of environmental resources are generally similar (EPA 2013a). The US Environmental Protection Agency (EPA) has defined 15 ecoregions within the EAWRPR (Figure 3.3). Ten of these ecoregions occur in the Mississippi Alluvial Plain. Two of the ecoregions are in the West Gulf Coastal Plain. Characteristics of all of the ecoregions in the EAWRPR are summarized in Table 3.1.

The natural vegetation of the Mississippi Alluvial Plain is southern floodplain forest, except in the Grand Prairie. In this ecoregion, aquatic and semi-aquatic freshwater habitats such as oxbow lakes, streams, and wetlands, are common. The majority of the wetlands in Arkansas are in this ecoregion. Streams in the Mississippi Alluvial Plain have very low gradients and fine-grained substrates. Streams and rivers within the meander belt ecoregions have the lowest gradients, with the greatest amount of meandering channels. Fish communities are generally characterized by few or no sensitive species. However, one of the most species-rich streams on the continent is located in the Mississippi alluvial plain (Woods, et al. 2004, Foti 2008, Stroud 2012).

The natural vegetation in the Mississippi Valley Loess Plains in the EAWRPR includes oak-hickory forest mixed with areas of beech-maple forest similar to those present in the Appalachian Mountains. This is the only region in the state where tulip poplar occurs naturally. Pines occur in sandier soils at the northern part of the ridge plain (Woods, et al. 2004, Foti 2008, Stroud 2011).Only headwater streams occur in this ecoregion, being shallow and having steep gradients. Streams in this ecoregion have finer-grained substrates. Fish communities present in these streams are dominated by headwater species (Fulmer and Harp 1977).

Because they comprise such small areas within the EAWRPR, the ecoregions of the Arkansas Valley, Ouachita Mountains, and South Central plains are not described in further detail here. Additional information about these ecoregions can be found in Woods et al. (2004) and in the West-central Arkansas Water Resources Planning Region and South-central Arkansas Water Resources Planning Region reports.

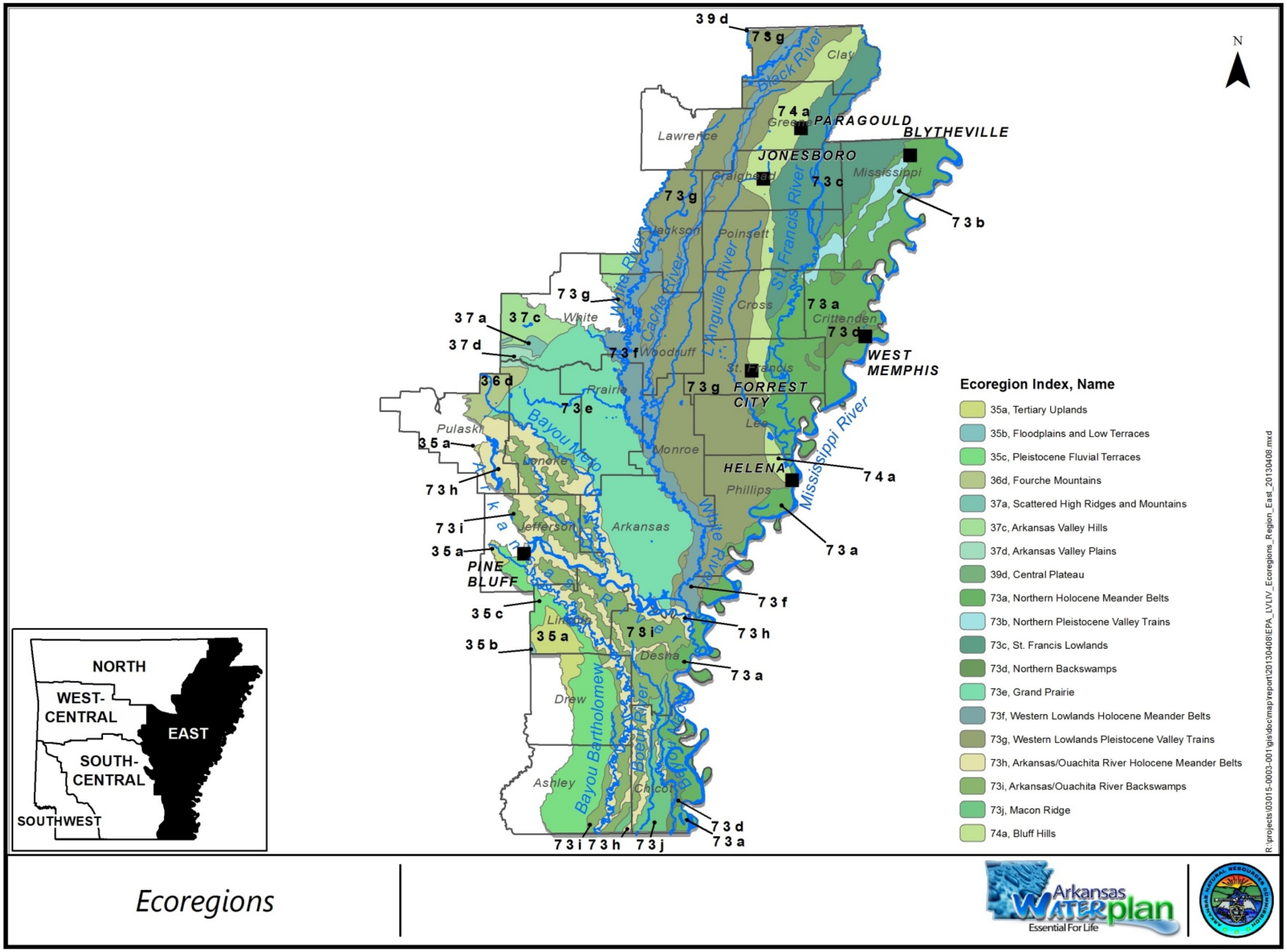

Figure 3.3. Ecoregions of the EAWRPR (Woods, et al. 2004)

Table 3.1. Ecoregions in the EAWRPR (Woods, et al. 2004).

Level III Ecoregion	Level IV Ecoregion	Native Vegetation	Hydrology
Arkansas Valley	Arkansas Valley Hills	Oak-hickory forest and oak-hickory-pine	Low gradient streams
Ouachita Mountains	Fourche Mountains	Oak-hickory-pine forest	High gradient streams
South-Central Plains	Tertiary Uplands	Oak-hickory-pine forest, mixed shortleaf pine-loblolly pine forest, upland deciduous forest, bottomland forest along rivers	Low gradient streams
South-Central Plains	Pleistocene Fluvial Terraces	Pine flatwoods of loblolly pine and oak, hardwood wetlands, pine savannah, prairie	Low gradient streams
Mississippi Alluvial Plain	Northern Holocene Meander Belts	Bottomland hardwood forest with species tolerant of wet and frequent flooding, e.g., willow, sycamore, cottonwood, water oak	Former Mississippi River channels, oxbow lakes common, low gradient streams
Mississippi Alluvial Plain	Northern Pleistocene Valley Trains	Bottomland hardwood forest with oak species typical of higher bottomlands, e.g., Nuttall oak	Low gradient streams
Mississippi Alluvial Plain	St. Francis Lowlands	Bottomland hardwood forest, cypress and tupelo in wettest areas, grassland on sandy terraces	Low gradient streams
Mississippi Alluvial Plain	Northern Backswamps	Bottomland hardwood forest, woodland, forested canebrake	Poorly drained flats & swales, marshes, swamps, oxbow lakes, low gradient streams
Mississippi Alluvial Plain	Grand Prairie	Tall grass prairie, oak-hickory open woodland and savannah	Low gradient streams
Mississippi Alluvial Plain	Western Lowlands Holocene Meander Belts	Bottomland hardwood forest and woodland of primarily oaks	Runoff from Ozark Highlands and Boston Mountains feeds most streams, former and current river channels of White, Black, Cache Rivers, low gradient streams
Mississippi Alluvial Plain	Western Lowlands Holocene Valley Trains	Bottomland hardwood forest, some loblolly pine, oak forest on ancient dunes, bottomland oak-hickory and pondberry in dune depressions and sand ponds	Ancient sand dunes with ponds in depressions between dunes, i.e., sandponds; low gradient streams
Mississippi Alluvial Plain	Arkansas/Ouachita River Holocene Meander Belts	Bottomland hardwood forest and woodland, palmetto and Spanish moss occur	Former river channels of Arkansas and Ouachita Rivers, existing Arkansas River channel, oxbow lakes common, low gradient streams, streams in abandoned channels, e.g., Bayou Bartholomew, Bayou Meto, Plum Bayou

Table 3.1. Ecoregions in the EAWRPR (continued).

Level III Ecoregion	Level IV Ecoregion	Native Vegetation	Hydrology
Mississippi Alluvial Plain	Arkansas/Ouachita River Backswamps	Bottomland hardwood forest, woodland, forested canebrake	Slackwater areas along Arkansas River, marshes, swamps, oxbow lakes, ponds, sloughs
Mississippi Alluvial Plain	Macon Ridge	Bottomland hardwood forest, upland hardwood forest, tall grass prairie, loblolly pine	Low gradient streams
Mississippi Valley Loess Plains	Bluff Hills	Oak-hickory forest mixed with areas of beech-maple forest similar to those present in the Appalachian Mountains, including tulip poplar.	Headwater streams are shallow with steep gradients and fine substrates

3.4 Aquatic Biodiversity

While it is true that much of the aquatic and wetland habitat in the EAWRPR has been significantly modified in the past, there is still considerable aquatic biodiversity in this planning region. Bayou Bartholomew is home to a diverse fish community, which ranks third in North America in terms of the number of fish species present. Habitats in this planning region support 107 of the 268 Arkansas species of greatest conservation need (Anderson 2006, ANHC 2013). Figure 3.4 provides a summary of the aquatic and semi-aquatic species of greatest conservation need found in the planning region. Of the over 180 aquatic and semi-aquatic plant species tracked by the Arkansas Natural Heritage Commission, over 70 occur in the EAWRPR (ANHC 2013). One of 14 Arkansas endemic (not found anywhere else in the world) insects, and the single Arkansas endemic plant are found in this planning region (Anderson 2006). Approximately 140 miles of streams in the planning region have been designated by ADEQ as Ecologically Sensitive Waterbodies because they provide habitat for endemic, threatened, or endangered species (Figure 3.5) (APCEC 2011). Additional information on threatened and endangered species in the planning region is provided in Section 5.3.7.

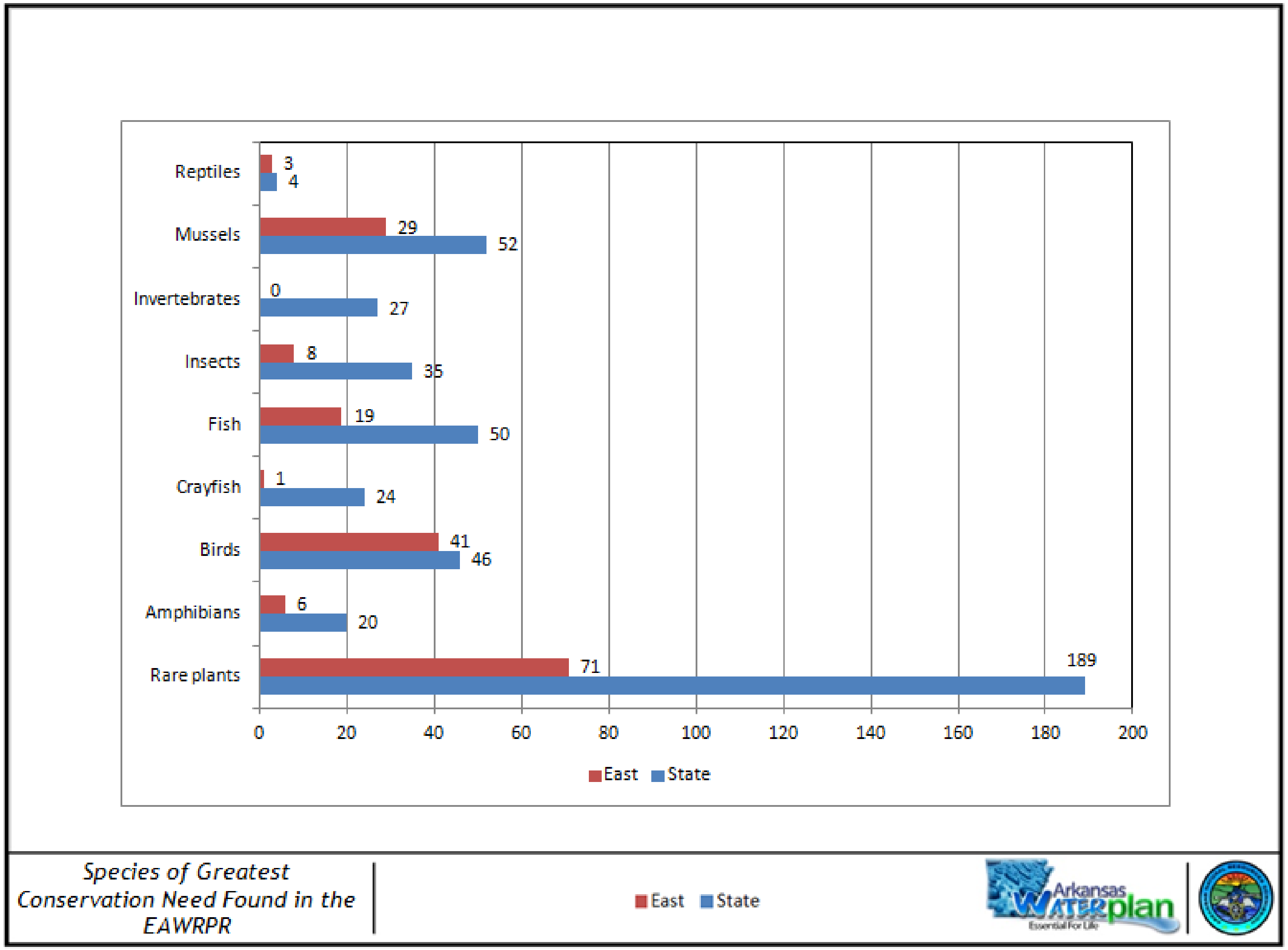

Figure 3.4. Species of greatest conservation need found in the EAWRPR (Anderson 2006, ANHC 2013).

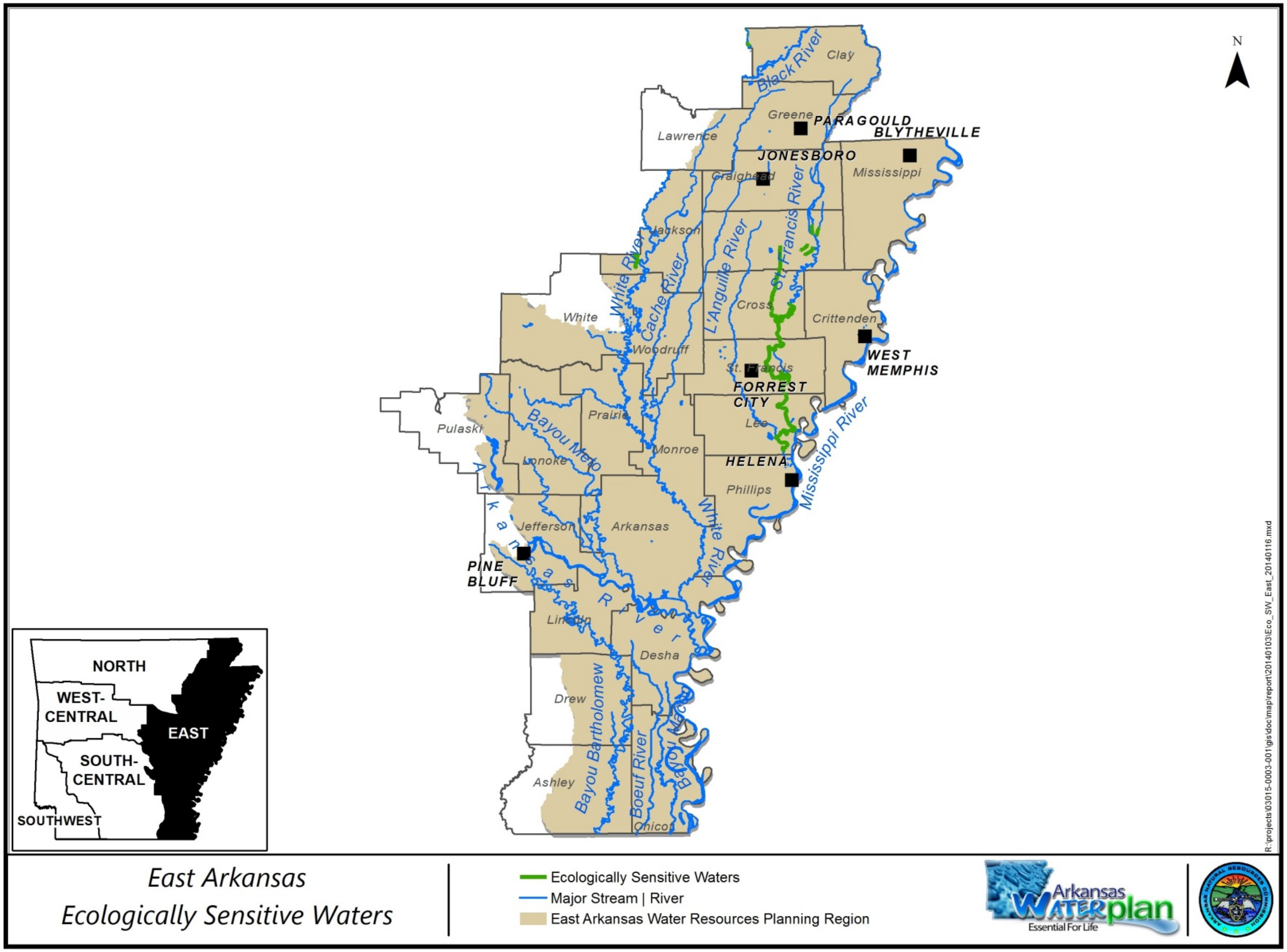

Figure 3.5. Ecologically sensitive waterbodies in the EAWRPR (APCEC 2011).

The water resources of the EAWRPR are important waterfowl habitat, 41 of the 46 aquatic bird species of greatest conservation need occur here (Figure 3.4). The planning region is located in the Mississippi River bird migration corridor, thus the wetlands and waterways in this region are internationally important as habitat for migrating and wintering waterfowl and shorebirds. In 1989, 145,690 hectares of wetlands within the watersheds of the Cache River and White River within the EAWRPR were designated as Wetlands of International Importance because of their importance for the support of wintering waterfowl and shorebirds (Ramsar Convention 2013). The designated area includes the White River National Wildlife Refuge and four state preserves containing wetland habitat.

Between 3,000 and 10,000 Canada geese, and up to 30,000 ducks, winter over in the White River National Wildlife Refuge each year. This is approximately one-tenth of the birds that use the Mississippi River migration corridor annually (Stroud 2012). Other bird species that migrate through the region include plovers, sandpipers, gulls, terns, pelicans, and cormorants. Over a dozen duck species winter in Arkansas, as well as geese, loon, cormorant, and gull species. This region hosts one of the world’s largest wintering populations of mallard ducks every year, and is considered the most important wintering area for these birds in North America (White 2010, 2011).

3.5 Climate

The climate of the EAWRPR is humid sub-tropical and is characterized by long summer and relatively short winters. Temperature, precipitation, and evaporation data for the planning region were obtained from the National Weather Service, National Oceanic and Atmospheric Administration National Climatic Data Center (NOAA NCDC), and the PRISM Climate Group and reviewed. These data are available for each of the climate divisions in Arkansas (Figure 3.6). Data for climate divisions 3, 6, and 9 were used to characterize climate in the EAWRPR. Summaries of these data are presented below, along with discussions of factors that influence climate in the EAWRPR and long-term climate trends in the region.

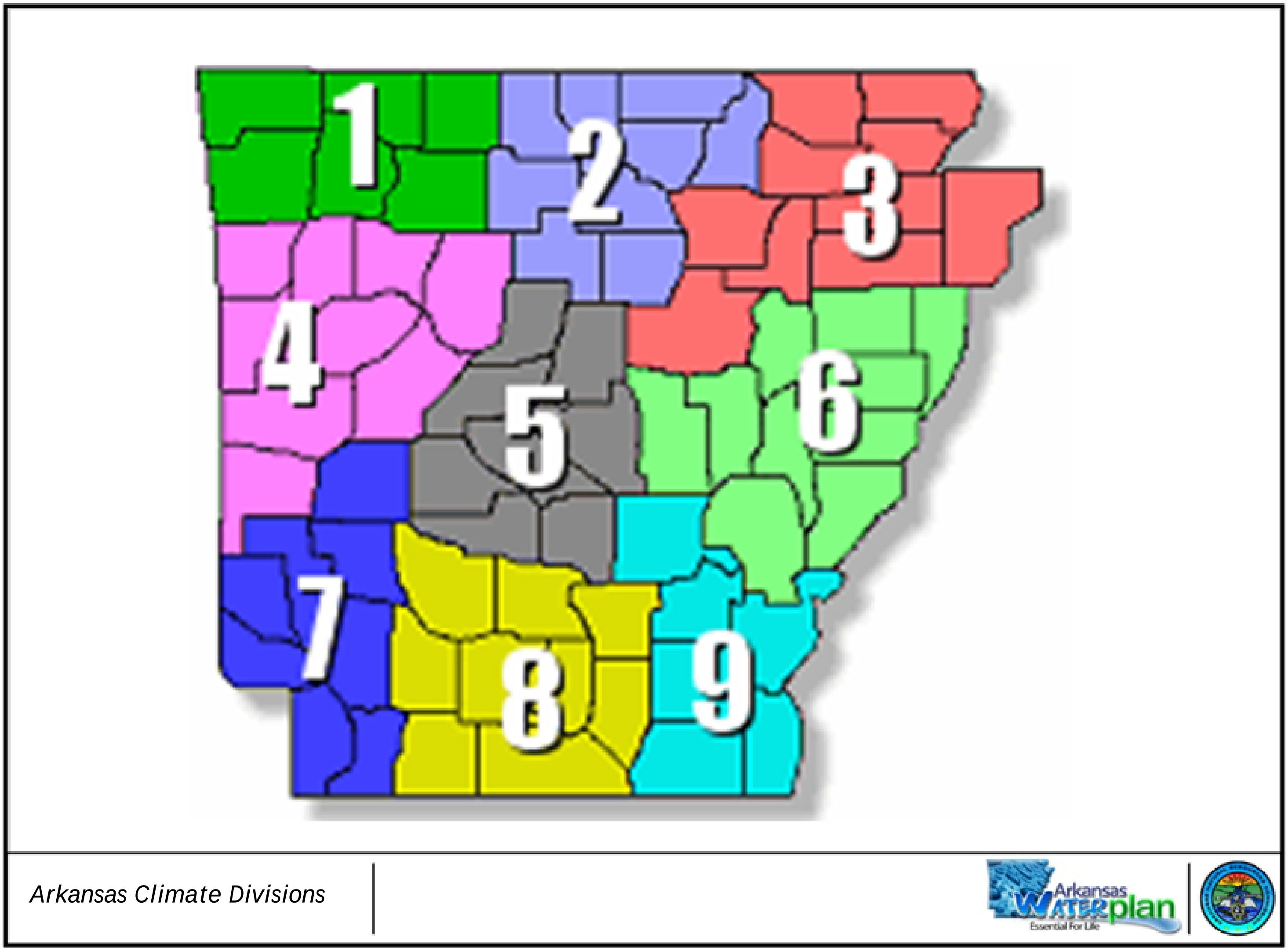

Figure 3.6. Arkansas climate divisions
(National Weather Service Weather Forecast Office Little Rock AR 2013)

3.5.1 Temperature

The average annual temperature in the EAWRPR is approximately 60 degrees Fahrenheit (ASWCC 1988). Normal daytime maximum temperatures range from 91 degrees Fahrenheit in July and August to 49 degrees Fahrenheit in January (Figure 3.7). Normal minimum nighttime air temperatures range from 69 degrees Fahrenheit in July to 26 degrees Fahrenheit in January. The average difference between the monthly normal minimum and maximum air temperatures is 24 degrees Fahrenheit (Woods, et al. 2004). Variations in annual maximum daily temperatures across the planning region are shown in Figure 3.8. Temperatures increase slightly from north to south. The growing season (frost free days) in the planning region ranges from 200 to 220 days in the north to 220 to 240 days in the south (Woods, et al. 2004).

3.5.1 Precipitation

The average annual precipitation (1981 – 2010) in the EAWRPR ranges from 45 inches to 56 inches. Annual precipitation increases from north to south (Figure 3.9) (Anderson 2006, Scott, et al. 1998). Average monthly precipitation for the EAWRPR for the period from 1981 through 2010 is shown in Figure 3.10. The months in late spring and late fall to early winter are generally the wettest. Precipitation is lowest during the summer growing season.

Summer precipitation primarily occurs during rainstorms, where locally high rainfall amounts can occur over a short period of time. During the fall, winter, and early spring, precipitation events are usually less intense and of longer duration. The majority of the precipitation in the EAWRPR falls as rain; snow rarely occurs here (NOAA NCDC n.d., Buckner 2011).

3.5.2 Evaporation

Evaporation is the process by which water changes from liquid in soil to gaseous water vapor. When the conversion from liquid to water vapor occurs on leaves, the process is called transpiration. Evapotranspiration is the combination of these processes. The amount of evapotranspiration is controlled primarily by sunlight, but is influenced by humidity and wind (Scott, et al. 1998).

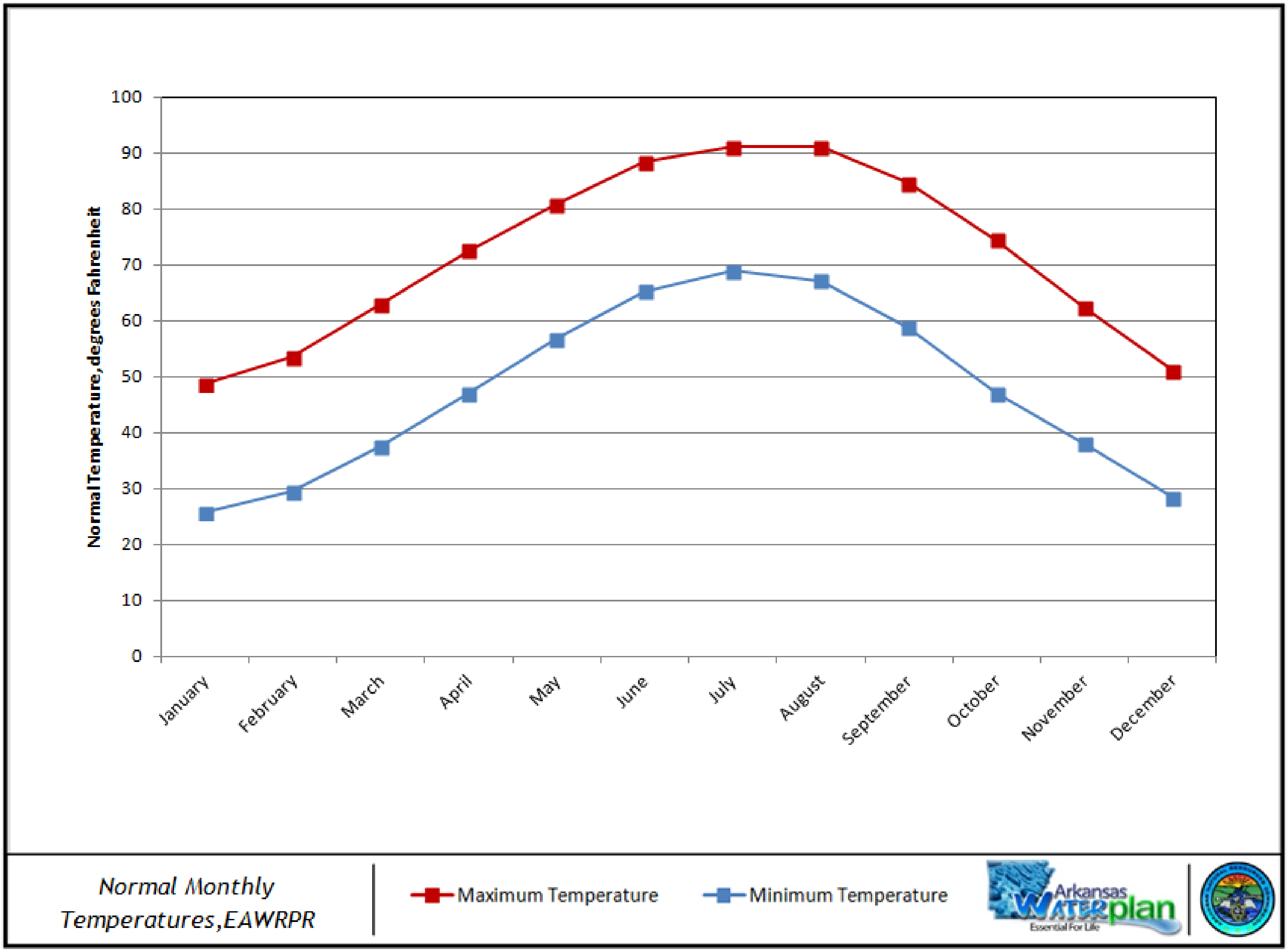

Figure 3.7. Normal monthly temperatures for the EAWRPR (PRISM Climate Group 2004).

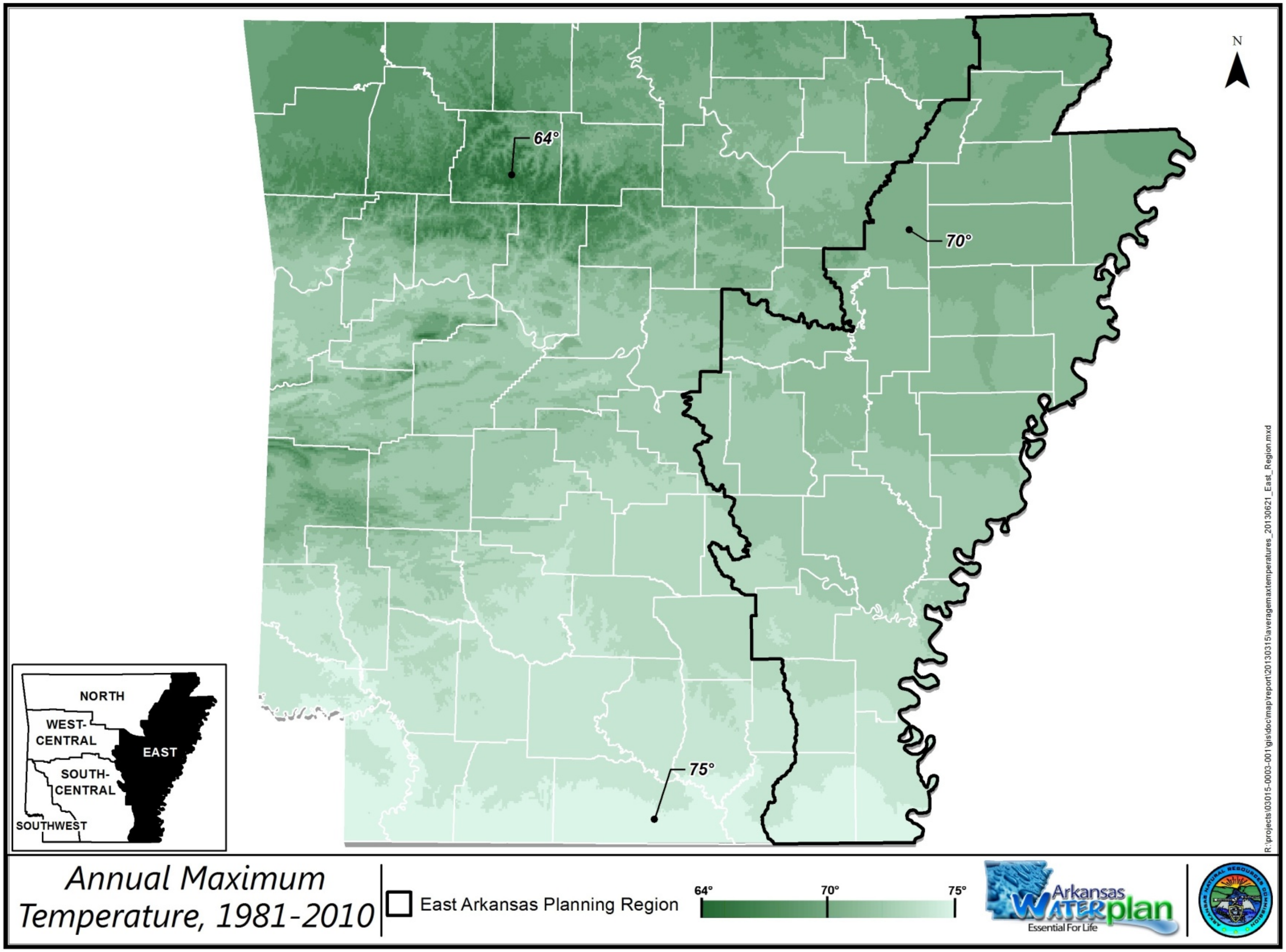

Figure 3.8. Average annual maximum daily temperature in degrees Fahrenheit, 1981-2010 (PRISM Climate Group 2004).

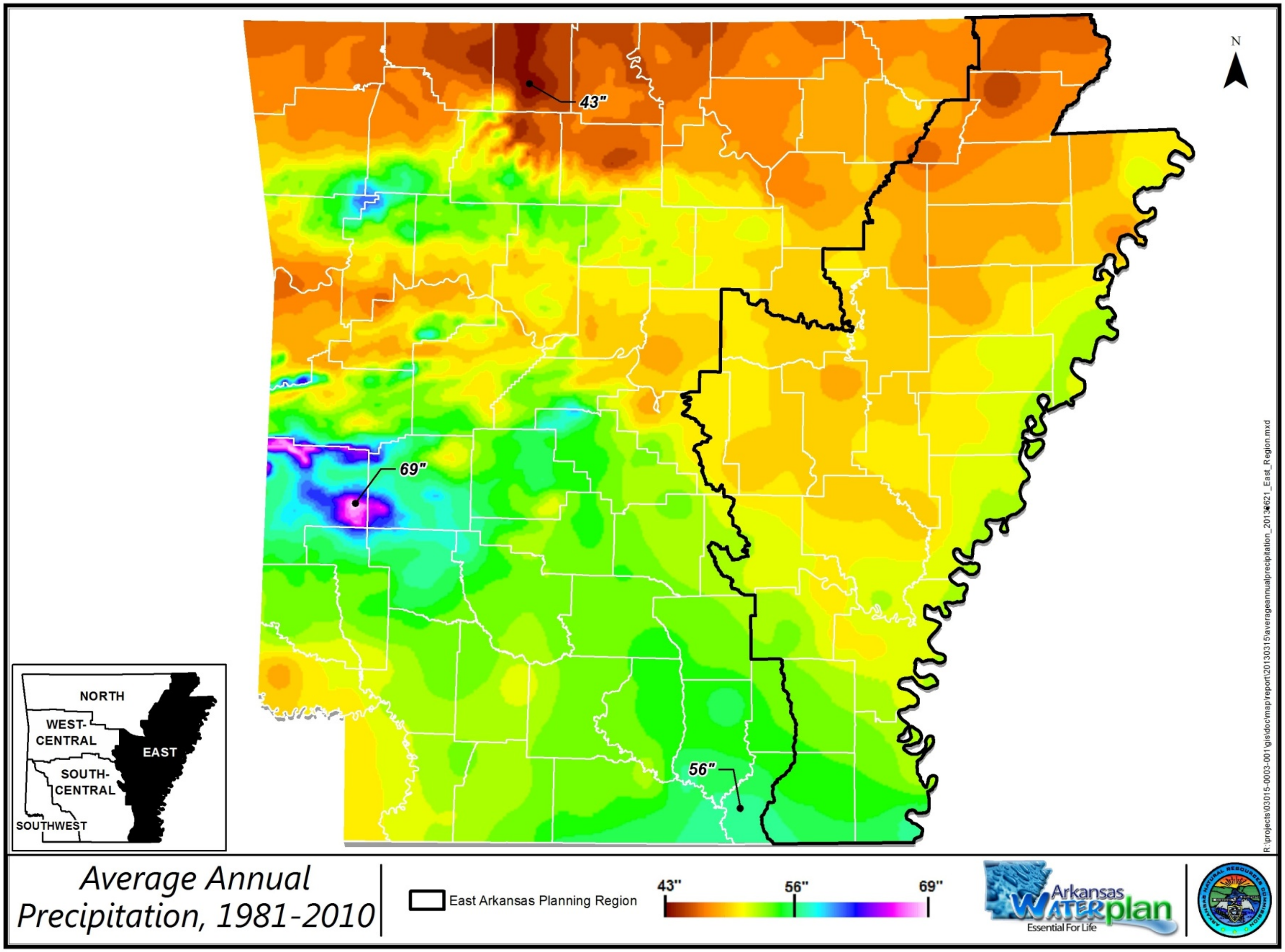

Figure 3.9. Average annual precipitation (inches) in the EAWRPR (PRISM Climate Group 2004).

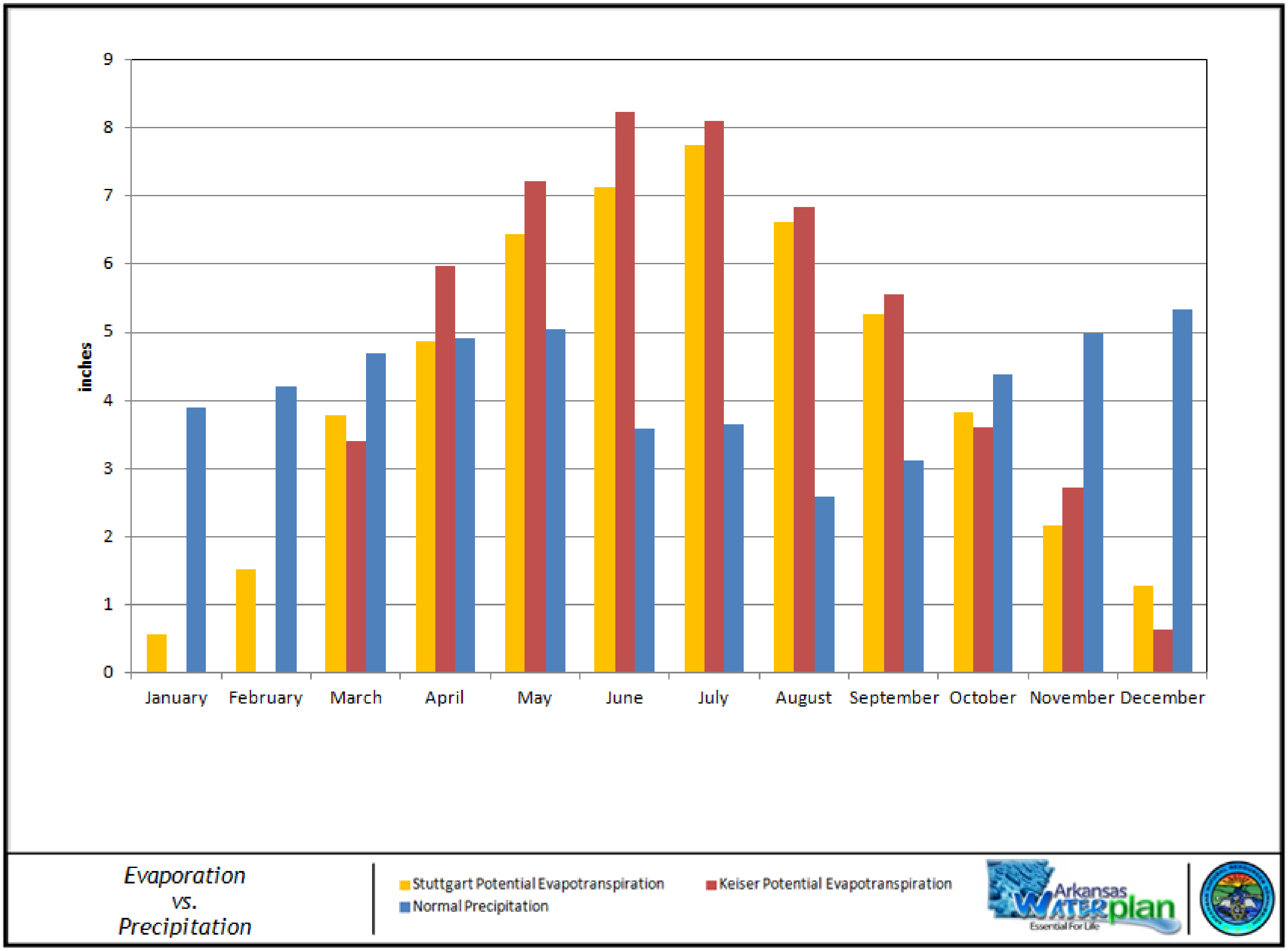

Figure 3.10. Average monthly precipitation compared to average monthly potential evapotranspiration, 1981 – 2010 (PRISM Climate Group 2004, NOAA NCDC 2013a).

Potential evapotranspiration is the maximum rate at which water in soil and on plants would change to water vapor, assuming there is no shortage of water to be changed. Actual evapotranspiration is usually less than the potential. Potential evapotranspiration is difficult to measure, but can be estimated from the meteorological measurement, pan evaporation. Pan evaporation is the rate of evaporation of water from a specific style of open pan at a weather station. In humid regions like East Arkansas, potential evapotranspiration is similar to pan evaporation. In this region, the ratio of potential evapotranspiration to pan evaporation is assumed to be 0.85. Evaporation exhibits less variation from year to year and place to place than precipitation (Scott, et al. 1998). Figure 3.10 shows monthly average potential evapotranspiration estimated from pan evaporation measurements at Keiser in Mississippi County for the period 1981 – 2010, and at Stuttgart in Arkansas County for the period 1981 – 1997 (the available period of record for this station). The estimated potential evapotranspiration exceeds the normal precipitation six months out of the year (April – September).

3.5.3 Drought

Although the EAWRPR receives precipitation throughout the year, drought conditions occur in the region. One of the tools NOAA uses to determine when drought conditions exist is the Palmer Drought Indices. These indices are based on the differences of precipitation and temperatures from normal. The Palmer Drought Severity Index (PDSI) also takes into account the length of time that drought conditions last. PDSI values less than zero indicate drought conditions. An index of -2 indicates moderate drought, -3 indicates severe drought, and -4 indicates extreme drought (NOAA 2012). Figure 3.11 shows a time series plot of PDSI values for climate division 6 in Arkansas (see Figure 3.6 for a map of Arkansas climate divisions). Periods with multiple consecutive years of drought have occurred frequently in this climate division (Figure 3.11). The planning region is currently experiencing a period of drought that began in 2009 (NOAA NCDC 2013b).

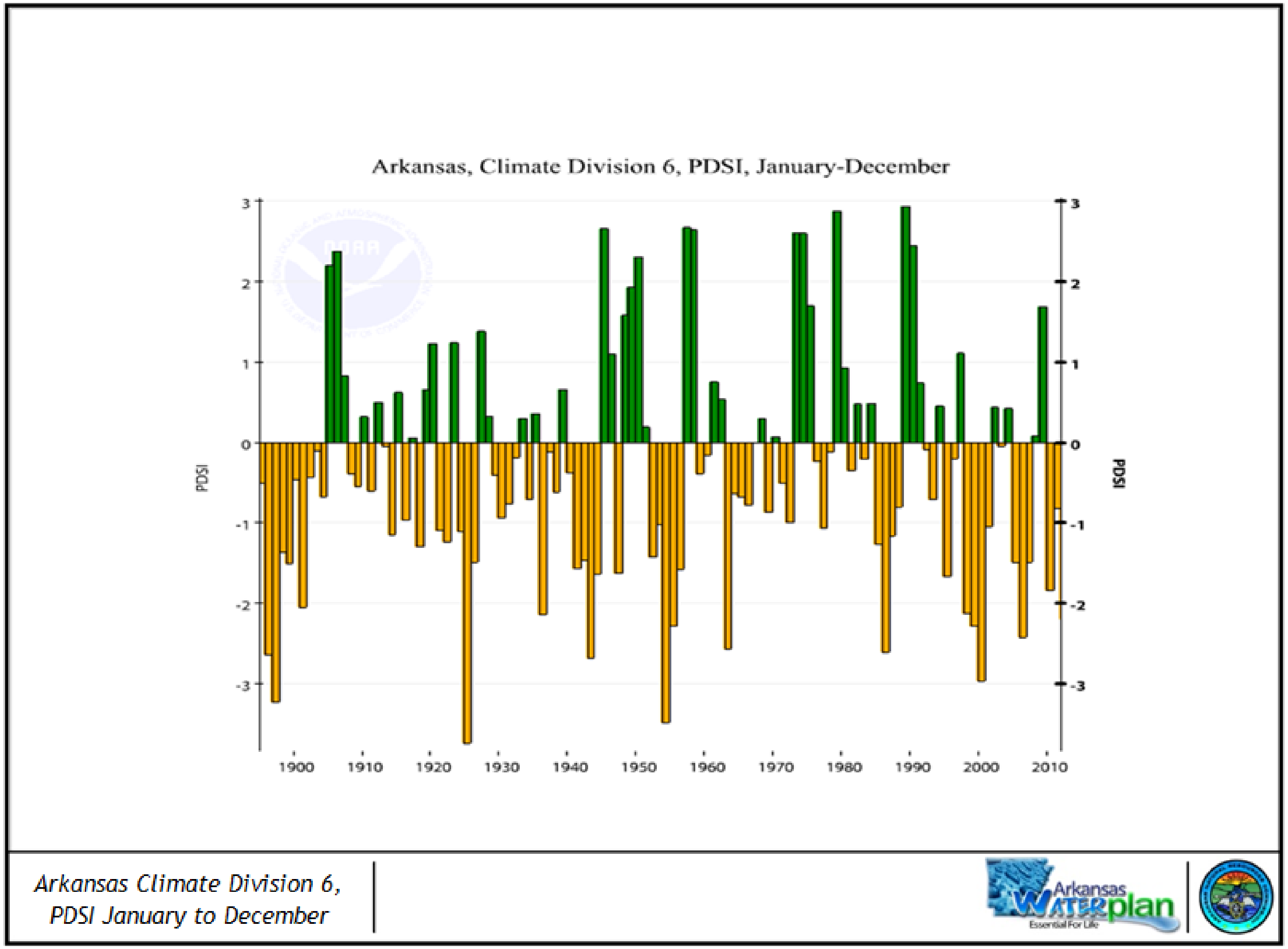

Figure 3.11. Historical values of the Palmer Drought Severity Index climate division 6 (east-central) (NOAA NCDC 2013b)

3.5.4 Climate Variability

In 2007, the Governor's Commission on Global Warming (GCGW) was established to, among other tasks, evaluate the potential impacts of global warming on the state citizens, natural resources, and economy. The literature review conducted by the GCGW identified the following climate change effects anticipated for the state (GCGW 2008):

- Increased incidence of severe weather events,
- Increased incidence of flooding,
- Increased incidence of drought,
- Possible saltwater intrusion into aquifers resulting from sea level rise, and
- Changes in climatic zones.

Plots of annual average temperature and total annual precipitation from 1895 to 2013 for the eastern Arkansas climate divisions (3, 6, and 9) are shown in Figures 3.12 and 3.13, respectively. The temperature data appear to exhibit a cycle of change, where temperatures in the first half of the 20th century were warmer than the second half, but appear to be warming again in the early 21st century (Figure 3.12). The US Department of Agriculture (USDA) develops a plant hardiness zone map which shows annual average minimum winter temperature. The 2012 update of the USDA map shows warmer minimum temperatures in the state as compared to the 1990 zone map, which follows the cycle shown on Figure 3.12 (Clark and Karklis 2012). Precipitation totals for climate divisions 6 (east-central) and 9 (southeast) appear to exhibit a slight long-term increasing trend, while the precipitation totals for climate division 3 (northeast) does not exhibit any trend (Figure 3.11). A detailed analysis of long-term precipitation trends across the state is being prepared as part of the 2014 water plan update and reported separately.

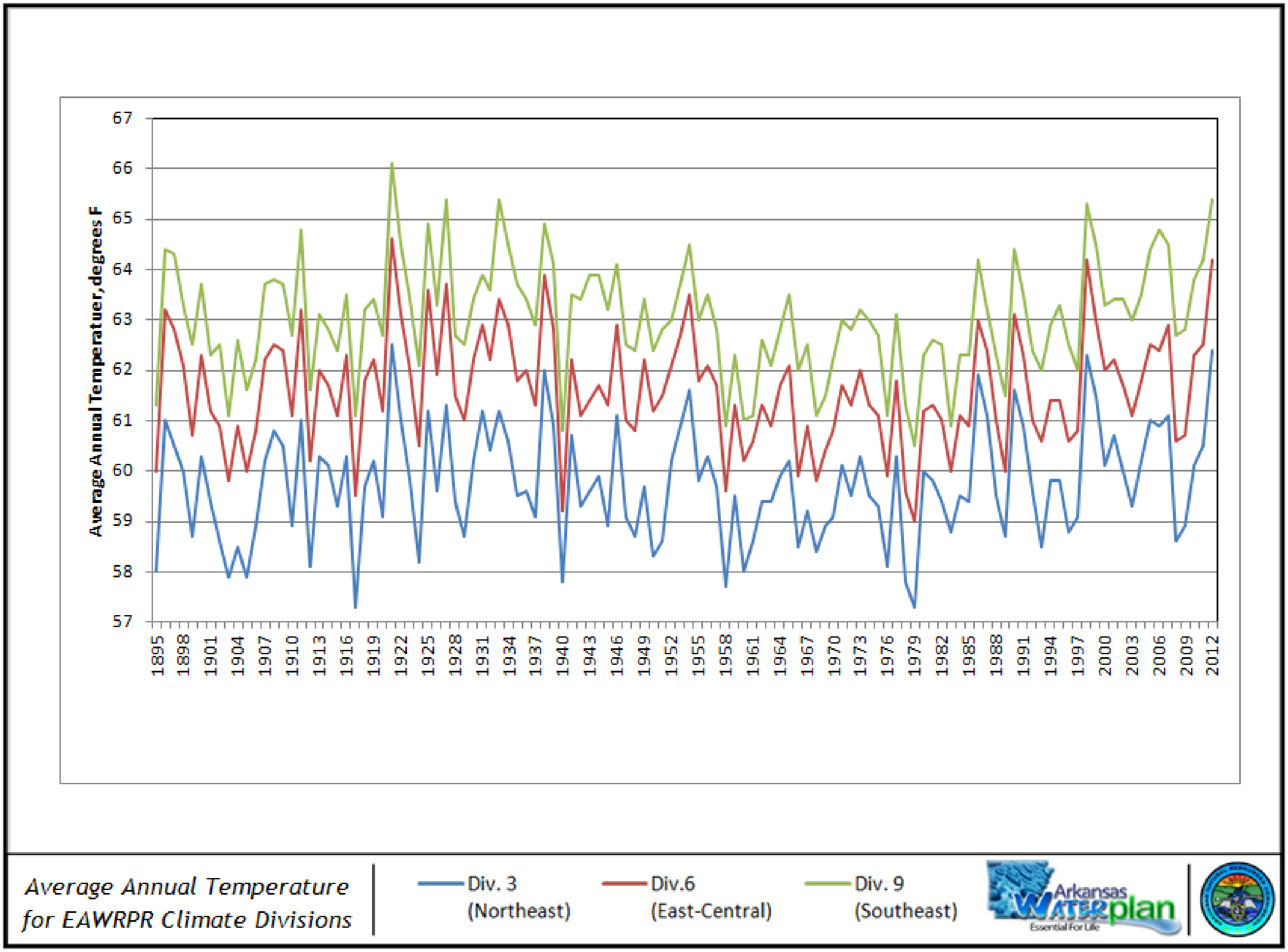

Figure 3.12. Average annual temperatures for the EAWRPR climate divisions (NOAA NCDC 2013c).

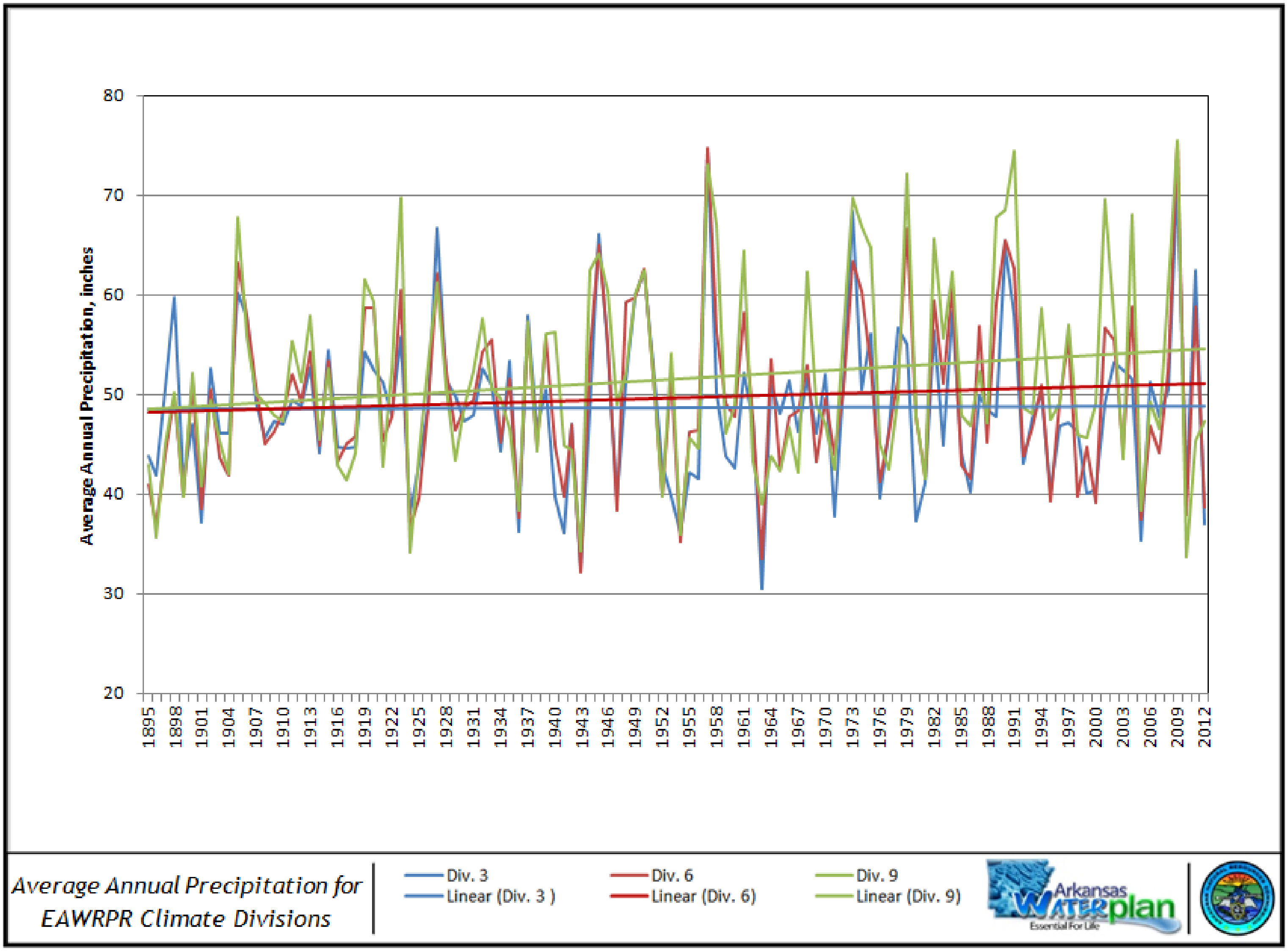

Figure 3.13 Average annual precipitation totals for eastern Arkansas climate divisions (NOAA NCDC 2013c).

3.6 Land Use

Land use in the EAWRPR is summarized in Figure 3.14 and mapped in Figure 3.15. Major land use categories are discussed in the sections below, including present day extent, and changes since the 1990 AWP.

3.6.1 Agriculture

The majority of the land in the EAWRPR is devoted to agricultural crop production (Figure 3.14). The major crops reported for the planning region in the 2007 Census of Agriculture were rice and soybeans, unchanged since the 1990 AWP update (ASWCC 1984, 1988; USDA National Agricultural Statistics Service 2007). The 2007 Census of Agricultural reported 6.1 million acres of cropland (harvested and other) in the counties within the planning region. The 1990 AWP reported 7.1 million acres of cropland in these counties. Because these cropland areas are from different sources, their comparability is uncertain. As a check, the 1987 Census of Agriculture reported 6.5 million acres of cropland in the counties of the EAWRPR. These numbers indicate that there has been a decline in the amount of cropland in the planning region since the 1990 AWP updates.

In the 2007 Census of Agriculture, approximately 71% of the cropland within the counties of the planning region was irrigated (USDA National Agricultural Statistics Service 2007). It was not possible to determine the amount of irrigated cropland for the EAWRPR from the information reported in the 1990 AWP. In the 1987 Census of Agriculture, the amount of cropland (harvested and other) in these counties reported as irrigated was 23% (note that the amount of irrigated land was not reported for 10 of the 26 counties in 1987 to protect farmers' privacy) (US Department of Commerce Bureau of the Census 1989). This indicates that while there has been a small decline in cropland land since the 1990 AWP update, there has been a significant increase in the amount of irrigated cropland during that time period.

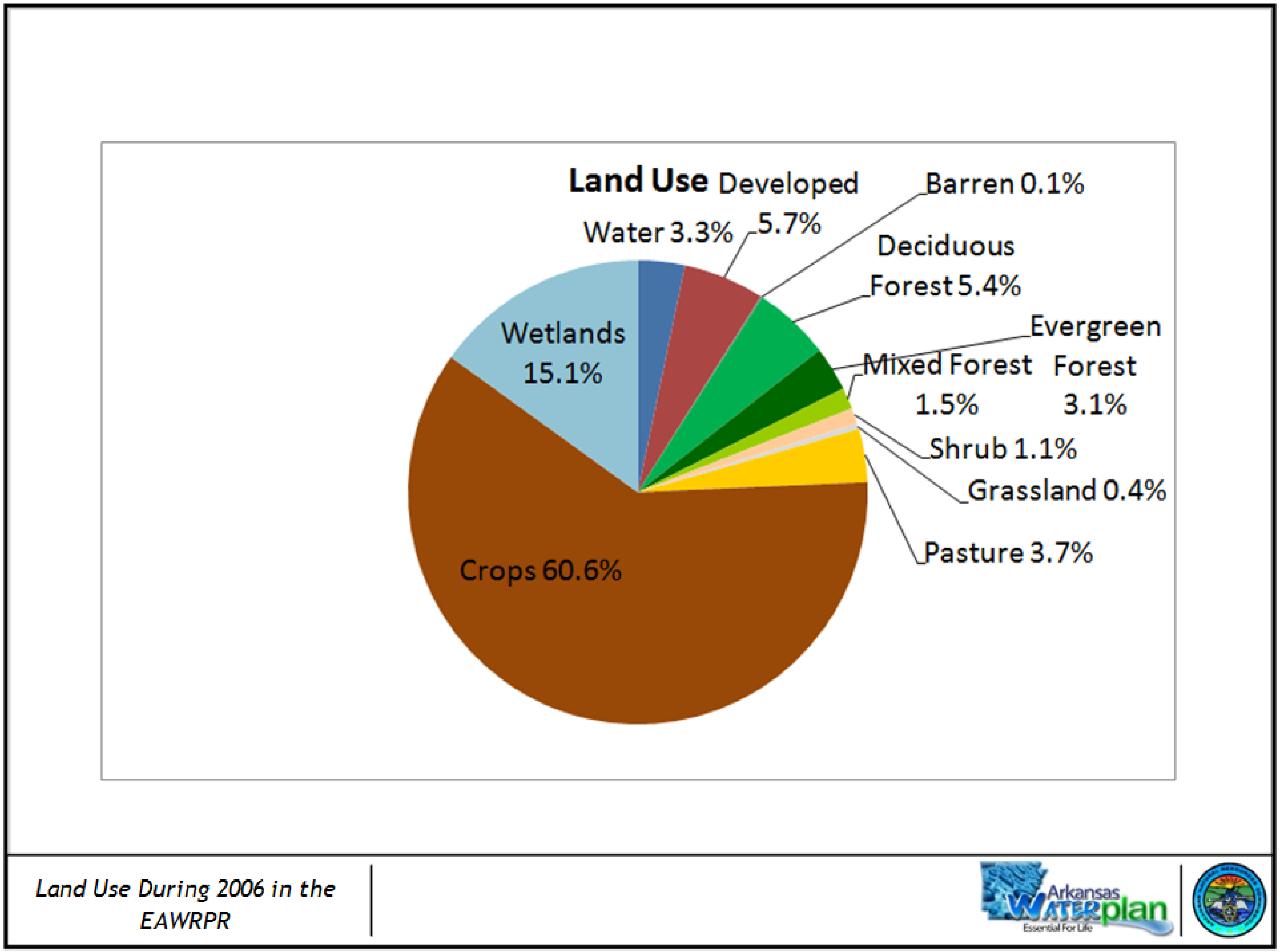

Figure 3.14. EAWRPR land use, 2006 (Fry, et al. 2011).

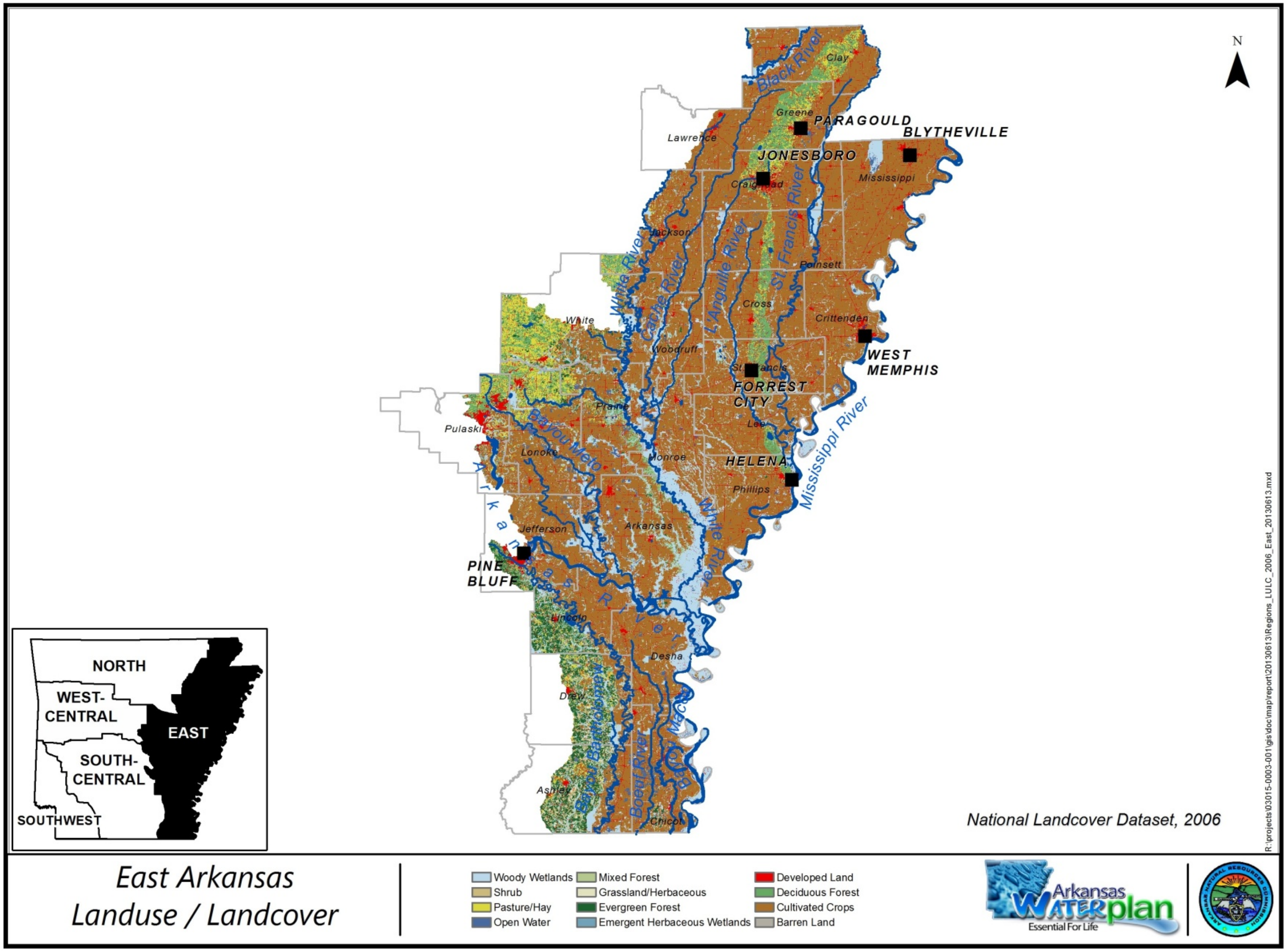

Figure 3.15. Land use map of the EAWRPR (Fry, et al. 2011).

3.6.1 Wetlands

After cropland, the next largest land use category for this planning region is wetlands, 15% of the land area, or 1.5 million acres. Despite the fact that the majority of the wetlands in this region have been converted to cropland, the majority of the state's wetlands are located in this planning region. Wetlands in this region are primarily located in the White River National Refuge and along the Cache River (see Figure 3.15). Wetland resources of the planning region are further described in Section 3.7.5.

In the 1990 AWP update, the area of wetlands in the Eastern Arkansas basin was estimated to be 0.6 million acres (ASWCC 1988). The wetland area in the Beouf-Tensas basin was estimated to be 5,154 acres (ASWCC 1984). Together, these two basins are roughly equivalent to the EAWRPR. Based on the wetland areas reported for these basins in the 1990 AWP update, the area of wetlands in the EAWRPR has increased since the 1990 AWP update.

3.6.2 Forest

Forest land use categories account for the third largest area in the EAWRPR ,10% of the land area. As can be seen in Figure 3.15, the majority of the forest in the region occurs outside of the Mississippi Alluvial Plain (see Figure 3.1 for the extent of the Mississippi Alluvial Plain). The St. Francis National Forest on Crowley's Ridge accounts for only 2% of the forest land in the planning region.

Data on forest area by county from the 1990 AWP basin reports is listed in Table 3.2, along with data from the 2012 USDA Forest Service (USFS) forest inventory. Because these data are from different sources, their comparability is uncertain, however, it does appear that the amount of forest land in the planning region has increased. In all of the counties, except Ashley, Clay, and Lincoln, the reported 2012 area is greater than the area reported in the 1990 AWP basin reports. It appears that forest area has increased by double or more since the 1990 AWP in approximately half of the counties within the EAWRPR. For the remaining counties, the pre-1990 areas and the 2012 areas are similar. Conservation and restoration efforts in this region may account for at least some of the increase in forest.

Table 3.2 Forest land comparison in the EAWRPR

County	Pre-1990 Forest Area (acres)	2012 Forest Area (acres)[e]	Change
Arkansas	73,885[b]	201,331	+
Ashley*	434,604[a,f]	408,851	-
Chicot	19,998[a]	131,190	+
Clay	108,574[b,d]	71,233	-
Craighead	47,938[b]	58,574	+
Crittenden	29,158[b]	37,026	+
Cross	45,220[b]	51,831	+
Desha	27,488[a,f]	154,046	+
Drew*	394,532[f]	407,198	+
Greene	87,785[b,d]	104,571	+
Jackson	61,704[b,d]	71,765	+
Jefferson*	200,007[a,c,f]	201,198	+
Lawrence*	110,589[d]	207,707	+
Lee	81,791[b]	94,129	+
Lincoln	171,139[a,f]	153,167	-
Lonoke	26,765[b,c]	123,237	+
Mississippi	22,981[b]	29,708	+
Monroe	61,035[b]	177,941	+
Phillips	66,471[b]	96,981	+
Poinsett	42,255[b]	73,238	+
Prairie	77,591[b]	111,910	+
Pulaski*	199,139[c,f]	234,669	+
St. Francis	63,259[b]	91,213	+
White*	144,001[c,d]	241,113	-
Woodruff	51,900[b,d]	117,240	+
Total	**2,649,809**	**3,651,067**	+

* part of this county is in another water resources planning region
a (ASWCC 1984)
b (ASWCC 1988)
c (USACE Little Rock District 1988)
d (USACE Little Rock District 1987)
e (USFS 2013)
f (ASWCC 1987)

3.6.3 Public Land

There are approximately 538,000 acres of public land in the EAWRPR, around 5% of the land in the planning region. Table 3.3 reports the number and acreage of each type of public land as reported by the Arkansas State Highway and Transportation Department (AHTD). Wildlife refuges and management areas account for the majority of this public land (Table 3.3). There is also the St. Francis National Forest, several state parks, a national park, natural areas, and military land (Pine Bluff Arsenal, Little Rock Air Force Base) in the planning region. There is some overlap of public land classes. For example, one natural area is located in the White River NWR.

Table 3.3. Public lands in the EAWRPR (AHTD 2006, AGFC 2009).

Public Land	Acreage	Percent of Area	Count
National Forest	29,571	5.6%	1
National Wildlife Refuges	247,393	46.8%	5
Wildlife Management Areas	198,909	37.6%	33
State Parks	10,143	1.9%	19
Military Land	19,485	3.7%	2
National Park	238	<1%	1
Natural Areas	5,930	1.1%	19
Total	**528,223**		

There have been additions to the public lands in the EAWRPR since the 1990 AWP. A few wildlife management areas have been established in the region since 1990 (see Table 2.4) (AGFC 2011). Four new state natural areas have been established in this region since 1990 (see Table 2.4) (ANHC 2010). The Delta Heritage Trail State Park was initiated in the early 1990s (Arkansas Department of Parks and Tourism 2005b).

3.7 Surface Water

There are approximately 44,000 miles of rivers, streams, and ditches in the EAWRPR, approximately 680 miles of waterways used for commodity transport, and over 150,000 acres of impounded water (ASWCC 1981, Arkansas Waterways Commission 2013, USGS 2013a). There is also one hydropower project in the planning region. Major rivers in the region include the Arkansas River and White River. The largest impoundments in this region are the navigation pools on the Arkansas River. Surface water availability issues, both water quantity and water quality, are discussed in detail in Section 5.

3.7.1 Rivers and Streams

Two of the state's major rivers flow through the EAWRPR, the Arkansas and the White. Additional principal streams in the planning region include the St. Francis River, and Bayou Bartholomew. The St. Francis River originates in Missouri, enters the planning region as the eastern border of Clay County, and empties into the Mississippi River in Lee County, draining the northeastern portion of the planning region (Figure 2.1). Tributaries of the St. Francis River include the Tyronza River, Right Hand Chute of Little River, and the L'Anguille River. The Tyronza River and the Right Hand Chute of Little River lie to the east of Crowley's Ridge. The Tyronza River originates in Mississippi County. The Little River originates in Missouri. The L'Anguille River originates on Crowley's Ridge and lies west of the ridge for almost its entire length, cutting through the ridge near its southern end.

The White River originates outside of the planning region, in northwestern Arkansas. The White River enters the planning region in Jackson County, near Newport, and empties into the Mississippi River in Desha County, draining the northwestern portion of the planning region. Tributaries of the White River in the planning region include the Black River, Cache River, Bayou DeView, Big Creek, and Cypress Bayou. All of these tributaries, except the Black River, originate in the planning region. The Black River originates in Missouri.

The Arkansas River originates in Colorado. It enters the planning region in Pulaski County, at Little Rock, and empties into the Mississippi River in Desha County, draining the central portion of the planning region. Tributaries of the Arkansas River include Bayou Meto and Wabbeseka Bayou, both of which originate in the planning region.

Bayou Bartholomew originates in Jefferson County, near Pine Bluff, and flows out of the state in Ashley County, draining the southern portion of the planning region. Tributaries of Bayou Bartholomew in the planning region include Cutoff Creek, Beouf River, and Bayou Macon. These tributaries all originate in the planning region. The Beouf River and Bayou Macon join Bayou Bartholomew outside of the state, in Louisiana.

Numerous manmade changes to waterways in the planning region to facilitate drainage of the land for cultivation and to improve the hydraulics of stream channels, have significantly altered surface water flow in the planning region. Drainage projects such as dredging of channels, construction of levees, and construction of drainage ditches have altered channels and drainage patterns to such an extent that they no longer resemble their natural state. Flow in both the White River and the Arkansas River is regulated. Flow in the Arkansas River is regulated by the dams that make up the McClellan-Kerr Arkansas River Navigation System. Flow in the White River is regulated by four mainstem reservoirs and two tributary reservoirs, all located outside of the EAWRPR.

The historical average annual surface runoff in the EAWRPR ranges from approximately 7 inches in the northwestern part of the planning region to approximately 11 inches in the western areas of the planning region (Figure 3.16). Seasonal variation in runoff mirrors seasonal variations in precipitation (Pugh and Westerman 2014).

Streamflow in the EAWRPR is generally highest from December through May because of the large amount of precipitation during this period (Figure 3.10). Similarly, streamflow is generally lowest during June through November due to lower precipitation and increased agricultural water use and evapotranspiration that occur during the growing season (see Figure 3.10). Mean monthly discharges at selected gaging stations are summarized in Figure 3.17. The location of these flow gages are shown in Figure 3.18.

Long term flow records in the EAWRPR have recently been analyzed for trends. Several flow gage stations on streams in this region exhibit declining trends. (Ludwig 1992, Czarnecki, Hays and McKee 2002). An updated state-wide analysis of long term trends in flow runoff is being conducted by the USGS and USACE as part of the 2014 AWP update.

3.7.2 Waterborne Commodity Transport

Commercial commodity transport occurs on federal navigation projects on two rivers in the EAWRPR, McClellan-Kerr Arkansas River Navigation System (MKARNS) and White River. Although commodity transport also occurs on the Mississippi River, which borders the EAWRPR, the Mississippi River is not generally considered waters of the state. There are three public ports on the Mississippi River that are located in the EAWRPR, at Osceola, West Memphis, and Helena-West Helena (Figure 2.2).

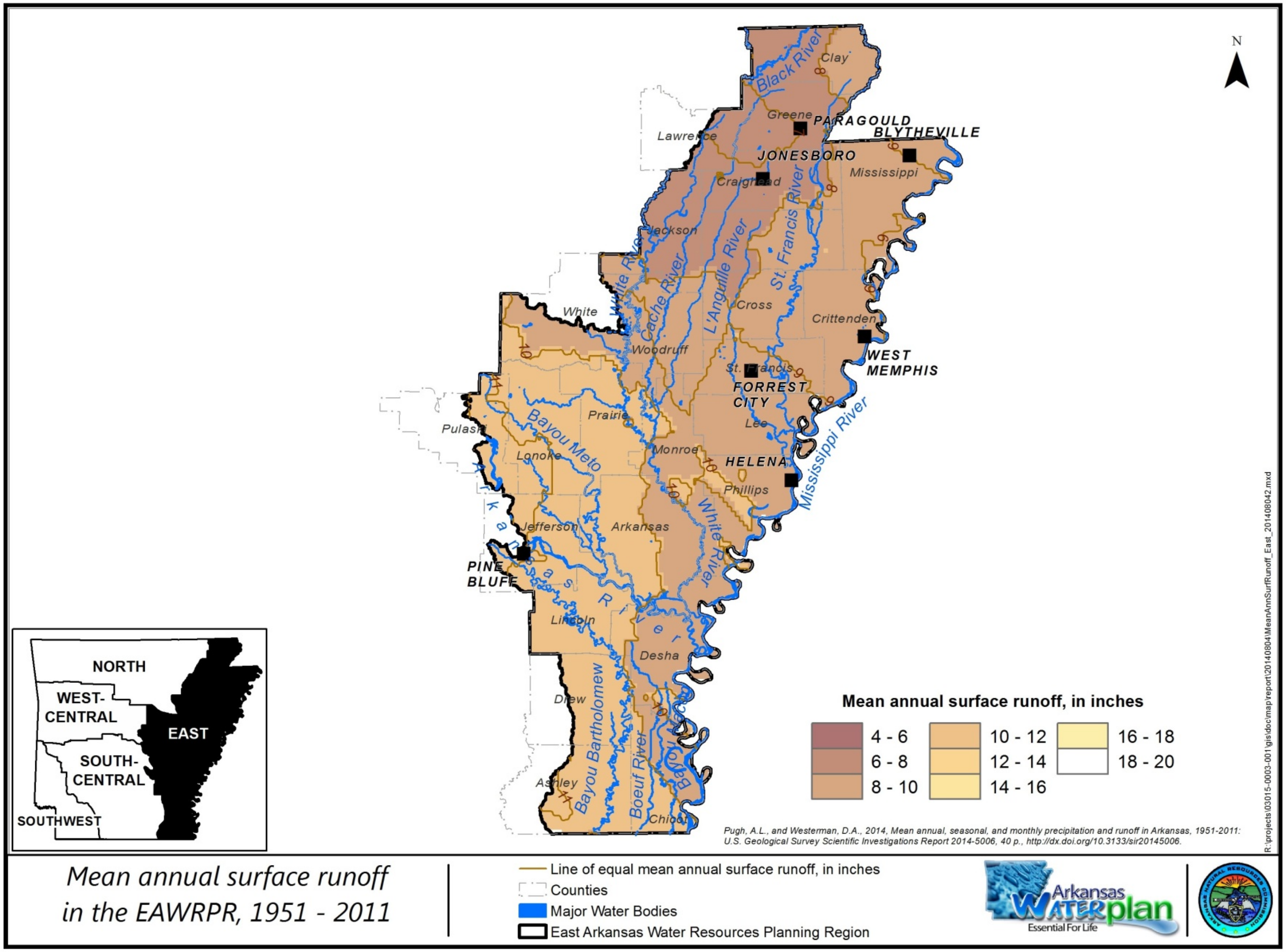

Figure 3.16. Average annual surface runoff in the EAWRPR, 1951 to 2011 (Pugh and Waterman 2014).

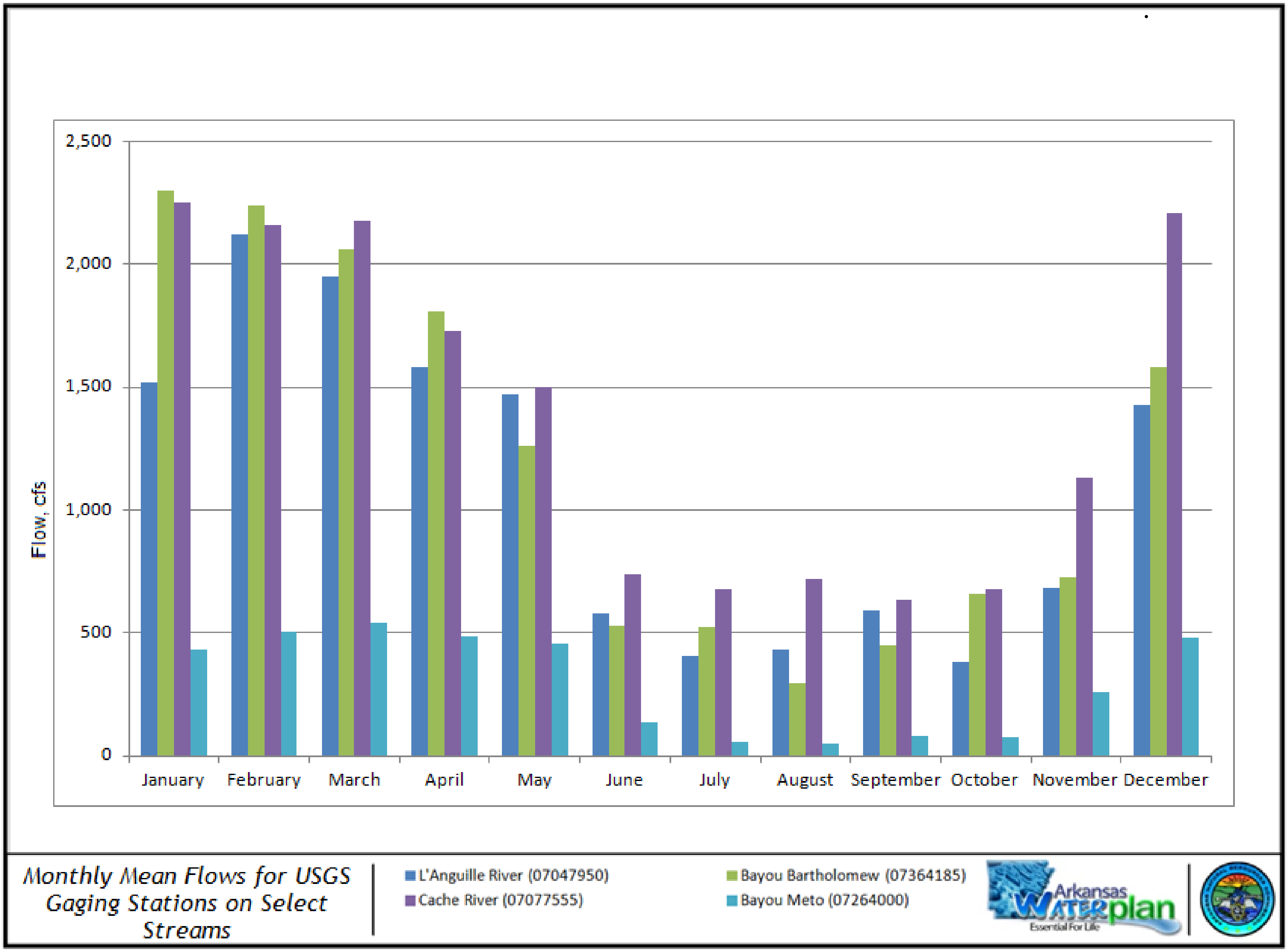

Figure 3.17. Mean monthly flows reported for USGS gaging stations on selected streams in the EAWRPR (USGS 2013b).

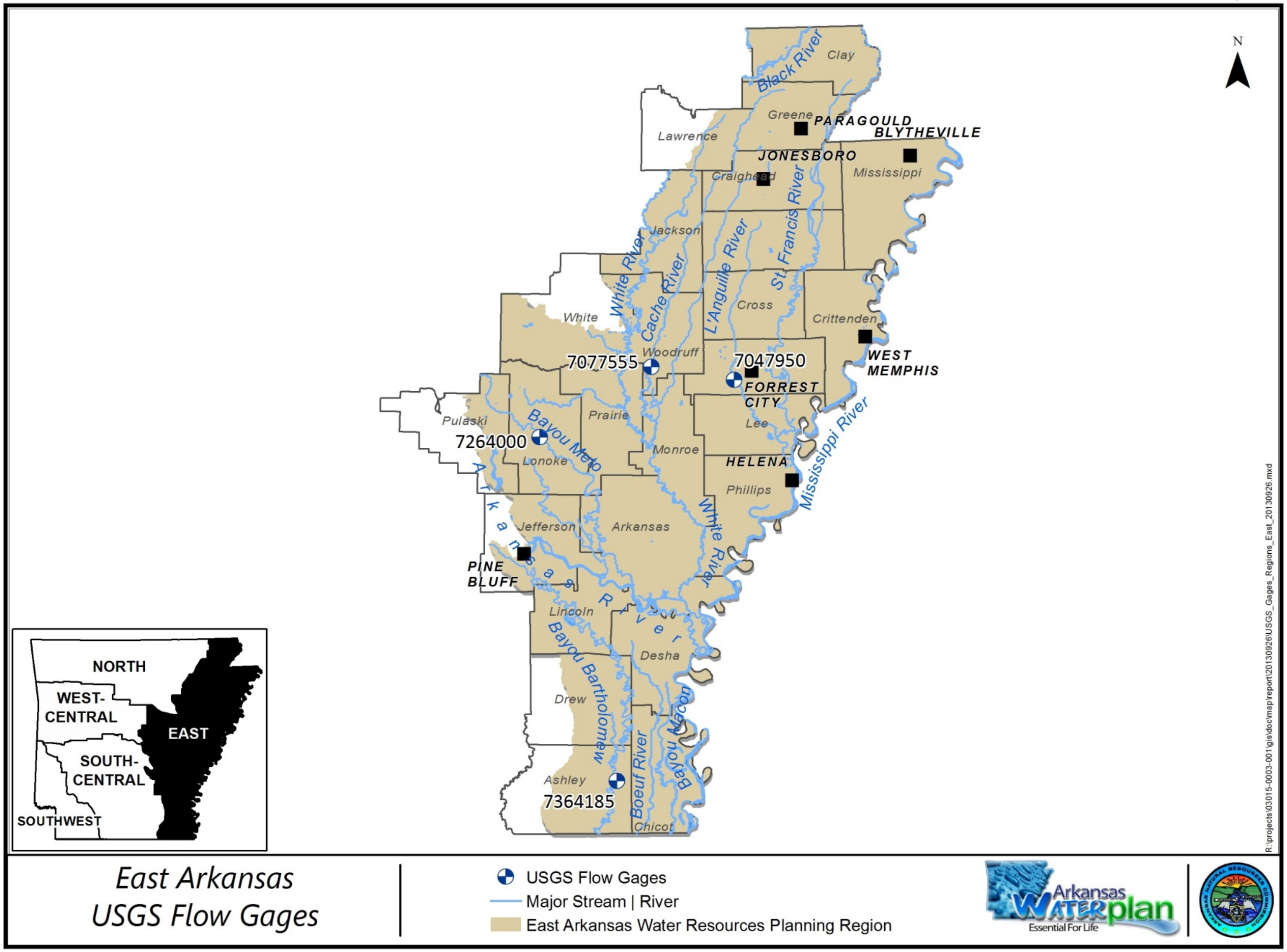

Figure 3.18. Flow gage locations in the EAWRPR.

In the EAWRPR, the MKARNS consists of a series of seven lock and dam structures and one dam, maintained and operated by the USACE Little Rock District. The system begins at the Mississippi River, at the mouth of the White River, at the Montgomery Point Lock & Dam at White River navigation mile 0.5 and continues approximately 10 miles up the White River. At that point, the approximately 10 mile long Arkansas Post Canal connects the White River to the Arkansas River. There are two locks and dams on the canal, Norrell Lock (Lock 1) and Lock 2. Wilbur D. Mills Dam (Dam 2), on the Arkansas River just downstream of the mouth of the Arkansas Post Canal maintains navigation depth on the Arkansas River upstream of Dam 2. The rest of the MKARNS in the planning region consists of a series of five more locks and dams on 90 miles of the Arkansas River. The MKARNS navigation channel is maintained to 9 feet. In 2005 Congress authorized construction of a 12 feet navigation channel along the entire length of the MKARNS, but funding has been limited. Therefore, the 12 feet navigation channel will not be maintained until a complete funding package is provided by Congress. There are two public ports on the MKARNS in the planning region, at Pine Bluff and Little Rock. In addition to the locks and dams, channel stabilization structures, and routine dredging are required to maintain the MKARNS navigation channel. Commercial navigation on the MKARNS is generally feasible year-round.

On the White River upstream of the MKARNS, a navigation channel 125 feet wide and 8 feet deep, when the water level is at 12 feet at the Clarendon gage, is maintained by the Memphis District USACE to Augusta, approximately 190 miles. Between Augusta and Newport, approximately 57 miles, a 100 foot wide channel with minimum depth of 4.5 feet at a gage reading of 3.5 feet at Newport is maintained. There are no structures on the White River navigation project, and no public ports. The navigation channel is maintained solely through dredging and snagging. The Memphis District also maintains nine harbors along the White River. Commercial navigation on the White River is dependent on river stage, and is currently feasible to Newport during only 57% of the year (Arkansas Waterways Commission 2012b). When the navigation channel is maintained, commercial navigation to Augusta is usually possible year round.

3.7.3 Impoundments

In 1981 there were over 15,000 acres of impoundments in the planning region (Table 3.4). The majority of these impoundments were irrigation and aquaculture ponds (ASWCC 1981). An updated state-wide inventory of impoundments is being prepared for the 2014 AWP update. The Arkansas Department of Environmental Quality (ADEQ) has identified 18 significant publicly owned lakes in the planning region. These are lakes that are at least 100 acres and have access designed to enhance public use (ADPCE 1990). Information for the significantly publicly owned lakes within the EAWRPR is summarized in Table 3.5.

Table 3.4. Summary of lakes and impoundments in the EAWRPR (ASWCC 1981).

County	Lakes	Area (acre)	Capacity (acre-feet)
Arkansas	545	21,207	113,283
Ashley*	485	4,064	17,244
Chicot	136	10,971	89,116
Clay	840	1,291	5,155
Craighead	634	923	4,323
Crittenden	89	7,697	97,017
Cross	365	887	5,618
Desha	27	9,564	72,819
Drew*	1,346	3,698	14,010
Greene	1,293	2,394	7,145
Jackson	371	1,090	6,649
Jefferson*	421	4,661	24,293
Lawrence*	915	1,242	6,574
Lee	256	1,292	4,841
Lincoln	809	3,027	15,053
Lonoke	1,760	21,452	77,751
Mississippi	59	6,950	12,351
Monroe	167	4,537	27,061
Phillips	57	3,782	16,428
Poinsett	391	2,612	10,434
Prairie	594	11,832	57,467
Pulaski*	806	13,798	236,921
St. Francis	377	3,680	17,470
White*	2,547	2,468	14,178
Woodruff	85	2,052	10,061
US Forest Service	2	1,045	11,000
Parks & Tourism	4	181	2,528
AGFC	27	5,616	41,851
Total	15,408	154,013	1,018,641

*Only part of county is in the EAWRPR; number of lakes shown is only those within this region

Table 3.5. Information for significant publicly owned lakes in the EAWRPR (ADEQ 2009a).

Name	County	Lake type	Surface area (acres)	Average Depth (feet)	Capacity (acre-feet)	Purpose
Lake Barnett	White	Reservoir	245	27	6,615*	Fishing
Lake Frierson	Greene	Reservoir	335	7.5	2,570	Fishing
Storm Creek Lake	Phillips	Reservoir	420	7.0	2,940*	Recreation
Lake Poinsett	Poinsett	Reservoir	550	7.0	16,296	Fishing
Bear Creek Lake	Lee	Reservoir	625	10.0	6,250*	Recreation
Cane Creek Lake	Lincoln	Reservoir	1,620	6.0	9,720*	Fishing
Lake Enterprise	Ashley	Oxbow	200	5.0	1,000*	Fishing
Pickthorne Lake	Lonoke	Reservoir	207	5.0	1,035*	Fishing
Lake Hogue	Poinsett	Reservoir	280	4.4	1,220	Fishing
Marion McCollum Greenlee Lake	Monroe	Reservoir	300	6.0	2,560	Fishing
Mallard Lake	Mississippi	Reservoir	300	6.0	2,400	Fishing
Lake Grampus	Ashley	Oxbow	334	6.0	1,200	Fishing
Lake Des Arc	Mississippi	Reservoir	350	6.0	2,100	Fishing
Lake Wallace	Drew	Oxbow	362	5.2	1,235	Fishing
Lake Ashbaugh	Greene	Reservoir	500	5.0	2,500	Fishing
Old Town Lake	Phillips	Oxbow	900	3.5	3,150*	Recreation
Horseshoe Lake	Crittenden	Oxbow	1,200	10	12,000*	Recreation
Upper Chicot Lake	Chicot	Oxbow	1,270	15	19,050*	Recreation
Lower Chicot Lake	Chicot	Oxbow	4,030	15.4	62,062*	Recreation
Grand Lake	Chicot	Oxbow	1,400	7.0	9,800*	Fishing

* capacity = surface area * average depth, info from ADEQ

3.7.1 Wetlands

The majority of the wetlands within Arkansas are located in the EAWRPR. In 2006, there were over 1.5 million acres of wetlands within this planning region (Fry, et al. 2011). These wetlands perform important functions, including storage of floodwaters, filtering of water to improve water quality, and storage of carbon. In addition, these wetlands provide habitat for a number of important bird and animal species (Anderson 2006, Ramsar Convention 2013). The White River National Wildlife Refuge in the planning region comprises the largest area of contiguous bottomland hardwood habitat within the Lower Mississippi River Valley (ADEQ 2009a).

3.7.2 Surface Water Quality

Surface water quality in the EAWRPR tends to be strongly influenced by land use. In general, surface waters in this planning region tend to have relatively high levels of turbidity and suspended solids. In addition, dissolved oxygen levels tend to be low, and biochemical oxygen demand in surface waters tends to be relatively high (Woods, et al. 2004). Surface water quality issues within the EAWRPR are discussed in detail in Section 5.

3.8 Groundwater

Groundwater in the EAWRPR represents one of the most valuable natural resources in the State. The primary water use of these aquifers is for agriculture, with crop irrigation accounting for 84% of water used in 2005 (USGS 2009). Additional water uses include commercial, industrial, and public-water supply.

3.8.1 Aquifers

Aquifers in the EAWRPR consist of various geologic units mainly of unconsolidated and alternating layers of sands, gravels, silts, and clays. In this setting, fine-grained material impedes flow and serves as confining units, and coarse-grained material serves as aquifers. There are eight recognized aquifers in the EAWRPR that are listed in Table 3.6 and mapped on Figure 3.19. Most of these aquifers are designated as regional aquifers and encompass parts of several states, whereas a few of these aquifers are considered minor and are only important as local sources of water. For a detailed description of the geologic formations that comprise the aquifers in the EAWRPR, refer to McFarland (2004). Kresse and others (2013) provide a comprehensive review of the aquifers of Arkansas including the geologic setting, hydrologic characteristics, water levels, water use, and water quality. Much of the information presented in this section was summarized from the Kresse and others (2013) report.

The primary aquifers in the EAWRPR are the Mississippi River Valley (MRV) alluvial and Sparta-Memphis aquifers. The remainder of the discussion in this section and following sections will focus on these two aquifers, with a brief description of the remaining aquifers (Cockfield, Wilcox, and Nacatoch) that have limited use in the EAWRPR.

Table 3.6. Summary of geologic formations in the EAWRPR and associated hydrogeologic unit names.

<table>
<tr><th>Province</th><th>Section</th><th>Group</th><th colspan="2">Formation</th><th>Hydrogeologic Unit Name</th></tr>
<tr><td rowspan="12">Coastal Plain</td><td rowspan="12">Mississippi Alluvial Plain and West Gulf Coastal Plain</td><td></td><td colspan="2">Alluvium and Terrace Deposits</td><td>Mississippi River Valley alluvial aquifer</td></tr>
<tr><td>Jackson</td><td colspan="2">Jackson</td><td>Vicksburg-Jackson confining unit</td></tr>
<tr><td rowspan="5">Claiborne</td><td colspan="2">Cockfield Formation</td><td>Cockfield aquifer</td></tr>
<tr><td colspan="2">Cook Mountain Formation</td><td>Middle Claiborne confining unit</td></tr>
<tr><td>Sparta Sand</td><td rowspan="3">Memphis Sand</td><td rowspan="3">Sparta-Memphis aquifer</td></tr>
<tr><td>Cane River Formation</td></tr>
<tr><td>Carrizo Sand</td></tr>
<tr><td>Wilcox</td><td colspan="2">Undifferentiated</td><td>Upper*– Lower Wilcox aquifer</td></tr>
<tr><td rowspan="2">Midway</td><td colspan="2">Porters Creek Clay</td><td rowspan="2">Midway confining unit</td></tr>
<tr><td colspan="2">Clayton Formation</td></tr>
<tr><td rowspan="2"></td><td colspan="2">Arkadelphia Marl</td><td></td></tr>
<tr><td colspan="2">Nacatoch Sand</td><td>Nacatoch aquifer</td></tr>
</table>

* Upper Wilcox aquifer includes sands in the Carrizo Sand that are in hydraulic connection with sands of the upper Wilcox Group

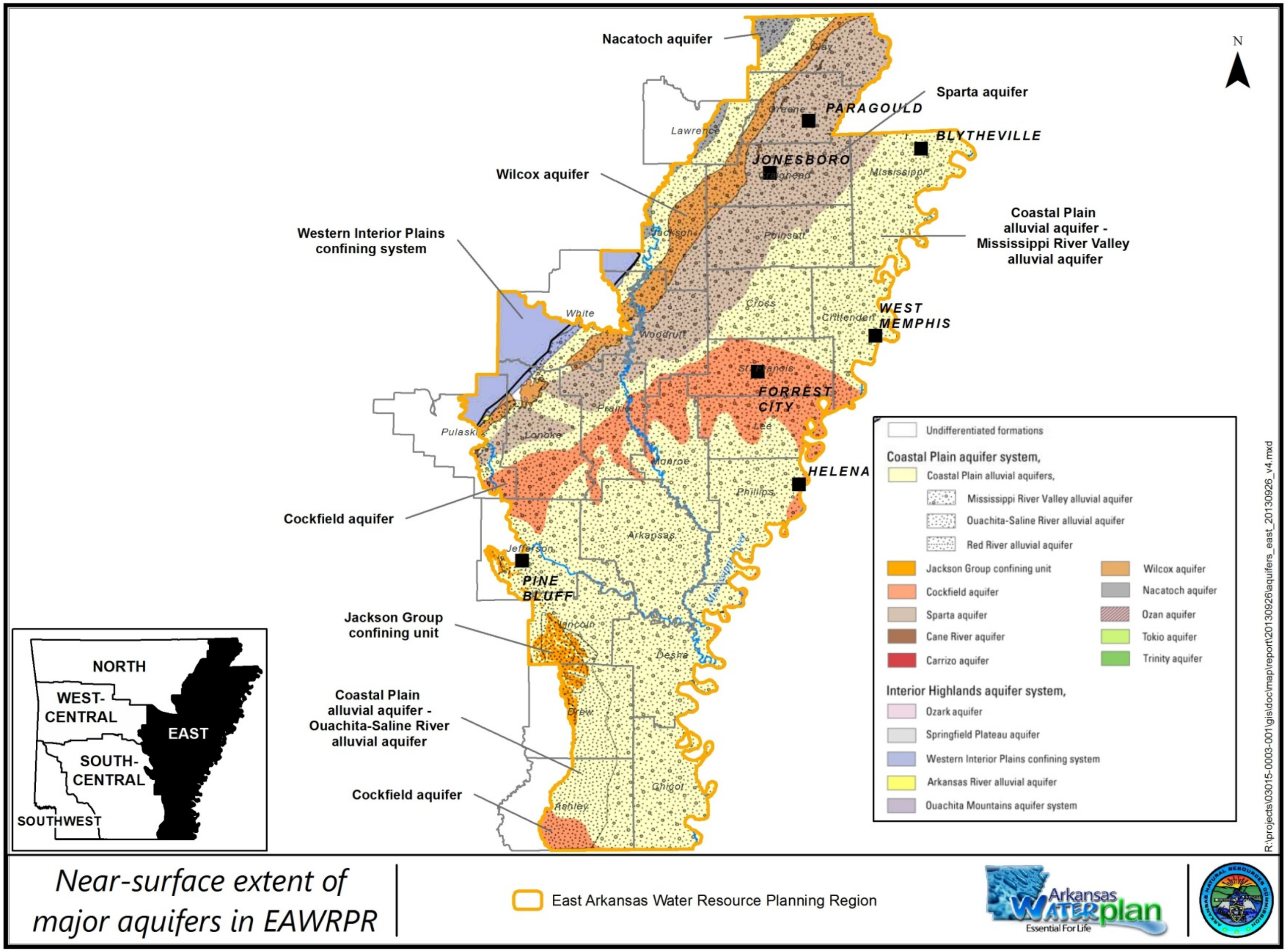

Figure 3.19. Major aquifers of the EAWRPR (Kresse, et al. 2013).

3.8.1.1 Mississippi River Valley alluvial aquifer

The MRV alluvial aquifer in terms of use is the most important aquifer in Arkansas. Nationally, the State ranks fourth in groundwater use, and 94 % of all groundwater used is from the MRV alluvial aquifer. As of 2010, there were over 47,000 wells reported as located in the MRV alluvial aquifer. The primary water use of this aquifer is to support irrigation agriculture. Secondary water uses include aquaculture, flooding of fields to provide duck hunting habitat, public supply, industrial, and domestic (Kresse, et al. 2013).

The MRV alluvial aquifer is the uppermost aquifer in eastern Arkansas (Figure 3.20) and consists of unconsolidated sediments of sand, gravel, silt, and clay of Quaternary age deposited in fluvial environments. The MRV alluvial aquifer is typically divided into two hydrologic units based on lithologies: a lower unit consisting of coarse sands and gravels that serves as the primary aquifer, and an upper unit that consists of fine sand, silt, and clay that can serve as a confining unit in some locations. The lower part of the alluvial aquifer ranges in thickness from 0 to 140 feet for an average thickness of 100 feet. Near the boundary between the Interior Highlands and the Coastal Plain, the gravels in the lower unit may be absent replaced by clay layers instead (Kresse, et al. 2013).

Primary recharge to the MRV alluvial aquifer occurs as precipitation over the extent of the aquifer in areas where the upper clay layer is thin to absent. Major rivers (such as the Arkansas, White, and Mississippi Rivers) may act as a source of recharge or serve as a regional drain depending on river stage. Reported yields range from 400 to 5,000 gallons per minute (gpm), with yields of 2,000 gpm commonly cited. The yield appears to be dependent on the thickness, sediment size and distribution, and other physical characteristics. Predevelopment water levels for the MRV alluvial aquifer were near ground surface (< 20 feet). Locally, groundwater flow tends to follow the topographic gradient, and regionally, groundwater flow is to the southern and eastern parts of the Mississippi Embayment. Sustained and intense pumping of the aquifer has resulted in widespread water-level declines and altered flow directions. Natural groundwater flow paths may range from tens to hundreds of miles before encountering a major river, which acts as a hydrologic flow boundary and serves as a regional drain (Kresse, et al. 2013).

As a result of its geology, Crowley's Ridge acts as a barrier to flow in the alluvial aquifer from the east side of the ridge to the west side. The exception to this constraint is found in areas, such as Poinsett County, where the Memphis Sand sub crops beneath the silt and loess deposits of the ridge. Here the Sparta-Memphis aquifer may act as a conduit through the ridge allowing for some induced flow from the east side, where the aquifer transmissivity is higher, and recharge from the Mississippi River is available. However, the amount of clay in the Memphis Sand in this area is uncertain and the flow through the ridge is not easily quantified.

3.8.1.2 Sparta-Memphis aquifer

The Sparta-Memphis aquifer is the second most used aquifer in the State. In 2010, over 700 wells were reported as located in the Sparta-Memphis aquifer. The Sparta-Memphis aquifer produced 196.64 million gallons per day (mgd), which accounts for 2.5 % of all groundwater use in Arkansas. The Sparta-Memphis aquifer is used primarily for agriculture followed by public and industrial supply (Kresse, et al. 2013).

The Sparta-Memphis aquifer is present throughout the entire extent of the Coastal Plain (i.e., Gulf Coastal Plain) in Arkansas. This aquifer is composed of the Sparta Sand and the Memphis Sand. In northeastern Arkansas, the Sparta Sand is indistinguishable from the underlying Cane River Formation and Carrizo Sand, and these formations are grouped together as the Memphis Sand and commonly referred to as the Memphis aquifer (Kresse, et al. 2013). To avoid confusion, in this document the term "Sparta-Memphis aquifer" will be used when referring to the sequence of saturated, productive, and hydraulically connected geologic formations that constitute the Sparta (Sparta Sand) and Memphis (Memphis Sand) aquifers. When referring to properties specific to one of the geologic units, the geologic formation names will be used.

The Sparta Sand consists of varying amounts of sand and occasionally gravel interspersed with layers of silt, clay, shale, and lignite. The occurrence, continuity, and thickness of the sand beds which constitute the aquifer are quite variable but in general appear to be hydraulically connected. The Sparta Sand outcrops in southern Arkansas and is unconfined at its western extent within the Mississippi Embayment. The sand becomes confined towards the axis of the

Mississippi Embayment and southward towards the Gulf of Mexico by the overlying Cook Mountain Formation and the underlying Cane River Formation (Kresse, et al. 2013).

Where the Sparta Sand underlies the MRV alluvial aquifer (Figure 3.19), the alluvial aquifer serves as a source of recharge. Additional sources of recharge include direct infiltration in the outcrop area, streams in the outcrop area, and leakage from overlying aquifers. Natural discharge occurs by leakage through the confining and adjacent units and discharge to rivers within the outcrop area. The natural groundwater flow is toward the axis of the Mississippi Embayment and southward toward the Gulf of Mexico. Intense development and sustained and intense pumping of the aquifer has resulted in widespread water-level declines and altered flow directions (Kresse, et al. 2013).

The Memphis Sand is primarily composed of thick bedded sands with minor clay layers that may hydraulically separate the sand beds. Except for some exposed erosional remnants along Crowley’s Ridge, the Memphis Sand does not outcrop in northern Arkansas. In the Memphis Sand subcrop area, the Memphis Sand underlies the MRV alluvial aquifer and is hydraulically connected to the alluvial aquifer (Figure 3.19). This hydraulic connection serves as an important recharge source to the Memphis Sand. Groundwater in the Memphis Sand generally flows east towards the axis of the Mississippi Embayment and then southward (Kresse, et al. 2013).

Hydraulic properties in the Sparta-Memphis aquifer vary widely, and water appears to be more easily transmitted in the thickest sand intervals. Reported well yields range from hundreds to thousands of gallons per minute (Kresse, et al. 2013).

3.8.1.3 Minor Aquifers

Aquifers that have limited use but still serve as important sources of water to some areas in the EAWRPR include the Cockfield, Wilcox, and Nacatoch aquifers. The Cockfield aquifer is present throughout southeastern and eastern Arkansas. In the outcrop area and where overlain by Quaternary alluvium, the aquifer is unconfined (Figure 3.19). Where overlain by the Jackson Group, the aquifer is confined. The Cockfield Formation consists of silt, clay, and lignite in the upper portions and sand beds near the base, which form the more permeable portions of the

Cockfield aquifer. There is considerable variability in unit thickness. Regional groundwater flow is to the southeast; however, sustained and intense pumping in some areas of southeastern Arkansas have led to the development of cones of depression and altered flow towards these pumping centers. Recharge to the aquifer occurs as precipitation in the outcrop area and as seepage from overlying Quaternary alluvium in the subrcop area. Discharge from the aquifer occurs to streams in the outcrop area, to adjacent units, and wells. In and near the outcrop area, well depths are typically shallow (less than 200 feet) and yields are generally less than 30 gpm . Further away from the outcrop area, well depths can exceed 600 feet and yields range from 100 to 500 gpm (Kresse, et al. 2013).

The Wilcox Group is present throughout the Coastal Plain of Arkansas. Three aquifer units are used to represent the Wilcox Group: lower Claiborne-upper Wilcox aquifer (hereafter referred to as the upper Wilcox), the middle Wilcox aquifer, and the lower Wilcox aquifer. In the northeastern Arkansas, the upper and lower Wilcox aquifers are present. The upper Wilcox aquifer consists of thin interbedded layers of sands and clays with lignite. The upper Wilcox aquifer includes sands of the overlying Carizzo Sand that are hydraulically connected with sands of the upper Wilcox Group. The lower Wilcox aquifer consists of three major sand units that are collectively referred to as the lower Wilcox. The lower sand unit known as the “1,400-foot sand” is recognized throughout most of the Mississippi Embayment, which is a common term used for the lower Wilcox aquifer in northeastern Arkansas. The lower Wilcox aquifer is considered confined (Kresse, et al. 2013). Remaining discussion of the lower and upper Wilcox aquifers will simply refer to the units as the Wilcox aquifer.

The Wilcox aquifer outcrops in the area of Crowley’s Ridge in Clay, Greene, and Craighead Counties. Recharge to the Wilcox aquifer primarily occurs as precipitation in the outcrop area (Figure 3.19) and as leakage from overlying sandy beds of the Claiborne Group in northern Arkansas. Wells completed in the Wilcox aquifer typically yield from 500 to greater than 2,000 gpm . Discharge from the Wilcox aquifers is mainly to wells (Westerfield 1994). Regional groundwater flow for the Wilcox aquifer is towards the axis of the Mississippi Embayment; however, sustained and intense pumping in some areas of have led to the development of cones of depression and altered flow towards these pumping centers (Kresse, et al. 2013).

While the Nacatoch aquifer is present throughout the extent of the Coastal Plain of Arkansas, use of the aquifer in EAWRPR is limited to the extreme northeastern portion (Clay, Greene, and Lawrence Counties). Compared to other aquifers in the EAWRPR, the Nacatoch aquifer has not been as studied. The Nacatoch Sand includes three distinct sand units, with the upper unit (a fine-grained quartz sand) forming the principle aquifer. The Nacatoch aquifer is overlain by the MRV alluvial aquifer in parts of northeastern Arkansas (Figure 3.19); otherwise, the aquifer is overlain by Eocene-aged deposits. Most wells completed in the Nacatoch aquifer have relatively low yields, although yields up to 500 gpm have been reported in Greene and Clay Counties (Broom and Lyford 1981). In Jackson County, wells could be developed to yield between 200 and 500 gpm; however, based on electric logs the water in this area is suspected to be saline (Albin, Hines and Stephens 1967). In some areas east of the fall line, the aquifer is believed to contain petroleum rather than water. In northeast Arkansas, regional groundwater flow is to the southeast (Kresse, et al. 2013).

3.8.2 Ground Water Quality

In general, ground water quality in the EAWRPR is considered good. Groundwater chemistry in the planning region is primarily calcium-bicarbonate. Water quality characteristics of the aquifers in the planning region are described below.

3.8.2.1 Mississippi River Valley Alluvial Aquifer

In general, groundwater quality of the MRV alluvial aquifer is good when compared to EPA primary drinking water standards. Groundwater within the majority of the MRV alluvial aquifer is classified as calcium-bicarbonate water type. In addition, sodium, magnesium, chloride, sulfate, silica, and iron comprise the major constituents by weight. These constituents show a wide variability based on residence time of groundwater and flow paths. Levels of dissolved solids in the groundwater throughout most of this aquifer are low enough for the water to be suitable for most uses (Kresse, et al. 2013).

3.8.2.2 Sparta-Memphis Aquifer

The Sparta-Memphis aquifer in eastern Arkansas generally provides water of excellent quality. Throughout most of its extent, the Sparta-Memphis aquifer is a sodium-bicarbonate water type. In the northeastern part of the state where the aquifer has lower clay content, the groundwater is reported as a calcium-bicarbonate water type. In localized areas, calcium and magnesium are reported as occurring in appreciable amounts. In general, pH values and bicarbonate and dissolved solids concentrations increase in the Sparta-Memphis aquifer as water moves downgradient from the outcrop area. An exception to this observation occurs in areas where the Sparta-Memphis aquifer underlies the MRV alluvial aquifer (Kresse, et al. 2013).

3.8.2.3 Minor Aquifers in the EAWRPR

The Cockfield aquifer contains groundwater that is typically of high quality, but is not used much in the EAWRPR. The groundwater is typically a calcium-bicarbonate water type in the outcrop and subcrop areas and transitions to a sodium-bicarbonate type downgradient of these areas (Kresse, et al. 2013).

The Wilcox aquifer produces water of generally excellent quality, and consumers often refer to the aquifer as having the best water quality in the state (Scott et al. 1998). In general, water quality is better in the eastern extent of the aquifer in northeastern Arkansas. For dissolved solids concentrations below 100 milligrams per liter (mg/L), the groundwater is a calcium-bicarbonate water type. For dissolved solids concentrations above 100 mg/L, the groundwater is a sodium-bicarbonate water-type. When dissolved solids concentrations exceed 800 mg/L, the groundwater is a strongly sodium-chloride water type (Kresse, et al. 2013).

In the EAWRPR, the Nacatoch aquifer is a viable and important source of water for the extreme northeastern part of the state. Very little groundwater data exists for the northeastern portion of the Nacatoch aquifer in Arkansas. In this area, bicarbonate is the dominant constituent present; pH values tend range from near neutral to basic (7.6 to 8.5); and nitrate, sulfate, and chloride concentrations are low. Iron is ubiquitous in aquifers throughout Arkansas; however, iron concentrations in the Nacatoch aquifer of northeastern Arkansas are some of the lowest in the State (all samples less than 0.05 mg/L) (Kresse, et al. 2013).

3.9 Groundwater-Surface Water Connections

Groundwater recharge throughout the EAWRPR generally comes from precipitation which percolates into the groundwater system, especially where major aquifers are exposed at land surface. Statewide groundwater recharge has been estimated at about 2 inches per year, and as low as 0.4 inches per year (Broom and Lyford 1981). Another estimate ranges from 3 to 8 inches depending on the permeability of the surface material (Bedinger and Jeffrey 1964). Other sources of groundwater recharge include rivers that are hydraulically connected to aquifers and lateral and vertical flow from adjacent and underlying water-bearing strata.

Purely by coincidence, the MKARNS on the Arkansas River has functioned for years as one of the most successful artificial recharge projects in the world. Water-level change data in the form of tables, maps, and hydrographs all indicate that the Grand Prairie groundwater supply has been augmented by the development of the navigation pools on the Arkansas River. The difference between the river stage elevation and the potentiometric surface of the groundwater system creates a hydraulic gradient in which water flows from the river to the MRV alluvial aquifer. The water moves into the aquifer through riverbank storage and floodplain percolation, then flows down-gradient toward the center of the cone of depression in the Grand Prairie near Stuttgart and DeWitt.

Wetlands may best be understood to be a natural expression of a high water table, often in an area where the surface material is of low permeability. The role of wetlands as a source of groundwater recharge is minor compared to other factors in the overall water budget. In one wetland study in the Cache River Basin, groundwater flow was a minor component of the water budget, accounting for less than one percent of both inflow and outflow (Gonthier and Kleiss 1996).

4.0 SOCIO-ECONOMIC CHARACTERISTICS

The socio-economic characteristics of the EAWRPR include demographics, income, employment, and industries. This section describes these characteristics and presents changes in these regional characteristics since the 1990 AWP update. In addition, the wastes generated by the communities and industries in the EAWRPR are characterized. These wastes must be properly managed to protect water quality in the EAWRPR.

4.1 Demographics

Demographic information from the 2010 US census for the counties within the EAWRPR are presented below. Demographic data presented include population totals, the percentages of people living in urban and rural areas, above or below selected ages, and of different races. Information from the 2010 census is compared to information from the 1990 census, to identify population changes that have occurred since the 1990 AWP update. Although the 1990 AWP update reported population data from the 1980 census, the 1990 census data better represents conditions at the time of the previous update. Population changes affect the need and demand for water resources, not just for drinking water, but also for recreation, food supply, irrigation, and aesthetics. Population demographics also affect the potential tax base to pay for water infrastructure upgrades, expansion, and repairs.

4.1.1 2010 Population

Population data from the 2010 census for the counties within the EAWRPR are summarized in Table 4.1 and mapped in Figure 4.1. The population of the EAWRPR in 2010 was just over one million. Pulaski and Craighead counties had the highest 2010 populations.

Table 4.1. County populations in EAWRPR from 2010 and 1990 census (US Census Bureau 2012a, U of A at Little Rock Institute for Economic Advancement 2002).

County	Total Population			Percent Urban Population		
	1990	2010	Change 1990 to 2010 (%)	1990+	2010	Change in percent urban population 1990 to 2010
Arkansas	21,653	19,019	-12%	64.0%	65.3%	1.2
Ashley*	24,319	21,853	-10%	50.4%	48.3%	-2.1
Chicot	15,713	11,800	-25%	65.7%	45.7%	-20.
Clay	18,107	16,083	-11%	37.7%	41.1%	3.4
Craighead	68,956	96,443	40%	61.3%	67.8%	6.5
Crittenden	49,939	50,902	2%	77.0%	79.1%	2.1
Cross	19,225	17,870	-7%	41.8%	43.2%	1.3
Desha	16,798	13,008	-23%	63.9%	68.6%	4.7
Drew*	17,369	18,509	7%	46.8%	51.4%	4.6
Greene	31,804	42,090	32%	50.7%	58.5%	7.8
Jackson	18,944	17,997	-5%	42.0%	34.9%	-7.1
Jefferson*	85,487	77,435	-9%	69.5%	69.1%	-0.4
Lawrence*	17,457	17,415	0%	37.8%	36.4%	-1.4
Lee	13,053	10,424	-20%	43.5%	36.5%	-7.0
Lincoln	13,690	14,134	3%	0%	0%	0
Lonoke	39,268	68,356	74%	36.6%	55.2%	18.6
Mississippi	57,525	46,480	-19%	69.5%	63.7%	-5.8
Monroe	11,333	8,149	-28%	36.1%	31.0%	-5.1
Phillips	28,838	21,757	-25%	59.7%	52.0%	-7.7
Poinsett	24,664	24,583	0%	37.4%	28.9%	-8.5
Prairie	9,518	8,715	-8%	0%	0%	0
Pulaski*	349,660	382,748	9%	87.9%	87.7%	-0.2
St. Francis	28,497	28,258	-1%	48.3%	48.4%	0.1
White*	54,676	77,076	41%	40.2%	45.7%	5.5
Woodruff	9,520	7,260	-24%	27.0%	0%	-27.0
Total	1,046,013	1,118,364	7%	64.7%	65.6%	0.9

*Part of this county is in another planning region.
+ These percentages calculated using the current urban area definition, not the 1990 definition (US Census Bureau 2003).

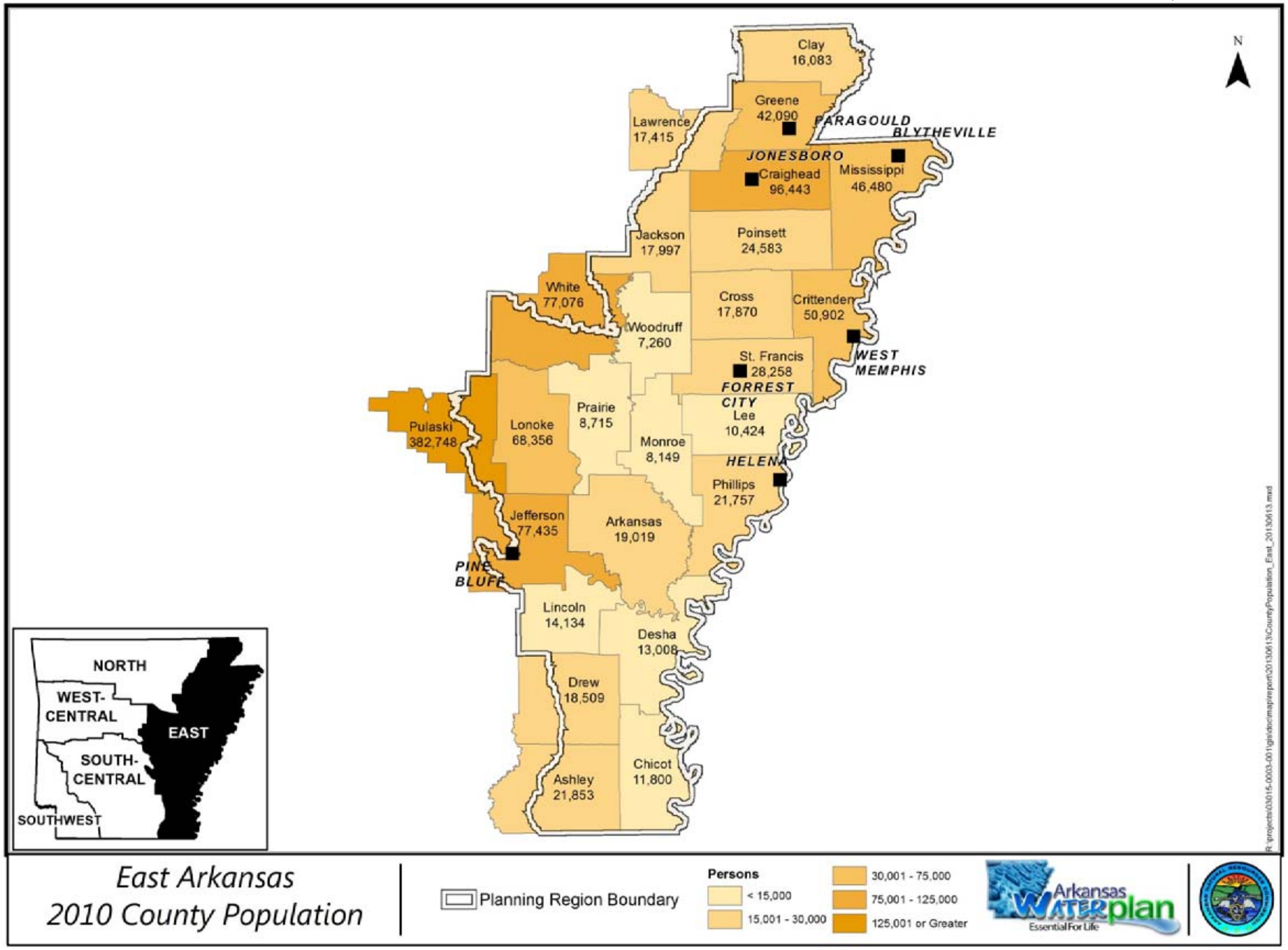

Figure 4.1. Population totals from the 2010 census for counties in the EAWRPR (US Census Bureau 2012a)

Parts of two Large Metropolitan Statistical Areas are located within the EAWRPR; Memphis, and Little Rock-North Little Rock-Conway (Figure 4.2) (US Census Bureau 2012b). Large Metropolitan Statistical Areas are geographic regions, defined by the US Office of Management and Budget, where an area of high population density has close economic ties. There are four Urbanized Areas identified in the 2010 census that are located in the EAWRPR; Pine Bluff, Little Rock, West Memphis, and Jonesboro (Figure 4.2). These are areas with population of at least 50,000 people at a density of 1,000 to 500 people per square mile (US Census Bureau 2011a). In addition, 23 areas within the planning region were identified as Urban Clusters in the 2010 census (Figure 4.2). Urban Clusters are areas with population densities of 500 to 1,000 people per square mile, which contain a total of 25,000 to 50,000 people (US Census Bureau 2011a, 2012a). The majority of the population in the EAWRPR (66%) lives in urban areas (Table 4.1). The percentage of the county population living in rural areas varies from 100% in Lincoln, Prairie, and Woodruff Counties, to 21% in Crittenden County (Table 4.1) (US Census Bureau 2012a).

Demographic data on race for the counties within the EAWRPR are summarized in Table 4.2. The racial make-up of the population is primarily white non-Hispanic (65%), black non-Hispanic (29%), and Hispanic (4%). Other races each account for 1% or less of the population. Demographic data on age, sex, and education level for the counties within the EAWRPR are summarized in Table 4.3. The majority of the population in this region is between the ages of 18 and 65, 23% of adults are high school graduates, and 13% have college degrees.

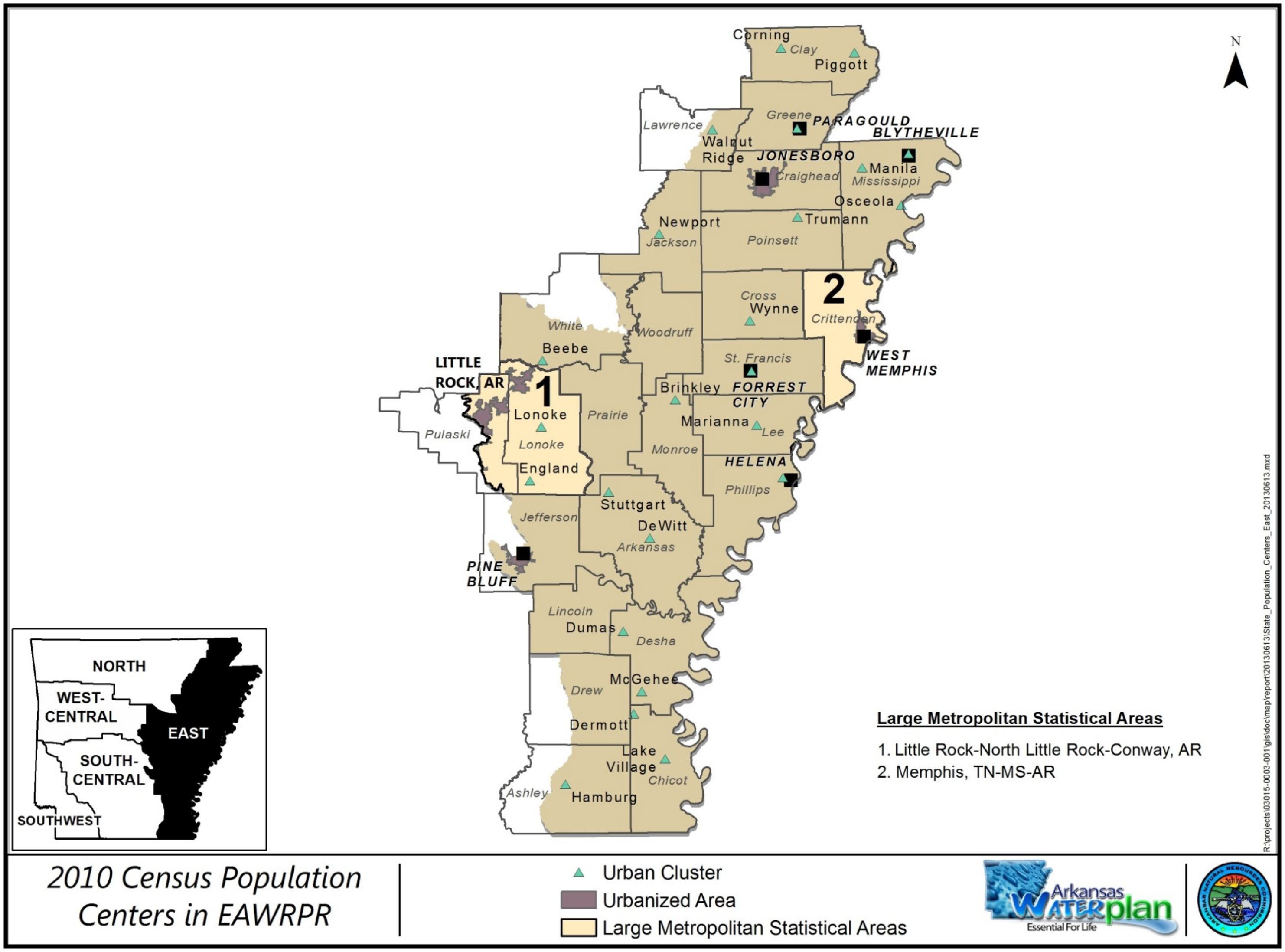

Figure 4.2. 2010 population centers located in the EAWRPR (US Census Bureau 2012a)

Table 4.2. 2010 demographic summary for counties in EAWRPR (US Census Bureau n.d.a).

County	White Non-Hispanic	Black	Hispanic	Asian	American Indian	Pacific Islander	Other Single Race	Multiple Race
Arkansas	13,659	4,661	513	92	36	2	320	249
Ashley*	15,143	5,640	1,069	40	70	3	709	248
Chicot	4,864	6,381	542	55	23	4	381	92
Clay	15,682	56	217	20	42	1	80	202
Craighead	78,323	12,640	4,277	1,075	342	29	2,339	1,695
Crittenden	23,446	26,051	1,014	301	135	8	404	557
Cross	13,495	3,972	266	83	47	3	83	187
Desha	6,230	6,216	578	42	35	2	364	118
Drew*	12,739	5,144	454	95	43	5	270	213
Greene	40,578	233	901	108	209	7	390	565
Jackson	14,363	3,000	436	53	91	16	205	269
Jefferson*	32,507	42,639	1,219	601	213	9	529	937
Lawrence*	16,952	137	158	22	63	4	32	205
Lee	4,381	5,761	168	41	49	2	69	121
Lincoln	9,407	4,223	452	27	38	1	298	140
Lonoke	61,353	4,075	2,246	532	363	32	766	1,235
Mississippi	28,653	15,817	1,695	233	136	3	943	695
Monroe	4,584	3,330	132	36	29	0	74	96
Phillips	7,618	13,719	287	67	51	1	95	206
Poinsett	22,089	1,775	543	45	59	4	281	330
Prairie	7,529	1,064	81	6	26	0	10	80
Pulaski*	220,051	133,858	22,168	7,505	1,555	272	11,646	7,861
St. Francis	12,502	14,667	1,149	136	148	9	386	410
White*	70,425	3,074	2,879	419	449	36	1,259	1,414
Woodruff	5,075	1,994	87	15	18	5	49	104
Total	741,648	320,127	43,531	11,649	4,270	458	21,982	18,229
Percentage	66%	29%	4%	<1%	<1%	<1%	2%	2%

*Part of this county is in another planning region.

Table 4.3. Additional demographic characteristics of counties in EAWRPR (US Census Bureau n.d.a).

County	Total female population	Total population under 18 years	Total population over 65 years	High School graduates	College graduates
Arkansas	9,799	4,425	3,115	5,276	1,705
Ashley*	11,255	5,330	3,544	6,573	1,855
Chicot	6,007	2,724	2,149	3,300	1,068
Clay	8,212	3,590	3,220	4,641	1,048
Craighead	49,366	24,141	11,740	20,479	14,102
Crittenden	26,736	14,809	5,477	10,940	4,195
Cross	9,249	4,494	2,759	5,547	1,457
Desha	6,905	3,377	1,970	3,506	1,164
Drew*	9,524	4,361	2,735	4,349	2,339
Greene	21,448	10,590	6,034	12,086	3,351
Jackson	9,067	3,734	2,856	5,803	1,011
Jefferson*	39,368	18,428	10,255	19,182	8,515
Lawrence*	8,947	3,992	3,160	4,957	1,098
Lee	4,618	2,160	1,607	3,021	476
Lincoln	5,633	2,743	1,758	3,978	874
Lonoke	34,727	18,831	7,625	15,218	7,473
Mississippi	23,982	13,104	5,685	10,982	3,682
Monroe	4,254	1,840	1,541	1,925	772
Phillips	11,627	6,113	3,254	4,251	1,683
Poinsett	12,646	5,959	3,900	6,979	1,563
Prairie	4,401	1,878	1,717	2,854	614
Pulaski*	198,810	92,185	45,908	69,368	79,162
St. Francis	12,865	6,677	3,447	7,220	1,920
White*	39,274	18,433	10,848	18,146	8,892
Woodruff	3,808	1,672	1,293	2,261	492
Total	572,528	275,590	147,597	252,842	150,511
Percentage	51%	25%	13%	23%[+]	13%[+]

*Part of this county is in another planning region.

+Percentage based on population 18 years of age or older

4.1.2 Changes from 1990

The population of the EAWRPR increased by 7% between the 1990 and 2010 census (Table 4.1). In 1990, Pulaski and Jefferson counties had the greatest total populations in the region. Fifteen of the 36 counties within the EAWRPR experienced population declines between 1990 and 2010 (Figure 4.3). Declines ranged from 1% in St. Francis County to 28% in Monroe County. Poinsett County did not experience a significant change in total population. The remaining counties in the EAWRPR experienced population increase between 1990 and 2010, ranging from 2% in Crittenden County to 74% in Lonoke County (Table 4.1). Population growth in Lonoke County is the result of growth of several of its northern cities as bedroom communities of the Little Rock metropolitan area and the Little Rock Air Force Base (McGraw 2013).

4.2 Income and Employment

Income and employment data are available by county from the US Census Bureau. Recent data are presented below to characterize the current income and employment levels within the EAWRPR. Data from 1990 are also presented for comparison, to provide insight into changes that have occurred in the region since the 1990 AWP update.

4.2.1 Current Income and Employment Levels

Median household incomes reported by the US Census Bureau in the 2007 – 2011 American Community Survey (ACS) for counties in the EAWRPR are shown in Table 4.4. The average median income in the region is $34,356, less than the state-wide median household income of $40,149 (US Census Bureau n.d.b). This region has the lowest per capita personal income in the state. Counties within the EAWRPR have some of the lowest median household incomes in the state, including Chicot County, which has the lowest median household income in the state, $23,954. However, Lonoke County has the third highest median household income in the state, and Pulaski County has the sixth highest.

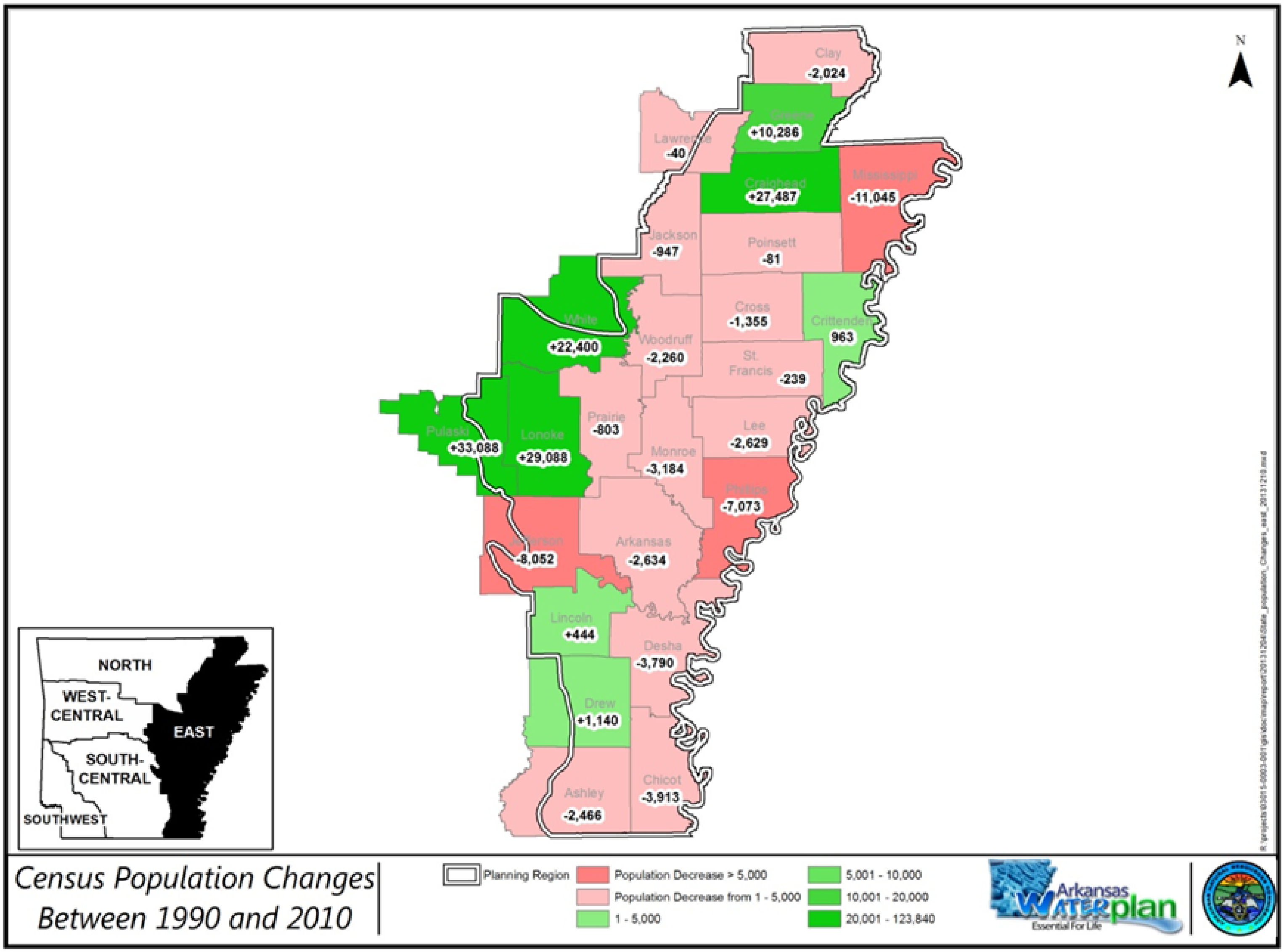

Figure 4.3 Population change from 1990 to 2010 in the EAWRPR.

Table 4.4 Income and employment characteristics for counties in the EAWRPR (US Census Bureau n.d.b).

County	Median household income		Families with income below poverty level		Population below poverty level		Unemployment	
	1989	2007 - 2011	1990	2007 – 2011	1990	2007 – 2011	1990	2007 – 2011
Arkansas	$19,516	$38,986	15.7%	12.3%	20.4%	18.2%	4.6%	7.6%
Ashley*	$20,609	$35,657	17.4%	16.1%	20.9%	17.9%	5.9%	9.7%
Chicot	$12,680	$23,954	32.3%	25.5%	40.4%	32.5%	10.3%	10.7%
Clay	$16,219	$35,410	16.1%	12.7%	21.2%	17.8%	6.9%	13.0%
Craighead	$22,150	$40,221	13.1%	16.1%	17.0%	20.3%	5.7%	8.7%
Crittenden	$20,948	$35,264	21.3%	23.1%	27.1%	27.9%	7.3%	12.7%
Cross	$19,049	$38,432	21.3%	12.6%	25.4%	16.7%	8.3%	8.8%
Desha	$15,719	$30,786	27.3%	19.9%	34.0%	23.8%	10.3%	12.6%
Drew*	$18,906	$32,038	20.2%	19.3%	24.2%	25.0%	8.7%	11.8%
Greene	$19,940	$39,090	13.6%	12.7%	17.9%	15.8%	6.8%	8.0%
Jackson	$16,641	$31,352	21.4%	20.0%	26.6%	25.1%	11.3%	12.2%
Jefferson*	$21,322	$37,682	19.3%	17.3%	23.9%	22.9%	8.9%	14.1%
Lawrence*	$15,337	$32,337	20.6%	19.0%	25.0%	23.3%	10.6%	9.2%
Lee	$11,949	$25,270	39.1%	24.5%	47.3%	28.7%	11.6%	17.7%
Lincoln	$18,457	$31,480	19.6%	18.1%	26.2%	23.9%	7.6%	10.8%
Lonoke	$23,831	$51,096	14.6%	10.7%	14.9%	13.4%	5.9%	7.2%
Mississippi	$18,522	$34,267	20.8%	21.2%	26.2%	26.1%	9.3%	12.6%
Monroe	$13,633	$28,306	29.1%	21.4%	35.9%	25.4%	7.5%	10.2%
Phillips	$13,071	$28,225	34.8%	26.1%	43.0%	31.6%	11.0%	17.7%
Poinsett	$16,858	$31,939	20.8%	21.7%	25.6%	26.0%	9.6%	12.9%
Prairie	$17,044	$36,194	19.2%	13.4%	22.7%	17.2%	6.4%	5.2%
Pulaski*	$26,883	$45,897	10.5%	12.5%	14.1%	16.7%	5.4%	8.1%
St. Francis	$15,029	$26,360	30.8%	25.2%	36.6%	29.7%	11.6%	13.2%
White*	$19,722	$41,618	14.7%	12.5%	18.7%	16.4%	9.6%	7.4%
Woodruff	$14,024	$27,047	28.3%	19.9%	34.5%	23.1%	10.3%	9.6%
Average	**$17,309**	**$34,356**	**21.7%**	**18.2%**	**26.8%**	**22.6%**	**8.5%**	**10.9%**

*Part of this county is in another planning region.

The 2007-2011 ACS shows that counties in the EAWRPR have some of the highest percentages of families and population with income below poverty level. The average percentage of families with income below poverty level in these counties is 18.2%, but county values range from 10.7% in Lonoke County to 26.1% in Phillips County. The percentage of families with income below poverty level for Arkansas as a whole is 13.8%. The average percentage of county population with income below poverty level is 22.6%, with values ranging from 13.4% in Lonoke County to 32.5% in Chicot County. The percentage of Arkansas population with income below poverty level is 18.4% (US Census Bureau n.d.a). All of the counties in this planning region, except Pulaski County, are classified as economically distressed (Delta Regional Authority 2013a). Unemployment is higher in this planning region than in the rest of the state, and the unemployment rates for all of the counties in the EAWRPR are higher than the overall state unemployment rate of 5% 149 (US Census Bureau n.d.b).

4.2.2 Changes in Income and Employment from 1990

Information on income and employment from the 1990 census (1989 data) for the counties in the EAWRPR is included in Table 4.4. This information indicates that the income characteristics of this region have not changed significantly over the past two decades. The average median income in the EAWRPR in 1989 was less than the state-wide median income of $21,147. In 1989, counties within the EAWRPR had some of the lowest median household incomes in the state, with Lee County having the lowest median household income in Arkansas. The 1989 median household income in Pulaski County was the second highest in the state, and Lonoke County had the sixth highest 1998 median household income in the state. Counties within the EAWRPR also had the highest percentages of families and people with incomes below the poverty level, and unemployment in 1990. Median incomes have increased since 1990, and there have been slight reductions in percentages of families and population with incomes below the poverty level. However, the unemployment rate has increased since 1990.

4.3 Economic Drivers

The EAWRPR is the primary crop-growing area of the state, and has been since statehood. The economy of the region is dependent upon agriculture and agriculture-related industries. Crop irrigation is the largest water user in the state (Holland 2007). As a result, water resources are very important to the economy of this region. There have not been significant changes in the regional economic landscape since the 1990 AWP update.

4.3.1 Current Regional Economic Drivers

The US Census Bureau conducts an economic census every 5 years. This includes information on the value of sales, and the number of people employed in each economic sector by county. The value of sales and receipts reported for the counties within the EAWRPR in the 2007 economic census is summarized in Figure 4.4. Manufacturing and wholesale trade are the economic sectors with the greatest value of sales and receipts in the region. Note that Pulaski County contributes 30% to 80% of the totals shown in Figure 4.4.

The number of people employed in the EAWRPR by economic sectors, as reported in the 2007-2011 ACS and the 2007 economic census, are summarized in Figure 4.5. The economic sectors for which employment is reported in these two sources are slightly different. However, both sources indicate that health care and education, retail trade, and manufacturing provide the majority of employment in the EAWRPR. It should be noted that, in these three economic sectors, Pulaski County accounts for at least one-third of the reported totals. Despite its economic importance to the region, less than 5% of the civilian workforce in the counties within the EAWRPR is engaged in farming.

Crop agriculture is the largest industry in the EAWRPR. Tourism also contributes significantly to the regional economy. In addition to the agriculture economic sector, crop agriculture generates revenue in the manufacturing, real estate, wholesale trade, and transportation and warehousing economic sectors, and generates jobs in all of the economic sectors shown in Figure 4.5 (U of A Divison of Agriculture 2012). Tourism generates revenue and jobs in many economic sectors, including recreation, accommodation and food services, retail trade, and real estate. Transport of commodities on the Arkansas and White Rivers in the planning region is important to both the regional and the state economy. The economic impact of agriculture, tourism, and waterborne commodity transportation in the EAWRPR are discussed in detail in the following sections.

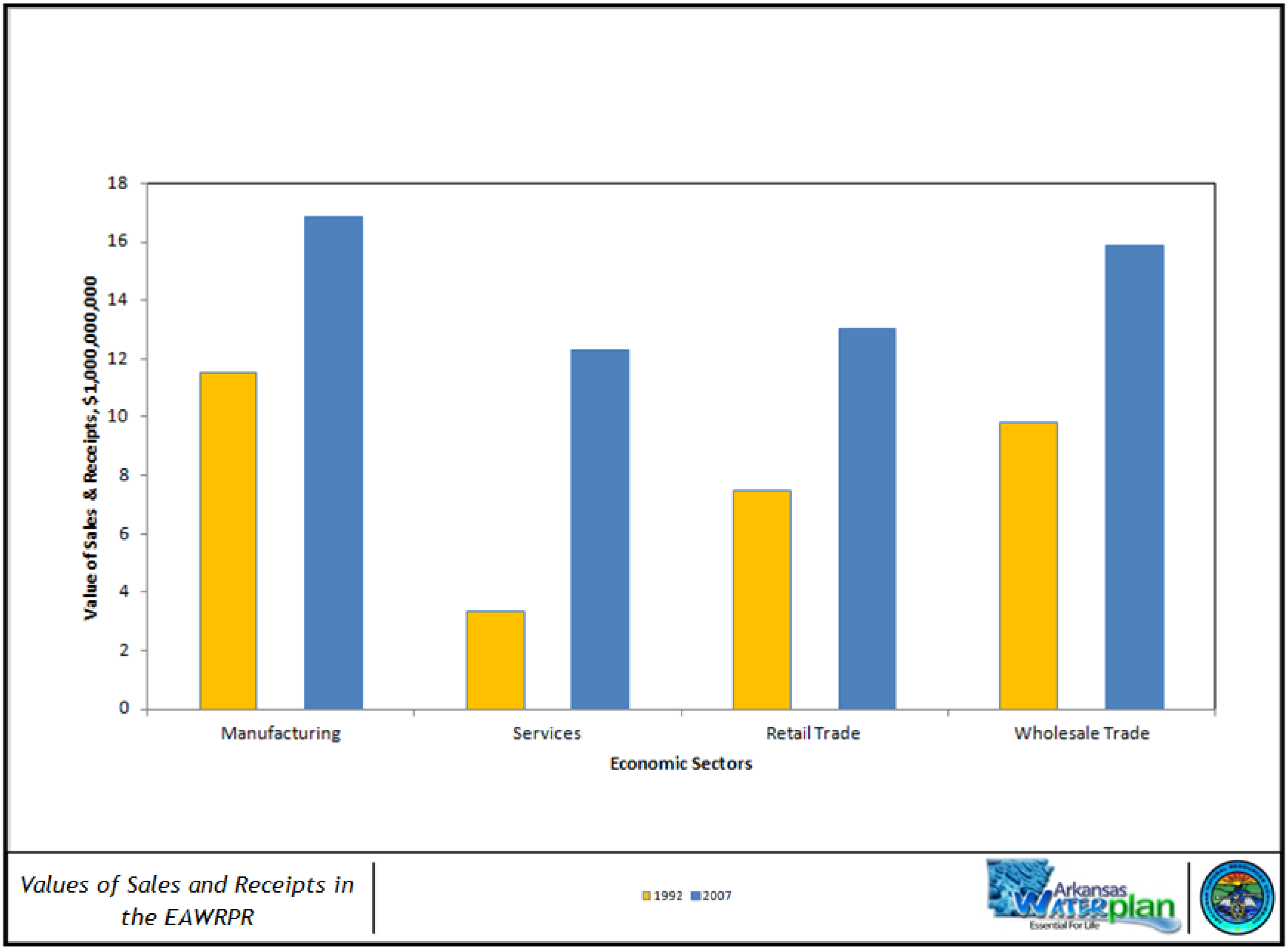

Figure 4.4. Value of sales and receipts in the EAWRPR (US Census Bureau 1993, 2011b).

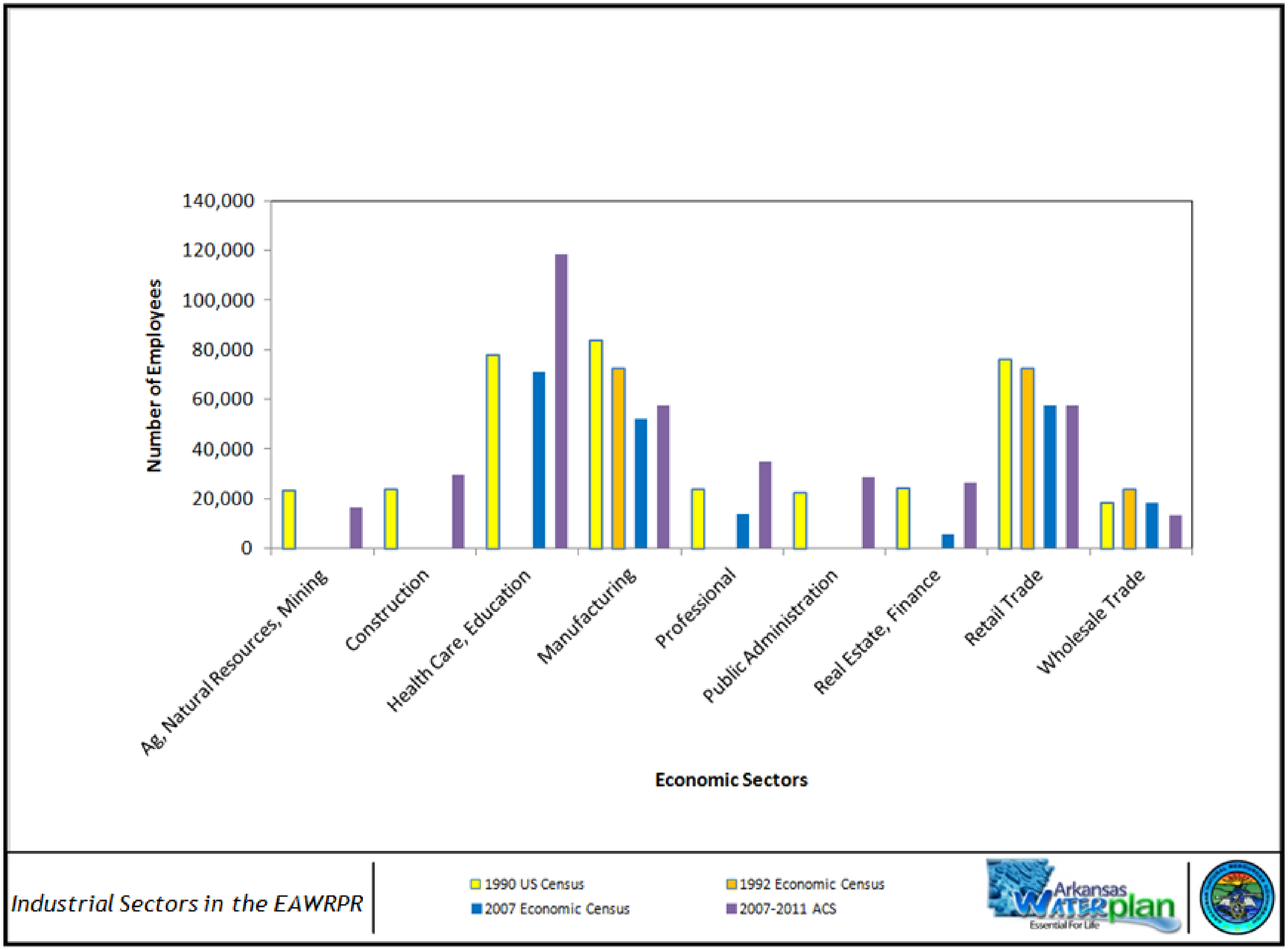

Figure 4.5. Employment by industrial sectors in the EAWRPR (US Census Bureau n.d.b, 2011b, University of Arkansas at Little Rock Institute for Economic Advancement 2002)

4.3.1.1 Agriculture

The predominant crops grown in the EAWRPR region include rice, cotton, corn, and soybeans. Arkansas is the country's largest producer of rice, and 96% of Arkansas rice is grown in this planning region. Arkansas is also third in the nation for cotton production, 94% of which is produced in this planning region (Arkansas Farm Bureau 2012, 2013, USDA National Agricultural Statistics Service 2007). The production of soybeans, rice, wheat, corn, grain sorghum, oats, and cotton, the majority of which are grown in this region (ranging from 70% of oats to 96% of rice), account for 35% of the economic contribution of crop production to the state economy. Processing of crops contributes almost twice as much as crop production to the state economy (U of A Divison of Agriculture 2012, USDA National Agricultural Statistics Service 2009). In 2007, approximately 68% of the cropland in the planning region was irrigated, primarily using groundwater (USDA National Agricultural Statistics Service 2009).

Aquaculture is also a major revenue generator and economic driver in the EAWRPR. Arkansas ranks second among aquaculture states, and is the nation's largest producer of baitfish, largemouth bass for stocking, hybrid striped bass fry, and Chinese carp; and third in the nation for catfish production. Aquaculture facilities in the planning region also produce crawfish, shrimp, prawns, turtles, and ornamental fish, such as goldfish and koi (Engle 2012). Catfish sales accounted for two-thirds of the reported fish sales revenue in the planning region in 2007. The majority of Arkansas aquaculture facilities and production are located in the EAWRPR (Table 4.5) region (Arkansas Farm Bureau 2012, 2013, USDA National Agricultural Statistics Service 2007). Aquaculture ponds in the EAWRPR are supplied almost exclusively by groundwater (USDA National Agricultural Statistical Service 2006).

Table 4.5 Fish production in the EAWRPR counties (US Department of Commerce 1994, USDA National Agricultural Statistics Service 2009).

County	Fish Sales ($1,000)				Fish Farms (number)		
	1987	1992	2007	Catfish 2007	1987	1992	2007
Arkansas	$138	$2,010	D	D	3	11	3
Ashley*	D	$3,808	$8,526	$8,522	10	10	14
Chicot	$4,790	$9,231	$43,153	$43,139	25	23	72
Clay	D	D	D	D	7	5	3
Craighead	D	D	D	NR	7	4	2
Crittenden	NR	NR	NR	NR	NR	NR	0
Cross	D	$258	D	NR	4	7	1
Desha	NR	$620	$3,021	$2,391	NR	6	10
Drew*	NR	NR	D	D	NR	NR	1
Greene	D	$526	$7,993	$3,803	5	10	7
Jackson	D	$562	D	D	5	4	4
Jefferson*	Nr	NR	D	D	NR	NR	1
Lawrence*	69	D	D	D	7	3	1
Lee	NR	NR	D	D	NR	NR	7
Lincoln	$2,120	NR	$1,206	$1,206	5	NR	4
Lonoke	$1,681	$15,230	$20,736	$2,697	5	51	30
Mississippi	NR	NR	NR -	NR	NR	NR	0
Monroe	NR	300	$3,209	NR	NR	4	9
Phillips	NR	NR	NR -	NR	NR	NR	0
Poinsett	D	$1,018	$209	$158	20	20	6
Prairie	D	$4,431	$4,952	D	5	20	14
Pulaski*	NR	NR	D	D	NR	NR	3
St. Francis	NR	NR	D	D	NR	NR	2
White*	D	$296	$769	$433	4	11	7
Woodruff	$14	$50	D	D	4	7	3
Total+	$8,812	$38,340	$93,774	$62,349	116	196	204
State total	$28,647	$44,394	$118,744	$78,133	270	251	248

* part of this county is included in another Water Resources Planning Region
D=data withheld to protect privacy
NR=not reported

4.3.1.2 Tourism

Tourism is the second-largest industry in Arkansas. The EAWRPR offers a variety of tourism and recreation opportunities, making this industry an economic driver for the region. Water resources are an important element of attractions in this region, including 20 public lakes for swimming, fishing, and boating; 19 state parks; the St. Francis National Forest; 33 wildlife management areas; 19 natural areas; 5 National Wildlife Refuges; and the MKARNS. ADEQ has designated 97.6 miles of streams in the planning region as Extraordinary Resources Waterbodies for “scenic beauty, aesthetics, …broad scope recreation potential, and intangible social values” (Figure 4.6) (APCEC 2011). The Arkansas Department of Parks and Tourism reports that, in 2012, over $836 million of travel expenditures were made in the counties within the EAWRPR, and tourism generated over $66 million in tax revenue (Table 4.6). Note that Pulaski County data are excluded from these totals because the majority of tourism in Pulaski County is associated with Little Rock.

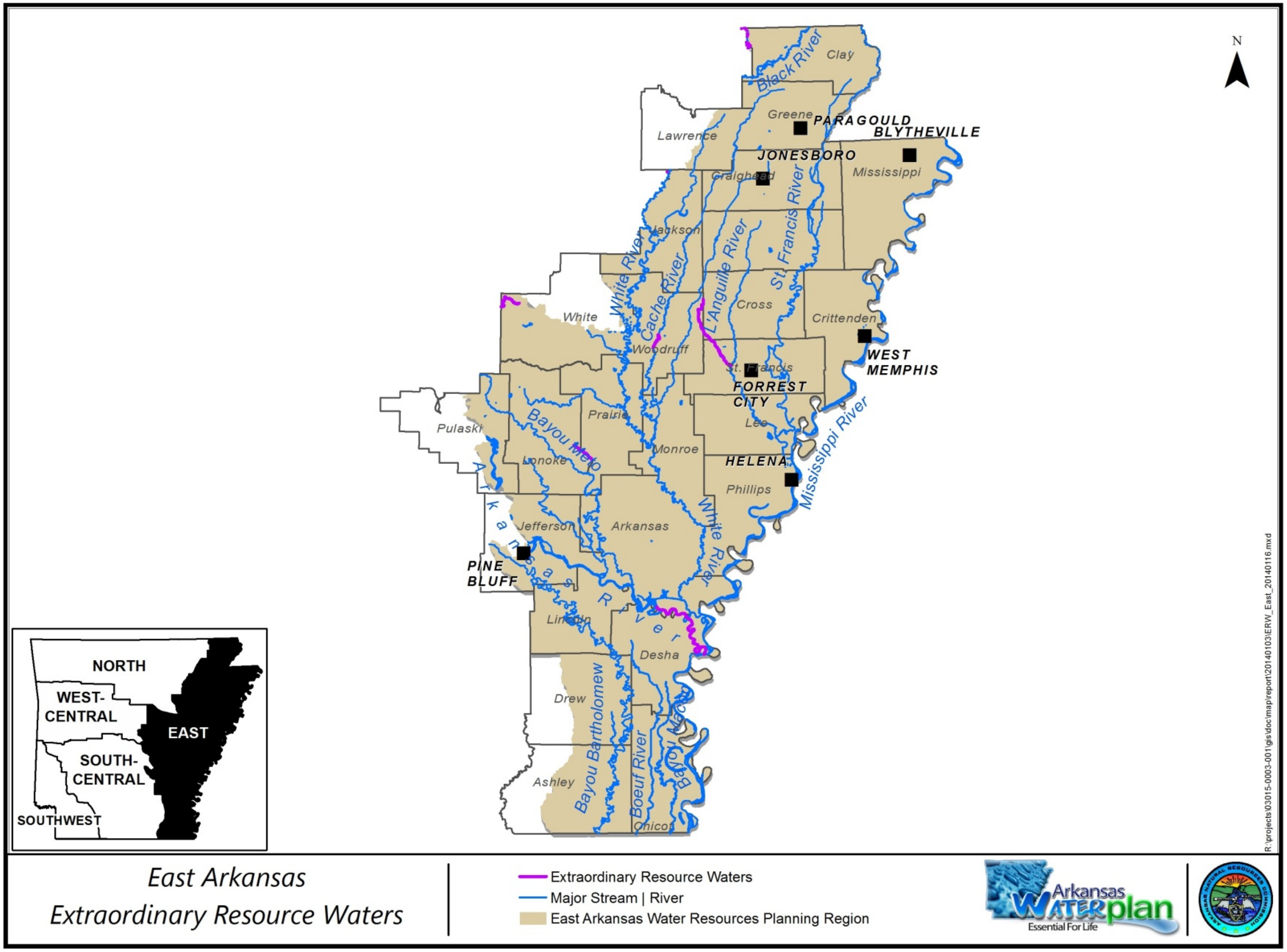

Figure 4.6 Extraordinary Resource Waters within the EAWRPR (APCEC 2011).

Table 4.6. Tourism and its economic impact in the counties of the EAWRPR (Arkansas Department of Parks and Tourism 1991, 2012)

County	Visitors		Total expenditures		State tax revenue		Local tax revenue		Jobs		Payroll	
	1990	2012	1990	2012	1990	2012	1990	2012	1990	2012	1990	2012
Arkansas	100,075	135,721	$14,016,555	$31,625,454	$658,778	$1,929,845	$168,199	$691,167	292	306	$2,536,997	$5,087,247
Chicot	35,294	48,303	$5,092,420	$11,453,727	$239,344	$699,790	$61,109	$236,276	106	132	$921,728	$2,322,578
Clay	35,936	53,291	$4,612,981	$12,955,075	$216,810	$788,469	$55,356	$321,530	96	118	$834,950	$1,989,545
Craighead	306,863	371,298	$44,679,496	$85,909,632	$2,099,936	$5,298,599	$536,154	$1,412,605	930	1,039	$8,086,989	$16,707,996
Crittenden	440,096	635,164	$60,608,494	$146,760,837	$2,848,599	$9,202,922	$727,302	$2,677,919	1,261	1,709	$10,970,137	$26,602,491
Cross	33,235	57,788	$4,804,242	$13,200,213	$225,799	$809,561	$57,651	$251,252	100	142	$869,568	$2,360,521
Desha	81,237	93,783	$11,035,830	$21,049,408	$518,684	$1,290,150	$132,430	$393,730	230	250	$1,997,485	$3,821,022
Drew*	70,154	95,329	$10,159,056	$22,235,266	$477,476	$1,367,912	$121,909	$402,649	211	282	$1,838,789	$4,236,627
Greene	29,980	90,447	$4,168,942	$20,671,926	$195,940	$1,259,164	$50,027	$441,222	87	248	$754,578	$3,807,174
Lee	9,497	11,205	$1,256,054	$3,485,118	$59,035	$212,334	$15,073	$97,850	26	34	$227,346	$499,153
Mississippi	376,004	409,584	$53,331,375	$91,384,478	$2,506,575	$5,621,897	$639,977	$1,827,062	1,110	1,156	$9,652,979	$19,408,644
Monroe	166,358	108,754	$23,363,832	$26,272,514	$1,098,100	$1,609,156	$280,366	$478,547	486	292	$4,228,854	$4,498,702
Phillips	95,556	120,960	$13,353,819	$29,112,641	$627,629	$1,795,890	$160,246	$632,197	278	289	$2,417,041	$4,821,137
Poinsett	53,640	51,836	$7,923,924	$11,311,595	$372,424	$719,725	$95,087	$204,757	165	82	$1,434,230	$1,366,431
St. Francis	164,223	158,427	$22,438,900	$36,924,745	$1,054,628	$2,300,188	$269,267	$739,961	467	390	$4,061,441	$6,492,622
Jackson	59,871	57,980	$8,430,287	$13,555,407	$396,223	$838,913	$101,163	$246,526	175	141	$1,525,882	$2,319,360
Lawrence*	100,511	54,949	$14,176,492	$12,892,326	$666,295	$799,970	$170,118	$289,655	295	122	$2,565,945	$1,913,952
White*	123,560	200,637	$18,063,196	$47,956,518	$848,970	$2,922,023	$216,758	$822,898	376	526	$3,269,439	$8,042,399
Woodruff	6,938	19,848	$1,071,569	$5,625,179	$50,364	$344,518	$12,859	$154,095	22	44	$193,954	$755,590
Lonoke	134,376	129,247	$19,262,937	$31,765,943	$905,358	$1,955,527	$231,155	$550,714	401	299	$3,486,592	$5,443,886
Prairie	5,249	18,012	$665,816	$4,237,167	$31,293	$268,364	$7,990	$97,170	14	43	$120,513	$642,570
Jefferson*	357,784	442,069	$49,703,500	$110,788,911	$2,336,065	$6,163,996	$596,442	$2,252,045	1,034	1,308	$8,996,334	$20,900,407
Lincoln	9,540	15,634	$1,270,450	$3,851,322	$59,711	$241,530	$15,245	$81,623	26	28	$229,951	$539,645
Ashley*	77,060	121,243	$10,797,773	$27,910,389	$507,495	$1,688,524	$129,573	$581,887	225	322	$1,954,397	$5,322,679
Total	2,873,037	3,501,509	$404,289,952	$822,937,781	$19,003,543	$50,128,967	$4,851,456	$15,885,337	10,425	11,292	$73,176,119	$149,902,378

* Part of this county is in another planning region.
Note: Highlighted counties are involved in the Rural Heritage Development Initiative.

Hunting, fishing, and wildlife watching account for a significant portion of the tourism economy of the EAWRPR. In 2011, Arkansas ranked seventh in the nation in hunting-related sales, and more mallard ducks were harvested in Arkansas than any other state (AGFC 2013b). Stuttgart, in Arkansas County, is the "Duck Capital of the World." Economic contributions from wildlife recreation in Arkansas are summarized in Table 4.7. Regional data are not available. Mack's Prairie Wings, a waterfowl outfitter, and Rich n Tone Duck Calls are two national leaders in the waterfowl hunting industry that are headquartered in Stuttgart.

Table 4.7. Economic contributions from wildlife recreation in Arkansas.

Activity	Total Expenditures (Million $)		2011 Retail Sales (Million $)[c]	2011 State/Local Tax Revenue (Million $)	2011 Federal Tax Revenue (Million $)
	1991[a]	2011[b]			
All Hunting	$85.0	$1,018.8	$877.4	$99.2	$99.5
Waterfowl Hunting	NR	$288.0	$236.7	$29.1	$23.9
Sport Fishing	$216.9	$495.6	$508.0	$49.4	$49.8
Wildlife Watching	NR	$216.1	NR	NR	NR

a USFWS, US Department of Commerce Bureau of the Census 1993
b USFWS, US Department of Commerce Census Bureau 2013
c AGFC 2013b
NR=not reported

The USACE has estimated economic impacts of recreational use of the Arkansas River navigation pools located in the EAWRPR. Overall, recreation associated with the Arkansas River navigation system in the planning region generates 95 jobs, and over $17 million in revenue, wages, and taxes (Table 4.8).

Table 4.8 Economic benefits from USACE reservoirs in the surrounding 30 miles in the EAWRPR in 2012 (USACE 2011).

Reservoir	Total Sales	Jobs	Payroll	Visitor Spending
Norrell Lock (Pool 1)	$681,000	12	$257,000	$1,469,000
Lock 2 (Pool 2)	$3,939,000	68	$1,434,000	$7,871,000
Joe Hardin Lock (Pool 3)	$852,000	15	$307,000	$1,651,000
Total	**$5,472,000**	**95**	**$1,998,000**	**$10,991,000**

In 2006, the Rural Heritage Development Initiative was initiated in the 15 counties in eastern Arkansas linked by the Great River Road and Crowley's Ridge Parkway National Scenic Byways. One of the purposes of this program is to promote tourism in this area of the state, centered around the history, musical heritage, and natural resources of the region, including duck hunting and bird watching. In addition, this initiative promoted local business development, historic preservation, and branding of locally produced products (Rural Heritage Development Initiative 2008, Lake 2010). The Arkansas Department of Parks and Tourism reports that in 2012, over 2 million visitors to these 15 counties spent over $564 million, generating over $104 million in payroll, and $10 million in local taxes (Table 4.6) (Arkansas Department of Parks and Tourism 2012).

4.3.1.3 Waterborne Commodities Transportation

Waterborne transportation of commodities directly and indirectly contributes to the economic growth of the State, and the EAWRPR, through economic value, employment, and earnings (Nachtmann 2002). A recent study determined that the total economic impact of river transportation of commodities on the Arkansas economy is $811 million annually (Arkansas Waterways Commission 2013). There are three inland waterways in the EAWRPR used to transport commodities into and out of the region, and the state; Mississippi River, MKARNS, and White River. There are six public ports and an additional 14 private terminals located on these waterways within the planning region (Figure 4.7).

Imports and exports of commodities reported for selected public Mississippi River ports and waterways located in the EAWRPR are listed in Table 4.9. The MKARNS accounts for the majority of commodity transportation in the planning region. In 2011, 8,161 thousand short tons of goods and materials passed through the lock and dam on the White River at the downstream end of the MKARNS (USACE Institute for Water Resources n.d.). The MKARNS is responsible for between $1 billion and $2 billion in trade transportation annually in Arkansas (Goss 2012).

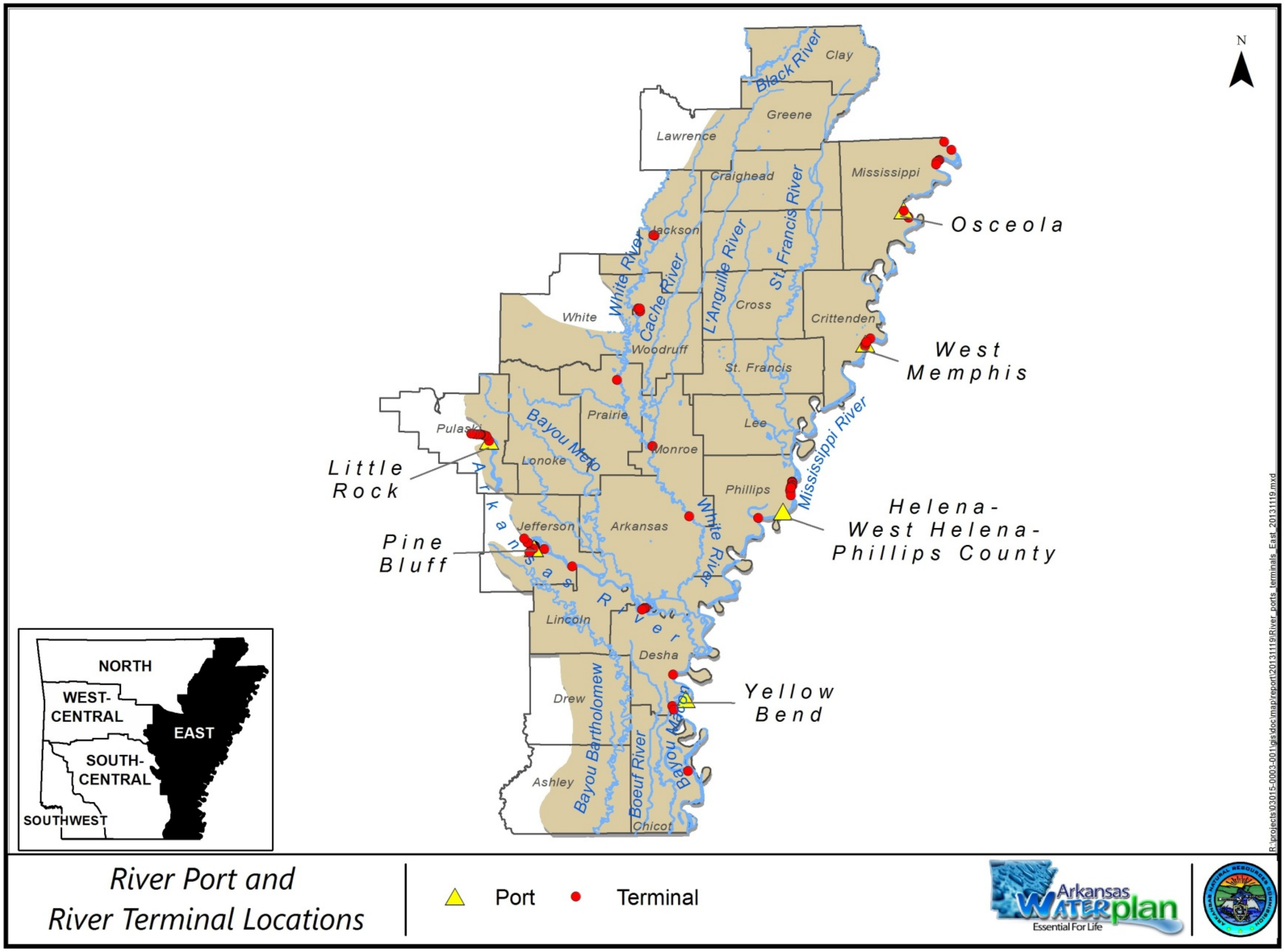

Figure 4.7. River port and river terminal locations.

Table 4.9 Tonnage of commodities transported through the EAWRPR reported for 2011 (USACE Institute for Water Resources 2011).

Port or System in EAWRPR	Import commodities	Import tonnage (1,000 short tons)	Export commodities	Export tonnage (1,000 short tons)
Helena	Fertilizer,	131	Fertilizer	2
	limestone	8	Grain and soybeans	1,294
	steel pipe	< 0.5	Manufactured goods	2
	Total	140	Total	1,298
Osceola	-	0	Grain, soybeans	409
MKARNS	Coal	123	Coal	278
	Petroleum products	324	Petroleum products	586
	Fertilizer	1,586	Fertilizer	293
	Sodium hydroxide	86	Ammonia	140
	Clay	93	Wood chips	47
	Sand, gravel, stone, rock	156	Sand, gravel, stone, rock	284
	Iron ore and scrap	22	Iron ore and scrap	767
	Other metal ore	32	Other metal ore	12
	Slag	2	Slag	81
	Other minerals	25	Other minerals	3
	Manufactured goods	900	Manufactured goods	71
	Grain	51	Grain	1,014
	Oil seeds	11	Oil seeds	1,147
	Animal feed	261	Animal feed	5
	Other Ag products	66	Machinery and other manufactured products	32
	Machinery and other manufactured products	4		
	Total	**3,743**	**Total**	**4,760**
St. Francis and L’Anguille Rivers and Blackfish Bayou	Fertilizer	3	-	0
White River below Batesville	Iron and steel scrap	1	-	0
Total		**7,629**		**12,525**

Waterborne transportation is important to crop agriculture in the planning region; the majority of the exported tonnage reported for 2011 (60%) consisted of grain and soybeans, and the majority of the imported tonnage (44%) consisted of fertilizer (Table 4.9). The steel industry in the planning region also utilizes waterborne transportation on the White River (iron and steel scrap) and Mississippi River, and sand and gravel mined in the planning region may be transported on the MKARNS.

4.3.2 Changes in Region Economy since 1990

Figure 4.4 also shows the value of sales and receipts reported in the 1992 economic census. Note that the 1992 economic census reported values only for the manufacturing, services, retail trade, and wholesale trade sectors. The 2007 value for services shown on Figure 4.4 is a summation of values reported for economic sectors that reportedly were included in the 1992 Value for Services (US Census Bureau 2011c). As in 2007, the economic sectors with the greatest value of sales and receipts in the region in 1992 were manufacturing and wholesale trade. It appears that all of the economic sectors have experienced expansion. The greatest increase appears to have occurred in the services economic sectors.

Employment data from the 1990 census and 1992 economic census are included in Figure 4.5. The economic sectors used to report employment are slightly different for the two sources and the different time periods shown in Figure 4.5. While these differences make direct comparisons uncertain, using the information from different sources during similar time periods allows us to have greater confidence when identifying changes over time. It appears that employment in manufacturing, retail trade, and wholesale trade has declined slightly since the 1990 AWP update. Other economic sectors, such healthcare and education, construction, and public administration, appear to be employing more people now than in the early 1990s. Overall, however, it appears that the same economic sectors provided the majority of employment in the region in 1990 as do now; manufacturing, health care and education, and retail trade.

4.3.2.1 Agriculture

As noted in Section 3.5.1, there has been little change in the crops grown in the EAWRPR counties between 1987 and 2007 (Figure 4.8). In the 1987 Census of Agriculture, approximately 28% of the cropland in the planning region was irrigated (note that the amount of irrigated land was not reported for 10 of the 26 counties in 1987 to protect farmers’ privacy) (US Department of Commerce Bureau of the Census 1989). Thus, there has been a significant increase in the amount of irrigated cropland between 1987 and 2007 (over 150%).

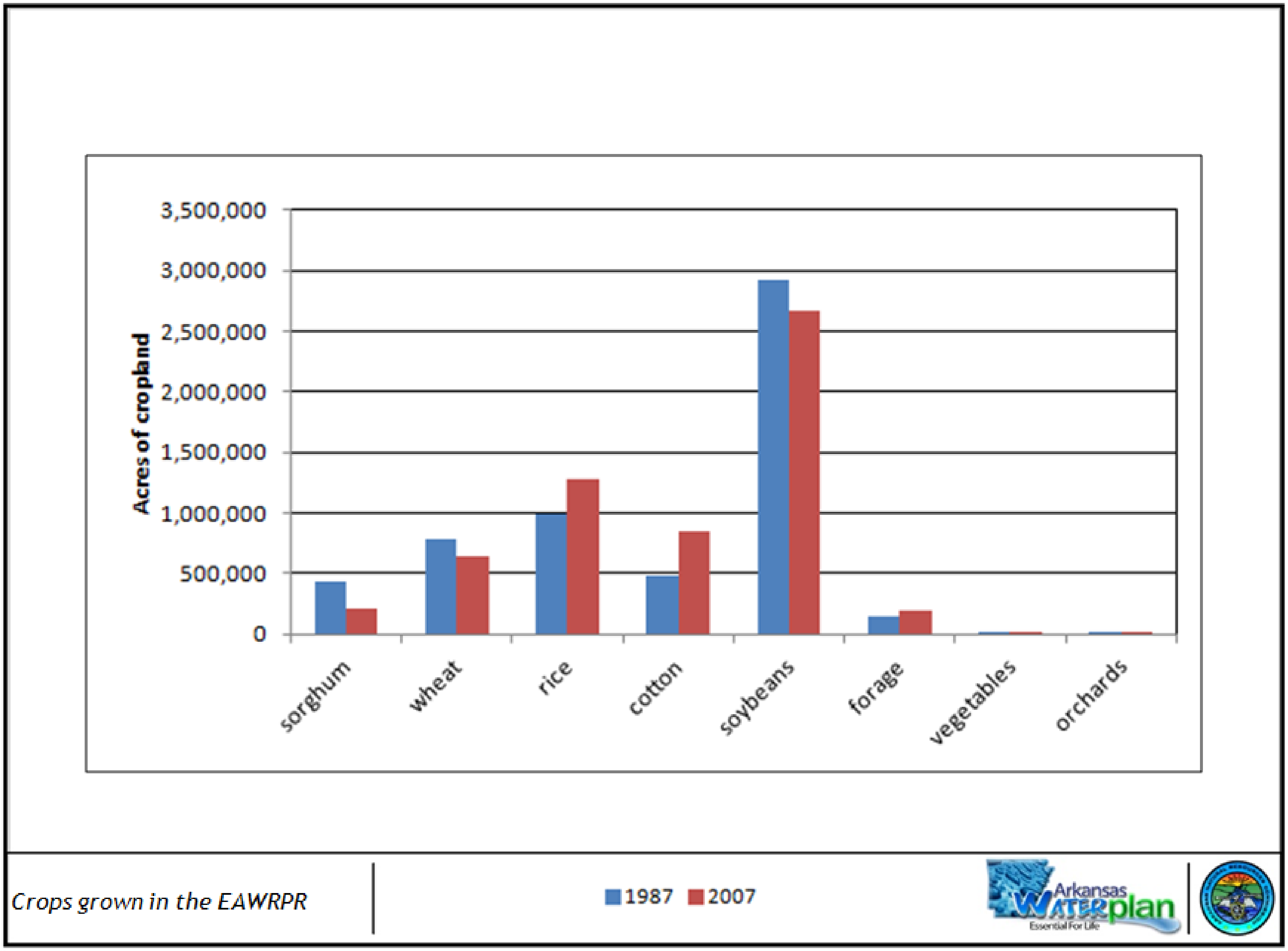

Figure 4.8. Crops grown in the EAWRPR (USDA National Agricultural Statistics Service 2009, US Department of Commerce 1994).

Table 4.5 includes information about aquaculture from the 1987 and 1992 agricultural census. Due to the fact that much of the information on fish production and sales in the agricultural census is not reported at the county level, it is uncertain whether the number of fish farms in the EAWRPR has increased or declined since 1990. For example, county data were reported only for catfish production in the 1987 agricultural census. In any case, revenues from fish sales do appear to have increased in the planning region since 1990. Statewide, catfish sales in 1987 accounted for only 42% of fish sales revenue, and baitfish sales accounted for 55%. Therefore, the proportion of fish sales revenue from catfish production has increased in the planning region since 1987. Aquaculture in the planning region is also more diverse today than in 1987. In 1987, revenues were reported only for catfish, trout, and "other fish" (US Department of Commerce Bureau of the Census 1989). In the 2007 census, revenue was reported also for "other food fish", baitfish, crustaceans, mollusks, sportfish, and ornamental fish (USDA National Agricultural Statistics Service 2009). Around 2002, farmers in the planning region began experimenting with growing marine shrimp (Green 2004). Ornamental fish production in the region has expanded since 1987 (Engle 2012).

4.3.2.2 Tourism

Overall, the number of visitors and the amount of the economic contribution of tourism in the EAWRPR has increased since 1990 (Table 4.6). Greene, Prairie, Lincoln, Ashley, and Woodruff Counties saw the largest increases in trips, visitors, and tourism revenue in the region. Several of the counties in the planning region had fewer visitors in 2013 than in 1990. In all of these counties, this decline resulted in a decline in tourism jobs, but not necessarily revenues (e.g., Lonoke County). The economic contribution of hunting and fishing in the state has also increased since 1990 (Table 4.7).

4.3.2.3 Waterborne Commodity Transportation

Data on waterborne commodity transportation on all of the waterways in the EAWRPR during 1990 was not readily available. However, data on shipping on the MKARNS in the 1990s was available. On the MKARNS, a total of 8.8 million tons was transported during 1990 (Bolton

1995). Information on the value of commodities transported on the MKARNS in 1990 was not available (US Census Bureau 1996). Information on the types of commodities shipped is discussed below.

During the period from 1971 through 1994, sand and gravel made up the majority (38%) of the commodities transported on the MKARNS (Bolton 1995). In 2011, sand and gravel accounted for only around 5% of the shipping, while agricultural products (including grains, soybeans, and animal feed) made up 30% of the shipping (Table 4.9). Exported grains and soybeans accounted for an average of 21% of the commodities shipped on the MKARNS during the period from 1971 through 1994 (Bolton 1995). This is similar to 2011, when exported grains and soybeans accounted for 25% of the shipping on the MKARNS (Table 4.9).

4.4 Waste Generation and Disposal

Industries and communities in the EAWRPR produce wastes that must be properly managed to protect water quality, which contributes to water availability for the water users of the EAWRPR. ADEQ is the state agency responsible for regulating solid waste, hazardous waste, and wastewater. These three waste streams are managed through separate permitting programs overseen by the EPA. Waste management in the EAWRPR is quantified below, along with changes in waste management that have occurred since the 1990 AWP update.

4.4.1 Solid Waste

There are four Regional Solid Waste Management Districts (RSWMDs), and portions of three RSWMDs, within the EAWRPR (Figure 4.9). Information on solid waste generation and disposal for each of these districts for 2010 is summarized in Table 4.10. For the most part, the RSWMDs report that their solid waste disposal facilities and collection services are sufficient to meet demand. However, illegal dumping that occurs in the districts could pose local threats to water quality (East Arkansas RSWMD 2011, Central Arkansas RSWMD 2011, White River RSWMD 2011, Southeast Arkansas RSWMD 2011, Northeast Arkansas RSWMD 2011, Craighead County RSWMD 2011, Mississippi County RSWMD 2011).

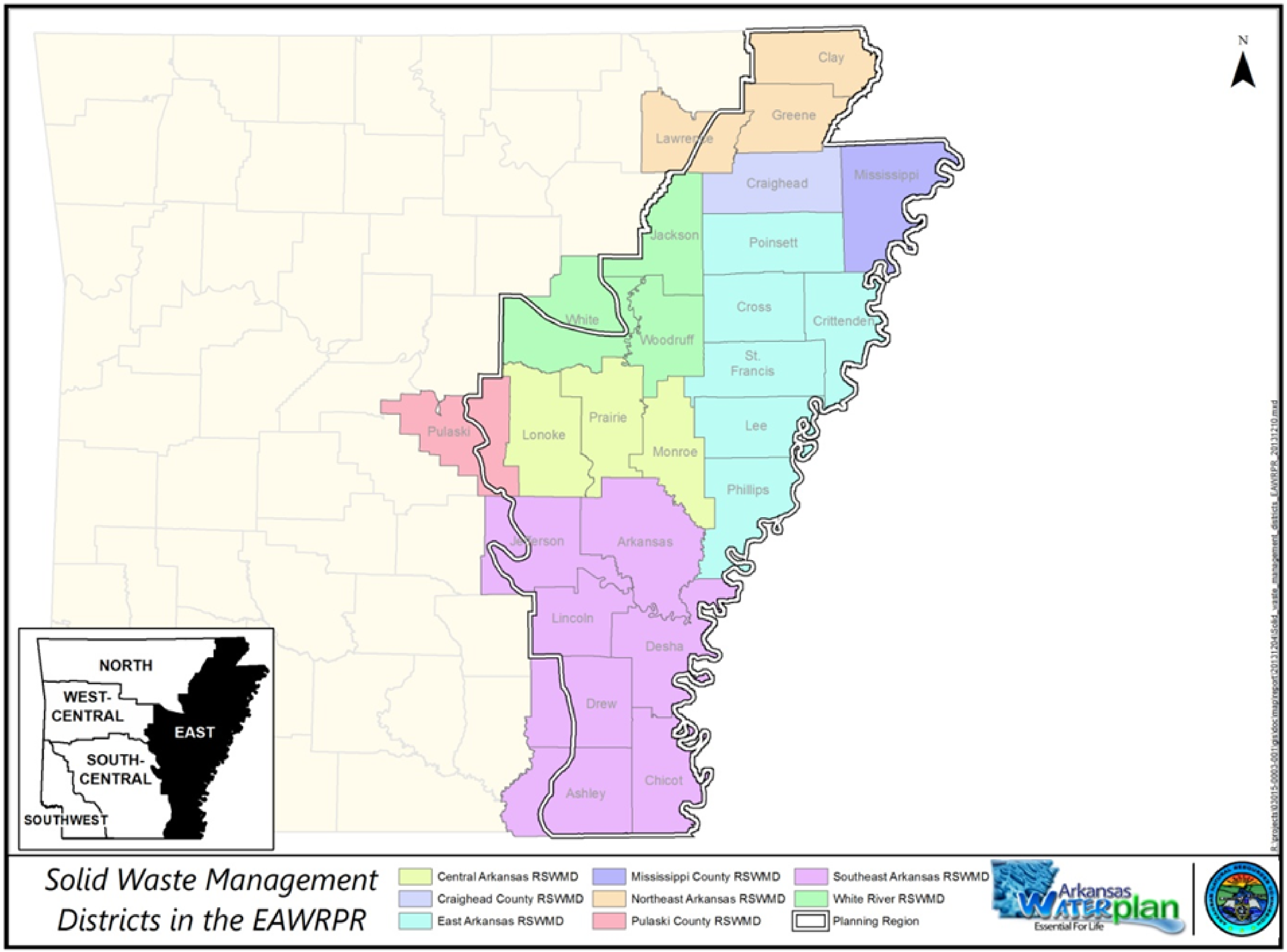

Figure 4.9 Regional Solid Waste Management Districts of the EAWRPR.

Table 4.10. 2010 solid waste generation and disposal information for RSWMDs in the EAWRPR.

RSWMD Name	Number of counties in RSWMD	Number of Counties in planning region	Number of landfills in planning region	2010 Solid Waste Generated In-district (tons)	2010 Solid Waste Disposed In-district (tons)	Number Illegal Dump Sites Identified 2010
Northeast	4	2		70,558		Not available
Craighead	1	1	1	101,055	101,055	Not available
Mississippi	1	1	1	22,269	22,269	2
East Arkansas	6	6	5	252,065	242,065	8
Central Arkansas	3	3	2	2,766,053	2,766,053*	0
White River	10	2 + 1 partial	1	127,845	101,794	12
Southeast Arkansas	10	4 + 3 partial	5	350,000*	340,000+	0

*estimated annual projection
+ 8,634 tons reportedly hauled out of district annually

There have been significant changes in the solid waste arena since 1990, driven by the need to protect water quality. In 1991, federal regulations changed, requiring improvements in the way landfills were constructed in order to protect groundwater quality. In addition, the new regulations required monitoring of groundwater quality around landfills (EPA 2012a, ADEQ 2011). At the same time, state regulations set up programs to fund cleanup of groundwater contamination from landfills, and for collection and recycling of batteries and waste oil, both of which pose risks to surface and groundwater quality when disposed of improperly. Around 1995, the Arkansas General Assembly established a policy to eliminate illegal dumping, another threat to surface and groundwater quality. State legislation to implement this policy was passed in 1997. In 2005, state legislation was passed that resulted in the development and implementation of a comprehensive mercury minimization program for the state. Mercury is a surface water quality issue throughout the state (ADEQ 2011). State programs initiated since 1990 for the collection and recycling of electronics, and collection of household hazardous wastes also protect water quality.

4.4.2 Hazardous Waste

There are 201 permitted hazardous waste generators in the counties within the EAWRPR (Table 4.11). The majority of these facilities are located in Pulaski County. Seventy-one of the facilities in the counties within the EAWRPR are classified as large quantity generators, meaning they generate at least 1,000 kilograms of hazardous waste per month (EPA 2012b). One hundred thirty of the facilities are classified as small quantity generators, meaning they generate between 100 and 1,000 kilograms of hazardous waste per month (EPA 2012c). Three of the 10 facilities in the state that generated the most hazardous waste in 2011 are located in the EAWRPR (EPA 2012d). There are also two hazardous waste treatment/storage/disposal facilities in the region; one in Lonoke County and one in Jefferson County (ADEQ 2012a).

Hazardous waste generation data is compiled annually, but this program was not implemented in Arkansas until after 1990. Information from 1990 on the number of hazardous waste generators is also not readily available. Therefore, a comparison with 1990 conditions is not made in this document.

Table 4.11. Permitted hazardous waste generators in counties within the EAWRPR (ADEQ 2012a).

County	Large Quantity	Small Quantity
Arkansas	1	4
Ashley*	3	2
Chicot	0	0
Clay	0	1
Craighead	3	10
Crittenden	6	6
Cross	1	1
Desha	0	5
Drew*	2	2
Greene	4	4
Jackson	1	2
Jefferson*	5	10
Lawrence*	0	2
Lee	0	0
Lincoln	0	0
Lonoke	1	2
Mississippi	8	9
Monroe	0	0
Phillips	6	2

Table 4.11. Permitted hazardous waste generators in counties within the EAWRPR (continued).

County	Large Quantity	Small Quantity
Poinsett	0	3
Prairie	0	0
Pulaski*	24	56
St. Francis	0	0
White*	5	9
Woodruff	1	0
Total	71	130

*Part of this county is in another planning region.

4.4.3 Wastewater and Stormwater

There are around 2,000 point sources permitted to discharge wastewater and stormwater in the EAWRPR (Table 4.12). These discharges are permitted by ADEQ through the federal National Pollutant Discharge Elimination System (NPDES). Industrial, municipal, and domestic wastewater discharges are permitted through NPDES as well as discharges of stormwater and runoff associated with industrial sites, municipalities (MS4s), and temporary construction sites. See Section 6 for more details on wastewater regulations and permitting in Arkansas.

Approximately 150 surface water bodies in the planning region receive discharges from permitted entities. Several of these water bodies receive discharges from more than one point source (ADEQ 2009a).

Table 4.12. NPDES permitted discharges in the EAWRPR (ADEQ 2013a, 2013b, 2013c, 2013d).

County	NPDES Industrial	NPDES Municipal	NPDES Domestic	NPDES Large MS4	NPDES Small MS4	NPDES Construction Stormwater[1]	NPDES Industrial Stormwater	NPDES Other[2]	Total
Arkansas	17	6	0	0	0	5	25	4	57
Ashley*	5	6	1	0	0	3	13	5	33
Chicot	3	4	2	0	0	5	6	4	24
Clay	2	11	0	0	0	3	9	0	25
Craighead	30	12	6	0	3	81	81	4	217
Crittenden	14	8	3	0	2	18	41	2	88
Cross	8	5	5	0	0	4	8	4	34
Desha	7	6	1	0	0	3	13	4	34
Drew*	6	2	1	0	0	2	12	1	24
Greene	14	4	2	0	0	18	29	1	68

Table 4.12. NPDES permitted discharges in the EAWRPR (continued).

County	NPDES Industrial	NPDES Municipal	NPDES Domestic	NPDES Large MS4	NPDES Small MS4	NPDES Construction Stormwater[1]	NPDES Industrial Stormwater	NPDES Other[2]	Total
Jackson	9	8	0	0	0	1	13	9	40
Jefferson*	26	7	6	0	4	23	60	11	137
Lawrence*	8	9	1	0	0	7	14	0	39
Lee	1	5	3	0	0	3	4	0	16
Lincoln	6	3	2	0	0	4	2	0	17
Lonoke	18	8	21	0	1	30	21	11	110
Mississippi	27	16	6	0	0	21	50	11	131
Monroe	2	3	0	0	0	9	7	2	23
Phillips	9	6	1	0	0	2	22	4	44
Poinsett	5	6	0	0	0	3	22	5	41
Prairie	4	5	0	0	0	6	4	2	21
Pulaski*	123	16	69	1	8	151	212	25	605
St. Francis	9	7	2	0	0	7	15	2	42
White*	39	15	2	0	0	34	45	11	146
Woodruff	5	4	1	0	0	1	8	0	19
Total	397	182	135	1	18	444	736	122	2035

*Part of this county is in another planning region.
[1]Construction stormwater permits are temporary.
[2]Includes filter backwash, process water, agricultural, cooling water, toxics, and saltwater discharges.

Table 4.13 compares the number of NPDES permits for municipal, domestic, and industrial wastewater reported for the EAWRPR in the 1990 state-wide water quality assessment with the current numbers for the same categories of NPDES permits. Overall, the number of permitted wastewater discharges in the EAWRPR has increased approximately 25% since the 1990 AWP update. Note that the state-wide water quality assessment reports do not include permits for municipal, industrial, or construction stormwater runoff. The first industrial and construction stormwater runoff NPDES permits were issued by ADEQ in 1992 (ADEQ 2013b, 2013c). ADEQ did not issue permits for small municipalities’ stormwater runoff until 2004 (ADEQ 2013d).

Table 4.13. Numbers of NPDES wastewater permits reported for the EAWRPR in 1990 and 2013 (ADPCE 1990, ADEQ 2013a).

Permit type	1990	2013	Change
Industrial	27	57	30
Municipal	145	160	15
Domestic	45	75	30
Cooling water	8	5	-3
Filter backwash	6	1	-5
Process water	0	2	2
Agricultural	1	1	0
Other	12	3	-9
Total	244	304	60

5.0 WATER RESOURCES ISSUES

Water resources issues in the EAWRPR include concerns about the amount of water that is available, how the water is used, and the chemical and biological quality of water resources. In addition, there are concerns in the region about how water is managed in terms of flood control, water supply infrastructure, and wastewater treatment infrastructure. These issues are discussed and, to some extent, quantified below. Changes in regional water resources issues since the 1990 AWP update are also discussed.

5.1 Flooding

The EAWRPR includes several large waterways, including the St. Francis River, Cache River, the lower Arkansas and White Rivers, Bayou Bartholomew, and the Mississippi River, which runs along the entire eastern border of the state. As was noted in Section 3.1, the EAWRPR is an area that generally has little topographic relief and includes flat, broad floodplains. Flooding occurs routinely throughout the planning region, but many of these are isolated events that affect only small areas, or are limited to a few watersheds. Large, widespread disasters also occur. Since 1957, there have been 34 major disaster declarations involving flooding in Arkansas. From 2003 to 2010, some or all of the counties included in the EAWRPR were included in 15 flooding disaster declarations (Arkansas Department of Emergency Management 2010).

The most recent significant flood event in Arkansas occurred largely in the EAWRPR. Major flooding occurred during April and May of 2011 that included the White River, Black River, Cache River, and Mississippi River, as well as the tributaries to these major rivers. The magnitude of the flooding was on a scale comparable to the historic 1927 flood and resulted in 22 of the 25 counties in the EAWRPR being declared disaster areas. For the Mississippi River, the White River, and the St. Francis River within the EAWRPR, the 2011 flood was classified as a 100-year flood (Westerman, et al. 2013).

5.2 Wetland Loss

Prior to development, there were approximately 8 million acres of wetlands in the EAWRPR (Dahl 1990). Over 6 million acres of those wetlands have been converted to cropland (Fry, et al. 2011). Loss of wetlands in the EAWRPR has altered the hydrology of the region (loss of flood storage and groundwater recharge), affected water quality (increased sediment and nutrients in surface water), and impacted numerous plant, animal, bird, and fish species (species loss and decline). Since the 1970's the rate of wetland loss has been declining. The majority of the lost wetlands will never be restored, however, there are numerous wetland restoration and construction projects active in the EAWRPR.

5.3 Channelization

The majority of the waterways in the EAWRPR are channelized drainage ditches. The digging of drainage ditches and straightening and channelization of natural streams in this region have made the large-scale crop production that is characteristic of this region possible. However, it has also reduced wetland area and in-stream fishery habitat, and impacted water quality.

5.4 Water Supply

Expansion of water-intensive industries in this region, such as irrigated agriculture, aquaculture, and hydrofracking, has resulted in concern over whether there is sufficient water available to supply current and future demands in the EAWRPR.

5.4.1 Groundwater

Groundwater depletion has been an issue in the EAWRPR since the 1920s (Kresse, et al. 2013). The agricultural economy of the planning region is dependent on the continued sustainability of groundwater resources in the region to supply water for irrigation and aquaculture. There is concern in this planning region about water level declines in several of the aquifers in the planning region. This is a somewhat localized issue as water use and groundwater recharge rates for these aquifers vary throughout the planning region.

5.4.1.1 Groundwater Water Level Monitoring

ANRC sponsors monitoring of water levels in five study areas within the EAWRPR. Water-level monitoring is a cooperative effort between the ANRC, USGS, NRCS, and local water-resources agencies. Each spring approximately 700 water levels are collected from wells in the MRV alluvial aquifer, resulting in the largest number of water-level measurements for any one aquifer in the state. Similarly, each spring there are approximately 300 water levels collected from wells in the Sparta-Memphis aquifer. Measurements are collected in the spring to minimize effects of groundwater drawdown from seasonal irrigation. To assess the drawdown caused by seasonal irrigation use, the NRCS and ANRC collect additional measurements from the MRV alluvial aquifer in the fall. Results of the monitoring program are published in the annual Arkansas Groundwater Protection and Management Report available on the ANRC website.

The USGS also conducts water-level monitoring independently as part of the National Water Information System (NWIS). Since 1969, the USGS has operated continuous groundwater-level recorders at real-time stations throughout the planning region. These data provide a valuable dataset for improved understanding of water resources of the State. Data from this program may be retrieved at the NWIS website (Kresse, et al. 2013). The USGS is performing a regional groundwater-assessment study that includes the EAWRPR. The Mississippi Embayment Regional Aquifer Study (MERAS) is designed to assess groundwater availability throughout the Embayment. In Arkansas, this study focuses on the MRV alluvial aquifer (Kresse, et al. 2013).

5.4.1.2 Mississippi River Valley alluvial aquifer

Groundwater withdrawal rates exceeding natural recharge rates and subsequent water-level declines have been a concern for the MRV alluvial aquifer since the 1920s. The agricultural economy of the planning region is dependent upon the continued sustainability of groundwater resources for irrigation. Water- use rates for the MRV alluvial aquifer have increased steadily from 1965 to 2010, with the majority of this use attributed to irrigation. In 1965, the average water use by county was 22.69 mgd, and in 2010, the average water use by county was 148.64 mgd. Water-use increases have focused in specific counties where agricultural use is intensive, such as Randolph, Independence, and Greene Counties and parts of the Grand Prairie region (Arkansas, Lonoke, and Prairie Counties). In addition to groundwater depletion, water-level declines in the MRV alluvial aquifer have resulted in extensive areas where portions of the aquifer have transitioned from confined to unconfined conditions; massive cones of depression; and reduction of hydraulic pressure, saturated thickness, storage volume, lateral flow, yield, and baseflow to streams; and aquifer compaction. In some areas, groundwater depletion has occurred to an extent that groundwater can no longer be pumped at rates to meet demand (Kresse, et al. 2013).

5.4.1.3 Sparta-Memphis aquifer

In the EAWRPR, the highest withdrawals from the Sparta-Memphis aquifer occur in the Grand Prairie area. Traditionally, the Sparta-Memphis aquifer was used for public and industrial supply. Multiple counties in the Grand Prairie, southern, and southeastern areas of Arkansas exclusively use the Sparta-Memphis aquifer as a drinking water source. As water levels continue to decline in the MRV alluvial aquifer, the use of the Sparta-Memphis aquifer as an irrigation supply source continues to increase. Reported withdrawals from the Sparta-Memphis aquifer doubled from 1965 to 2000, with the highest percent increases in Lonoke (over 6,500%) and Arkansas (234%) Counties, which were attributed to irrigation use. As of 2010, the primary use of the Sparta-Memphis aquifer is to support agriculture (Kresse, et al. 2013).

Water level data collected from the Sparta-Memphis aquifer over a 25-year period shows a long-term decline of 0.8 feet/yr. The estimated sustainable yield for the aquifer is 87 mgd. In 2009, groundwater withdrawals were estimated to be 142.42 mgd (ANRC 2012a). Large cones of depression in the Sparta-Memphis aquifer have been observed in Poinsett, Jefferson, and Crittenden Counties. In Crittenden County, the water-level declines are attributed to large pumping centers for the West Memphis and Memphis, TN, metropolitan area. In Poinsett and Cross Counties, the water-level declines are attributed to agricultural uses or recharge of the depleted MRV alluvial aquifer. Large water-level declines and an extensive cone of depression in the Grand Prairie led to the ANRC listing the Sparta-Memphis aquifer along with the MRV alluvial aquifer as a Critical Groundwater Area in 1998. Two surface-water diversion projects are planned for the Grand Prairie area to provide irrigation water and decrease dependence on the MRV alluvial and Sparta-Memphis (Kresse, et al. 2013).

5.4.1.4 Minor aquifers

The Cockfield aquifer is an important groundwater resource throughout eastern Arkansas. The aquifer is primarily used for domestic purposes, but in some areas, such as Ashley County, yields are high enough to support municipal and industrial supply. As a result of sustained and intense pumping of the Cockfield aquifer, water level declines have led to cones of depression in western Drew and Chicot Counties in this planning region (Kresse, et al. 2013).

Owing to good water quality and high yields, the Wilcox aquifer is used for municipal, domestic, and industrial supply. Public supply accounts for 65% of the water use for this aquifer. Water use is the greatest in northeastern Arkansas in the Counties of Mississippi, Crittenden, and Greene, which heavily depend on the Wilcox aquifer. As of a result of heavy and sustained pumping, water-level declines and coalescing cones of depression were observed at major pumping centers in Paragould (Greene County) and West Memphis (Crittenden County). While water-level declines have been observed near Blytheville (Mississippi County), pumping in this area does not appear to have made as large of an impact (Kresse, et al. 2013).

Use of the Nacatoch aquifer in eastern Arkansas has been restricted to areas near its outcrop. Poor water quality has prevented the use of the aquifer in areas further away from the outcrop area. Primary use of the aquifer has been for public and industrial supply (Terry, et al. 1986). In 2010, the primary reported use in northeastern Arkansas was for public-water supply by the Clay County Regional Water District and the Cities of Piggott and Rector (also located in Clay County). Prior to 1990, water-decreases were noted in wells in northeastern Arkansas. Since then, water levels appear to have stabilized in these areas owing to decreased use of the aquifer (Kresse, et al. 2013).

5.4.1.5 Critical Groundwater Areas

The 1990 Arkansas Water Plan update advocated sustainable, conjunctive use of groundwater and surface water resources in this region to meet water resources needs. A number of voluntary programs have been initiated to try to reduce the rate of groundwater depletion in areas where groundwater level declines are the greatest. These include federal irrigation projects utilizing surface water in the Grand Prairie, Bayou Meto, and the Beouf-Tensas basin; federal and state agricultural water conservation incentive programs; and designation of Critical Groundwater Areas (Figure 5.1). Designation of Critical Groundwater Areas focuses resources, providing enhanced tax credits for conservation activities, focused educational programs, priority for federal programs and funding, and enhanced opportunities for locally-led groundwater conservation programs (ANRC 2010). In 2000, the NRCS initiated a cost-share program to assist with the construction of on-site farm structures (surface-water reservoirs and tail-water recovery systems) to assist in water conservation measures. As of 2012, more than 250 reservoir and tail-water recover systems were completed (Kresse, et al. 2013).

In 1998, the ANRC designated the Grand Prairie Area (Figure 5.1) as a Critical Groundwater Area due to drastic water-level declines in the MRV alluvial and Sparta aquifers. Two surface-water diversion projects were planned to provide irrigation water and decrease dependence upon groundwater in this region. The Grand Prairie Area Demonstration Project is planned to divert surface water from the White River to supply users in Arkansas and Prairie Counties. A similar project, known as the Bayou Meto Project, is planned to divert surface water from the Arkansas River to farmland in Lonoke, Prairie, Jefferson, and Arkansas Counties. Despite numerous delays over the years associated with political and environmental concerns, lawsuits, and other problems, planning and construction of these projects still continues (Kresse, et al. 2013).

In 2010, the ANRC declared the Cache Study Area (Figure 5.1) a Critical Groundwater Area for excessive water-level declines in the MRV alluvial aquifer and Sparta-Memphis aquifer. From 2006 to 2011, the MRV alluvial aquifer in this study area showed an average water-level decline of 1.65 feet, with 95 of the 127 (74.8%) wells monitored showing decreases. For this time period, the highest average declines in water levels occurred in Craighead (3.80 feet) and Cross (3.47 feet) Counties. From 2006 to 2011, the Sparta-Memphis aquifer in this study area showed an average water level decline of 2.23 feet, with 22 of the 30 (73.3%) wells monitored showing decreases. For this time period, the highest average declines in water

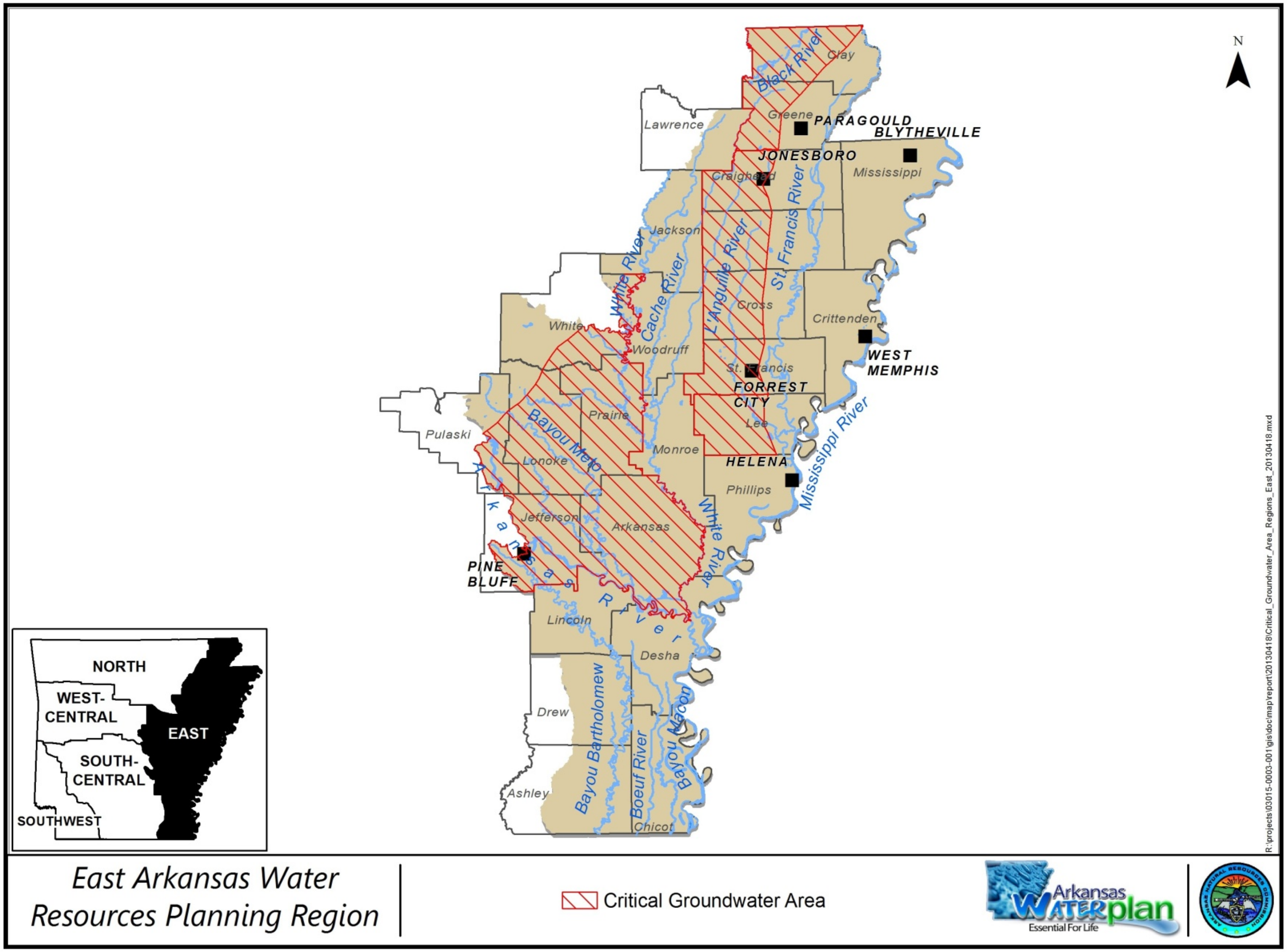

Figure 5.1. Critical groundwater areas in the EAWRPR Planning Region.

levels occurred in Poinsett (3.90 feet) and Woodruff (3.40 feet) (ANRC 2012b). Designation as a Critical Groundwater Area provides enhanced tax credits for conservation activities, focused educational programs, and places the area as a priority for potential federal programs and funding.

5.4.2 Surface Water

Surface water flow in several streams in the EAWRPR has been shown to be declining (Ludwig 1992, Czarnecki, Hays and McKee 2002). In addition, demand for surface water is increasing as users are being encouraged to convert from groundwater to surface water.

5.4.2.1 Surface water depletion due to groundwater withdrawals

Streams in the EAWRPR are being impacted by the lowering of the groundwater table resulting from the large volume of groundwater withdrawals in the region. Prior to the large scale use of the MRV alluvial aquifer, the water levels in the aquifer were high enough that groundwater contributed to flow in rivers and streams in the EAWRPR. Currently, water levels in the MRV alluvial aquifer are too far below ground, and the rivers do not cut deeply enough into the aquifer, for water to move directly from the aquifer to the rivers. Water from these rivers and streams flowing over the MRV alluvial aquifer does percolate into the aquifer (Czarnecki, Hays and McKee 2002). As a result, there is less flow in many East Arkansas rivers and streams. Several flow gage stations on streams in the planning region exhibit declining trends (Ludwig 1992, Czarnecki, Hays and McKee 2002).

Aquifer recharge from streams during high-flow is a natural process. However, when the groundwater gradient is altered by pumping from wells, additional aquifer recharge is induced. Recharge is induced when water is withdrawn from an aquifer adjacent to a stream or other surface water source, to which it is hydrologically connected. This process is also commonly referred to as “stream capture”. This scenario was identified in the EAWRPR by the USGS as early as the 1960’s. Analysis of the potentiometric map for the fall of 1959 indicates that during this period water was moving from the Arkansas River into the alluvial aquifer in Lincoln and Arkansas counties at a rate of about 12 mgd. The spring potentiometric surface indicated a flow from the river to the alluvial aquifer of about 9 mgd (Bedinger and Jeffrey 1964). In 1968, the

USGS reported that withdrawals of water for rice irrigation had resulted in a cone of depression centered in Arkansas County and stretching to the White River, and that movement of water from the river into the aquifer had apparently begun (Kresse, et al. 2013). These early observations of stream capture occurred before the construction of the lock and dam system on the Arkansas River.

Another observed case of stream capture is in the MRV alluvial aquifer along the Cache River west of Crowley's Ridge. As early as 1981, digital-model analysis indicated that 430,000 acre-feet per year of water was moving from the Cache River into the aquifer as a direct result of agricultural pumping (Broom and Lyford 1981).

In 2003, the USGS groundwater flow model reported data was evaluated to determine the volume of White River flow being diverted/intercepted by irrigation wells in the MRV alluvial aquifer. It was determined that 20,231,644 cubic feet per day of water was being indirectly withdrawn from the White River due to stream capture, reducing base flow to the river from the aquifer (Kresse, et al. 2013).

5.4.2.2 Increased Surface Water Demand/Use

There are two large irrigation projects under construction in the EAWRPR intended to supply surface water to producers to supplement groundwater for irrigation. The Grand Prairie project is designed to supply water from the White River to 362,662 acres of cropland in Arkansas, Lonoke, and Prairie Counties. The Bayou Meto irrigation project is designed to supply water from the Arkansas River to approximately 268,000 acres of cropland and 22,000 acres of aquaculture ponds in Arkansas, Jefferson, Lonoke, Prairie, and Pulaski Counties (ANRC 2012c).

The Arkhoma Basin Fayetteville Shale, a geologic formation being heavily developed for natural gas resources in the state, extends into parts of White County and Jackson County. The gas is being extracted from this formation using the hydrofracking process at several active wells within the EAWRPR (Arkansas Oil and Gas Commission 2013). This process uses large volumes of surface water. As natural gas production has increased in the Fayetteville Shale Play, the demand for surface water has also increased.

5.5 Waterborne Commodity Transport Infrastructure

As discussed in Section 3.7.2, there are three waterways in the EAWRPR that are used for the transport of goods and materials, the Mississippi River, MKARNS and the White River. Maintenance of these waterways and their associated public port facilities so that they can continue to support the economy of the region, and the State, is a constant and expensive activity. Needs identified by the Arkansas Waterways Commission are summarized below.

5.5.1 Mississippi River

Low water levels on the Mississippi River during the summer of 2012 and winter 2013 resulted in closure of one of the four Arkansas ports on the river. This raised concerns that additional dredging may be needed in Arkansas harbors to maintain their usefulness during low water conditions. No funding was appropriated in the USACE 2013 budget for this activity (Arkansas Waterways Commission 2013).

5.5.2 Arkansas-White River Cutoff

The White River channel is migrating toward the Arkansas River channel downstream of the Arkansas Post Canal. A connection between these two rivers at that point could temporarily shut down transportation on the MKARNS, impacting the regional and State economy, and result in the loss of thousands of acres of bottomland hardwoods. There are temporary structures in place to prevent the White River from joining the Arkansas River. The USACE has proposed a reconnaissance study to determine potential permanent solutions. However, this study has not yet been federally funded (Arkansas Waterways Association 2011, USACE Little Rock District 2012). The Arkansas Waterways Commission has proposed a private study to be funded by the Arkansas General Assembly. This study has not yet been funded (Arkansas Waterways Commission 2013).

5.5.3 MKARNS Maintenance

The USACE is having difficulty obtaining funding for maintenance activities, such as dredging, required to keep the MKARNS operational. At the end of 2012, there were 15 critical maintenance projects currently on hold (Arkansas Waterways Commission 2013).

5.5.4 MKARNS Twelve Foot Channel

A project to deepen the MKARNS navigation channel to a minimum of 12 feet was authorized by the US congress in 2005, and the work was initiated. However, funding for the project has been sporadic and was not appropriated in 2012 nor 2013. As a result, work on this project has ceased.

5.5.5 White River

The navigation channel in the White River upstream of the MKARNS has not been dredged since 2009 (USACE Memphis District 2013). Concerns about impacts of dredging on the surrounding wetlands ecosystem have resulted in opposition to maintaining the White River navigation channel (Rogers 2013).

5.6 Water Quality Issues

Federal law requires states to assess the water quality of the waters of the state (both surface water and groundwater) and prepare a comprehensive report documenting the water quality, which is to be submitted to EPA every 2 years. ADEQ is the agency in Arkansas responsible for enforcing the water quality standards and preparing the comprehensive report for submittal to EPA. This section discusses surface water and groundwater quality issues that have been identified in the EAWRPR. These issues include non-attainment of surface water quality standards, non-attainment of drinking water standards and water quality guidelines in groundwater, fish consumption advisories, nonpoint source pollution of surface water and groundwater, and contaminants of emerging concern.

5.6.1 Water Quality Monitoring

To assess water quality, it is necessary to collect water quality data through monitoring programs. Monitoring of water quality in the EAWRPR occurs under a range of programs, including routine ambient, special project, and research-oriented monitoring. Multiple agencies are responsible for the various water quality monitoring programs, and numerous entities assist with monitoring activities. Surface water and groundwater monitoring programs in the planning region are outlined below.

5.6.1.1 Surface Water

ADEQ monitors water quality of surface waters through several programs. The ambient water quality monitoring network includes 23 sites on rivers and streams in the EAWRPR that are sampled monthly for chemical analysis (Figure 5.2). The roving water quality monitoring network includes 56 stream sites in the planning region. These sites are divided into four regional groups. Each group of roving sites is sampled for chemical and bacterial analysis on a rotating basis, bimonthly over a 2-year period, every 6 years. Bacterial analysis is also performed on samples from the ambient water quality monitoring network within the active region of the roving water quality monitoring network. In addition, ADEQ conducts water quality monitoring during “intensive surveys.” These surveys can involve water sampling for chemical and bacterial analysis, as well as biological sampling to evaluate water quality. Intensive surveys are conducted for a variety of purposes, including determination of total maximum daily loads (TMDLs), and to augment water quality information from the routine water quality monitoring networks for more accurate assessment of designated use support. ADEQ also routinely monitors water quality in 18 significant publicly owned lakes within the planning region (ADEQ 2009a, 2012b, 2013e).

Through its nonpoint source management program, ANRC oversees water quality monitoring programs in 10 nonpoint source priority watersheds. Three of these watersheds, Bayou Bartholomew, Cache River, and L’Anguille River, are located in the EAWRPR. These programs involve universities, contractors, and nonprofit organizations. Parameters monitored by these programs typically include nutrients and sediment, turbidity, and/or total suspended solids.

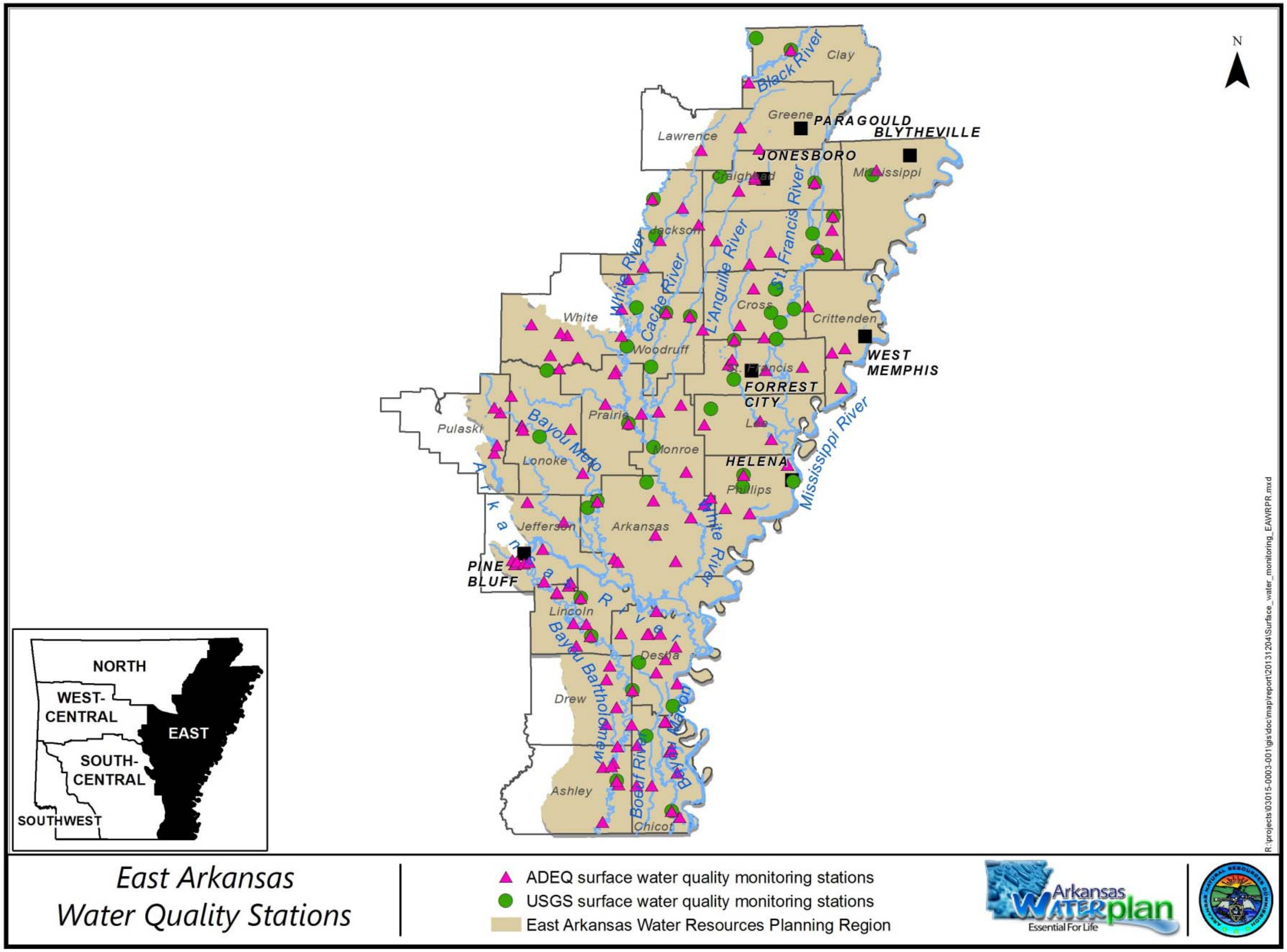

Figure 5.2. Routine surface water quality monitoring stations in the EAWRPR.

The monitoring and reporting requirements for surface water used for human consumption are authorized by both federal and state regulations. A summary of these requirements can be found in Chapter 5 of *Arkansas Public Water System Compliance Summary*, "Microbial Disinfection By-Products Rules" (ADH 2012). There are less than 20 public water supply systems in the EAWRPR that use surface water (ADH n.d.). Depending on the treatment methods used and the number of customers served by the public water supply utilizing surface water, the monitoring requirements for the raw surface water, or source water, will vary and may include turbidity, *Escherichia coli* (*E. coli*), cryptosporidium, total organic carbon (TOC), and alkalinity.

The USGS also routinely monitors surface water quality data in the EAWRPR. Data from USGS monitoring stations may also be used in the biennial assessment. There are six active USGS water quality monitoring stations in the EAWRPR. Samples are collected at these stations monthly, bi-weekly, or quarterly (USGS 2013c). The USGS National Water Quality Assessment Program Mississippi Embayment Study Unit includes the EAWRPR. The USGS conducted an intensive study of water quality in this region during the period from 1995 through 1998 (Kleiss et al 2000).

5.6.1.2 Groundwater

In the EAWRPR, groundwater quality monitoring is performed on many levels ranging from ambient to research-oriented and mandated monitoring. Multiple agencies are responsible for the various groundwater monitoring programs, and numerous entities assist with monitoring activities. Divisions of ADEQ administer mandated groundwater monitoring programs at various sites that are regulated by state and federal programs. The purpose of this monitoring is to evaluate potential and actual impacts to groundwater resulting from human activities and natural phenomenon (ADEQ 2009a, 2012c). For example there are seven Superfund sites located within the planning region and six of these have active groundwater monitoring. Within the planning region are four properties in the State's Brownfields program that are currently being evaluated; three sites that are on the State Priority List that are monitored; two sites in the Elective Cleanup program; six Class I solid waste landfills; and an unknown number of hazardous waste sites and leaking underground storage tank sites that are being evaluated or monitored through other regulatory mechanisms.

ADEQ developed the Arkansas Ambient Ground Water Monitoring Program in 1986, which currently consist of 12 monitoring areas and approximately 250 wells and springs throughout the state (ADEQ 2012d, Kresse and others 2013). Five of the ADEQ groundwater quality monitoring areas are located in the EAWRPR: Brinkley, Chicot, Jonesboro, Lonoke, and Pine Bluff (Figure 5.3). Under this ADEQ program, samples are collected from wells complete in the MRV alluvial aquifer, the Sparta/Memphis aquifer, the Wilcox aquifer, and the Cockfield aquifer (Table 5.1) to develop baseline conditions and monitor potential impacts of agriculture and industry on groundwater. Data from this monitoring program are presented in ADEQ publications available on their website, and in the EPA STORET database (ADEQ 2009).

The University of Arkansas (U of A) has conducted a significant amount of groundwater research that has resulted in scientific data and information necessary to understand, manage, and protect water resources within the state (Kresse, et al. 2013). Hard-copy or digital reports, theses, dissertations, and journal articles are available at the U of A Mullin’s Library, Arkansas Water Resources Center technical library, or through various online sources.

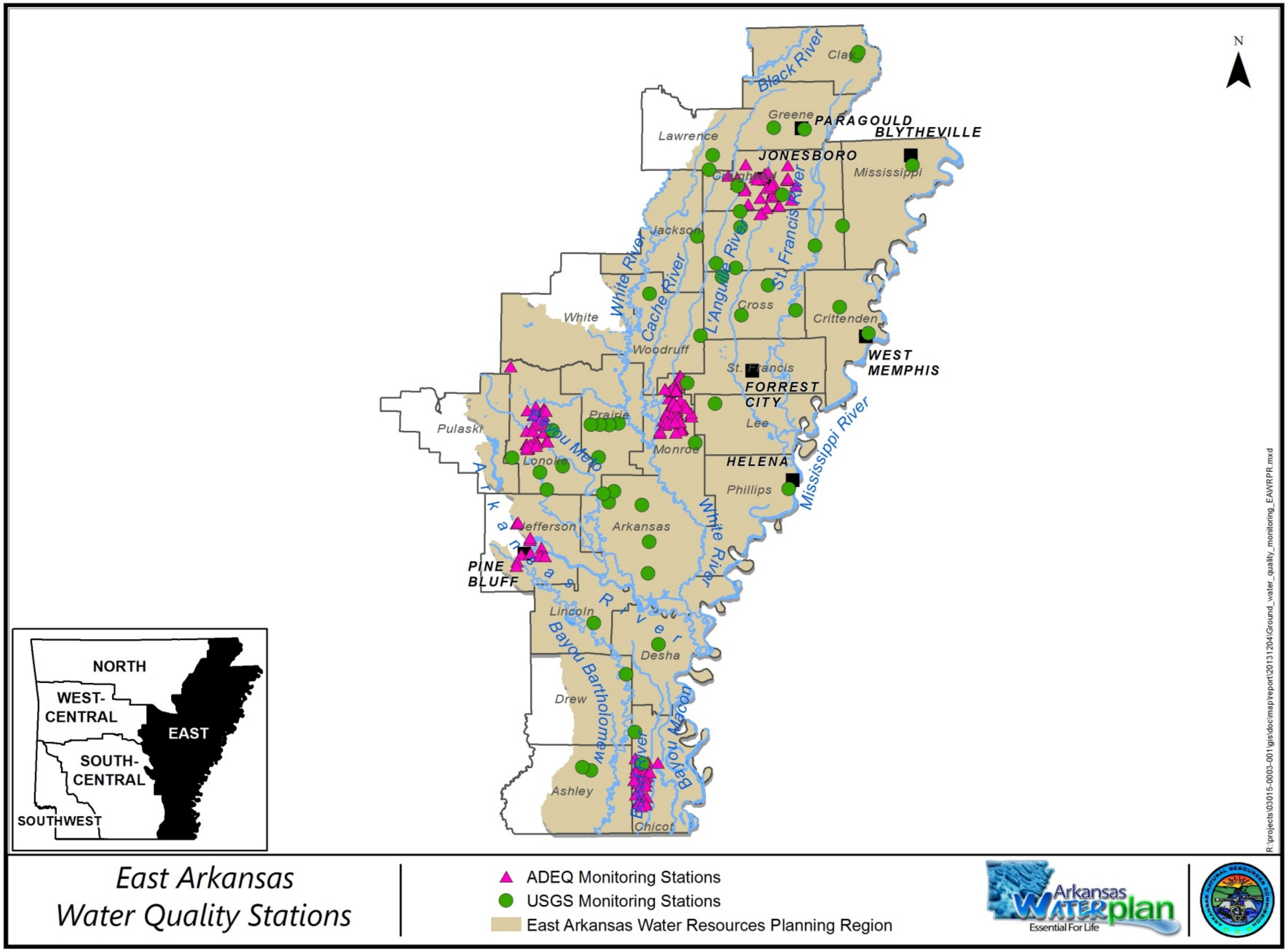

Figure 5.3. Ambient groundwater quality monitoring locations in the EAWRPR.

Table 5.1. ADEQ groundwater quality monitoring sites in the EAWRPR (ADEQ 2012d).

Monitoring Area	Most recent sampling	Total number of wells	Aquifer	Number of wells
Brinkley	2011	29	MRV alluvial	29
Chicot	1997	26	MRV alluvial	26
Jonesboro	2009	17	MRV alluvial	9
			Sparta/Memphis	4
			Wilcox	1
			Unknown	3
Lonoke	2010	16	MRV alluvial	8
			Sparta/Memphis	3
			Unknown	5
Pine Bluff	2011	16	MRV alluvial	3
			Sparta/Memphis	11
			Cockfield	2

The Arkansas Department of Health (ADH) is the primary agency for the federal Safe Drinking Water Act (SDWA) and is responsible for monitoring public water-supply wells. ADH maintains a statewide database that consists of 1300 wells (Kresse, et al. 2013). Every three years, these wells are sampled for inorganic, organic (including pesticides, herbicides, synthetic organic compounds, and volatile organic compounds), and radiochemical contaminants. The Total Coliform Rule of the SDWA requires sampling on monthly basis, where the number of samples required is dependent upon the population size. Nitrate monitoring is performed on a yearly basis unless a sample greater than or equal to 50% of the maximum containment levels (MCL) is detected and prompts the need for increased frequency. Additionally, the Disinfection Byproduct Rule of the SDWA requires monitoring of trihalomethanes and haloacetic acids (byproducts of chlorine and other disinfectants used to treat drinking water) on a quarterly or annual basis. While all of the programs above collect samples from treated drinking water, ADH also collects samples from untreated water sources (surface and groundwater) that include bacteria, particulates, algae, organics, pathogens, total organic carbon on a weekly or monthly basis as required by the SDWA (ADEQ 2009a, 2012c).

The Arkansas State Plant Board (ASPB) monitors groundwater throughout the state to detect pollution by agricultural chemicals, such as pesticides. If agricultural chemicals are found, the ASPB takes measures to respond appropriately. The groundwater program is voluntary. Since the program initiated in 2004, ASPB has sampled 271 wells in 30 counties. Results of sampling activities are included in annual reports and posted on the Plant Board web site (Kresse, et al. 2013).

Several ambient groundwater quality monitoring programs exist that involve cooperative efforts among the USGS, ANRC, and ADEQ. Ambient groundwater-quality monitoring activities are primarily funded by EPA grants under Sections 106 and 319 of the Clean Water Act.

The USGS collects groundwater quality data at a number of wells in the EAWRPR. There are 63 active USGS groundwater quality sites in the planning region (USGS 2013c). Ten of the twenty-five USGS master wells are located in this planning region. These wells are sampled for water quality every five years. The USGS, in cooperation with ANRC, also collects water quality samples from 100 wells in the MRV alluvial aquifer and 100 wells in the Sparta/Memphis aquifer every 3 years in a rotating sampling program. In addition, conductivity is measured in 50 of the wells in each aquifer every year (ADEQ 2009a).

ANRC collects groundwater data statewide in areas where water-level declines or water-quality degradation have been historically observed (Kresse, et al. 2013). In EAWRPR, ANRC performs water quality monitoring of groundwater at locations throughout the MRV alluvial aquifer (36 sites) and Sparta-Memphis aquifer (6 sites). These wells were installed as part of the Section 319 Core Program Monitoring Enhancement Wells program to establish long-term water quality trends and assist with the development of water quality standards for groundwater. Samples are collected for the analysis of major water quality parameters and metals (Jay Johnston, ANRC, written communication, 2013). When water quality samples are collected, analytical results are published in the annual Arkansas Groundwater Protection and Management Report available on the ANRC website (ANRC 2008).

5.6.2 Non-attainment of Surface Water Quality Standards

In 2008, 3,369 of the 44,000 miles of streams and 15,428 of the 150,000 acres of lakes in the EAWRPR were assessed for water quality. Of the waterbodies assessed, 1,664 stream miles and 5,817 lake acres did not meet numeric water quality criteria or did not support all of their designated uses. Sediment/siltation, low dissolved oxygen, minerals (chloride, sulfate, and total dissolved solids [TDS]), and lead were the causes of impaired water quality in the majority of the stream miles assessed (Table 5.2) (ADEQ 2009a, b). Nutrients, copper, and sediment/siltation were the sources of impairment for lakes in the EAWRPR (Table 5.2). A detailed listing of EAWRPR stream water quality impairments identified in the Arkansas 303 (d) list is included in Appendix A. The cause of impairment was unknown for over 1,000 acres of lakes in the EAWRPR. Figures 5.4 through 5.6 show locations of impaired waterbodies in the EAWRPR.

It should be noted that while a waterbody may be impaired due to sediment, there is no numeric water quality standard for sediment/siltation. Arkansas has a numeric water quality standard for turbidity but not total suspended solids (TSS); thus turbidity is the chemical parameter that is assessed to determine if sediment impairment exists. There is currently no other method that is consistently used by EPA or ADEQ to measure sediment or siltation in water.

Table 5.2 Summary of impaired waters in the EAWRPR (ADEQ 2009b).

Pollutant	Miles of impaired stream	Acres of impaired lakes
Sediment/Siltation	584.5	335
Dissolved Oxygen	861.6	0
Chloride	605.1	0
Lead	363.7	0
TDS	454.8	0
Pathogens	297.9	0
Zinc	224.1	0
Sulfate	106.3	0
Copper	51.4	335
Mercury	101.9	0
Aluminum	20.3	0
Nutrients	0	4,425
Unknown	0	1,057

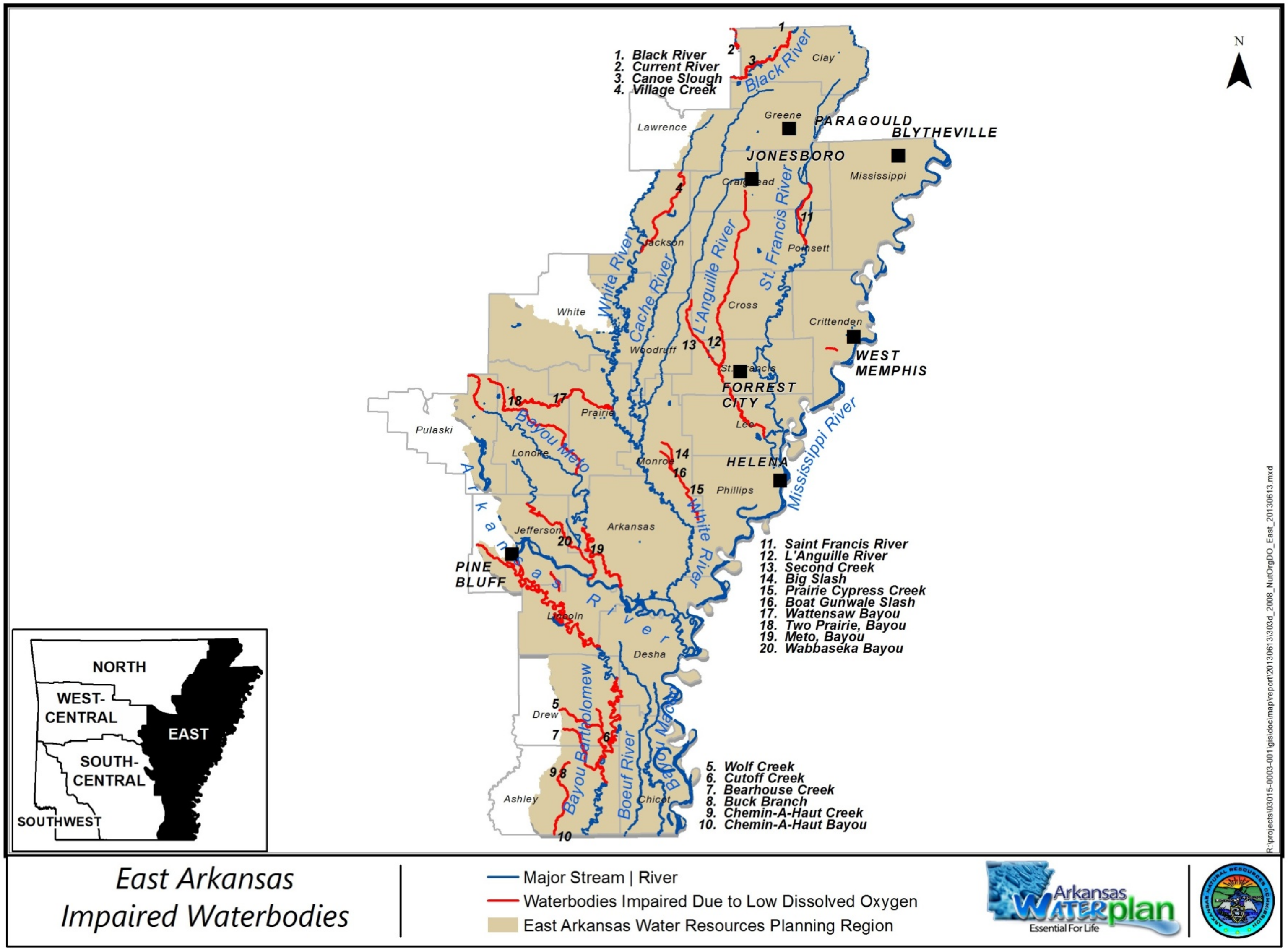

Figure 5.4. Waterbodies in the EAWRPR classified as impaired due to low dissolved oxygen in the 2008 303(d) list (ADEQ 2009b).

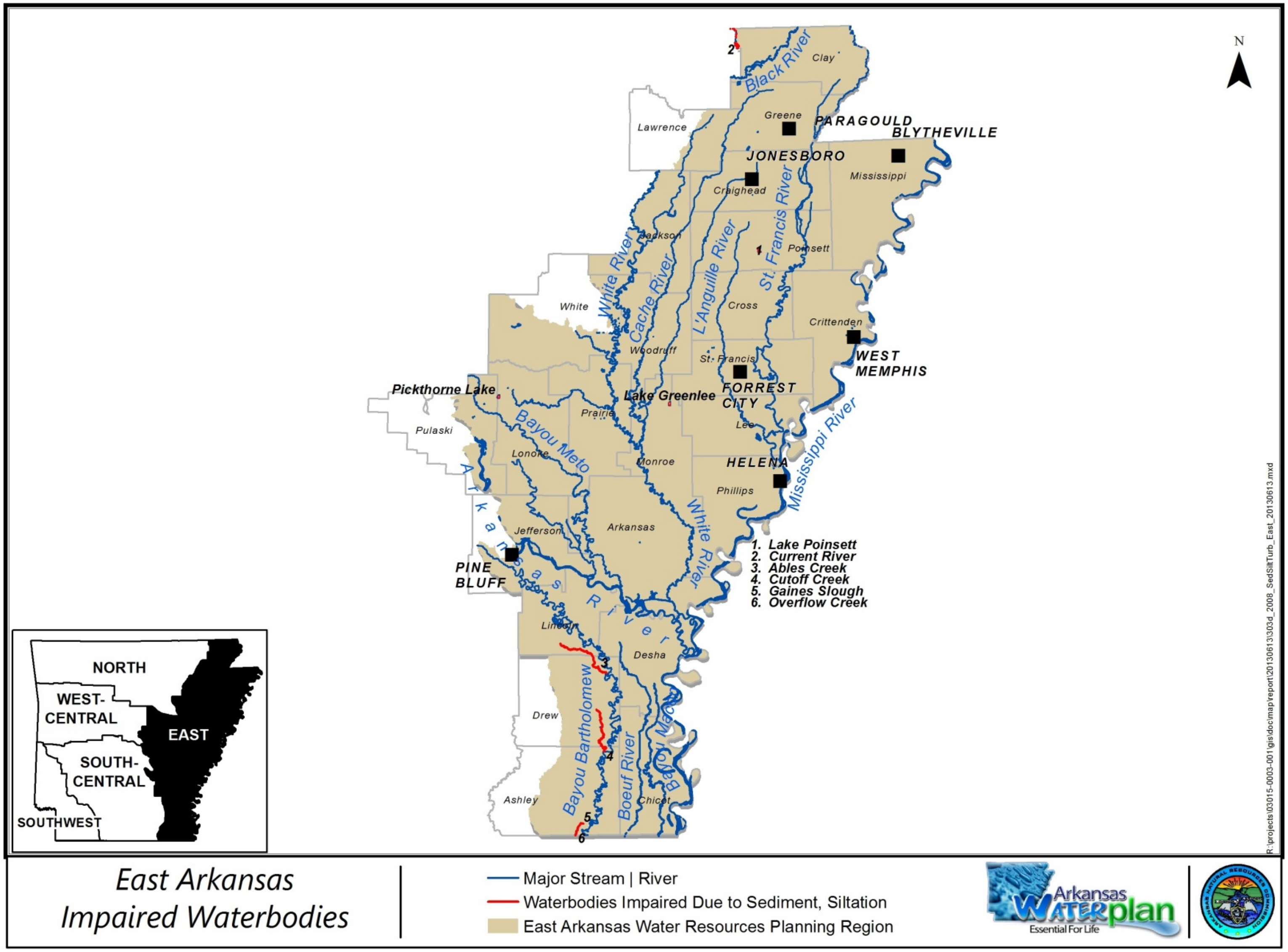

Figure 5.5. Waterbodies in the EAWRPR classified as impaired due to sediment/siltation in the 2008 303(d) list (ADEQ 2009b).

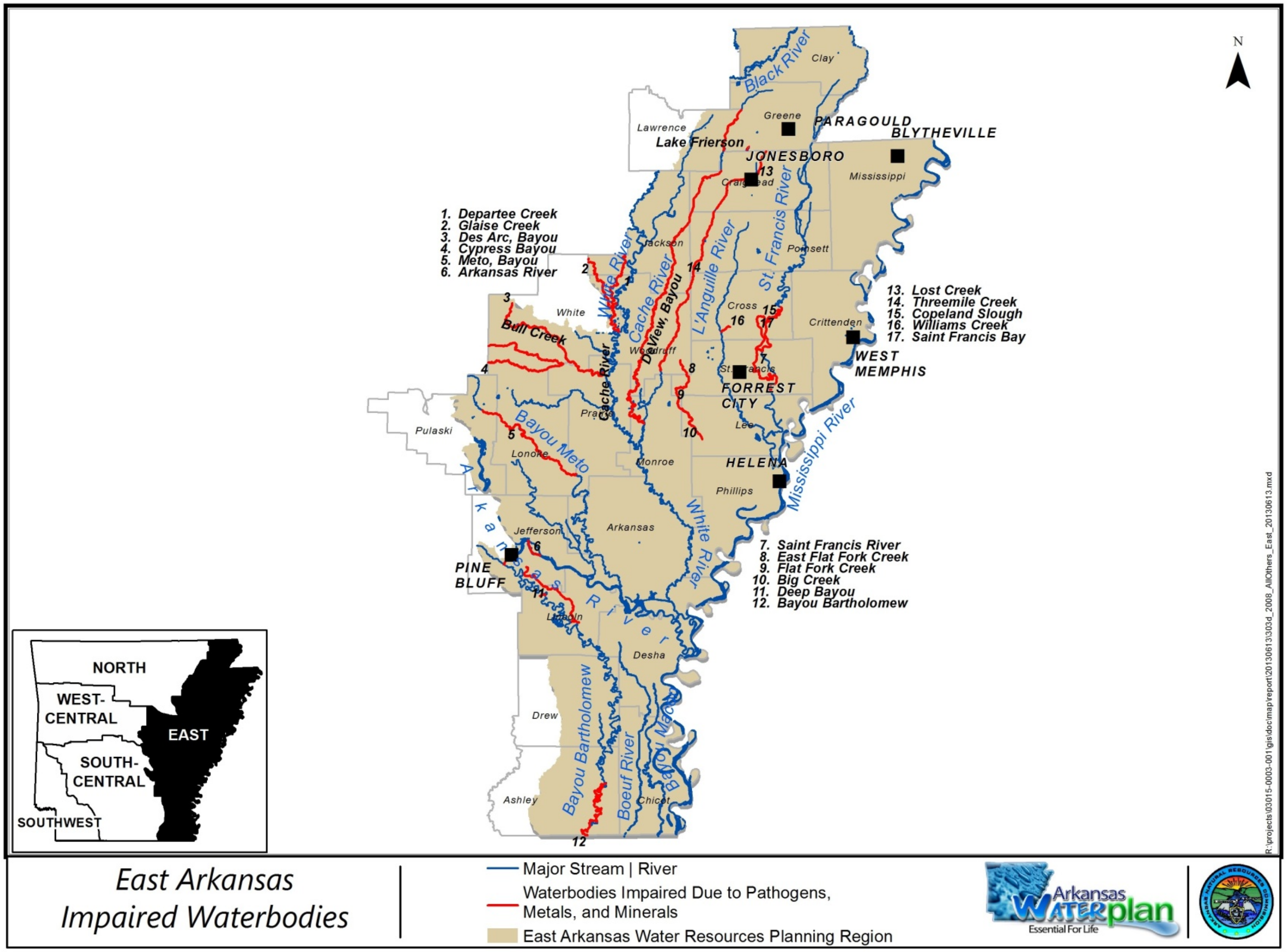

Figure 5.6. Waterbodies in the EAWRPR classified as impaired due to pathogens, metals, and minerals in the 2008 303(d) list (ADEQ 2009b).

.

Row-crop agriculture is the most frequently identified source of pollutants causing water quality impairment in the EAWRPR, including sediment, chloride, pathogens, TDS, sulfate, lead, and zinc (ADEQ 2009b). Bayou Bartholomew, L'Anguille River, and Cache River watersheds are classified as nonpoint source priority watersheds by ANRC. Nonpoint source pollutants of concern identified by ANRC for these watersheds include siltation/turbidity, pathogens, minerals (TDS, chlorides, and sulfates), nutrients, and low dissolved oxygen. Factors contributing to nonpoint source water quality issues include lack of riparian buffers/vegetation, localized urbanization, row crop agriculture, septic systems, and surface mining (e.g., topsoil, gravel, sand) (ANRC 2012d).

Low dissolved oxygen levels are a naturally occurring problem throughout the EAWRPR. Low dissolved oxygen levels occur in streams in this region during the summer when flows are low and temperatures are high. ADEQ will address this issue either through changing the dissolved oxygen water quality standards for this region, or changing the assessment methodology used to identify oxygen impaired waterbodies in this region (ADEQ 2009a).

In cases where exceedances of water quality criteria are preventing the attainment of a designated use, a TMDL must be developed. A TMDL is the maximum amount of a pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant, resulting in the waterbody being listed as impaired. A TMDL allows for the allocation of pollutant loads between point sources and nonpoint sources discharging to the waterbody, as well as a margin of safety.

TMDL reports have been prepared for a number of waterbodies in the EAWRPR addressing sediment/turbidity, minerals, metals, nutrients, and low dissolved oxygen (Table 5.3). Plans for implementing TMDLs have been developed for the Bayou Bartholomew and L'Anguille River watersheds (Arkansas Water 2013).

Table 5.3. TMDLs for waterbodies in the EAWRPR (ADEQ 2012b).

Waterbody	Impaired Uses	Pollutants	TMDL Status
Bayou Bartholomew	Aquatic life	Chloride, copper, lead, turbidity, zinc	2012
	Fish consumption	Mercury	Final 5/3/2002
	Primary contact recreation	pathogens	Final 6/1/2007
	Agricultural and industrial water supply	Chloride, sulfate, TDS	Final 3/31/2008
Bayou DeView	Aquatic life	Chloride, copper, lead, zinc	2012
		Turbidity	Final 1/6/2006
Bayou Macon	Aquatic life	Turbidity	Final 3/3/2005
Bear Creek Lake	Aquatic life	Nutrients	Final 1/16/2007
Bearhouse Creek	Primary contact recreation	Pathogens	Final 6/1/2007
Big Bayou	Aquatic life	Chloride, turbidity	Final 3/3/2005
Blackfish Bayou	Aquatic life	Turbidity	Final 3/27/2008
Boeuf River	Aquatic life	Chloride, sulfate, TDS, turbidity	Final 3/3/2005
Cache River	Aquatic life	Chloride, sulfate, lead	2013
		Turbidity	Final 1/6/2006
Chemin-A-Haut Creek	Primary contact recreation	Pathogens	Final 6/1/2007
Cross Bayou	Primary contact recreation	Pathogens	Final 6/1/2007
Cut-off Creek	Aquatic life	Turbidity	Final 3/31/2008
	Fish consumption	Mercury	Final 5/30/2002
Cypress Bayou	Primary contact recreation	Pathogens	Final 9/1/2009
Deep Bayou	Aquatic life	Turbidity	Final 10/8/2002
	Primary contact recreation	Pathogens	Final 6/1/2007
Harding Creek	Secondary contact recreation	Pathogens	Final 6/1/2007
Horseshoe Lake	Aquatic life	Nutrients	Final 1/16/2007
Jack’s Bayou	Primary contact recreation	Pathogens	Final 6/1/2007
L’Anguille River	Aquatic life	Turbidity	Final 10/1/2001
	Primary contact recreation	Pathogens	
Lake Frierson	Aquatic life	Turbidity	Final 1/16/2007
Lake Monticello	Fish consumption	Mercury	Final 11/20/2003
Mallard Lake	Aquatic life	Nutrients	Final 1/16/2007
Melton’s Creek	Primary contact recreation	Pathogens	Final 6/1/2007
Oak Bayou	Aquatic life	Chloride, TDS, turbidity	Final 3/3/2005
Old Town Lake	Aquatic life	Nutrients	Final 1/16/2007
Tyronza River	Aquatic life	Turbidity	Final 1/6/2005
Village Creek	Aquatic life	Turbidity	Final 1/6/2005
Wabbaseka Bayou	Aquatic life	Turbidity	Final 1/6/2005

5.6.3 Non-attainment of Drinking Water Quality Standards and Water Quality Guidelines by Groundwater

Most of the aquifers in the planning region are considered to have good to very good water quality. However, areas of poor water quality have been identified. In some areas, poor groundwater quality is a natural phenomenon. In other areas, human activities have caused contamination of the groundwater. In Arkansas, groundwater quality issues primarily occur in shallow aquifers (ADEQ 2009a). For the most part, groundwater quality issues have not changed significantly since the 1990 AWP update (ADEQ 2009a, Bryant, Ludwig and Morris 1985).

5.6.3.1 Mississippi River Valley alluvial aquifer

In general the groundwater quality of the MRV alluvial aquifer throughout the EAWRPR is good when compared to EPA primary drinking water standards. Certain basic water-quality characteristics limit the use of this aquifer for domestic, industrial, and municipal supply purposes, which include elevated concentrations of hardness, iron, and manganese.

Groundwater in this aquifer has naturally high levels of iron, manganese, and hardness, which can cause problems in industrial and domestic applications such as staining, scaling, and unpleasant taste (Renken 1998). As a result, groundwater from this aquifer is mostly used for irrigation (ADEQ 2009a). Additionally, some areas contain elevated concentrations of chloride that can affect crop production, deteriorate soil structure, and reduce soil infiltration rates.

Kresse and Clark (2008) performed a comprehensive study to determine the occurrence, distribution, and sources of elevated chloride in the alluvial aquifer. Their study defined two distinct areas of elevated chloride concentrations (greater than 100 mg/L) with two different sources: Area I included most of Jefferson, Lincoln, and Desha Counties; and Area II included most of Chicot County. In Area I, elevated chloride concentrations were contributed to evapotranspiration in low-permeability, clay-dominated backswamps, which tended to concentrate chloride. In Area II, elevated chloride concentrations were contributed to upwelling of brine water from the Smackover Formation. Outside of these areas, elevated chloride concentrations are observed in areas north of the Arkansas River and along the transition between the Interior Highlands and the Coastal Plain (commonly referred to as the fall line) from

Pulaski to Clay Counties, especially near Bald Knob in White County where it is not uncommon for chloride concentrations to exceed 1000 mg/L. Although no definitive sources have been identified to explain the occurrence of elevated chloride concentrations north of the Arkansas River, elevated chloride concentrations along the fall line are believed to be related to upwelling from deeper aquifers of poorer water quality along this boundary (Kresse, et al. 2013).

In the deeper parts of the aquifer, naturally-occurring arsenic can exceed federal primary drinking water standards. Studies have attributed the arsenic to the dissolution of iron minerals (iron oxyhydroxides) under reducing conditions, which releases trace amounts of arsenic (Sharif, Davis, et al. 2008a, 2008b, 2011). However, since wells used as drinking sources are completed in the shallower portion of the aquifer, arsenic contamination does not pose a problem to domestic supply (Kresse, et al. 2013).

Because row-crop agriculture is the dominant land use in eastern Arkansas, pesticides and fertilizer use pose the most common and widespread threat from human activity to groundwater quality in the shallow alluvial aquifer. Steele and others (1994) observed elevated nitrate concentrations (median value of 2.94 mg/L as nitrogen) in shallow alluvial wells (less than 50 feet) that were attributed to fertilizer application. Pesticide monitoring in Arkansas became routine in the early 1990s when Federal mandates required each state to develop a State Management Plan for pesticide use. Based on results of annual pesticide monitoring and findings from studies, pesticide occurrence in groundwater is related to the physical and chemical properties of the pesticide rather than the amount of pesticide applied, where highly water soluble chemicals are more likely to be present in groundwater. Transport of pesticides to groundwater is primarily the result of vertical infiltration through normal application practices. Review of pesticide monitoring since the early 1990s reveals an average 14% detection rate; however, concentrations are typically low and far below maximum contaminant levels and health advisory standards (Kresse, et al. 2013).

5.6.3.2 Sparta-Memphis aquifer

The Sparta aquifer in eastern Arkansas generally provides water of excellent quality. Only a few areas of the state have problems with use of groundwater from the Sparta-Memphis aquifer, which are primarily related to elevated salinity. Chloride values exceeding levels that can effect crop production are observed in portions of Chicot, Prairie, Monroe and Lee Counties. In addition, isolated areas where the Sparta-Memphis aquifer underlies the MRV alluvial aquifer are noted for elevated levels of iron, which may stain or impart an unpleasant taste to water without treatment (Kresse, et al. 2013).

5.6.3.3 Minor aquifers

The Cockfield aquifer contains groundwater that is typically of high quality and is used throughout southeastern Arkansas. Isolated areas of the aquifer contain elevated sulfate and chloride concentrations as a result of mixing with water of poor quality in underlying formations. The Wilcox aquifer produces water of generally excellent quality. In general, water quality is better in the eastern extent of the aquifer in northeastern Arkansas. Numerous samples from wells contained iron concentrations that exceed EPA secondary drinking water standards, which could cause problems for various commercial, industrial, and public uses. In south-central to southern Arkansas high salinity and elevated dissolved solids prevent the use of this aquifer. In the EAWRPR, the Nacatoch aquifer is a viable and important source of water for the extreme northeastern part of the state. High salinity in this aquifer prevents its use outside of the extreme northeastern portion of the planning region (Kresse, et al. 2013).

5.6.4 Fish Consumption Advisories

There are active fish consumption advisories due to mercury and dioxins for several waterbodies in the EAWRPR. Details of these advisories are given in Table 5.4. A mercury-related fish consumption advisory for Lake Monticello was lifted in 2011 (ADH 2011a). The locations of these water bodies are shown on Figure 5.7.

Table 5.4. Fish consumption advisories in EAWRPR (ADH, AGFC, ADEQ 2011, ADEQ 2009a).

Waterbody	Miles Affected	Pollutant of Concern	Restrictions for high risk groups[1]	Restrictions for general public
Cut-off Creek from Highway 35 to Bayou Bartholomew	16.8	Mercury	Should not eat any fish.	Should not eat drum, buffalo, redhorse, or suckers. No more than 2 meals a month of largemouth bass, catfish, crappie, gar, pickerel, or bowfin.
Bayou Bartholomew from the Drew-Ashley county line to the Arkansas-Louisiana state line	48	Mercury	Should not eat flathead catfish, gar, bowfin, pickerel, or blue catfish that are 20 inches or longer; nor largemouth bass longer than 12 inches; nor buffalo 18 inches or longer.	No more than 2 meals a month of flathead catfish, gar, pickerel, blue catfish 20 inches or longer, largemouth bass 12 inches or longer, or buffalo 18 inches or longer
Bayou Meto	48	Dioxin	Should not eat any fish	Should not eat any fish

[1] pregnant or breastfeeding women, women who plan to become pregnant, and children under 7 years of age.

5.6.5 Nonpoint Source Pollution

Nonpoint source pollution was identified as a water resources issue in the 1990 AWP (ASWCC 1990). Nonpoint source pollution still contributes significantly to surface water and groundwater quality issues in the EAWRPR. As discussed in Sections 5.6.2, in this planning region, row crop agriculture is the primary source of nonpoint source pollution. Loss of wetlands, ditching and channelization of streams for drainage, and maintenance dredging of ditches and streams associated with agricultural activities in this region contribute to nonpoint source pollution issues. Hazardous waste sites in the planning region also contribute nonpoint source pollution.

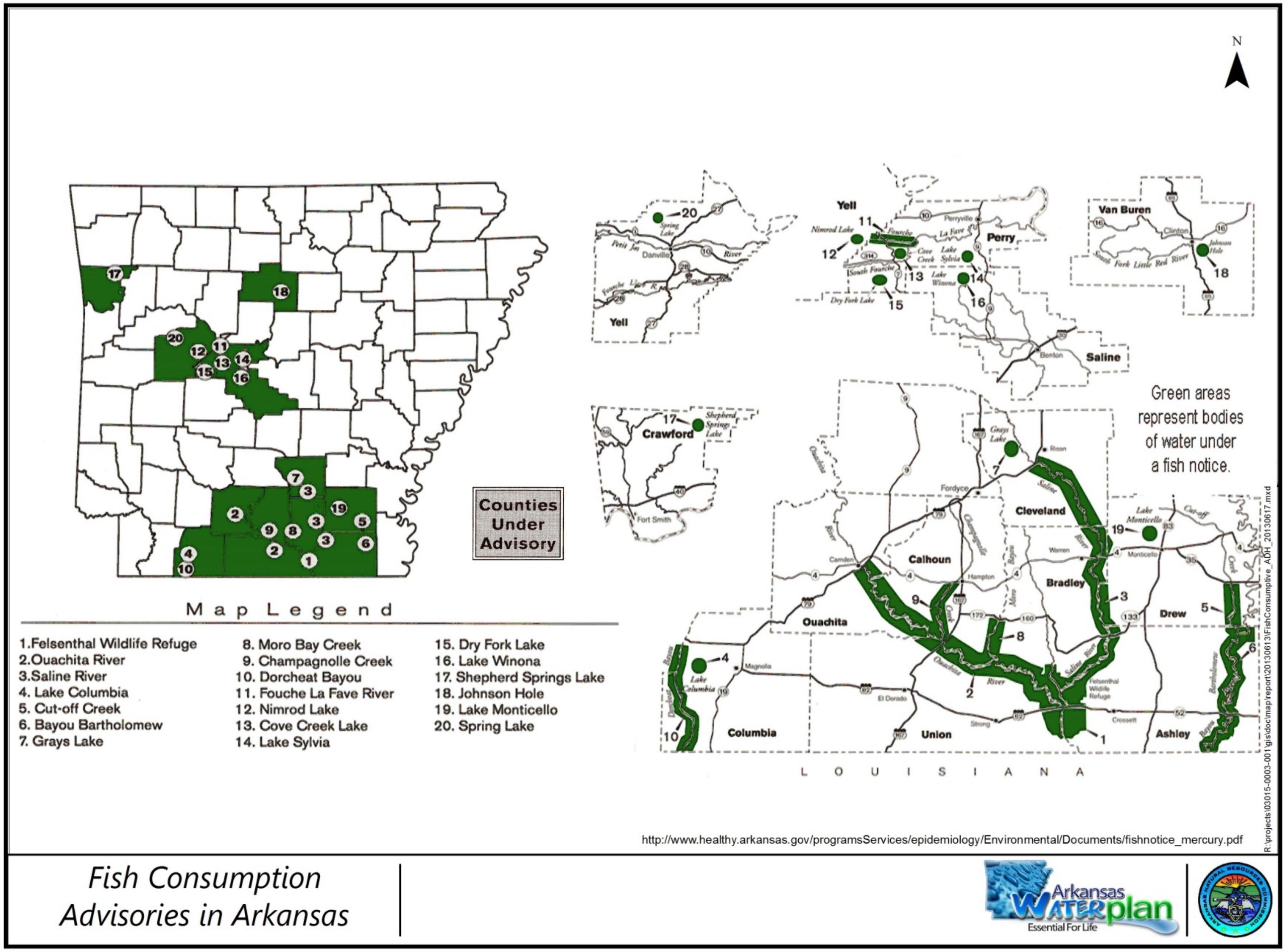

Figure 5.7. Waterbodies in the EAWRPR for which fish consumption advisories have been issued (ADH, AGFC, ADEQ 2011)

5.6.5.1 ANRC Priority Watersheds

In the 2011 – 2016 Nonpoint Source Pollution Management Plan, three watersheds within the EAWRPR have been identified as priority watersheds for nonpoint source pollution issues; Bayou Bartholomew, Cache River, and L'Anguille River (Figure 5.8). The pollutants of concern identified in the management plan for these watersheds are listed in Table 5.5. In these priority watersheds, the targeted source of nutrients is row crop agriculture (ANRC 2012d).

Table 5.5 Pollutants of concern in nonpoint source pollution priority watersheds (ANRC 2012d).

Watershed	Pollutants of Concern
Bayou Bartholomew	Siltation/turbidity, pathogens, TDS, chlorides, low dissolved oxygen
Cache River	Nutrients, sediment
L'Anguille River	Siltation/turbidity, nutrients, low dissolved oxygen, minerals

5.6.5.2 Hazardous Waste Remedial Action Priority Sites

There are eight sites in the EAWRPR identified as federal priority for hazardous waste cleanup (i.e., Superfund sites) due to contamination of water resources. All of these sites have had, or have, groundwater contamination issues. Surface water contamination has been an issue at four of these sites. Table 5.6 summarizes the information about these sites. Six of these sites were active at the time of the 1990 AWP update. The South 8th Street Landfill site was added to the national priority list (NPL) in 1992 and the Cedar Chemical Company site in 2012. Groundwater remediation has been implemented at seven of these sites, and several have been removed from the NPL (EPA 2013b).

There is one site in the planning region that was identified as a state priority for hazardous waste cleanup due to contamination of groundwater. Soil and shallow groundwater at the abandoned Starr Starrette facility in Dumas, Arkansas in Desha County, were determined to be contaminated with benzene, trichloroethylene and its degradation products, and metals, primarily arsenic, chromium, and cadmium. The site was added to the state priority list in 2010. Additional evaluation of the site contamination resulted in the conclusion that no remediation was necessary beyond monitoring of the chemical plume (ADEQ 2013f).

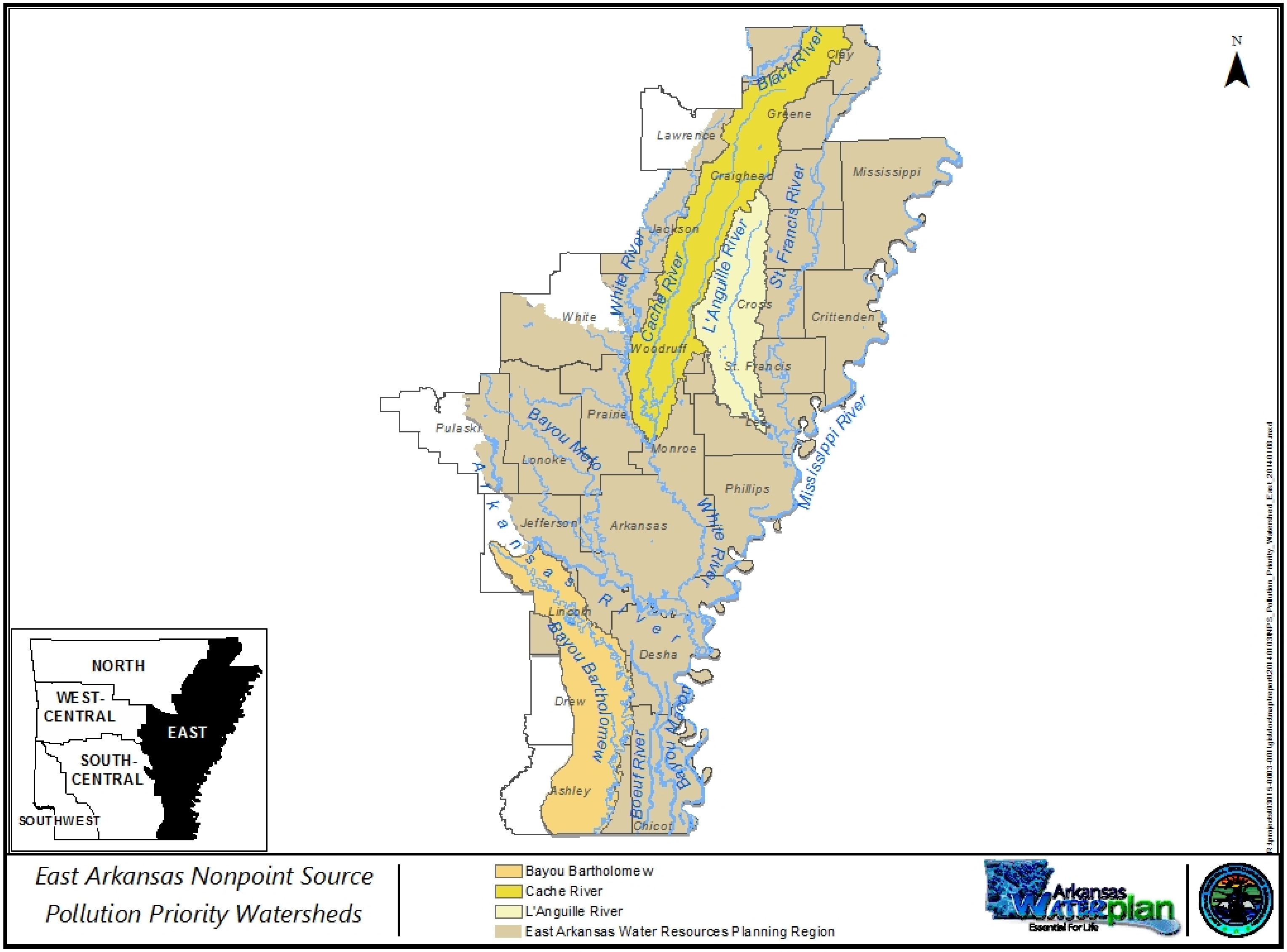

Figure 5.8. Nonpoint source pollution priority watersheds in the EAWRPR (ANRC 2012d).

Table 5.6. Status of Superfund sites in the EAWRPR with surface water quality issues. (Region 6 EPA 2013).

Site name	EPA ID	Site Location	Pollutants of concern	Contaminated water resources	Remediation status	Removed from NPL
Cedar Chemical Co.	ARD990660649	Phillips County	Dieldrin; 1,2-dichloroethane; aldrin; dinoseb; chloroform; methylene chloride; toxaphene; methoxychlor; heptachlor; pentachloro-phenol	Surface water and groundwater	Ongoing	NA
Gurley Pit	ARD035662469	Crittenden County	Lead, barium, zinc, PCB	Groundwater and Fifteen Mile Bayou	Threat controlled with de-watering of pits and treatment of surface runoff, Runoff management system completed in 1994	2003
Jacksonville Municipal Landfill	ARD980809941	Pulaski County	Dioxin; 2-4D; 2-4-5 T; 2-4-5 TP	Groundwater	Threat controlled through removal of hazardous substances in 1994, groundwater monitoring	2000
Monroe Auto Equipment Co. (Paragould Pit)	ARD980864110	Greene County	1-1dicholoroethane; 1-2 dicholoroethane; Xylenes, metals	Groundwater	Removal of contaminated soil in 1999, groundwater monitoring of natural attenuation in 1988	NA
Rogers Road Municipal Landfill	ARD981055809	Pulaski County	2-4 D; 2-4-5 T; 2-4-5 TP; dieldrin; 2-3-7-8 TCDD	Groundwater	Groundwater monitoring	2010
South 8th Street Landfill	ARD980496723	Crittenden County	Low pH; lead, PCB, PAHs	Groundwater	Groundwater monitoring	2004
Vertac	ARD000023440	Pulaski County	dioxin	Groundwater and Rocky Branch Creek	French drain in 1986, groundwater recovery and treatment in 1998; on-going groundwater monitoring, Removal of contaminated soil and hazardous materials in 1997	NA
Frit Industries	0600106	Lawrence County	Zinc sulfate, cadmium, chromium, lead	Cook Creek	Surface water collection and treatment system completed in 1985	1997

Note: Highlighted rows indicate sites that were added to the NPL after the 1990 AWP update.

5.6.6 Contaminants of Emerging Concern

There is growing interest, nationally and in Arkansas, in the occurrence of a group of chemicals called contaminants of emerging concern, which include pharmaceuticals, personal care products (e.g., soap and shampoo), natural and synthetic hormones, surfactants, pesticides, fire retardants, and plasticizers primarily in surface waters, but also starting to be measured in groundwater across the nation. The risks to human health and the environment from the majority of these chemicals are unknown, which is why they are referred to as “contaminants of emerging concern.” Contaminants of emerging concern have been detected in surface waters in Arkansas (Galloway, et al. 2005). Detection, however, does not indicate there is an effect.

5.7 Loss of Aquatic Biodiversity

In a 2002 report, NatureServe ranked Arkansas 13th in the nation for the level of reportedly extinct species (NatureServe 2002). In 2005, 369 animal species of greatest conservation need were identified for Arkansas by a team of specialists. These species of greatest conservation need include 107 species associated with aquatic and semi-aquatic habitats that occur in the EAWRPR (see Section 3.4). Figures 5.9 through 5.12 show the number of aquatic species of greatest conservation need present in watersheds within the EAWRPR. The greater the numbers of aquatic species of greatest conservation need present in a watershed, the more important it is to protect and restore water resources and their habitats (e.g., water levels, flow volumes, seasonal variablility in water levels and flows) in the watershed. The highest numbers of species of greatest conservation need are present in the St. Francis River and its tributaries. Other important streams for species of greatest conservation need in the planning region include Village Creek, the lower White River, and Bayou Bartholomew (Figure 5.12). Eight aquatic and semi-aquatic species present in the planning region are on the federal list of threatened and endangered species (Table 5.7).

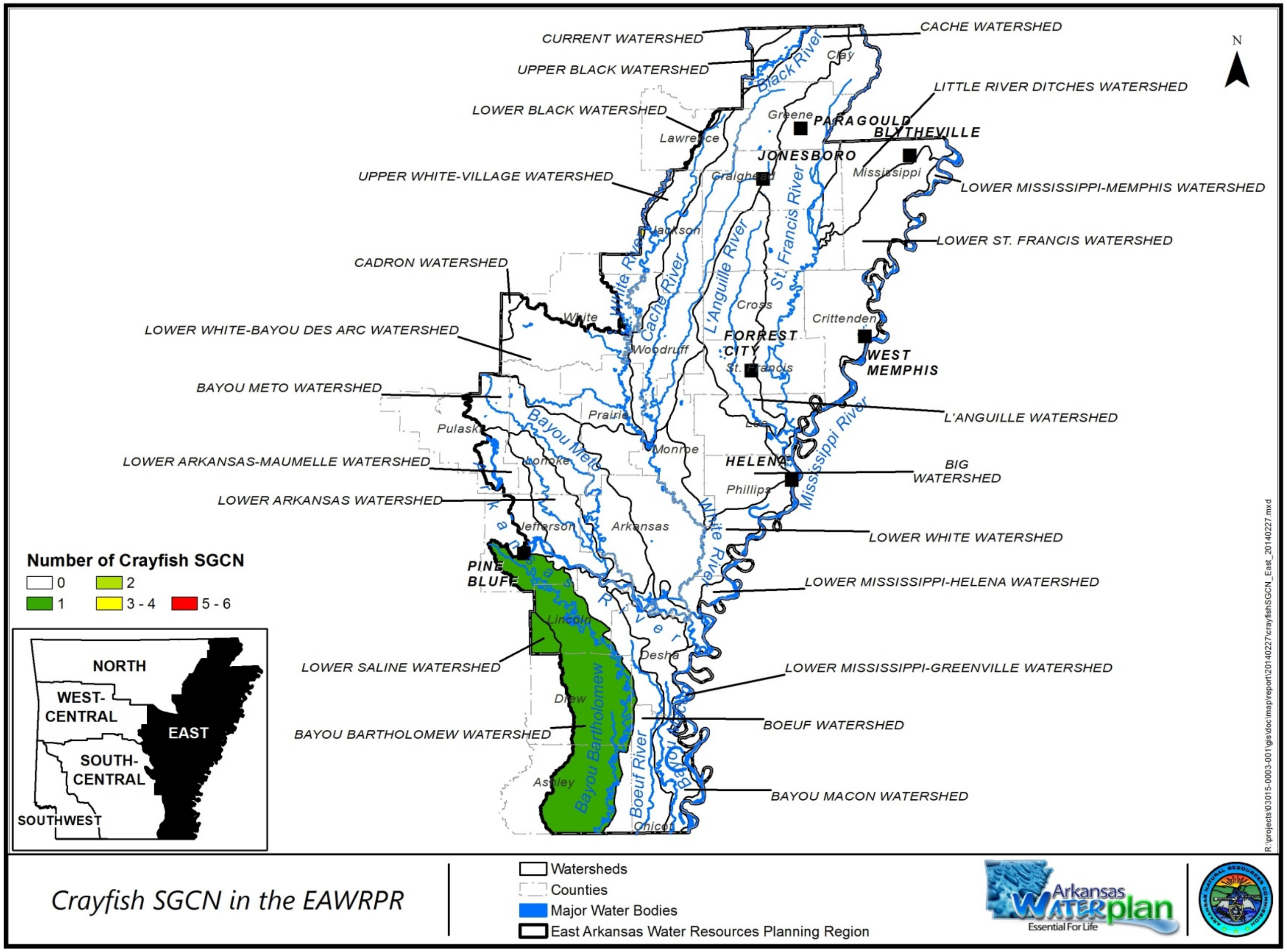

Figure 5.9. Numbers of crayfish Species of Greatest Conservation Need (SGCN) in watersheds of the EAWRPR.

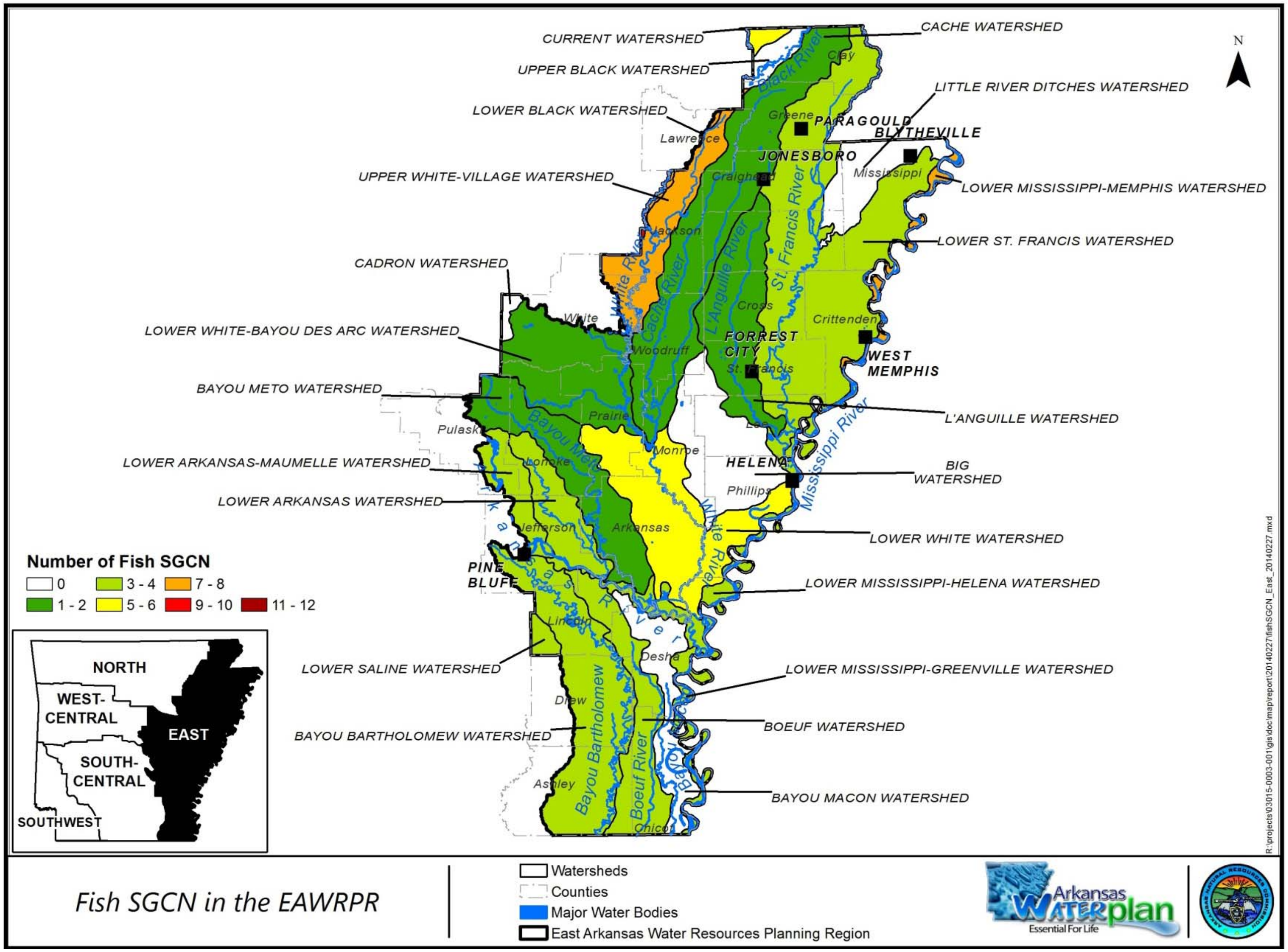

Figure 5.10. Numbers of fish SGCN in watersheds of the EAWRPR.

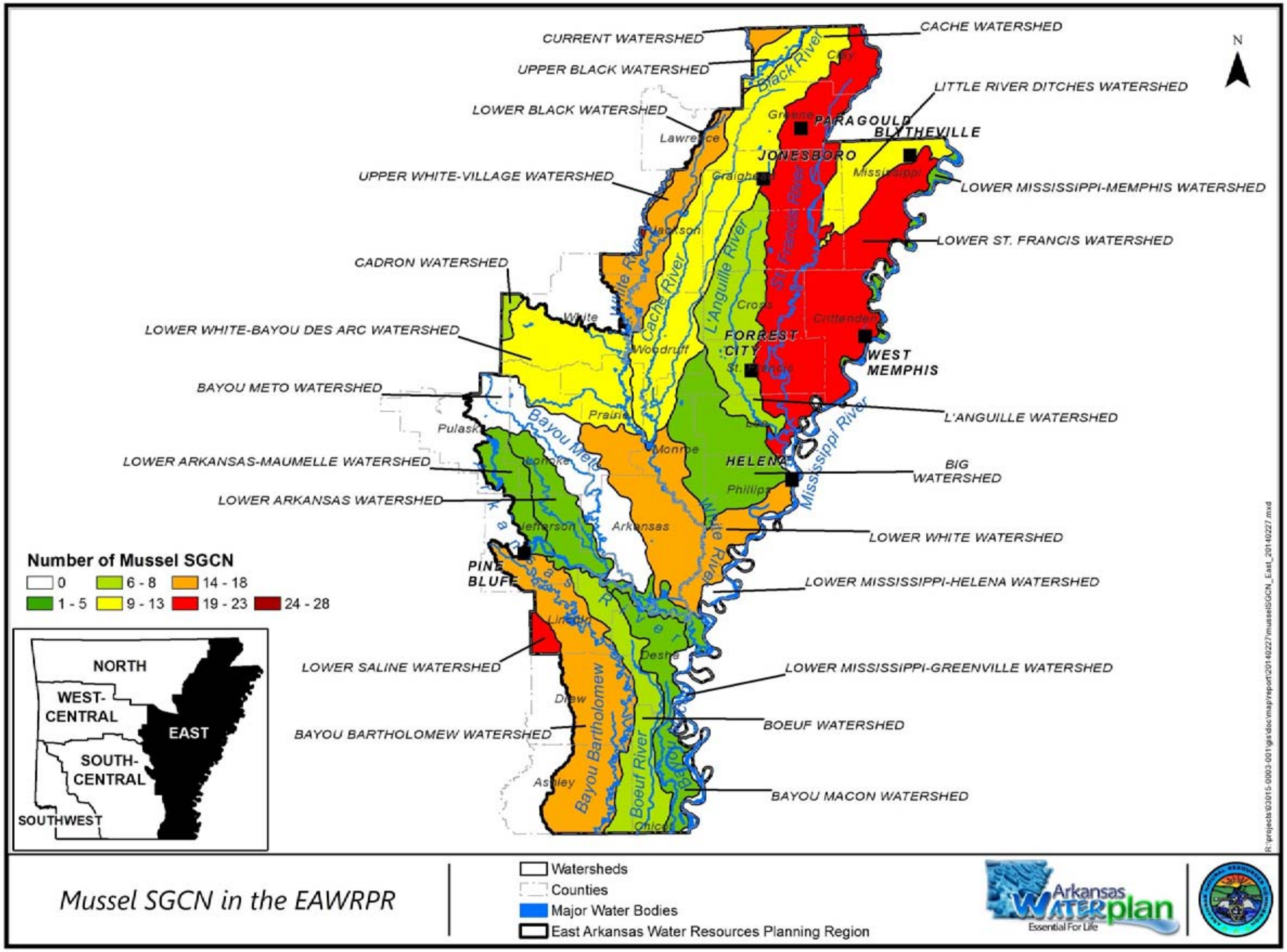

Figure 5.11 Numbers of mussel SGCN in the watersheds of the EAWRPR.

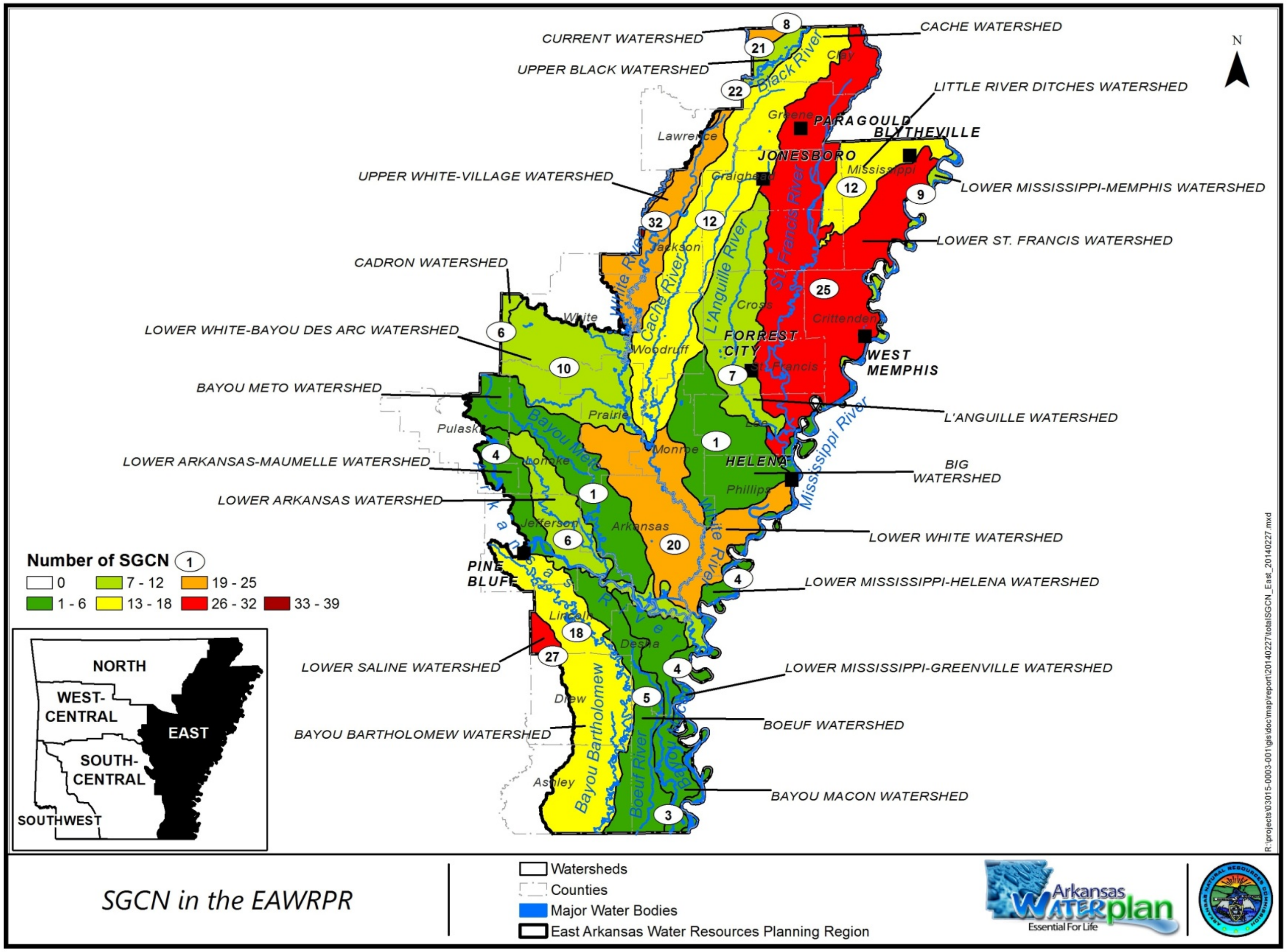

Figure 5.12. Total numbers of crayfish, fish, and mussel SGCN in the watersheds of the EAWRPR.

Table 5.7. Threatened and endangered species occurring in aquatic and semi-aquatic habitats in EAWRPR (ANHC 2013, Anderson 2006).

Common Name	Species Name	Status	EAWRPR habitat
Pallid Sturgeon	Scaphirhynchus albus	Endangered	Large pools of Mississippi River, White River, St. Francis River, Arkansas River
Scaleshell	Leptodea leptodon	Endangered	St. Francis River headwater glides, riffles, runs, gravel/cobble substrate
Fat Pocketbook	Potamilus capax	Endangered	St. Francis River, White River, headwater runs, headwater pools, sand/clay substrate
Pink Mucket	Lampsilis abrupta	Endangered	White River runs, pools, shoals, sand/gravel substrate
Ivory-billed Woodpecker	Campephilus principalis	Endangered	Mississippi alluvial plain bottomland depression, lower Mississippi River high bottomland forest, lower Mississippi River low bottomland forest
Interior Least Tern	Sterna antillarum athalassos	Endangered	Mud flats, ponds, lakes
Piping Plover	Charadrius melodus	Threatened	Mud flats
Pondberry	Lindera melissifolia	Endangered	Mississippi alluvial plain bottomland depression, lower Mississippi River high bottomland forest, lower Mississippi River low bottomland forest

In addition to the animal species of greatest conservation need, the Arkansas Natural Heritage Commission has identified 71 species of rare aquatic and semi-aquatic plants in the EAWRPR. There is one aquatic plant present in the planning region that is classified as endangered by the federal government (Table 5.7). Eleven semi-aquatic plant species present in the planning region are on the state threatened and endangered plant species list (Table 5.8). These plant species are affected by water quality, water levels, flow rates, and/or seasonal changes in water or levels or flow.

Table 5.8. State threatened and endangered species occurring in aquatic and semi-aquatic habitats in the EAWRPR counties (Arkansas Natural Heritage Commission 2013).

Common Name	Species Name	Status
Sedge	Carex opaca	Endangered
Snowy orchid	Platanthera nivea	Endangered
Southern tubercled orchid	Platanthera flava	Threatened
Winterberry	Ilex verticillata	Threatened
Pondberry	Lindera melissifolia	Endangered
Texas sunnybell	Schoenolirion wrightii	Threatened
Purple fringeless orchid	Platanthera peramoena	Threatened
Rose turtlehead	Chelone obliqua var. speciosa	Endangered
Slender rose-gentian	Sabatia campanulata	Endangered
Small-headed pipewort	Eriocaulon koernikianum	Endangered
White-top sedge	Rhynchospora colorata	Endangered

In some cases, the presence of non-native aquatic species is believed to affect aquatic biodiversity. There are 26 non-native aquatic animal species known to occur in the EAWRPR (Table 5.9). The majority of the non-native fish species present in the region are sportfish species that have been introduced purposely and are regularly stocked. Some of the non-native fish species are believed to have escaped from aquaculture ponds. The impact of many of these species on native species is unknown. Some species, such as carp, are suspected to affect native species as a result of modifying aquatic habitats, e.g., removing vegetative cover and increasing turbidity. Other species, such as non-native sportfish and exotic clams, are suspected to affect native species by competing with them for food and/or habitat (USGS 2013d). There are also seven species of invasive aquatic plants known to occur in the planning region Table 5.9.

5.8 Water Infrastructure

Communities throughout the state struggle to maintain drinking water and wastewater infrastructure, including treatment plants and distribution lines. A few communities in the EAWRPR are experiencing growth that is requiring expansion of water supply and wastewater capacity (see Section 4.1). In other areas within the planning region, maintaining aging infrastructure with limited financial resources is more likely an issue.

Table 5.9. Non-native aquatic species identified in the EAWRPR (University of Georgia - Center for Invasive Species and Ecosystem Health 2013, USGS 2013d).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
Waterflea	*Daphnia lumholtzi*	Asia	Lake Poinsett, Horn Lake, Spring Lake, Lake Pine Bluff, Merrisach Lake, Lake Chicot	1995	accidental	Competition with natives
	Eurytemora affinis	Atlantic & Gulf Coasts	Merrisach Lake	1967	Accidental	unknown
Inland silverside	Menidia beryllina	Mississippi & Red Rivers	White River, lower Arkansas River	1987	Stocking	Competition with natives
Redbreast sunfish	Lepomis auritus	Atlantic drainage	White River	2007	Stocking	Competition & hybridization with natives
Northern snakehead	Channa argus	China, Russia, Korea	Piney Creek & Little Piney Creek	2008, 2009	unauthorized stocking	Competition with natives
Blue tilapia	Oreochromis aureus	Africa, Middle East	Lower Arkansas River	1998	Stocking or accidental	Competition with natives, mussel decline
Goldfish	Carassius auratus	Asia	L'Anguille River	1988	Accidental	Unknown
Grass Carp	Ctenopharyngodon idella	Eastern Asia	Throughout the region	1988, 1970,	stocking	Habitat modification
Common carp	Cyprinus carpio	Eurasia	Throughout the region	1988, 1986, 1985, 2005, 1950	Stocking	Habitat modification
Silver carp	Hypophthalmichthys molitrix	Asia	Little River drainage, Lost Creek, lower White River drainage, Bayou Meto drainage, Arkansas River	1988, 1981, 1975	Accidental	Competition with natives
Bighead carp	Hypophthalmichthys nobilis	China	Lower St. Francis drainage, lower White River drainage, Bayou Meto drainage, Arkansas River	1988, 2003	Accidental	Unknown
Black carp	Mylopharyngodon piceus	Asia	White River	2005	Accidental	Reduction of mussel populations
Fathead minnow	Pimephales promelas	US	Piedmont Bayou, lower St. Francis River, Bayou Macon drainage, Overflow Creek, Bayou Bartholomew	1988, 1980	Accidental	Unknown
Rudd	Scardinius erythrophthalmus	Western Europe	Horseshoe Lake	1991	Accidental	Unknown

Table 5.9. Non-native aquatic species identified in the EAWRPR (University of Georgia - Center for Invasive Species and Ecosystem Health 2013, USGS 2013d) (continued).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
White catfish	Ameiurus catus	Atlantic drainage	East Bayou, Bayou Des Arc, Big Cypress Creek, Big Creek drainage	1988	Stocked	Competition with natives
Brown bullhead	Ameiurus nebulosus	Northern US, Atlantic drainage	Otter Bayou, Bayou Bartholomew, Arkansas River	1988	Stocked	Competition with natives
Blue catfish	Ictalurus furcatus	Mississippi River basin, Gulf coast drainage	Lake Des Arc	1997	Stocked	None
Wiper	Morone chrysops x M. saxatilis	None, artificial hybrid	Storm Creek, Arkansas River	1988, 1984	Stocked	Hybridize with native bass
Striped bass	Morone saxatilis	Atlantic & Gulf drainages	St. Francis River, Arkansas River, White River	1988	Stocked	Can impact populations of small fishes
Cutthroat trout	Oncorhynchus clarkia	Pacific coast drainage	White River	1982, 1983	Stocked	None
Rainbow trout	Oncorhynchus mykiss	Pacific drainage	White River	1988	Stocked	Unknown
Brook trout	Salvelinus fontinalis	Northeastern & Great Lakes drainage	White River	1988	Stocked	Unknown
Nutria	Myocastor coypus	South America	Throughout region	1978, 2005, 1958,	Accidental	Over-grazing of wetlands
Asian clam	Corbicula fluminea	Asia	St. Francis River, Little River ditch, L'Anguille River, White River, La Grue Bayou, Arkansas River, Coon Bayou, Lake Chicot, Boeuf River	1968, 1976, 1969, 1978, 1973, 1966, 1977, 1964, 1980, 2005, 1974, 1975	Accidental	Competition with natives, biofouling
Zebra mussel	Dreissena polymorpha	Black, Caspian, & Azov Seas	Arkansas River, Plum Bayou, White River	1993, 1994, 1998	Accidental	Competition with natives, habitat modification, biofouling
Yellow anaconda	Eunectes notaeus	South America	Wapanocca Wildlife Refuge	2004, 2005	Released	Unknown
Alligator weed	*Alternanthera philoxeroides*	South America	Arkansas, Ashley, Chicot, Desha, Drew, Jefferson, and Lincoln Counties	1988, 2009	Accidental	Habitat modification
Sessile joyweed	*Alternanthera sessilis*	Asia	Arkansas and Prairie Counties	2001	Introduced	nuisance

Table 5.9. Non-native aquatic species identified in the EAWRPR (University of Georgia - Center for Invasive Species and Ecosystem Health 2013, USGS 2013d). (continued).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
Water hyacinth	*Eichhornia crassipes*	South America	Jefferson County, Chicot County	1999, 2001	Accidental	Habitat modification
Hydrilla	*Hydrilla verticillata*	Asia	Ashley County	2005	accidental	Competition with natives
Purple loosestrife	*Lythrum salicaria*	Europe & Asia	Craighead County	1985	Introduced	Displacement of natives
Parrotfeather	*Myriophyllum aquaticum*	South America	Arkansas, Ashley, Greene, Cross, Crittenden, Prairie, and Jefferson Counties	1988, 1970	Introduced	Competition with natives
Eurasian water milfoil	*Myriophyllum spicatum*	Europe, Asia, Africa	Chicot County	2011	Accidental	Habitat modification, displacement of natives
Brittleleaf niad	***Najas minor***	Europe	Lonoke County	2010		
Watercress	***Nasturtium officinale***	Europe, Africa, Asia	Lawrence and Phillips County	1988		
Water fern	***Salvinia minima***	Mexico, South America	Arkansas, Chicot, Desha, Jefferson, Lee, Lincoln, Lonoke, Monroe, Phillips, Prairie, and Pulaski County	1998, 1999		

Of particular concern, is the recent increased focus on nutrients in wastewater discharges. Historically, permitted point source discharges in Arkansas were not limited with regard to the amount of nutrients that can be in the wastewater they discharge. Current regulations require that all point source discharges in watersheds of waterbodies included on the Arkansas list of impaired waters due to phosphorus, be limited in the amount of phosphorus that can be present in their discharge (Arkansas Regulations 2.509). While there are no phosphorus impaired waterbodies in the EAWRPR, several municipalities in the planning region have wastewater treatment plants that are currently required to monitor nutrient levels in their wastewater discharge (ADEQ 2009b, 2013a). Substantial upgrades to existing wastewater facilities may be required to meet discharge nutrient limits.

6.0 INSTITUTIONAL AND REGULATORY SETTING

This section provides a description of the regulatory and institutional framework for water resources management in EAWRPR. It includes general descriptions of federal and state laws, regulations, and programs that deal with water resources management in the region, as well as a listing of federal, state, and local governmental and nonprofit institutions that are involved in water resources management in the region. In addition, the interrelationships between regulations and institutions at the federal, state, and local levels in the EAWRPR are illustrated.

6.1 Legal Framework

The legal framework for management and use of water resources in Arkansas is based on court case law, laws enacted by the Arkansas General Assembly, and rules and regulations enacted by state agencies. Federal laws and regulations also influence the regulation of water resources in the state (ANRC 2011). The discussion below identifies and summarizes the laws and regulations and associated programs that guide water management in EAWRPR, and summarizes changes that have occurred in this legal framework since the 1990 AWP update.

6.1.1 Federal Laws and Regulatory Programs

Federal policy recognizes that states have primary authority for regulation of water usage within their borders. Therefore, the federal laws, regulations, and associated programs that influence water resources management in the EAWRPR primarily relate to water quality. Federal legislation and programs also deal with other aspects of management of water resources in the region such as conservation and protection of waterbodies, flood control, and navigation.

6.1.1.1 Water Quality

The current federal laws and programs that guide management of water quality in the EAWRPR are summarized in Table 6.1. The Clean Water Act (CWA) of 1972 (most recently amended in 2002) and the Safe Drinking Water Act (SDWA) of 1974 (most recently amended in 1996) are two important pieces of federal water quality legislation that authorize a number of federal water quality programs. Legislation related to forest conservation, such as the Cooperative Forestry Assistance Act, is included here because forests can protect and improve water quality. The EPA is responsible for administering the majority of these laws and programs; however, EPA has delegated some of this authority to state agencies such as ADEQ and the Arkansas Department of Health.

The CWA of 1972 established the NPDES that regulates point source discharges through a permit program. The NPDES program is managed by EPA, but ADEQ has been delegated authority to issue NPDES permits. NPDES permits are based on a combination of technology-based and water quality based standards. Technology-based standards are developed by EPA for certain categories based on the performance of pollution control technologies available to the industry without regard for the receiving water body. Water quality based standards are developed after consideration of the designated uses of the receiving water body and the water quality criteria necessary to protect those uses. In 1987, Congress amended the CWA to include nonpoint sources of pollution such as stormwater runoff from industries, construction sites, and municipalities. NPDES permits for the EAWRPR are summarized in Section 4. The 1987 amendments also addressed management of biosolids (sewage sludge). The CWA also requires permits for dredge and fill activities in wetlands, lakes, streams, rivers, and other waters of the US. These permits are issued by the USACE.

Table 6.1. Federal laws and regulatory programs that address EAWRPR water quality.

Federal Law	Federal Water Quality Regulatory Programs	Responsible Federal Agency
Clean Water Act	Ambient nutrient water quality standards	EPA
	Biosolids regulations	
	Impaired waters	
	Nonpoint source pollution management	
	NPDES point source permitting	
	NPDES stormwater permitting	
	NPDES pesticide application permitting	
	NPDES confined animal feeding operations permitting	
	State ambient water quality standards	
	State biennial water quality assessment	
	Total maximum daily loads (TMDL)	
	Dredge and fill permitting	USACE
Safe Drinking Water Act	Source water protection	EPA
	Underground injection wells	
Underground storage tank regulations	Underground storage tank program	EPA
Resource Conservation and Recovery Act	Hazardous waste management	EPA
	Solid waste management	
	Subtitle D	
Comprehensive Environmental Response, Compensation, and Liability Act	Hazardous waste site clean up	EPA
Federal Insecticide, Fungicide, and Rodenticide Act	Endangered species protection program	EPA
	Labeling requirements	
	Registration	
Surface Mining Control and Reclamation Act	Mine reclamation	US Department of the Interior (USDI)
	Surface mining control	
Toxic Substances Control Act	Polychlorinated Biphenyls (PCB) Program	EPA
Soil and Water Resources Conservation Act	Conservation Effects Assessment Program	USDA
Arkansas Wilderness Act	National forests	USFS
National Forest Management Act		
Weeks Act		
Oil Pollution Act	Oil spill response planning	EPA
Pollution Prevention Act	Pollution prevention planning	EPA
National Environmental Policy Act	Environmental impact analysis of Federal projects, with mitigation	EPA, Council on Environmental Quality

Note: Highlighted laws and programs were promulgated after the 1990 AWP update.

The TMDL program was established by the CWA in 1972; however, TMDLs were rarely developed for waterbodies until the 1990s, after environmental groups began suing the EPA over the lack of TMDLs being performed (EPA 2008). The CWA requires that a TMDL study be conducted for waterbodies identified as having impaired water quality. The TMDL study is conducted to determine the maximum amount of a pollutant that a waterbody can receive and still meet ambient water quality standards. This maximum load is split between point sources and nonpoint sources. These loads are then compared to the estimated existing point source and nonpoint source loads to determine the amount of reduction required for the waterbody to meet its water quality standards. The first TMDLs for waterbodies in the EAWRPR were completed in 2001. Prior to this, beginning in the 1980s, ADEQ routinely performed Wasteload Allocation Studies as part of the NPDES permitting process to determine the amount of a pollutant that could be discharged to a waterbody. Since 2001, 17 TMDLs have been completed for waterbodies in the EAWRPR (see Section 5).

In 1998, EPA initiated a program to develop ambient water quality criteria for nutrients, i.e., nitrogen and phosphorus. At the time, nutrients were identified as a leading cause of water quality issues across the nation, including such high profile events as the hypoxic zone in the Gulf of Mexico and algal blooms along the national seacoast. In 2001, EPA published recommended criteria development plans (EPA 2013c).

The drinking water source water protection program was initiated as a result of the 1996 amendment to the SWDA. The purpose of this program is to prevent the need for increased treatment of drinking water (resulting in increased treatment costs and costs to customers) due to water quality degradation, by protecting the quality of the drinking water source. In the majority of cases, the cost of protecting drinking water sources from pollution is far lower than the cost of upgrading water treatment to remove increased pollution. There are approximately 335 public water utilities in the EAWRPR that are subject to SDWA regulations (ADH n.d.).

Subtitle D of the 1991 amendment of the Resource Conservation and Recovery Act (RCRA) introduced specifications for how landfills were to be constructed and managed to protect water quality. This led to sweeping changes in solid waste management across the country and in Arkansas (ADEQ 2011).

6.1.1.2 Water Resources Management

The federal regulations and programs that address non-water quality aspects of water resources management are summarized in Table 6.2. These include regulations and programs that address flood control, river navigation, wetlands tracking, or water-based recreation. Programs related to drinking water infrastructure are also included in Table 6.2 and discussed below. Some of the legislation and programs that address water quality also address other aspects of water resources management. For example, preservation of forest lands protects water quality and hydrology. As a result, there is some duplication in Tables 6.1 and 6.2. Federally appropriated water, such as the water required to maintain navigation on the MKARNS, is not available for other uses. Federal water appropriations preempt other beneficial water uses, such as irrigation.

Table 6.2. Federal laws and regulatory programs that address aspects of Arkansas water resources other than water quality.

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Clean Water Act	Wetland and stream mitigation	USACE	Physical protection of waterbodies, including wetlands
Safe Drinking Water Act	Consumer confidence reports	EPA	Protects/improves public water supply
	Finished water criteria	EPA	Protects human health
	Operator certification	EPA	Informs the public
Endangered Species Act	Freshwater species protection	US Fish and Wildlife Service (USFWS)	Mechanism for physical protection of waterbodies that are habitats for endangered species
	Waterfowl protection		
Soil and Water Resources Conservation Act	Census of Agriculture	USDA	Irrigation and agriculture
	Conservation Effects Assessment Program	USDA	Water resources protection/improvement
	Natural Resources Inventory	USDA	Characterize water resources
National Environmental Policy Act	Environmental Impact Statements and Mitigation	EPA, Council on Environmental Quality	Water resources protection/mitigation
Flood Control Act/Water Resources Development Act	Dam safety	USACE	Water storage, water supply, flood reduction, flow management, restoration of physical aquatic habitat
	Flood control reservoirs		
	Levees		
	Navigation systems		

Table 6.2. Federal laws and regulatory programs that address aspects of Arkansas water resources other than water quality (continued).

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Arkansas Wilderness Act	National forests	USFS	Well managed forestlands improve and protect water resources
National Forest Management Act			
Weeks Act			
Rivers and Harbors Act	Navigation	USACE	Federal navigation systems in Arkansas
	Section 10	USACE	Protects waterbodies, including wetlands
Migratory Bird Hunting and Conservation Stamp Act	Small wetland acquisition program	USFWS	Protects wetlands
Emergency Wetlands Resources Act	National Wetlands Inventory	USFWS	Track wetland resources
Dam Safety and Security Act	National Dam Safety Program	Federal Emergency Management Agency (FEMA)	Protection of lives and property
National Parks Acts	National Parks	USDI National Park Service	Protection of water resources associated with national parks
Migratory Bird Conservation Act	Acquisition of lands for wildlife refuges	Migratory Bird Conservation Commission	Preservation of water resources for bird habitat
National Wildlife Refuge System Improvement Act	National Wildlife Refuges	USFWS	Preservation of water resources for habitat
National Flood Insurance Act	National Flood Insurance Program	FEMA	Insurance against flood losses
	Floodplain management	FEMA	Reduction of flood damage
	Flood hazard mapping	FEMA	Identification of flood hazard areas
None	Climate monitoring	NOAA	Tracking precipitation and evaporation – water availability
	Climate prediction	NOAA	Future water availability
	Drought status	NOAA	Enactment of water shortage specific management
Wild and Scenic Rivers Act	National Wild and Scenic Rivers	USFS	Preservation of unregulated rivers and streams for recreation

Note: Highlighted programs were initiated after the 1990 AWP update

An important federal program for conservation of water resources in the EAWRPR is the dredge and fill permitting program of the CWA (Section 404). In 1990, the EPA and the USACE signed a memorandum of agreement establishing a process for determining the need for mitigation of impacts to wetlands, streams, and other water resources under the CWA Dredge and Fill Permitting program. This program provides a means for dredge and fill permit applicants to compensate for unavoidable destruction of aquatic habitat by either restoring or creating similar habitat either on site or at another location (EPA 2013d). There are four sites within the EAWRPR that have been designated as commercial mitigation banks for CWA dredge and fill permitting (Table 6.3). The program is a mechanism for implementing the federal policy of no-net-loss of wetlands (EPA 2013d). Revised regulations governing this mitigation program were issued in 2008.

Table 6.3. Commercial mitigation banks within and serving areas within the EAWRPR (USACE 2013).

Name of site	Location	Year Established	Area (acres)	Primary service area	Secondary service area	Sponsor	Credits
Camp Nine	Chicot County		320	Beouf River watershed in Chicot, Ashley, Desha, Drew, and Lincoln Counties	None	ANRC	355.13408 wetland
Lower Cutoff	Drew County		473.48	Bayou Bartholomew watershed in Ashley, Drew, Lincoln, and Jefferson Counties	None	Natural Resources Investment Group	493.4 wetlands, 236,814 stream
Davis Creek	Searcy County	2010	319	None in EAWRPR	Small areas of White and Jackson Counties in the EAWRPR	Mitigation Solutions LLC	93,778.7 stream
Little Creek	White County			Cadron Creek watershed, which includes a small area of White County in the EAWRPR	None in EAWRPR	Keathley Farms	5.85 wetland, 25619 stream

The Endangered Species Act provides for protection and recovery of imperiled terrestrial, freshwater, and marine plant and animal species (except pest insects) (USFWS 2013b). The EAWRPR contains aquatic and semi-aquatic habitat important for a number of endangered species (Table 5.5).

The 1996 amendments to the SDWA directed EPA and the states to develop requirements for certification of water treatment system operators (EPA 2012e). These amendments also initiated a program that required public water suppliers that operate community water systems to provide annual reports to drinking water utility customers on the quality of their drinking water (EPA 2013e).

Under the National Flood Insurance Act, flood hazard maps have been completed for the entire EAWRPR, and most of the mapping has been, or is in the process of being, modernized, within the last 8 years, with the exception of Lee, Prairie, Monroe, and Woodruff Counties (Figure 6.1). Flood hazard maps for these counties are more than 25-years old. Flood hazard mapping for St. Francis County was updated in 2005. Modernized flood hazard maps typically include updated Special Flood Hazard Areas (SFHAs), and are created in a digital countywide format. For the communities participating in the National Flood Insurance Program, the flood hazard maps identify the regulatory SFHA whereby the community floodplain administrator applies the locally adopted and enforced floodplain management ordinance. Participation the National Flood Insurance Program is voluntary, however non-participation results in federal flood insurance not being available to residents and limits post-disaster financial assistance. All of the counties included in the EAWRPR are participating in the program, as well as a large percentage of the communities.

Surface waters in the EAWRPR that are under some degree of federal management include the Arkansas River (MKARNS); Mississippi River (navigation); White River (USACE reservoirs upstream of the alluvial plain, MKARNS, White River navigation to Newport, White River National Wildlife Refuge); St. Francis River (flood control project); and L'Anguille River (St. Francis National Forest). Federally authorized uses for the portions of the Arkansas River and White River in this planning region include navigation and flood control. The Arkansas River is also authorized for hydropower.

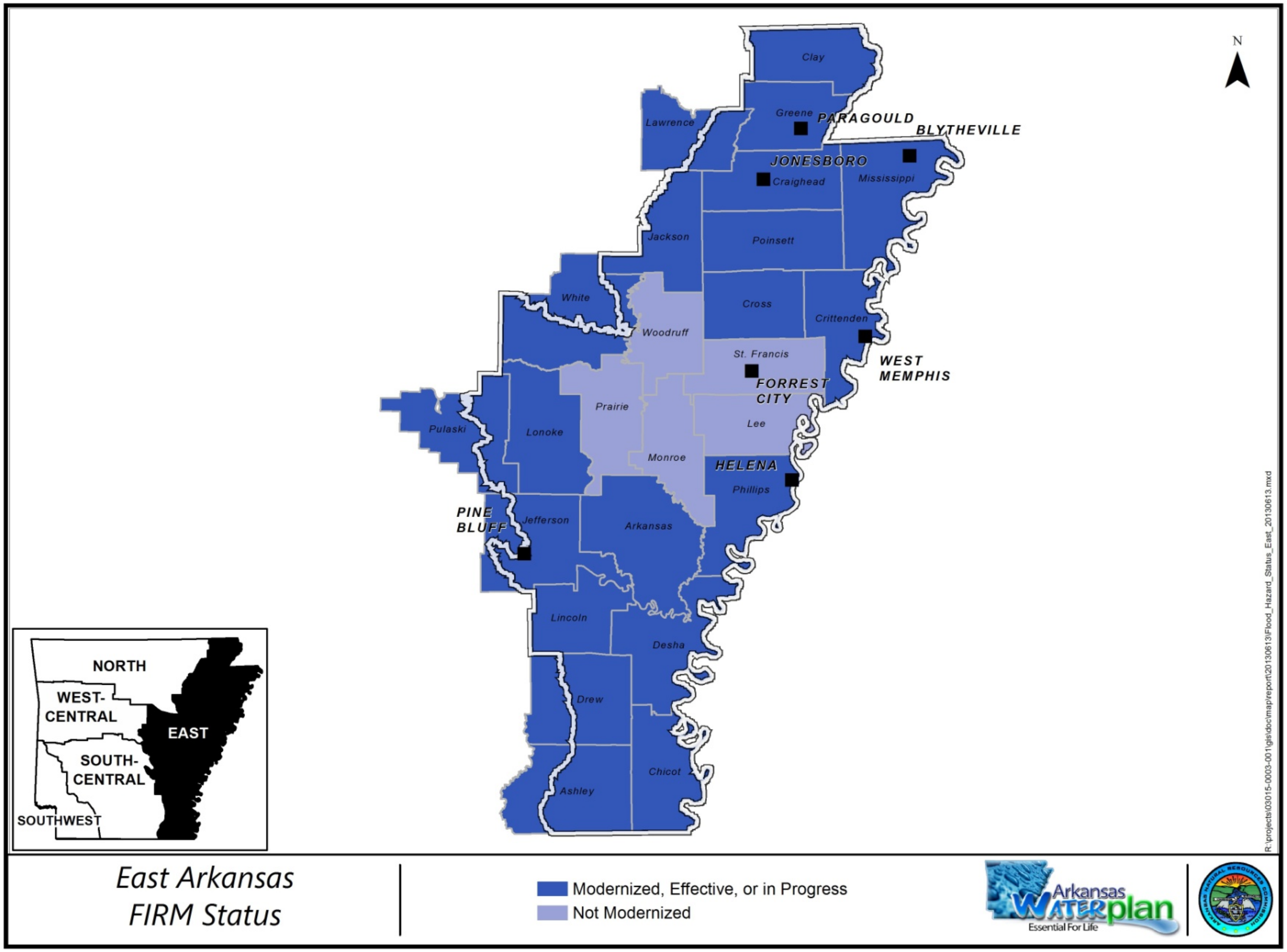

Figure 6.1. Status of flood hazard mapping in the EAWRPR.

Federally appropriated water, such as the water required to maintain navigation on the MKARNS, is not available for other uses. Federal water requirements preempt other beneficial water uses, such as irrigation. The Arkansas River minimum flow at Little Rock (Murray Lock and Dam 7) required for navigation is 3,000 cfs. On the White River, water elevation is more important for maintaining a passable navigation channel. White River stages necessary to maintain commercial navigation are listed in Table 6.4.

Table 6.4. Spring 2014 estimated minimum White River stages for commercial navigation (Paul Hamm, USACE Memphis District, personal communication, 3/20/13).

Location	Elevation/Stage	Gage Zero Elevation (feet above sea level)	Discharge (cfs)
RM 15	Elevation 121feet above sea level	NA	NA
Clarendon gage	18 feet	139.91	21,200[2]
DeValls Bluff gage	14 feet	152.96	26,800[1]
Georgetown gage	11 feet	170.08	24,600[1]
Augusta gage	23 feet	169.85	22,200[1]
Newport gage	11 feet	194.09	22,500[1]

[1] USGS Ratings Depot [2] USACE, Memphis Rating

6.1.2 Federal Laws and Assistance Programs

Federal laws have also established a number of programs to provide technical and financial assistance for water resources management, that are available in Arkansas. Assistance programs for management of water quality and other aspects of water resources are discussed in the following sections.

6.1.2.1 Water Quality

Table 6.5 summarizes current federal assistance programs available in the EAWRPR and the associated federal laws. The majority of the federal assistance programs listed in Table 6.5 originated through the Farm Bill. The Farm Bill has been amended four times since 1990, most recently in 2013 (National Agricultural Law Center 2012). New conservation programs that are intended to assist farmers in protecting and restoring water quality have been added with each amendment (see Table 6.5). In 2012, over 423,000 acres in the counties of the EAWRPR were enrolled in Farm Bill programs, and over $27 million in funding provided to those counties for water quality practices (Table 6.6) (NRCS 2012).

The CWA authorizes EPA to provide federal funding assistance to states and local entities through three funding programs. Through the Clean Water State Revolving Fund, federal funds are provided to ANRC to fund a low interest loan program for wastewater treatment, nonpoint source pollution control, and watershed management projects in the state. Grants for nonpoint source pollution control projects are authorized under Section 319 of the CWA. Finally, Section 106 of the CWA authorizes federal funding assistance to states and interstate agencies through grants for pollution control programs such as discharge permitting and water quality monitoring.

There are additional federal laws that authorize programs that provide assistance for community waste treatment and management to protect water quality. HUD grants for construction and upgrading of wastewater infrastructure were also authorized by the Housing and Community Development Act. Several programs to provide financial assistance for wastewater systems and solid waste programs in rural areas were authorized by the Consolidated Farm and Rural Development Act.

Table 6.5. Federal laws and assistance programs that affect the EAWRPR water quality.

Federal Law	Federal Water Quality Funding Assistance Programs	Responsible Federal Agency
CWA	Clean water state revolving fund	EPA
	Nonpoint source pollution management grants	
	Water pollution control program grants	
Comprehensive Environmental Response, Compensation, and Liability Act	Hazardous waste site clean up	EPA
Cooperative Forestry Assistance Act	Forest Stewardship Program	USFS
	Forest Legacy Program	
	Urban and Community Forestry Program	
Housing and Community Development Act	Community Development Block Grant program	US Department Housing and Urban Development (HUD)
Farm Bill	Agricultural Water Enhancement Program	NRCS
	Conservation Reserve Program (CRP)	USDA Farm Services Agency
	Conservation Innovation Grants Program	NRCS
	Conservation Stewardship Program (CSP)	
	Cooperative Conservation Partnership Initiative	
	Environmental Quality Incentives Program (EQIP)	
	Farm and Ranch Land Protection Program	
	Grassland Reserve Program	
	Grazing Lands Conservation Initiative	
	Mississippi River Basin Healthy Watersheds Initiative	
	National Water Management Center	
	National Water Quality Initiative	
	Organic Initiative	
	Wetlands Reserve Program	
	Wildlife Habitat Incentives Program	
Consolidated Farm and Rural Development Act	Water and waste disposal systems for rural communities	USDA Rural Utilities Service
	Water and Waste Disposal Loans and Grants	
	Solid Waste Management Grants	
	Grant Program to Establish a Fund for Financing Water and Wastewater Projects	
American Recovery and Reinvestment Act	Clean Water State Revolving Fund	Recovery Accountability and Transparency Board
	Clean-up of leaking underground storage tanks	
Clean Vessel Act	Funding for pumpout stations and waste reception facilities for recreational boaters	USFWS

Note: Highlighted laws and programs were promulgated after the 1990 AWP update.

Table 6.6. NRCS conservation programs summary for 2012 (NRCS 2012).

County	CRP			EQIP			National water quality initiative			Mississippi River Basin Healthy Watersheds		
	Contracts	Acres	Money obligated	Contracts	Acres	Money obligated	Contracts	Acres	Money obligated	Contracts	Acres	Money obligated
Arkansas	66	61,110.8	$2,766,311	30	19,420.4	$1,293,331	NA			0	0	0
Ashley	3	1,740.0	$45,314	9	8,415.5	$121,642	NA			1	220.5	$61,344
Chicot	4	5,505.9	$153,288	52	21,956.3	$2,240,770	NA			37	16142	$1,993,065
Clay	5	5,634.5	$158,920	23	21,414.7	$88,899	NA			0	0	0
Craighead	19	15,412.6	$490,221	33	10,621.3	$772,415	NA			7	1,054.7	$245,156
Crittenden	3	2,757.2	$61,080	76	25,102.2	$1,380,785	NA			55	7,238.3	$1,251,288
Cross	58	86,959.0	$2,261,088	36	12,535.6	$1,361,510	NA			36	11,204.42	$1,262,326
Desha	36	44,768.3	$1,968,904	84	42,664.9	$3,688,879	NA			67	10,767.2	$3,598,056
Drew	3	4,870.4	$160,949	22	14,158.2	$404,132	NA			0	0	0
Greene	1	673.0	$8,002	20	37,352.3	$61,921	NA			0	0	0
Jackson	81	77,367.4	$2,254,550	35	11,080.0	$814,772	NA			10	1,697.31	$297,507
Jefferson	34	36,081.1	$1,251,011	43	15,082.2	$2,258,878	14	4,949.8	$758,983	1	152.2	$97,643
Lawrence	68	52,330.3	$2,326,961	8	6,559.0	$149,718	NA			0	0	0
Lee	14	10,941.4	$289,841	28	3,768.2	$827,155	NA			9	1,513.40	$133,158
Lincoln	54	66,598.9	$2,237,067	53	10,899.0	$1,117,499	25	5,400.7	$925,436	0	0	0
Lonoke	7	5,139.0	$166,913	16	5,884.3	$1,212,522	NA			7	3,027.9	$915,220
Mississippi	5	9,872.9	$132,994	35	8,840.1	$1,223,175	NA			30	3,759.3	$1,159,683
Monroe	3	3,482.8	$56,917	7	737.2	$292,416	NA			2	203	$79,772
Phillips	8	10,265.7	$307,938	38	4,545.5	$1,244,393	NA			10	889.8	$537,740
Poinsett	10	9,937.2	$323,366	37	9,141.0	$919,041	NA			34	7,789.8	$690,246
Prairie	10	9,078.7	$222,826	16	7,198.7	$1,854,269	NA			8	4023	$1,147,226
Pulaski	0			4	12.7	$33,604	NA			0	0	0
St. Francis	26	34,920.8	$916,195	34	4,663.3	$859,632	NA			10	916.7	$308,525
White	2	1,964.3	$50,600	4	298.5	$82,932	NA			0	0	0
Woodruff	2	3,058.0	$89,403	11	3,119.4	$443,413	NA			9	2,426	$373,041
Totals		**39,943.1**	**$1,056,198**		**305,470.5**	**$24,747,703**		**5,400.7**	**$925,436.00**		**73,025.53**	**$14,150,996.00**

The American Recovery and Reinvestment Act was promulgated in 2009 to save and create jobs during the recession that began in 2008. This act initiated several programs that provide money to states for a range of activities, including improvements to wastewater treatment systems and clean up of leaking underground storage tanks and hazardous waste sites (EPA 2013f). Recovery money was awarded to the Arkansas State Clean Water Revolving Loan Fund, and the ADEQ Leaking Underground Storage Tank Program. Through these programs, recovery money was awarded to three leaking underground storage tank remediation projects and one clean water project in the planning region (EPA n.d.).

The Clean Vessel Act was promulgated in 1992. This act established a program to provide grants to states to pay for construction, maintenance, operation, or renovation of boat pumpout stations and waste reception facilities (US Congress 1992). Money from this program was used to install fixed pumpout facilities at an Arkansas River marina near Pine Bluff (ADH 2011b).

Forestry assistance programs are included in Table 6.5 because forest land improvement can improve water quality.

6.1.2.2 Water Resources Management

The federal assistance programs that address non-water quality aspects of water resources management are summarized in Table 6.7. These include programs that address flood control, water conservation, water supply systems, fisheries, and aquatic habitat for wildlife. Some of the programs that provide assistance for addressing water quality also address other aspects of water resources management. For example, some Farm Bill programs support practices that conserve water, as well as practices that protect water quality. As a result, there is some duplication in Tables 6.6 and 6.7.

Table 6.7 Federal assistance programs for aspects of EAWRPR water resources other than water quality.

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Safe Drinking Water Act	Drinking water state revolving fund	EPA	Protects human health
Farm Bill	Agricultural Water Enhancement Program	NRCS	Water conservation
	Cooperative Conservation Partnership Initiative	NRCS	Water conservation
	Conservation Innovation Grants Program	NRCS	Water conservation
	Emergency Watershed Protection	NRCS	Flooding reduction, recovery
	Groundwater Decline Initiative	NRCS	Water Conservation
	National Water Management Center	NRCS	Waterbody protection/restoration
	On-farm Energy Initiative	NRCS	Water conservation
	Watershed protection and flood prevention	NRCS	Flooding management
	Wetlands Reserve Program	NRCS	Physical waterbody protection/restoration
	Wildlife Habitat Incentives Program	NRCS	Physical waterbody protection/restoration
Cooperative Forestry Assistance Act	Urban and Community Forestry Program	USFS	Trees in communities reduce stormwater runoff, improving hydrology
	Forest Stewardship Program Forest Legacy Program	USFS	Well-managed forestlands improve and protect water resources
Flood Control Act/Water Resources Development Act	Habitat restoration Irrigation projects Basin studies	USACE	Water storage, water supply, flood reduction, flow management, restoration of physical aquatic habitat
Housing and Community Development Act	Community Development Block Grant program	HUD	Protects/improves public water supply

Table 6.7 Federal assistance programs for aspects of EAWRPR water resources other than water quality (continued).

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
American Recovery and Reinvestment Act	Funding for Drinking Water State Revolving Fund	Recovery Accountability and Transparency Board	Protects/improves public water supply
Consolidated Farm and Rural Development Act	Water and waste disposal systems for rural communities	USDA Rural Development	Protects/improves public water supply
	Water and waste disposal loans and grants		
	Household water well system grant program		
	Grant program to establish a Fund for financing water and wastewater projects		
	Emergency community water assistance grants		
Land and Water Conservation Fund Act	Matching grants for acquisition and development of public recreation areas and facilities	USDI National Park Service	Preservation of water resources for recreation
Pittman-Robertson Wildlife Restoration Act	Wildlife restoration grants programs	USFWS	Preservation of water resources for fish and wildlife habitat
Sport Fish Restoration Act	Boating infrastructure grants	USFWS	Recreational boating and fishing
	Multistate conservation grants	USFWS	Aquatic habitat research and education
	Sports fish restoration grants	USFWS	Preservation of water resources for fish and wildlife habitat

Note: Highlighted laws and programs were initiated after the 1990 AWP update.

The 1996 amendment of the Safe Drinking Water Act established the Drinking Water State Revolving Fund to assist drinking water utilities in financing infrastructure improvements and pollution control activities. Using this fund, states can offer utilities low-cost loans and other types of assistance. Funds available through the American Recovery and Reinvestment Act were awarded to the Arkansas Drinking Water State Revolving Fund and used for three projects in the EAWRPR (EPA n.d.).

The 1996 amendment of the Safe Drinking Water Act established the Drinking Water State Revolving Fund to assist drinking water utilities in financing infrastructure improvements and pollution prevention activities. Using this fund, states can offer utilities low-cost loans and other types of assistance for funding improvements. Funds available through the American Recovery and Reinvestment Act were awarded to the Arkansas Drinking Water State Revolving Fund and used for three drinking water projects in the EAWRPR (EPA n.d.).

Farm Bill amendments and associated assistance programs, as well as the Conservation Effects Assessment Program, the assistance programs associated with the Consolidated Farm and Rural Development Act, and the HUD Community Block Development Grant Program were discussed in Section 6.1.2.1. Farm Bill programs address water conservation (e.g., Groundwater Decline Initiative), flood control (e.g., Watershed protection and Flood prevention), and conservation and restoration of aquatic habitat (e.g., Wetlands Reserve Program, Wildlife Habitat Incentives Program). In 2012, over 11,600 acres of land in EAWRPR counties were enrolled in these programs, and $12 million in funding was allocated to these counties (Table 6.6) (NRCS 2012).

Several water resources projects have been authorized in Arkansas since 1990 under the Water Resources Development Act (WRDA). Projects located in the EAWRPR that have been authorized and funded through WRDA are described in Table 6.8.

Table 6.8. WRDA projects in EAWRPR initiated after 1990 (USACE Memphis District 2012, 2013, NRCS 2011, Bayou Meto Water Management District 2013, Dickard 2013).

Project Name	Location	Description	Authority	Status
Lower Cache Restoration	Monroe County	Increase fish and wildlife habitat by restoring flow to three old meanders	WRDA 1986	2012 federal funding for implementation allocated
White River Basin Comprehensive Study	White River basin to the Arkansas River	Identify water resources needs and opportunities for water supply, flood control, navigation, recreation, power generation, wastewater management, and environment	WRDA 1986, 2000, 2007	
White River Backwater	Phillips and Desha Counties	Maintenance of levees and pump station for flood control	Flood Control Act 1952	On-going
Bayou Meto Basin	Lonoke, Pulaski, Prairie, Jefferson, Arkansas Counties	Diversion from Arkansas River for irrigation, channel improvements and pumping station for flood control, waterfowl conservation and management, environmental restoration	WRDA 1996	First diversion pump station 89% complete, Flood control pump station under construction
St. Francis Basin	Clay, Green, Mississippi, Craighead, Poinsett, Crittenden, St. Francis, and Lee Counties	Levees and pump stations for flood protection	WRDA 2007	Mitigation underway
St. Francis River and Tributaries	Clay, Green, Mississippi, Craighead, Poinsett, Crittenden, St. Francis, and Lee Counties	Maintenance and repair of existing levees, pump stations, and drainage ditches for flood control	Flood Control Act 1968	On-going
Helena Harbor maintenance	Phillips County, Mississippi River mile 652	Dredging to maintain channel, berthing and fleeting areas, and turning basin	WRDA 1986	Dredged 2012
Oceola Harbor maintenance	Mississippi County, Mississippi River mile 785	Dredging to maintain navigation channel	WRDA 2007	Dredged 2012
Beouf-Tensas flood control project	Chicot, Ashley, and Drew Counties	Maintenance and report of existing levees, pump station, and drainage ditches	WRDA 1986	On-going

Table 6.8. WRDA projects in EAWRPR initiated after 1990 (continued).

Project Name	Location	Description	Authority	Status
Grand Prairie Area Demonstration Project	Arkansas and Prairie Counties, small areas in Lonoke and Marion Counties	Diversion from White River for irrigation, tailwater recovery systems, surface water storage reservoir for irrigation	WRDA 1996	Pump station under construction
Lower Mississippi River Resource Assessment	Mississippi River and floodplain, which includes lower Arkansas River and White River	Identify information needs for river management, natural resource habitat needs, needs for river access and related recreation for preparation of a comprehensive watershed management plan	WRDA 2000	Assessment 1 scheduled for January 2014 completion

6.1.3 State Laws and Regulatory Programs

Arkansas has primary authority for regulation of water usage within the state. Many of the state laws and agency regulations related to water quality implement federal laws. The federal government has delegated authority to the state for a number of the regulatory administrative activities of both the Clean Water Act and the Safe Drinking Water Act.

6.1.3.1 Water Use Regulations

State water use law is based on a policy where riparian land owners, i.e., persons owning land that abuts a waterbody, have the right to reasonable use of the water within that waterbody. The reasonable use policy means that all landowners along a stream have the right to free and unrestricted use of the stream flow, provided that their use does not negatively affect the availability of water for other riparian users. Similarly, landowners have the right to reasonable use of groundwater under their property, as long as that use does not adversely affect the ability of other landowners to use the groundwater. In addition to water rights related to water withdrawals and consumptive use, Arkansas regulations address water rights related to public recreational uses of surface water such as boating and fishing (ANRC 2011).

In Arkansas, at the state level, regulations and programs authorized by the General Assembly that are related to water use are generally administered by ANRC. In addition, the

Arkansas Water Well Construction Commission promulgates rules for construction of water supply wells, and the Arkansas Public Services Commission regulates private water utility fees. State incentive programs for water conservation, as well as funding for water resources development projects, have also been legislated. Table 6.9 summarizes selected Arkansas water use regulations that apply in the EAWRPR.

Table 6.9. State regulations related to water use.

Water Use Regulations	Subjects Addressed by Regulations	Related State Legislation
Title 3: Rules for the Utilization of Surface Water[1]	Registration of surface water withdrawals	Arkansas Code §15-22-215
	Minimum streamflows	Arkansas Code §15-22-222
	Surface water transfers to non-riparian users	Arkansas Code §15-22-304
	Regulation of dam construction	Arkansas Code §15-22-210 - 214
	Allocation during periods of water shortage	Arkansas Code §15-22-217
Title 4: Rules for the Protection and Management of Groundwater[1]	Registration of groundwater withdrawals	Arkansas Code §15-22-302
	Groundwater protection program	Arkansas Groundwater Protection and Management Act (Arkansas Code §15-22-901 et seq.)
Arkansas Water Well Construction Commission Rules and Regulations[2]	Licensing of water well contractors	Arkansas Code §17-50-201 et seq.
	Construction requirements	
	Well reporting requirements	
Affiliate Transaction Rules[3]	Requirements for utility rates	Arkansas Code §23-2-101 et seq.
General Service Rules[3]	Standards of service for utilities	
Special Rules Water[3]	Standards of service for water utilities	

1 Enforcement by ANRC
2 Enforcement by Arkansas Water Well Construction Commission
3 Enforcement by Arkansas Public Service Commission

State law requires ANRC to "establish and enforce minimum stream flows for the protection of instream water needs" (Arkansas Code § 15-22-222). Minimum streamflow is defined by Arkansas Code §15-22-202(6) as "…the quantity of water required to meet the largest of [specified] instream flow needs as determined on a case-by-case basis." The needs to be met that are specified in the statute are interstate compacts, navigation, fish and wildlife, water quality, and aquifer recharge. This definition is used to set minimum streamflows by rulemaking under Arkansas Code §15-22-222. Where no minimum flow is set by rule, these factors are used to make a case-by-case determination of minimum flow. ANRC has adopted minimum streamflow by rule for the main stem of the Arkansas River (1990) and the main stem of the White River (2009).

The minimum streamflow, set by rule or determined on a case-by-case basis, represents the trigger point for a "shortage" requiring allocation of water use. Because of the critical low flow conditions which may exist at the minimum streamflow level, the 1990 AWP recommended taking steps to reduce water withdrawals before water levels drop to minimum streamflow levels. The ANRC may allocate water among uses during a shortage.

Prior to adoption of Act 593 of 2013, minimum streamflows were classified as a "reserved" use when allocating water during a shortage, along with drinking water use and federal water rights. The legislation removed this reserved status and demoted minimum streamflows to a position below agriculture and industry in the allocation hierarchy, and ahead of hydropower and recreation. The intent was to ensure that agricultural and industrial surface water use is not curtailed during a shortage in an effort to protect instream flow needs (interstate compacts, navigation, fish and wildlife, water quality, and aquifer recharge). This change, especially as it applies a state law limitation on federal interests in navigation, interstate compacts and water quality, including wastewater discharge permits for sewer systems and industries, has not been tested.

In 1985, the Arkansas General Assembly adopted a departure from traditional riparian law by allowing transfer of water for use on non-riparian land. Prior to determining how much water is available to transfer, ANRC must first calculate the amount of water that must remain in the stream. The amount of water that must remain in the stream must be enough to cover: (1) existing riparian water rights as of June 28, 1985; (2) water needs of federal water projects as they existed on June 28, 1985; (3) firm yield of all reservoirs in existence on June 28, 1985; (4) maintenance of instream flows for fish and wildlife, water quality, aquifer recharge requirements, and navigation; and (5) future water needs of the basin of origin as projected in the AWP. The General Assembly limited the amount of excess surface water that may be permitted for non-riparian transfer to 25% of the average annual yield from the watershed after the greatest of the instream needs listed above is met. In the White River Basin, Arkansas Code §15-22-304(e) further limits excess to an amount not to "exceed on a monthly basis an amount which is 50% of the monthly average of each individual month of excess surface water."

Minimum streamflow is often mistakenly equated with fish and wildlife flow requirements. Fish and wildlife flows are one of the 5 elements of minimum streamflow, which also includes interstate compacts, navigation, water quality, and aquifer recharge. Two different methods are used to calculate fish and wildlife flows for different situations. For case-by-case determinations of minimum flow for use in characterizing shortage and allocating water during a shortage, fish and wildlife flow requirements are estimated using a modified Tennant Method (ASWCC 1988). To calculate fish and wildlife flow requirements when determining the amount of excess water available for transfer to nonriparian users, the "Arkansas Method" (Filipek, Keith and Giese 1987) is used.

In 1991, the Arkansas Ground Water Protection and Management Act (Arkansas Code §15-22-901 et seq.) was signed into law, providing ANRC with authority to designate critical groundwater areas. As of 2013, two critical groundwater areas have been designated in the EAWRPR (Figure 4.8). ANRC publishes annual reports on the condition of the state's groundwater resources, including recommendations concerning aquifer safe yield and designation of critical groundwater areas.

Legislation passed in 2001 requires the use of water meters on all non-domestic wells withdrawing water from sustaining aquifers, beginning in 2006 (Arkansas Code §15-22-915). Designated sustaining aquifers in the EAWRPR include the Nacatoch, Wilcox, Sparta/Memphis, and Cockfield aquifers (Figure 3.14).

6.1.3.2 Water Quality Regulations

Water quality regulations are promulgated by the General Assembly, APCEC, the State Board of Health, and ANRC. Table 6.10 identifies state regulations and laws, along with associated federal laws, that address water quality.

Table 6.10 illustrates that there are myriad state regulations, covering a range of activities, which address water quality. The most basic of these are the regulations that set criteria for the quality of state surface waters and groundwater. These regulations identify the uses that state waterbodies should support, and specify narrative and numeric criteria for water quality to ensure the identified uses can be supported. In Arkansas, numeric water quality criteria for dissolved oxygen, turbidity, temperature, and minerals are ecoregion-based (APCEC 2011). Arkansas is in the process of developing numeric criteria for nutrients in surface water to meet federal requirements (ADEQ 2012c). State numeric water quality criteria for groundwater are in development.

A summary of the designated uses assigned to surface waterbodies in the EAWRPR under Regulation 2 is provided in Table 6.11. Delta ecoregion numeric surface water quality criteria apply in the EAWRPR. Delta ecoregion numeric water quality criteria also apply to surface waters on Crowley's Ridge as there are no ecoregion-specific water quality criteria for that ecoregion. Numeric surface water quality criteria for the water bodies in the planning region are listed in Tables 6.12 through 6.14. Figure 6.2 shows the ADEQ Water Quality Planning Segments that are located in the planning region.

To protect surface water and groundwater quality, there are state regulations and laws that regulate discharge of wastewater, discharge of stormwater, underground storage tanks, underground injection of fluids, management of livestock, and disposal of solid waste (see section 3.12).

Table 6.10. State regulations that protect water quality.

Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Regulation 1: Prevention of Pollution by Salt Water and Other Oil Field Wastes Produced by Wells in All Fields or Pools[1]	Environmental protection during oil drilling	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	CWA
Regulation 2: Water Quality Standards for Surface Waters of the State of Arkansas[1]	Water quality standards (designated uses and numeric criteria)	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	CWA
Regulation 3: Licensing of Wastewater Treatment Operators[1]	Licensing program for wastewater treatment operators	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	CWA
Regulation 4: Disposal Permits for Real Estate Subdivisions in Proximity to Lakes and Streams[1]	State wastewater permit	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	CWA
Regulation 5: Liquid Animal Waste Systems[1]	State wastewater permit	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	CWA
Regulation 6: Regulations for State Administration of the NPDES Program[1]	Federal wastewater permits (NPDES)	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	CWA
Regulation 12: Storage Tank Regulations[1]	Petroleum storage tank trust fund	Petroleum Storage Tank Trust Fund Act (Arkansas Code § 8-7-901 et seq.)	CWA, Underground Storage Tank Regulations, including Energy Policy Act of 2005
Regulation 15: Open-Cut Mining and Land Reclamation Code[1]	Environmental protection during non-coal mining activities Restoration of non-coal mining sites	Arkansas Open Cut Land Reclamation Act (Arkansas Code §15-57-301 et seq.) Arkansas Quarry Operation, Reclamation, and Safe Closure Act (Arkansas Code §15-57-401 et seq.)	None
Regulation 17: Underground Injection Control Code[1]	Underground injection of wastewater	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	SDWA
Regulation 22: Solid Waste Management Rules[1]	Landfill construction specifications	Arkansas Solid Waste Management Act	RCRA, Pollution Prevention Act

Table 6.10. State regulations that protect water quality (continued).

Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
	Acceptable materials for landfill disposal	(Arkansas Code § 8-6-201 et seq.), Arkansas Pollution Prevention Act (Arkansas Code § 8-10-201 et seq.)	
	Regional solid waste management districts		
	Pollution prevention		
Regulation 23: Hazardous Waste Management[1]	Hazardous waste management	Arkansas Hazardous Waste Act (Arkansas Code § 8-7-201 et seq.), Arkansas Hazardous Materials Transportation Act (Arkansas Code § 27-2-101 et seq.)	RCRA, Pollution Prevention Act
	Pollution prevention	Arkansas Pollution Prevention Act (Arkansas Code § 8-10-201 et seq.)	
Regulation 27: Licensing of Landfill Operators and Illegal Dumps Control Officers[1]	Licensing of landfill operators	Arkansas Code § 8-6-901 et seq.,	RCRA
	Licensing of illegal dumps control officers	Illegal Dump Eradication and Corrective Action Program Act (Arkansas Code § 8-6-501 et seq.)	
Regulation 29: Brownfields Redevelopment[1]	Clean-up and redevelopment of contaminated sites	Arkansas Hazardous Waste Act (Arkansas Code § 8-7-201 et seq.), Remedial Action Trust Fund Act, Arkansas Voluntary Clean-up Act (Arkansas Code § 8-7-1101 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
	Clean-up funding		
Regulation 32: Environmental Professional Certification[1]	Certification program for professionals involved in clean-up of contaminated sites	Phase I Environmental Site Assessment Consultant Act (Arkansas Code § 8-7-1301 et seq.)	CERCLA
Regulation 34: State Water Permit Regulation[1]	Regulation of systems with the potential to pollute water resources, that are not otherwise regulated	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	CWA

Table 6.10. State regulations that protect water quality (continued).

Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Title 4: Rules for the Protection and Management of Groundwater[2]	Groundwater Protection Program	Arkansas Groundwater Protection and Management Act (Arkansas Code § 15-22-901 et seq.)	None
Rules and regulations pertaining to general sanitation[3]	Groundwater pollution Surface water pollution Sewage treatment	Arkansas Sewage Disposal Systems Act (Arkansas Code § 14-236-101 et seq.)	CWA
Rules and regulations pertaining to public water systems[3]	Safety of drinking water supplied by public water systems	Arkansas Code § 20-7-101 et seq.	SDWA
Rules and regulations pertaining to semi-public water systems[3]	Safety of drinking water supplied by semi-public water systems	Arkansas Code § 20-7-101 et seq.	SDWA
Rules and regulations pertaining to water operator licensing[3]	Licensing for drinking water treatment systems	Arkansas Code § 17-51-101 et seq.	SDWA
Rules and regulations pertaining to onsite wastewater systems, designated representative, and installers[3]	Permitting of onsite wastewater treatment systems (septic systems) Licensing of designated representatives for onsite wastewater treatment systems Licensing of installers of onsite wastewater treatment systems	Arkansas Sewage Disposal Systems Act (Arkansas Code § 14-236-101 et seq.)	CWA
Rules and regulations pertaining to mobile home and recreational vehicle parks[3]	Water supply Wastewater disposal Solid waste management	Arkansas Code § 20-7-101 et seq.	CWA, SDWA, RCRA
Arkansas regulations on pesticide classification[4]	Pesticide classification	Arkansas Pesticide Control Act (Arkansas Code § 2-16-401 et seq.), Arkansas Pesticide Use and Application Act (Arkansas Code § 20-20-201 et seq.)	Federal Insecticide, Fungicide, and Rodenticide Act
Arkansas regulations on pesticide applicator licensing[4]	Licensing of pesticide applicators	Arkansas Pesticide Use and Application Act (Arkansas Code § 20-20-201 et seq.)	Federal Insecticide, Fungicide, and Rodenticide Act

Table 6.10. State regulations that protect water quality (continued).

Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Arkansas Water Well Construction Commission Rules and Regulations[2]	Specifications for construction of water wells to provide safe drinking water	Water Well Construction Act (Arkansas Code § 17-50-101 et seq.)	SDWA
Rules and regulations pertaining to outdoor bathing places[3]	Swim beach water quality	Arkansas Code § 20-7-101 et seq.	CWA
Marine sanitation[3]	Marine sanitation	Arkansas Code § 27-101-401 et seq.	CWA

Note: Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update.
1 Responsible state agency is ADEQ 2 Responsible state agency is ANRC
3 Responsible state agency is Arkansas Department of Health 4 Responsible state agency is Arkansas State Plant Board

Table 6.11. State designated uses for surface waters in the EAWRPR (APCEC 2011).

Designated Use	Waterbodies
Extraordinary Resource Waters	Second Creek Cache River above Cache Bayou and adjacent to natural areas Arkansas River below Dam 2 Strawberry River Two Prairie Bayou adjacent to natural areas
Ecologically Sensitive Waterbodies	Lower St. Francis River Lower 10 miles of Straight Slough Right Hand Chute at confluence with St. Francis River Departee Creek Black River at mouth of Spring River
Channel-altered Delta Ecoregion Streams	Streams characterized by substantial alteration of the morphology of the main-stem and tributary channels, including the following: • Cache River, • Bayou DeView, • Village Creek, and • Blackfish Bayou.
Primary Contact Recreation	All lakes and reservoirs, and streams with watersheds greater than 10 square miles, except Little Lake Bayou
Secondary Contact Recreation	All waters
Domestic, Industrial, and Agricultural Water Supply	All waters, except no domestic water supply use for: • Coon Creek, • Unnamed tributary to Coon Creek from Frit Industries, • Rocky Branch Creek, • Bayou Meto from Rocky Branch Creek to Bayou Two Prairie, • Ditch No. 27, and • Ditch No. 6
Fishery	All lakes and reservoirs
Seasonal Fishery	All streams with watersheds smaller than 10 square miles, and Little Lake Bayou
Perennial Fishery	All streams with watersheds of 10 square miles or larger, All streams where discharge is 1 cfs or more, and Unnamed ditch to Little Lagrue Bayou

Table 6.12. Temperature and turbidity numeric criteria that apply in the EAWRPR.

Water body	Temperature (degrees Fahrenheit)	Turbidity – base flow (NTU)	Turbidity – all flows (NTU)
Delta Least altered streams	86.0	45	84
Delta Channel altered streams	89.6	75	250
White River	89.6	75	250
St. Francis River	89.6	75	100
Mississippi River	89.6	50	75
Arkansas River	89.6	50	52
Lakes and reservoirs	89.6	25	45
Ditch No. 27	95.0	75	250
Bayou Bartholomew from headwaters to Able's Cr, and tributaries	86.0	21	32
Seven Devils Swamp	89.6	25	45

Table 6.13. Dissolved oxygen numeric water quality criteria that apply in the EAWRPR.

Water body	Dissolved Oxygen Primary (mg/L)	Dissolved Oxygen Critical (mg/L)
Streams with watershed < 10 square miles	5	2
Streams with watershed 10 – 100 square miles	5	3
Streams with watershed > 100 square miles	5	5
Lakes and reservoirs	5	NA

Table 6.14. Numeric water quality criteria for minerals that apply in the EAWRPR.

Water body	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
Bayou Bartholomew Chemin-A-Haut Creek	50	20	500
Bayou DeView from Arkansas Hwy 14 to Whistle Ditch	48	38	411.3
Bayou DeView from mouth to Arkansas Hwy 14	48	37.3	411.3
Big Creek from Whistle Ditch to mouth of unnamed tributary	58	49	500
Big Creek Cache River Lost Creek Ditch Black River	20	30	270
Delta reference streams	48	37.3	411.3
Delta streams	63.84	49.61	500
Ditch No. 27	63.84	480	1200
Ditch No. 6 from Ditch No. 27 to mouth	63.84	210	630
L'Anguille River	20	30	235
Little River	20	30	365
Mississippi River from Arkansas River to Missouri state line	60	175	450
Mississippi River from Louisiana state line to Arkansas River	60	150	425
Overflow Creek	20	30	170
Pemiscot Bayou	20	30	380
Rocky Branch Creek Bayou Meto from Rocky Branch Creek to Bayou Two Prairie	64	49.61	500
St. Francis River 36 N Latitude to 36d 30s N Latitude	10	20	180
St. Francis River mouth to 36 N Latitude	10	30	330
Tyronza River from Ditch No. 6 to mouth	20	60	500
Tyronza River from headwaters to Ditch No. 6	20	30	350
Unnamed tributary to Big Creek	71	60	453
Unnamed Tributary to Coon Creek from Frit Industries	63.84	48	500
White River from mouth to Dam 3	20	60	430
Bakers Bayou Bayou Meto from mouth to Bayou Two Prairie Bayou Two Prairie from mouth to Rickey Branch Bear Bayou Big Ditch Blue Point Ditch Boggy Slough Bradley Slough Brownsville Branch Brushy Slough Bubbling Slough Buffalo Slough Caney Creek Castor Bayou Caney Creek Ditch Crooked Creek Ditch Cross Bayou Dennis Slough Eagle Branch Fish Trap Slough Five Forks Bayou Flat Bayou Flynn Slough Government Cypress Slough Hurricane Slough Indian Bayou Indian Bayou Ditch Little Bayou Meto Long Pond Slough Main Ditch Newton Bayou Plum Bayou Ricky Branch Salt Bayou Salt Bayou Ditch Shumaker Branch Skinner Branch Snow Bayou Tipton Ditch Tupelo Bayou Wabbaseka Bayou West Bayou White Oak Branch	95	45	500

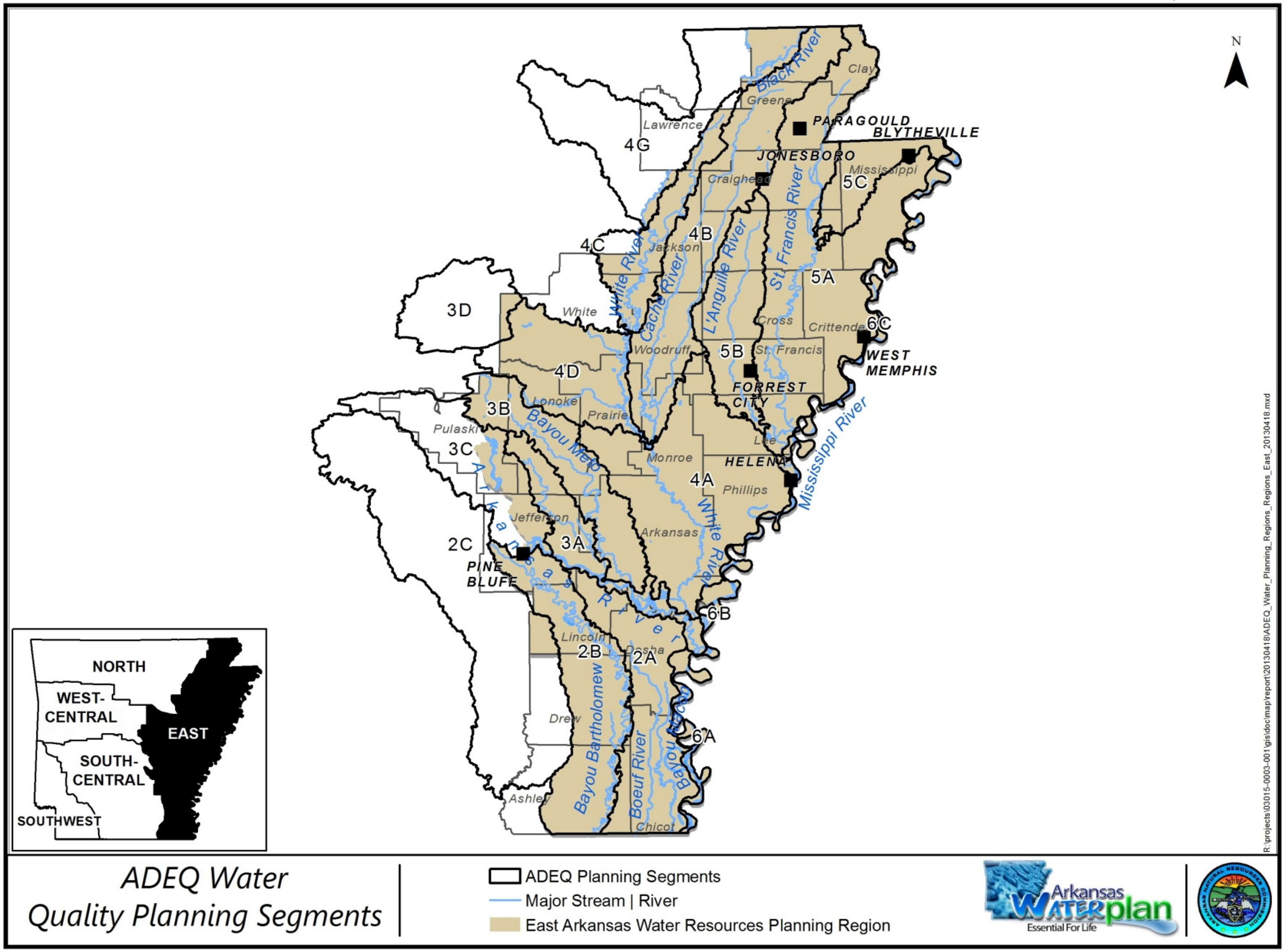

Figure 6.2. ADEQ water quality planning segments included in the EAWRPR

The state source water and wellhead protection programs address protection of the quality of surface waters and aquifers used as public drinking water supplies. There are just over 335 active public water supply utilities in the EAWRPR. Almost 230 of these utilities use groundwater from their own wells, and are subject to the state wellhead protection program. Only one utility uses surface water and is subject to the state source water protection program. The remainder of the water utilities in the Planning Region purchase groundwater and/or surface water to supply to their customers (ADH n.d.).

6.1.3.3 Floodplain Management Regulations

Arkansas Code provides that it is the policy of the state to encourage and support actions to prevent and lessen flood hazards and losses. The state has the authority to adopt measures that will discourage development in flood-prone land, assist in reducing damage caused by floods, and improve long-range land management in flood-prone areas (Arkansas Code §14-268-101, 104).

Arkansas statute also requires each county, city, or town that is participating in the National Flood Insurance Program to designate a "person to serve as the floodplain administrator to administer and implement the ordinance and any local codes and regulations relating the management of flood-prone areas." The designated floodplain administrator must also be accredited by ANRC under the commission's authority regarding flood control. State accreditation of flood plain administrators is regulated under ANRC Title 18 rules. Continuing education for the floodplain administrator is an especially important component of the state's accreditation program (Arkansas Code §14-268-106, 15-24-102, and 15-24-109).

6.1.3.4 Water Management Regulations

Other state regulations and programs address additional aspects of water resources and their management. Table 6.15 summarizes these regulations, and the associated federal legislation.

Table 6.15 State regulations related to water management.

State Water Resources Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Title 6: Water Plan Compliance Review Procedures[1]	Arkansas Water Plan	Arkansas Code § 15-22-503 and 504	None
Title 7: Rules Governing Design and Operation of Dams[1]	Dam safety	Arkansas Code § 15-22-201 et seq.	Water Resources Development Act/Dam Safety and Security Act
Title 12: Rules governing the Arkansas wetland mitigation bank program[1]	Wetland mitigation bank	Arkansas Wetlands Mitigation Act	Rivers and Harbors Act, Clean Water Act
Arkansas Wildlife Resources Regulations[2]	Allowance for fish passage at dams.	Arkansas Code § 15-44-110	
	Screens required on surface water intakes to protect fish	Arkansas Code § 15-44-111	

1 Enforcement by ANRC
2 Enforcement by Arkansas Game and Fish Commission
Note: Highlighted legislation was promulgated after 1990 AWP update

The Arkansas Wetland Mitigation Banking Program (Arkansas Code §15-22-1002), authorized in 1995, is a state-sponsored initiative that promotes, in cooperation with federal, state, non-profit, and other interested entities, the restoration, creation, enhancement, and conservation of aquatic resources, including wetlands, streams, and deep-water aquatic habitat. This legislation authorizes ANRC to operate wetland and stream mitigation banks and to sell mitigation "credits" to private, nonprofit, and public entities required to provide mitigation for dredge and fill activities under the Clean Water Act. The "credits" represent the accrual or attainment of aquatic resource function at the mitigation bank site which results from restoration, creation, enhancement, or conservation efforts. The state wetland mitigation bank provides a cost-effective alternative for mitigating impacts. The USACE regulates both public and private mitigation banking and is responsible for approving the number of "credits" available within any individual bank. When an individual or entity is required to provide compensatory mitigation for unavoidable loss of function, the USACE can approve the purchase of "credits" from the state mitigation bank to satisfy all regulatory mitigation requirements. The Camp 9 Mitigation Bank was created in 1998, in Chicot County, through the Arkansas Mitigation Bank program (USACE Vicksburg District 2013).

6.1.4 State Financial Assistance Programs

Arkansas has several state programs that provide financial incentives and assistance for water resources management. The federal government has also delegated authority to the state to administer federal assistance programs such as those authorized by the Clean Water Act, the Safe Drinking Water Act, and the Housing and Community Development Act.

6.1.4.1 Financial Assistance for Public Water and Wastewater Projects

ANRC is responsible for managing and distributing monies from several federal assistance programs intended to assist communities in constructing and maintaining drinking water and wastewater systems (Table 6.16). There are also state-funded programs that provide financial assistance for drinking water and wastewater systems (Table 6.17). Programs shown in both Table 6.16 and 6.17 use both federal and state funding sources.

Table 6.16. Federal water supply assistance programs managed by ANRC.

Federal Program	Federal funding source	State Program
Community Development Block Grant Program	Housing and Urban Development	Arkansas Community and Economic Development Program
Drinking water state revolving fund	EPA	Water resources cost share revolving fund program
		Construction assistance revolving loan fund
Clean water state revolving fund	EPA	Water resources cost share revolving fund program
		Construction assistance revolving loan fund

Table 6.17. State programs for public water and wastewater system assistance (administered by ANRC).

State Water Use Regulations	State Financial Assistance Programs	Related State Legislation
Title 5: Administrative rules and regulations for financial assistance	Water resources development general obligation bond fund	Arkansas Water Resources Cost Share Finance Act (Arkansas Code §15-22-801 et seq.)
	Water development fund program	
	Water resources cost share revolving fund program	
	Water, sewer, and solid waste management systems program	
	Water, waste disposal, and pollution abatement facilities general obligation bond program	Arkansas Water, Waste Disposal, and Pollution Abatement Facilities Financing Act of 2007 (Arkansas Code §15-20-1301 et seq.)
Title 15: Rules governing loans from the safe drinking water revolving loan fund	Safe drinking water revolving loan fund	Arkansas Code §15-5-901 et seq., Arkansas Code §15-22-1101 et seq.
	Construction assistance revolving loan fund	
Title 16: Rules governing the Arkansas Clean Water Revolving Loan Fund Program	Clean water state revolving loan fund	Arkansas Code §15-5-901 et seq.
	Construction assistance revolving loan fund	
Title 23: Rules governing water and wastewater project funding through the Arkansas community and economic development program	Funding for construction or improvement of community treatment facilities for drinking water and wastewater	Arkansas Code §15-5-901 et seq.

6.1.4.2 State Financial Incentive and Assistance Programs for Promoting Water Quality and Water Resource Management

ADEQ and ANRC administer a number of incentive and assistance programs related to water resources management (Table 6.18). These include programs to assist with clean-up of hazardous waste contamination, reduction of nonpoint source pollution, and management of solid wastes to protect water quality. In addition, there are state programs to encourage water conservation and preservation of wetlands. All but one of the programs listed in Table 6.18 are funded by state sources. The state nonpoint source pollution management grant program is federally funded under the authority of the Clean Water Act Section 319.

Table 6.18. State incentive and assistance programs that protect water quality and promote water resources management.

State Regulation	State Incentive and Assistance Programs	Related State Legislation	Related Federal Legislation
Regulation 11: Solid Waste Disposal Fees, Landfill Post-Closure Trust Fund, and Recycling Grants Programs[1]	Recycling Fund	Solid Waste Management Recycling Fund Act (Arkansas Code §8-6-601 et seq.)	Resource Conservation and Recovery Act
Regulation 12: Storage Tank Regulations[1]	Petroleum storage tank trust fund	Petroleum Storage Tank Trust Fund Act (Arkansas Code . § 8-7-901 et seq.)	Clean Water Act, Underground Storage Tank Regulations, including Energy Policy Act of 2005
Regulation 29: Brownfields Redevelopment[1]	Clean-up funding	Arkansas Hazardous Waste Act (Arkansas Code § 8-7-201 et seq.), Remedial Action Trust Fund Act (Arkansas Code § 8-7-501 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Regulation 30: Remedial Action Trust Fund, Site Priority List[1]	Clean-up funding, prioritization of contaminated sites for clean-up	Remedial Action Trust Fund Act (Arkansas Code § 8-7-501 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Title 5: Administrative rules and regulations for financial assistance[2]	Sewer and solid waste management systems program Waste disposal and pollution abatement facilities general obligation bond program	Arkansas Code § 14-230-101 et seq., § 15-22-601 et seq., § 15-22-701 et seq.	None
Title 10: Rules governing the Arkansas water resource agricultural cost-share program[2]	Arkansas water resources agricultural cost-share program	Arkansas Groundwater Protection and Management Act (Arkansas Code §15-22-913 through 914) Arkansas Code §15-22-507	None
Title 13 – Rules governing the tax credit program for the creation and restoration of private wetland and riparian zones[2]	Wetlands and Riparian Zone Tax Credit Program	Arkansas Private Wetland Riparian Zone Creation and Restoration Incentive Act (Arkansas Code § 26-51-1501 et seq.)	None

Table 6.18. State incentive and assistance programs that protect water quality and promote water resources management (continued).

State Regulation	State Incentive and Assistance Programs	Related State Legislation	Related Federal Legislation
Title 14: Rules for implementing the Water Resources Conservation and Development Incentives Act[2]	Groundwater conservation tax incentives	Water Resource Conservation and Development Incentives Act (Arkansas Code §26-51-1001 et seq.)	Title 14: Rules for implementing the Water Resources Conservation and Development Incentives Act
None	Nonpoint source pollution grant program[2]	None	Clean Water Act (Section 319)

Note: Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update.
1 Responsible state agency is ADEQ
2 Responsible state agency is ANRC

6.1.5 Non-regulatory State Water Management Programs

There are state agency programs for natural resources protection and management that apply to water resources. These include planning, guidance, and incentive programs. These programs do not necessarily have regulations associated with them. However, they guide the activities of state agencies related to water resources. The AWP is one such program. Others are described below.

6.1.5.1 Arkansas Wildlife Action Plan

A state wildlife action plan was prepared by the Arkansas Game and Fish Commission, and approved by USFWS in 2007. This plan prioritizes activities to protect species of concern and their habitats throughout the state. This plan addresses amphibians, birds, fish, crayfish, insects, mammals, mussels, and reptiles. There are 154 species of greatest conservation need identified for Arkansas in this plan that are found in the EAWRPR. The most highly recommended conservation activity for this planning region is habitat restoration and improvement (Anderson 2006).

6.1.5.2 Arkansas State Wetland Strategy

A state wetland strategy was ed in 1995 by a team of Arkansas agencies. This strategy consisted of 10 elements that addressed conservation and restoration of wetlands, and improving understanding of wetlands, both by the scientific and natural resources community and by the public. Implementation of this strategy resulted in legislation that created the Arkansas Mitigation Banking Program, and the Arkansas Riparian Zone and Wetland Creation Tax Credit Program. The primary focus of this wetland strategy is the EAWRPR (Arkansas Multi-agency Wetlands Planning Team 1995).

6.1.5.3 Arkansas Nonpoint Source Pollution Management Plan

ANRC regularly prepares a state nonpoint source pollution management plan. The purpose of this plan to provide a guide and focus for public agencies, nonprofit organizations, interest groups, and other stakeholders to work together to "develop, coordinate, and implement programs to reduce, manage or abate" nonpoint source pollution. The plan is updated every five years. The current plan was updated in 2010.

6.1.5.4 Arkansas Forestry Best Management Practices

The Arkansas Forestry Commission has prepared a booklet of approved guidelines for conducting forest management practices in a way that minimizes water quality impacts. Implementation of these best management practices is voluntary. These management practices are applicable to commercial and private timber operations on public or private land.

6.1.6 Local Regulations

There are also local regulations that influence management of water resources. These can include zoning laws; regulations promulgated by municipalities, counties, water and wastewater utilities; and regulations promulgated by irrigation, drainage, water, and sewer districts.

6.1.7 Regional Water Resources Management

Several agencies and organizations have developed management or restoration programs for areas within the EAWRPR. The purpose of some of these programs is to implement a state or federal regulation or policy, such as ambient water quality standards, no net loss of wetlands, or conservation of wildlife. These programs constitute a framework that provides opportunities for leveraging resources (personnel and funding) to accomplish water resources management goals.

6.1.7.1 Nine-element Watershed Plans

Watershed plans are required by the CWA to guide activities for reducing pollution in waterbodies for which TMDLs have been developed. EPA has prepared guidance describing the nine elements that should be included in watershed plans to achieve TMDLs calculated for impaired waterbodies. A nine-element watershed plan must be completed and approved by EPA before restoration projects in the watershed can receive funding from the CWA Nonpoint Source Program (Section 319 funding). There are two watersheds in the planning region for which nine-element watershed management plans have been approved by EPA. Both the L'Anguille River Nine-Element Plan and the Bayou Bartholomew Watershed Plan Update were completed in 2009. Both of these plans address reduction of siltation and turbidity (Arkansas Water 2013).

6.1.7.2 Wetland Planning Areas

The Arkansas Wetland Strategy designated eight watersheds in the EAWRPR as Wetland Planning Areas. Wetland Planning Area reports have been completed for three of these watersheds; Bayou Bartholomew, St. Francis River, and Bayou Meto (Layher BioLogics RTEC, Inc. n.d., 2003, FTN Associates, Ltd. n.d.). These reports are part of implementation of the Arkansas Wetlands Strategy. They include information on the current physical, biological, demographic, socioeconomic characteristics of the watershed, an overview of the history of land and water resources management in the watershed, characteristics of the current wetland ecosystems in the watershed, and the potential for loss of wetlands in the watershed (Arkansas Multi-agency Wetlands Planning Team 1995).

6.1.7.3 Lower Mississippi River Conservation Initiatives

The Lower Mississippi River Conservation Committee is a coalition of natural resources and environmental quality agencies from the six states that border the lower Mississippi River, supported by the USFWS. In 2000, this committee completed and approved the Aquatic Resources Management Plan for the Lower Mississippi River. The goals of this plan included restoration of aquatic habitats and species, and improving water quality. The Mississippi River Conservation Initiative is the implementation phase of this plan. Over 60 potential conservation and restoration projects were identified in Arkansas under this initiative. Three of these projects were completed in 2008 (Lower Mississippi River Conservation Committee 2013).

6.1.7.4 Fayetteville Shale Best Management Practices

A team consisting of multiple agencies has developed BMPs for natural gas activities in the Fayetteville Shale area intended to protect natural resources, including water quality (USFWS 2007).

6.1.7.5 Nonprofit Organizations

There are several nonprofit organizations that have active programs within the EAWRPR. These include The Nature Conservancy, Ducks Unlimited, the Lower Mississippi River Conservation Committee, and the Walton Family Foundation.

The Nature Conservancy has designated the Big Woods in Arkansas as a priority area for their activities. The Big Woods is the area of bottomland hardwoods that exists along the White River, Arkansas River, Cache River, and Bayou DeView. Activities in the Big Woods include reforestation, reconnecting creeks to their floodplains, purchasing bottomland hardwood wetlands, and assisting with enrolling bottomland hardwood wetlands in reserve programs, such as the NRCS Wetlands Reserve Program (The Nature Conservancy 2013).

Ducks Unlimited has identified the Mississippi Alluvial Valley from Illinois and Missouri to the Gulf of Mexico as a Level 1 conservation priority area. They have identified this area as the most significant winter habitat area for mallards in North America. The EAWRPR is part of this conservation priority area. Ducks Unlimited has participated in hundreds of wetland conservation and restoration projects on private lands and in Wildlife Management Areas (Ducks Unlimited n.d.).

The Walton Family Foundation has partnered with the Lower Mississippi Valley Joint Venture to fund restoration and enhancement of habitat for waterfowl within the Mississippi Delta in Arkansas, Louisiana, and Mississippi. The first grants were funded through this partnership in 2010 (Lower Mississippi River Joint Venture 2013).

6.1.8 Interstate Compacts

Arkansas is part of the Red River Compact, an interstate compact agreement among the states of Arkansas, Oklahoma, Texas, and Louisiana. One purpose of the compact is to promote the equitable apportionment and development of the water in the river basin among the participating states. According to Article II, Section 2.01 of the Red River Compact, each member state may use the water allocated to it by the compact in any manner deemed beneficial by that state. Each state may freely administer water rights and uses in accordance with the laws of that state, but such uses shall be subject to availability of water in accordance with the apportionments made by the compact.

There are five defined reaches in the Red River Basin covered by the compact (Figure 6.3). Bayou Bartholomew, Boeuf River, and Bayou Macon in the EAWRPR are included in Reach IV of the Red River. Guaranteed minimum flows are not set for these streams in the compact. However, flow criteria for these streams are defined (Table 6.19). When these flows are reached, diversions from these streams must be managed to ensure an equitable portion of flow passes into Louisiana (Red River Compact Commission 1978).

Table 6.19. Red River Compact flow criteria for Reach IV streams in Arkansas.

Stream	Flow criterion, cfs
Bayou Bartholomew	80
Boeuf River	40
Bayou Macon	40

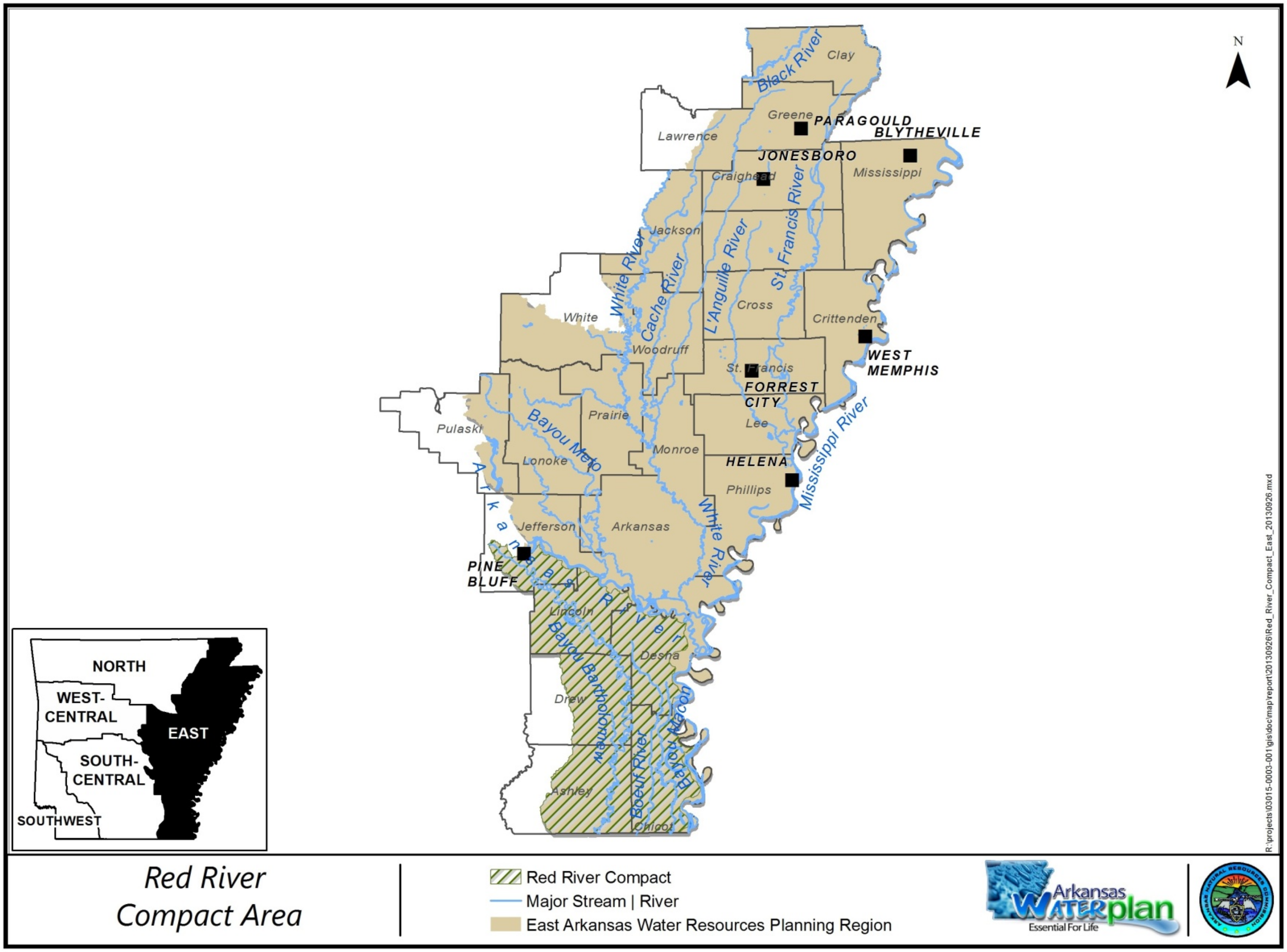

Figure 6.3. Boundaries of Reaches II through V of the Red River Compact (Oklahoma Water Resources Board n.d.).

6.2 Institutional Framework

Governmental responsibility for water resources management in the EAWRPR is split among many agencies on three levels (federal, state, and local). As a result, management of water resources in the EAWRPR can require coordination among a number of government entities. In addition, there are a number of nonprofit organizations that participate in water resources management in the planning region.

6.2.1 Federal Agencies

There are 16 federal agencies involved in water resources management in the EAWRPR. These federal agencies are listed in Table 6.20, along with their respective activities in this planning region.

Table 6.20. Federal agencies with water resources-related responsibilities in the EAWRPR.

Federal Agency	Responsibility in Arkansas
EPA	• Oversees state agencies in implementation of management and funding programs under o Clean Water Act, o Safe Drinking Water Act, o RCRA, o Superfund, o Federal Insecticide, Fungicide, and Rodenticide Act, and o Surface Mining Control and Reclamation Act • Conducts TMDL studies and other water quality studies in the state • Implements programs under the Toxic Substances Control Act
Federal Energy Regulatory Commission	Oversees environmental matters related to natural gas and hydropower projects in the planning region
FEMA	Prepares flood hazard maps for the state and encourages State and local governments to guide development decisions away from defined flood hazard risk areas through participation in the National Flood Insurance Program
HUD	Provides funding for water and wastewater infrastructure improvements
NOAA	Participates in monitoring precipitation and climate in the planning region

Table 6.20. Federal agencies with water resources-related responsibilities in the EAWRPR (continued).

Federal Agency	Responsibility in Arkansas
NRCS National Water Management Center	• Located in Little Rock • Serves as a water resources information exchange • Provides support and training related to o environmental compliance, o hydrology and hydraulics, o stream geomorphology and restoration, o water quality and quantity, o watershed and dam rehabilitation, and o technology outreach
Southwestern Power Administration	Markets and delivers hydroelectric power produced at USACE hydropower projects in the planning region
US Department of Defense	Manages land and surface water resources within the boundaries of the Little Rock Air Force Base
USACE	• Manages federal water, navigation, flood control, and hydropower projects in the planning region • Implements sections of the Clean Water Act related to impacts to navigable waters and wetlands • Constructs flood control, irrigation, and water supply projects authorized by the Water Resources Development Act • Oversees dam safety for federal dams
USDA	• Conducts the Census of Agriculture • Conducts the Natural Resources Inventory • Manages Conservation Effects Assessment Projects (watershed and regional)
USDA Farm Services Agency	Implements the Conservation Reserve Program for erosion control and habitat restoration in the planning region
USFS	• Manages the Ozark-St. Francis National Forest and associated surface waters • Forest management incentive programs • Participates in forest inventory • Manages Urban and Community Forestry Program
NRCS	• Implements over 20 Farm Bill erosion control and habitat restoration funding and technical assistance programs in the planning region • Appraises the status and trends of soil, water, and related resources on non-federal land in the state and assesses their capability to meet present and future demands
USDA Rural Development	• Implements USDA rural utilities financial assistance programs
USDI National Park Service	• Manages one national park and associated water resources within the planning region • Provides funds for land and water conservation projects

Table 6.20. Federal agencies with water resources-related responsibilities in the EAWRPR (continued).

Federal Agency	Responsibility in Arkansas

USFWS	• Implements the Endangered Species Act and programs to
	  o Promote management of ecosystems,
	  o Promote conservation of migratory birds,
	  o Promote preservation of wildlife habitat,
	  o Promote restoration of fisheries,
	  o Combat invasive species, and
	  o Promote international wildlife conservation
	• Manages Big Lake, White River, and overflow National Wildlife Refuges
	• Implements the Partners For Wildlife Program for restoration of bottomland hardwood forests
	• Conducts the National Wetland Inventory
	• Oversees state wildlife planning through the State Wildlife Grant Program

USGS	• Flow and stage monitoring of rivers and streams • Groundwater level monitoring • Water quality monitoring • Groundwater modeling • Water quality modeling • Water data storage and management

6.2.2 Arkansas Agencies

There are over 20 Arkansas agencies involved in water resources management in the EAWRPR. These state agencies are listed in Table 6.21, along with a description of their water resources management responsibilities within the planning region.

Table 6.21. Arkansas agencies and entities with responsibilities related to water resources in the EAWRPR (continued).

Table 6.21. Arkansas agencies and entities with responsibilities related to water resources in the EAWRPR.

State Agency	Responsibility
ADEQ	• Implements state water quality policy and the Clean Water Act NPDES program • Develops and enforces water quality standards • Investigates citizen complaints regarding water pollution • Oversees solid waste management • Operates the hazardous waste management program • Manages contaminated site clean-up and redevelopment programs • Develops and enforces mining and mine site reclamation regulations • Manages the storage tank regulation program • Permits no-discharge facilities and underground injection operations • Water quality monitoring and assessment
ANRC	• Regulates, permits, and tracks water use and dam construction • Monitors climate • Administers federal water resources funding programs • Prepares water resources and nonpoint source pollution management plans • Develops and maintains mitigation banking and restoration incentive programs for aquatic resources • Supports conservation districts • Registers poultry feeding operations • Certifies nutrient management planners and applicators • Promotes public health and safety and minimize flood losses through o training, o education, o technical assistance in floodplain management, and o accrediting floodplain administrators
Arkansas Department of Health (ADH)	• Regulates public water supply systems • Implements the Safe Drinking Water Act source water protection programs • Issues fish consumption advisories • Implements state health rules and regulations that apply to water resources • Regulates septic tanks and licenses septic tank cleaners • outdoor bathing and swimming • Implements state marine sanitation program
Arkansas Department of Parks and Tourism	• Manages the 19 state parks and associated water resources in the planning region • Prepares comprehensive outdoor recreation plan • Manages outdoor recreation grant program

Table 6.21. Arkansas agencies and entities with responsibilities related to water resources in the EAWRPR (continued).

State Agency	Responsibility
Arkansas Forestry Commission	• Provides guidelines for protection of water resources in forestry operations • Monitors use of forestry BMPs • Participates in forest inventory • Implements forest management incentive programs • Implements Urban and Community Forestry program • Designates and manages state forests for a variety of purposes, including o watershed protection o erosion and flood control
AGFC	• Manages protection, conservation and preservation of fish and wildlife in the planning region through o habitat management, o wildlife management areas, o fish stocking, o hunting and fishing regulations, and o education and outreach programs • Prepares state Wildlife Action Plan • Implements conservation grant programs • Manages over 5,000 acres of public waters in the planning region
Arkansas Geological Survey	• Participates in research of, and provides information and education about, state water resources • Mapping • Water well construction records
Arkansas Livestock and Poultry Commission	Regulates disposal of livestock carcasses
Arkansas Multi-agency Wetland Planning Team	Developed the State Wetland Strategy and is the lead for developing state numeric nutrient criteria for wetlands
Arkansas Natural Heritage Commission (ANHC)	• Surveys and conducts research on natural communities in the state • Acquires natural areas for preservation • Manages the Arkansas Natural and Scenic Rivers system
Arkansas Oil and Gas Commission	• Provides technical assistance related to protection of water resources from wastes associated with production of o oil, o natural gas, and o brine • Issues permits for drilling and operation of o oil, natural gas, and brine production wells o injection and disposal wells
Arkansas Pollution Control and Ecology Commission (APCEC)	Environmental policy-making body for the state
Arkansas Public Service Commission	Regulates rates and services of private water utilities, as well as utilities water crossings

Table 6.21. Arkansas agencies and entities with responsibilities related to water resources in the EAWRPR (continued).

State Agency	Responsibility
Arkansas State Board of Health	Promulgates health rules and regulations for the state
Arkansas State Highway and Transportation Department (AHTD)	• Hazardous waste transportation permits • Stormwater management • Develops and implements construction BMPs
Arkansas State Plant Board	Implements • Insecticide, Fungicide, and Rodenticide Act programs, o pesticide registration o user and applicator training o dealer licensing • state pesticide management plan for groundwater protection, • groundwater quality monitoring, and • climate/weather monitoring
Arkansas Water Well Construction Commission	• Regulates development of groundwater through licensing water well contractors and registering drillers and pump installers • Regulates specifications for construction of wells • Maintains water well construction records
Arkansas Waterways Commission	Studies and promotes navigable waterways for transportation and economic development
University of Arkansas (U of A) Cooperative Extension Service	Provides technical assistance to Arkansans related to water conservation, and protection and restoration of water quality
U of A Water Resources Center	Participates in research related to water resources, and in water resources management projects
Military Department of Arkansas Arkansas National Guard	Manages land and surface water resources within the boundaries of Camp Robinson

6.2.3 Federal-State Organizations

There are at least six federal-state organizations involved in water resources management in the EAWRPR:

- Red River Compact Commission,
- Delta Regional Authority,
- Lower Mississippi River Conservation Committee,
- Lower Mississippi River Joint Venture,
- Arkansas Conservation Partnership,
- Arkansas Watershed Advisory Group

The Red River Compact Commission administers the Red River Compact, which applies to Bayou Bartholomew, Beouf River and Bayou Macon (see Section 6.1.6). The commission is made up of one representative from the water agency of each of the member states (ANRC in Arkansas), a resident from each state chosen by the governor, and a federal representative appointed by the US president (Oklahoma Water Resources Board n.d.).

The Delta Regional Authority was established in 2000 to enhance economic development and improve quality of life in the Mississippi River delta region of eight states, including the EAWRPR. These goals are accomplished through improvements to infrastructure, funded by grants from the Delta Regional Authority, to support job creation and retention. Infrastructure improvements include improvement of water supply and wastewater infrastructure. This organization is managed by a board made up the governors from each of the eight states, and a federal representative appointed by the US president and confirmed by the US Senate (Delta Regional Authority 2013b).

The Lower Mississippi River Conservation Committee is a coalition of natural resources and environmental quality agencies from the six states that border the lower Mississippi River, supported by the US Fish and Wildlife Service. This committee provides a regional forum for conservation of the natural resources of the Mississippi River floodplain. The committee addresses long-term conservation and restoration planning and implementation, and nature-based economic development in the Mississippi River floodplain (Lower Mississippi River Conservation Committee 2013).

The Lower Mississippi River Joint Venture is a non-regulatory partnership of non-government, state, and federal conservation organizations focused on implementing the National Waterfowl Management Plan (see Section 5.3.1.5). The management board for this joint venture project includes wildlife agencies from eight states, Ducks Unlimited, The Nature Conservancy, The Conservation Fund, NRCS, USFWS, USGS, and USFS (Lower Mississippi River Joint Venture 2013).

The Arkansas Conservation Partnership supports locally-led natural resources conservation through coordination of education, financial, and technical assistance to landowners. Water resources and implementation of Farm Bill programs are two of the six natural resource issues that are the focus of the partnership. Members of the partnership include the NRCS, other federal agencies, ANRC, Arkansas Association of Conservation Districts, U of A Cooperative Extension, U of A at Pine Bluff, and Arkansas Forestry Commission. This partnership was formed in 1992 (ANRC 2012d, Cooperative Conservation America n.d.).

The Arkansas Watershed Advisory Group (AWAG) provides technical assistance to form local watershed groups, hosts an annual water quality conference, and facilitates quarterly discussions of voluntary water quality management approaches. AWAG is a consortium of federal and state agencies with private citizens (ANRC 2012d).

6.2.4 Regional and Local Entities

There are numerous regional and local entities in the EAWRPR that are involved in activities related to water resources management. Examples of the types of local and regional entities present in this planning region are shown in Table 6.22, along with descriptions of their activities related to water resources management.

Table 6.22. Some of the regional and local government entities involved in water resources management in the EAWRPR.

Regional or Local Entity	Water Resources Involvement
Local Conservation Districts	Work with state and federal agencies to implements measures for the control of erosion and flooding, and conservation of soil and water resources
County Government	Responsible for unincorporated areas, sometimes including floodplain management and zoning
Drainage Districts	Usually created by circuit court order to plan, construct, and maintain a system to drain lands
Improvement Districts	Created by circuit court order to implement federal projects for improvement of any river, tributary, or stream bordering the state
Irrigation Districts	Created by circuit court order to distribute water resources
Levee Districts	Provide for the construction and maintenance of levees for flood protection
Red River Compact Commission	Administers the Red River Compact
Regional Planning and Economic Development Districts	• Water supply and wastewater infrastructure improvements • Assist Regional Solid Waste Management Districts
Regional Solid Waste Management Districts	Manage collection, disposal, and recycling of solid waste
Regional Water Distribution Districts	Public nonprofit organizations for distribution of water from federal water projects
Southeast Arkansas Regional Planning Commission	Stormwater management education and outreach
Universities	Water resources and management research, education, and outreach
Water districts and associations	Water supply planning and management

6.2.5 Nonprofit Organizations

There are several nonprofit organizations that conduct activities in the EAWRPR that are related to water resources management. These organizations are listed in Table 6.23 with a description of their water resources related activities in the planning region.

Table 6.23. Examples of nonprofit groups involved in water resources management in the EAWRPR.

Nonprofit	Water Resources Involvement
Arkansas Environmental Federation	Advocate for industry
Arkansas Farm Bureau	Advocate for agriculture
Arkansas Rural Water Association	Support of rural water and wastewater utilities
Arkansas Water Works and Water Environment Association	Support of water and wastewater utilities
Arkansas Waterways Association	Promotes and protects Arkansas inland transportation waterways
Arkansas Wildlife Federation	Conservation of aquatic habitat for fish and wildlife
Audubon Arkansas	Ten Important Bird Areas in the planning region include wildlife management areas, Stuttgart airport, and Lake Chicot
Ducks Unlimited	Conservation and restoration of aquatic habitat for waterfowl
ECO	Water quality monitoring on Bayou Bartholomew and L’Anguille River
Stream teams	Water quality monitoring, stream bank rehab, restoration of fish habitat
The Nature Conservancy	Big Woods priority area Cache River priority area Benson Creek preserve Burke Crowley’s Ridge Preserve Conservation forestry at Pine City
Watershed organizations (at least 5)	Water resources planning, Sponsor for water quality and quantity projects

6.2.6 Institutional Interactions in Water Resources Management

As noted at the beginning of this section, water resources management in the EAWRPR involves numerous entities at multiple scales. Examples of the interactions among federal, state, and local entities that occur in water resources management in the EAWRPR are presented in Table 6.24.

Table 6.24. Examples of interactions of federal, state, and local entities in water resources management within the EAWRPR.

State Water Resources Responsibility/Program	Involves: Federal Entities	State Entities	Regional or Local Entities
Water use registration	USGS (houses registration database)	ANRC (program lead)	Water utilities, irrigation districts (water withdrawers)
Dam safety	USACE (federal dams) FEMA (oversight)	ANRC (program lead), AGFC (dam builder), Arkansas Department of Parks and Tourism (dam builder)	Water utilities, municipalities, counties (dam builders)
State climate monitoring	NOAA National Weather Service, NOAA National Climatic Data Center, USGS (precipitation monitoring), USACE (climate monitoring),	ANRC (State Climatologist), Arkansas State Plant Board (monitoring)	Community Collaborative Rain, Hail & Snow Network
Safe Drinking Water Act funding	EPA (funding)	ANRC (program lead)	Water utilities, municipalities/ communities, water districts
Interstate water compacts	NRCS, USGS, USACE	ANRC (state representative)	Red River Compact Commission
Water Resources Conservation Tax Incentives	NRCS	ANRC (program lead), U of A Cooperative Extension Service	Conservation districts
Conservation district grants program	None	ANRC (program lead)	Conservation districts
Community development block water and wastewater grants	HUD (funding)	ANRC (program lead), Arkansas Economic Development Commission	Water utilities, wastewater utilities, water districts, sewer districts
Floodplain management	FEMA	ANRC (certification)	Levee districts, counties, and municipalities
Nonpoint source pollution management	EPA (funding), NRCS (conservation programs), USFS (BMPs), The Nature Conservancy (projects), USDA Farm Services Agency (conservation program)	ANRC (program lead), Universities, Arkansas Water Resources Center, Audubon Arkansas, U of A Cooperative Extension Service, Arkansas Farm Bureau, ADEQ (TMDLs)	Watershed organizations, Conservative districts, water districts, stream teams
Clean Water Act funding program (including nonpoint source and clean water revolving loan fund)	EPA (funding)	ANRC (program lead)	Watershed organizations, sewer districts, municipalities

Table 6.24. Interactions of federal, state, and local entities in water resources management (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
Groundwater protection and management – critical groundwater areas	USGS, USACE (water projects)	ANRC (program lead), Water Well Construction Commission	Counties, Irrigation Districts (water projects)
Wetland and riparian zone tax credit program	None	ANRC (state mitigation banks)	Watershed organizations
Wetland and stream mitigation	USACE (lead)	ANRC (state mitigation banks), AHTD, AGFC, ADEQ, ANHC	Local conservation districts, nonprofit organizations, watershed organizations
Non-riparian water use permitting	None	ANRC (program lead)	Water utilities
Arkansas Recovery Act water and wastewater funding	Recovery Accountability and Transparency Board	ANRC (program lead)	Water utilities, wastewater utilities, water districts, sewer districts
State water utility funding	None	ANRC (program lead)	Water utilities, water districts
State wastewater utility funding	None	ANRC (program lead)	Wastewater utilities, sewer districts
NPDES discharge permits	EPA (oversight, guidance)	ADEQ (program lead)	Dischargers
Underground injection control	EPA	ADEQ (program lead), Arkansas Oil and Gas Commission (program lead)	Dischargers
Wastewater pretreatment program	EPA	ADEQ (program lead)	Dischargers
Water quality standards	EPA	APCEC (regulations), ADEQ (implementation, enforcement), ANRC (groundwater standards), Multi-agency Wetland Planning Team (wetlands nutrient standards)	Interest groups
Water quality assessment	EPA (oversight, guidance), USGS (data), USACE (data)	ADEQ (implementation)	None
TMDLs	EPA (oversight, guidance), USGS (data), USACE (data)	ADEQ (program lead)	None
Storage tank regulation	EPA	ADEQ (program lead)	None
Solid waste management	EPA (oversight)	ADEQ (program lead)	Regional solid waste management districts

Table 6.24. Interactions of federal, state, and local entities in water resources management (continued).

State Water Resources Responsibility/Program	**Involves:**		
	Federal Entities	**State Entities**	**Regional or Local Entities**
Landfill post-closure trust fund	None	ADEQ (program lead)	Regional solid waste management districts
Hazardous waste management	EPA	ADEQ (program lead), AHTD (transport)	Interest groups
Remedial action trust fund	None	ADEQ	Interest groups
Brownfields	EPA	ADEQ	Municipalities
Superfund	EPA	ADEQ	Interest groups
Mining reclamation	US Department of the Interior	ADEQ	Interest groups
Water quality monitoring	EPA (oversight, studies), USGS (monitoring, studies), USACE (monitoring, studies)	ADEQ, ANRC, U of A Water Resources Center (studies), AGFC (stream teams), Arkansas State Plant Board (groundwater monitoring)	Stream teams (monitoring), water utilities (monitoring)
Fish tissue sampling	None	ADEQ (program lead), ADH (consumption advisories), AGFC (sampling)	None
Stormwater management	EPA	ADEQ, U of A Cooperative Extension Service	Counties, municipalities
Spill prevention	EPA	ADEQ	None
Finished drinking water criteria	EPA	ADH	Water utilities, water districts
Source Water Protection	EPA	ADH, Arkansas Water Well Construction Commission	Water utilities (planning)
Consumer Information	EPA	ADH	Water utilities
Regulation of drinking water utilities	EPA	ADH, Arkansas Public Service Commission	Water utilities
Pesticide registration, labeling and classification	EPA	Arkansas State Plant Board	Pesticide distributors and users
Community Forestry	USFS	Arkansas Forestry Commission, Arkansas Urban Forestry Council	Municipalities

Table 6.24. Interactions of federal, state, and local entities in water resources management (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	**State Entities**	**Regional or Local Entities**
Forest stewardship	USFS, USDA Farm Services Agency, NRCS	Arkansas Forestry Commission, AGFC, ANRC, Arkansas Historic Preservation Program, U of A Cooperative Extension Service, Arkansas Natural Heritage Commission	Landowners
Forest Legacy	USFS (funding), Land Trust Alliance	Arkansas Forestry Commission	Landowners
State parks	USACE, National Park Service (funding)	Arkansas Department of Parks and Tourism	Northeast chapter Arkansas Master Naturalists
Stream teams	None	AGFC	Northeast chapter Arkansas Master Naturalists
Wildlife management areas, refuges	USFWS	AGFC	Nonprofit organizations
Fishing and boating programs	USACE, USFWS	AGFC, Arkansas Department of Parks and Tourism	None
Pollution prevention program	EPA	ADEQ	Municipalities
Commercial navigation	USACE Memphis and Little Rock Districts	Arkansas Waterways Commission	None
Federal irrigation projects	USACE Memphis and Vicksburg Districts, USDA Natural Resources Conservation Service	ANRC	Irrigation Districts, Regional Water Distribution Districts

7.0 REFERENCES

Adamski, J. C., J. C. Petersen, D. A. Freiwald, and J. V. Davis. 1995. *Environmental and hydrologic setting of the Ozarks Plateaus study unit, Arkansas, Kansas, Missouri, and Oklahoma.* U.S. Geological Survey Water-Resources Investigations Report 94-4022, USGS.

ADEQ. 2009a. *2008 Integrated Water Quality Monitoring and Assessment Report.* Water Division, Little Rock, AR: Arkansas Department of Environmental Quality, 350.

ADEQ. 2009b. *2008 List of Impaired Waterbodies (303(d) List.* Little Rock, AR: Arkansas Department of Environmental Quality, Water Division.

ADEQ. 2011. *Timeline of Historical Events of Arkansas Solid Waste Management, 1971 - 2011.* Little Rock: Arkansas Department of Environmental Quality.

ADEQ. 2012a. *Arkansas Hazardous Waste Generators Facility Summary.* http://www.adeq.state.ar.us/hazwaste/rcra2/facil_sum.asp (accessed May 14, 2013).

ADEQ. 2012b. *Arkansas TMDLs.* http://www.adeq.state.ar.us/water/tmdls/default.asp#Display (accessed April 12, 2013).

ADEQ. 2012c. *State of Arkansas Nutrient Criteria Development Plan.* Little Rock: Arkansas Department of Environmental Quality.

ADEQ. 2012d. *2012 Integrated Water Quality Monitoring and Assessment Report.* Little Rock: Arkansas Department of Environmental Quality.

ADEQ. 2013a. *ADEQ Facility and Permit Summary.* http://www.adeq.state.ar.us/home/pdssql/pds.asp (accessed March 13, 2013).

ADEQ. 2013b. *NPDES Industrial Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/industrial/npdes_industrial_permit_tracking.asp (accessed July 10, 2013).

ADEQ. 2013c. *NPDES Construction Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/construction/npdes_constructionstormwater_permit_tracking.asp (accessed July 2, 2013).

ADEQ. 2013d. *NPDES MS4 Small Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/ms4/npdes_ms4_stormwater_permit_tracking.asp (accessed July 2, 2013).

ADEQ. 2013e. *Surface Water Quality Monitoring Station Data Search Page.* http://www.adeq.state.ar.us/techsvs/water_quality/water_quality_station.asp (accessed July 24, 2013).

ADEQ. 2013f. *Star Starrett Facility*. Arkansas's Remedial Action Trust Fund. http://www.adeq.state.ar.us/ftproot/Pub/hw/PriorityList/pdf/Star%20Starrett%20SPL%20Summary.pdf (accessed January 17, 2014).

ADH. 2011a. *Environmental Epidemiology*. http://www.healthy.arkansas.gov/programsServices/epidemiology/Environmental/Pages/default.aspx (accessed June 19, 2013).

ADH. 2011b. "Marine Sanitation." *Arkansas Department of Health.* http://www.healthy.arkansas.gov/programsServices/environmentalHealth/MarineSanitation/Pages/MarineSanitation.aspx (accessed July 26, 2013).

ADH. 2012. "Arkansas Public Water System Compliance Summary." *Arkansas Department of Health, Environmental Health, Engineering, Reports and Forms.* http://www.healthy.arkansas.gov/programsServices/environmentalHealth/Engineering/Documents/Reports/Compliance/ComplianceSummary.pdf (accessed July 30, 2013).

ADH. n.d. *Drinking Water Information for Arkansans.* http://www.healthy.arkansas.gov/eng/autoupdates/pwslist0.htm (accessed March 20, 2013).

ADH, AGFC, ADEQ. 2011. *Fish Consumption Notice - Mercury in Fish.* Little Rock: Arkansas Department of Health.

ADPCE. 1990. *Arkansas Water Quality Inventory Report 1990.* Little Rock: Arkansas Department of Pollution Control and Ecology.

AGFC. 2009.*Wildlife Management Area Boundary (polygon)*, *Arkansas*. Geocommons. http://geocommons.com/overlays/18197 (accessed April 25, 2013).

AGFC.2011. *Wildlife Management Areas.* http://www.agfc.com/hunting/pages/wmalist.aspx (accessed March 22, 2013).

AGFC. 2013a. *General Fishing Regulations.* http://www.agfc.com/fishing/pages/fishingregulations.aspx (accessed September 18, 2013).

AGFC. 2013b. *The Great Outdoors, A $1.8 Billion Business in Arkansas.* brochure, Little Rock: Arkansas Game and Fish Commission.

AHTD. 2006. *Public Land Boundary (polygon).* GeoStor. http://www.geostor.arkansas.gov/G6/Home.html?q=public+land+boundary (accessed April 25, 2013).

Albin, D. R., M. S. Hines, and J. W. Stephens. 1967. *Water resources of Jackson and Independence Counties, Arkansas.* US Geological Survey Water Supply Paper 1839-G, USGS.

Anderson, J.E. (ed.). 2006. *Arkansas Wildlife Action Plan.* Little Rock: Arkansas Game and Fish Commission.

ANHC. 2010. *Natural Areas.* http://www.naturalheritage.com/natural-area/default.aspx (accessed March 22, 2013).

ANHC. 2013. *Rare Species Search Engine: Find Arkansas Endangered Species.* http://www.naturalheritage.com/research-data/rarespecies-search.aspx (accessed July 2013).

ANRC. 2008. *Arkansas ground water protection and management report for 2008, a supplement to the Arkansas Water Plan.* Little Rock, AR: Arkansas Natural Resources Commission.

ANRC. 2010. "Facts About Critical Groundwater Designation." *Arkansas Natural Resources Commission Water Resources Management Division.* http://www.anrc.arkansas.gov/groundwater/gw_designation_graphic.pdf (accessed May 16, 2013).

ANRC. 2011. *Water Law in Arkansas.* Little Rock: Arkansas Natural Resources Commission.

ANRC. 2012a. *Arkansas Ground-Water Protection and Management Report for 2011*. Little Rock: Arkansas Natural Resources Commission.

ANRC. 2012b. *Arkansas Groundwater Protection and Management Report for 2011*. Little Rock: Arkansas Natural Resources Commission.

ANRC. 2012c.*Status Report to Legislative Council on Grand Prairie and Bayou Meto Projects.* Little Rock: Arkansas Natural Resources Commission.

ANRC. 2012d. "2011-2016 Nonpoint Source Pollution Management Plan." http://arkansaswater.org/data/Full_NPSPlan_Document.pdf (accessed April 17, 2013).

APCEC. 2011. *Regulation No. 2, Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas.* Little Rock: Arkansas Pollution Control and Ecology Commission.

Arkansas Department of Emergency Management. 2010. *All Hazard Mitigation Plan, State of Arkansas.* Little Rock: Arkansas Department of Emergency Management.

Arkansas Department of Parks and Tourism. 1991. *1990 Arkansas Travel and Tourism Report.* Little Rock, AR: Arkansas Department of Parks and Tourism.

Arkansas Department of Parks and Tourism. 2005a. *Lower White River Museum State Park.* park information brochure, Ltitle Rock: Arkansas Department of Parks and Tourism.

Arkansas Department of Parks and Tourism. 2005b. *Delta Heritage State Park.* Park information brochure, Little Rock: Arkansas Department of Parks and Tourism.

Arkansas Department of Parks and Tourism. 2012. *2012 Annual Report*. Arkansas Tourism Official Site. http://www.arkansas.com/!userfiles/editor/docs/apt-annual-report-financials-2012.pdf (accessed June 2013).

Arkansas Electric Cooperative Corporation. *LIHI Certificate #51 --- Arkasnas River Dam No. 2 Hydroelectric Project (FERC No. 3033) Arkansas River, Arkansas.* Low Impact Hydropower Institute Certified Facilities. http://www.lowimpacthydro.org/lihi-certificate-51-arkansas-river-dam-no.2-hydroelectric-project-ferc-no.-3033-arkansas-river-arkansas.html (accessed November 19, 2013).

Arkansas Farm Bureau. 2012. *Arkansas Agricultural Profile.* Little Rock: Farm Bureau.

Arkansas Farm Bureau. 2013. *Farm Bureau Arkansas, Arkansas Ag Data.* http://www.arfb.com/ag-markets- Arkansas Farm Bureau statistics/arkansas-ag-data/default.aspx (accessed April 22, 2013).

Arkansas Oil and Gas Commission. 2013. *Google Earth Maps.* Arkansas Oil and Gas Commission. October 24, 2013. http://www.aogc.state.ar.us/Maps_GoogleEarth.htm (accessed October 24, 2013).

Arkansas Geological Survey. 2012. *Mississippi River Alluvial Plain, Geology.* http://www.geology.ar.gov/education/geo_mississippi_plain.htm (accessed March 2013).

Arkansas Geological Survey. n.d. *Physiographic Regions.* http://www.geology.ar.gov/education/physio_regions.htm (accessed March 2013).

Arkansas Multi-agency Wetland Planning Team. 2001. *Wetlands in Arkansas.* http://www.mawpt.org/wetlands/loss_gain.asp (accessed March 18, 2013).

Arkansas Multi-agency Wetlands Planning Team. 1995. *Arkansas Wetland Resource Information System, Arkansas State Wetland Strategy.* http://awrims.cast.uark.edu/home/ar-wetland-strategy.aspx (accessed March 2013).

Arkansas Water. 2013. *ArkansasWater.org.* http://arkansaswater.org/index.php?option=com_content&view=article&id=29&Itemid=2 (accessed June 25, 2013).

Arkansas Waterways Association. 2011. *Ark-White Cutoff.* http://arkansaswaterways.com/navigablewaterways/ouachitaredwhiterivers.html (accessed November 21, 2013).

Arkansas Waterways Commission. 2013. *2011-2012 Biennial.* Biennial report, Little Rock: Arkansas Waterways Commission.

Arkansas Waterways Commission. 2012a. *Arkansas Waterways Commission, Rivers.* http://waterways.arkansas.gov/rivers/Pages/default.aspx (accessed March 18, 2013).

Arkansas Waterways Commission. 2012b. *White River.* http://waterways.arkansas.gov/rivers/Pages/whiteRiver.aspx (accessed April 11, 2013).

ASWCC. 1981. *Arkansas State Water Plan, Lakes of Arkansas.* Little Rock: Arkansas Soil and Water Conservation Commission.

ASWCC. 1984. *Arkansas State Water Plan Boeuf-Tensas basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

ASWCC. 1987.*Arkansas State Water Plan Lower Ouachita Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

ASWCC. 1988. *Arkansas State Water Plan Eastern Arkansas Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

ASWCC. 1990. *Arkansas Water Plan Executive Summary.* Little Rock: Arkansas Soil and Water Conservation Commission, Balogh, George W. 2012. *Encyclopedia of Arkansas History and Culture - Timber Industry*. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2143&type=Category&item=Industries&parent=Business+and+Economics&grandparent= (accessed March 18, 2013).

Bayou Meto Water Management District. 2013. *Bayou Meto Water Management Project.* http://www.bayoumetowatermanagementproject.com/ProjectStatus.html (accessed June 25, 2013).

Bedinger, M.S., and H.G. Jeffrey. 1964. *Groundwater in the Lower Arkansas River Valley.* Water Supply Paper 19669-v, Little Rock: US Geological Survey.

Bolton, S. Charles. 1995. *25 Years Later A History of the McClellan-Kerr Arkansas River Navigation System in Arkansas.* Little Rock: USACE Little Rock District.

Bolton, S. Charles. 2012. *Louisiana Purchase through Early Statehood, 1803 through 1860*. http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Broom, Matthew E., and Forest P. Lyford. 1981. *Alluvial Aquifer of the Cache and St. Francis River Basins, Northeastern Arkansas.* Open-file Report 81-476, Little Rock: US Geological Survey.

Bryant, C.T., A.H. Ludwig, and E.E. Morris. 1985. *Ground-water Problems in Arkansas.* Water Resources Investigations Report 85-4010, Little Rock: US Geological Survey.

Buckner, Ed. 2011. *Climate and Weather*. Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=4579 (accessed March 15, 2013).

Cavaneau, Jerry. 2012. *Encyclopedia of Arkansas History and Culture - Black River.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryid=4120 (accessed March 18, 2013).

Central Arkansas RSWMD. 2011. *Combined Regional Solid Waste Management Needs Assessment & Plan.* Lonoke: Central Arkansas Regiona Solid Waste Management District.

Clark, B. R., R. M. Hart, and J. J. Gurdak. 2011. *Groundwater availability of the Mississippi embayment.* US Geological Survey Professional Paper 1785, USGS.

Clark, Patterson, and Laris Karklis. January 25, 2012. *USDA Upgrades Plant Hardiness Zone Map.* Washington Post. http://www.washingtonpost.com/wp-srv/special/local/planthardinesszones/index.html (accessed March 2013).

Cooperative Conservation America. n.d. *Cooperative Conservation Case Study, Arkansas Conservation Partnership.* http://www.cooperativeconservation.org/viewproject.asp?pid=103 (accessed July 29, 2013).

Craighead County RSWMD. 2011. *Regional Solid Waste Management Plan for Craighead County Regional Solid Waste Management District.* Jonesboro: Craighead County Regional Solid Waste Management District.

Czarnecki, John B., Phillip D. Hays, and Paul W. McKee. 2002. *The Mississippi River Valley Alluvial Aquifer in Arkansas: A sustainable water resource?* Fact Sheet FS-041-02, Little Rock: US Geological Survey.

Dahl, T.E. 1990. *Wetlands - Losses in the United States, 1780's to 1980's.* Washington, DC: US Fish and Wildlife Service.

DeBlack, Thomas A. 2012. *Civil War through Reconstruction, 1861 through 1874.* http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Delta Regional Authority. 2013a. *Economic Development, Distressed Counties and Parishes.* http://www.dra.gov/econom-devel/project-info/default.aspx (accessed March 2013).

Delta Regional Authority. 2013b. *About DRA.* http://www.dra.gov/about-us/default.aspx (accessed June 26, 2013).

Dickard, Jason. 2013. *Lower Mississippi River Resource Assessment*. Memphis District US Army Corps of Engineers Memphis District Projects. http://www.mvm.usace.army.mil/Portals/51/docs/missions/projects/LMRRA/LMRRA.pdf (accessed June 25, 2013).

Ducks Unlimited. n.d. *Conservation, Mississippi Alluvial Valley.* http://www.ducks.org/conservation/where-we-work/mississippi-alluvial-valley (accessed April 26, 2013).

Early, Anne M. 2011. *Pre-European Exploration, Prehistory through 1540.* http://www.encyclopediaofarkansas.net/ (accessed February 13, 2013).

East Arkansas RSWMD. 2011. *Regional Solid Waste Management Plan for East Arkansas Regional Solid Waste Management District.* Jonesboro: East Arkansas Regional Solid Waste Management District.

Engle, Carole R. 2012. *Aquaculture*. Arkansas Encyclopedia of History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=3640 (accessed September 5, 2013).

EPA. 2008. *Handbook for Developing Watershed TMDLs.* Washington, DC: US Environmental Protection Agency, Office of Wetlands, Oceans & Watersheds.

EPA. 2012a. *Landfills.* http://www.epa.gov/osw/nonhaz/municipal/landfill.htm (accessed June 3, 2013).

EPA. 2012b. *Large Quantity Generators.* http://www.epa.gov/osw/hazard/generation/lqg.htm (accessed July 9, 2013).

EPA. 2012c. *What Are Water Quality Standards?* http://water.epa.gov/scitech/swguidance/standards/about_index.cfm (accessed July 2013).

EPA. 2012d. *State Detail Analysis, The National Biennial RCRA Hazardous Waste Report (Based on 2011 Data).* Washington DC: US EPA.

EPA. 2012e. *Basic Information.* http://water.epa.gov/scitech/swguidance/standards/about_index.cfm (accessed June 11, 2013).

EPA. 2013a. *Western Ecology Division.* www.epa.gov/wed/pages/ecoregions.htm (accessed June 2013).

EPA. 2013b. *National Priorities List.* http://www.epa.gov/superfund/sites/npl/ (accessed July 26, 2013).

EPA. 2013c. *Regulatory Topics.* http://www.epa.gov/lawsregs/topics/#water (accessed March 2013).

EPA. 2013d. *Compensatory Mitigation.* http://water.epa.gov/lawsregs/guidance/wetlands/wetlandsmitigation_index.cfm (accessed June 17, 2013).

EPA. 2013e. *Consumer Confidence Reports.* http://water.epa.gov/lawsregs/rulesregs/sdwa/ccr/index.cfm (accessed June 11, 2013).

EPA. 2013f. *EPA Information Related to the American Recovery and Reinvestment Act of 2009. EPA.* July 12, http://www.epa.gov/recovery/basic.html (accessed April 1, 2014).

EPA. n.d. *EPA Recovery Mapper*. http://epamap17.epa.gov/arra/# (accessed April 2014).

Filipek, Steve, William E. Keith, and John Giese. 1987. *The Status of the Instream Flow Issue in Arkansas*. Proceedings Arkansas Academy of Science Vol. 41: 43-48.

Foti, Thomas. 2008. *The Natural Divisions of Arkansas.* Little Rock: Arkansas Natural Heritage Commission.

Fry, J, et al. 2011. *Completion of the 2006 national land cover database for the conterminous United States*. PE&RS, Vol.77(9): 858-864.

FTN Associates, Ltd. n.d. *Bayou Meto Wetland Planning Area Report*. http://anrc.cast.uark.edu/assets/wetland_rep/bayo_meto.pdf (accessed April 17, 2013).

Fulmer, Robert F, and George L Harp. 1977. *The fishes of Crowley's Ridge in Arkansas.* Arkansas Academy of Sciences Proceedings 31: 42-45.

Galloway, JM, BE Haggard, MT Meyers, and WR Green. 2005. *Occurence of Pharmaceuticals and Other Organic Wastewater Constituents in Selected Streams in Northern Arkansas, Scientific Investigations Report 2005-5140.* Reston, Va: USGS.

GCGW. 2008. *Arkansas Governor's Commission on Globla Warning Final Report.* Little Rock: Arkansas Governor's Commission on Global Warming.

Gonthier, Gerard J., and Barbara A. Kleiss. 1996. *Ground-water Flow Patterns and Water Budget of a Bottomland Forested Wetland, Black Swamp, Eastern Arkansas.* Water Resources Investigation Report 95-4192, Little Rock: US Geological Survey.

Goss, Kay C. 2012. *Encyclopedia of Arkansas History and Culture - McClellan-Kerr Arkansas River Navigation System.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2309&type=Category&item=Water&parent=Transportation&grandparent= (accessed March 18, 2013).

Green, Brooks. 1986. *Irrigation expansion in Arkansas: A preliminary investigation*. Arkansas Historical Quarterly: 261-268.

Hawkins, Van. 2011. *Cotton Industry*. http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Holland, Terrence W. 2007. *Water Use in Arkansas, 2005.* Scientific Investigations Report 2007-5241, Reston: US Geological Survey.

Jackson, Donna Brewer. 2011. *Levees and Drainage Districts*. Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=1165 (accessed September 5, 2013).

Key, Joseph Patrick. 2012. *European Exploration and Settlement, 1951 through 1802*. http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Kleiss, B.A., R.H. Coupe, G.J. Gonthier, and B.J. Justus. 2000. *Water Quality in the Mississippi Embayment, Mississippi, Louisiana, Arkansas, Missouri, Tennessee, and Kentucky, 1995-98.* Circular 1208, USGS.

Kresse, T. M., et al. 2013. *Aquifers of Arkansas: protection, management, and hydrologic and geochemical characteristics of Arkansas' groundwater resources.* USGS In Review (USGS).

Kresse, Timothy M., and Brian R. Clark. 2008. *Occurrence, Distribution, Sources, and Trends of Elevated Chloride Concentrations in the Mississippi River Valley Alluvial Aquifer in Southeast Arkansas.* Scientific Investigations Report 2008-5193, Resont, VA: US Geological Survey.

Lake, Amy. 2010. *A slice of the pie in the Arkansas Delta with Beth Wiedower*. Center for Rural Entrepreneurship. http://www.energizingentrepreneurs.org/site/images/research/es/se/se29.pdf (accessed June 19, 2013).

Lancaster, Guy. 2011. *Red River*. Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2650 (accessed July 16, 2013).

Layher BioLogics RTEC, Inc. n.d. *Bayou bartholomew Wetland Planning Area Report.* http://anrc.cast.uark.edu/assets/wetland_rep/BB_Cover_ToC.pdf (accessed April 17, 2013).

Layher Biologics RTEC, Inc. 2003. *St. Francis River Wetland Planning Area Report.* http://anrc.cast.uark.edu/assets/wetland_rep/StF_Cover_TOC.pdf (accessed April 17, 2013).

Lochmann, Steve. 2013. *Fish*. Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2097 (accessed September 18, 2013).

Lower Mississippi River Conservation Committee. 2013. *Lower Mississippi River Conservation Committee.* http://www.lmrcc.org/who_we_are.htm (accessed March 22, 2013).

Lower Mississippi River Joint Venture. 2013. *Lower Mississippi Joint Venture.* http://www.lmvjv.org/ (accessed June 28, 2013).

Ludwig, A.H. 1992. *Flow Duration and Low-flow Characteristics of Selected Arkansas Streams.* Water Resources Investigations Report 92-4026, Little Rock: US Geological Survey.

Manger, W. L., D. L. Zachry, and M. L. Garrigan. 1988. *An introduction to the geology of northwestern Arkansas.* The Compass: 242-257.

Mayfield, Walter. 2001. *Arkansas Mineral Resources (map)*. Little Rock: Arkansas Geological Commission.

McFarland, J. D. 2004. *Stratigraphic summary of Arkansas*. Arkansas Geological Commission Information Circular: 36-38.

McGraw, Shirley. 2013. *Lonoke County*. Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=787 (accessed July 8, 2013).

Mississippi County RSWMD. 2011. *Regional Solid Waste Management Plan for Mississippi County Regional Solid Waste Management District.* Blytheville: Mississippi County Regional Solid Waste Management District.

Mississippi River Commission. 2008. *The Mississippi River & Tributaries Project: Backwater Areas*. Mississippi Valley Division US Army Corps of Engineers. http://www.mvd.usace.army.mil/Portals/52/docs/Backwater_Areas_info_paper.pdf (accessed September 5, 2013).

Mississippi River Commission. 2007. *The Mississippi River & Tributaries Project: History of the Lower Mississippi River Levee System*. Mississippi Valley Division US Army Corps of Engineers. http://www.mvd.usace.army.mil/Portals/52/docs/Levees%20info%20paper.pdf (accessed September 5, 2013).

Morrow, Lynn A. n.d. *Duck and Goose Shambles: Sportsmen and market hunters at Big Lake, Arkansas*. Big Muddy. http://www6.semo.edu/universitypress/bigmuddy/NF/A_Duck_and_Goose_Shambles.htm (accessed September 16, 2013).

Nachtmann, Heather. 2002. *Economic Evaluation of the Impact of Waterways on the State of Arkansas.* Fayetteville: University of Arkansas.

National Agricultural Law Center. 2012. *United States Farm Bills.* http://www.nationalaglawcenter.org/farmbills/ (accessed June 11, 2013).

National Weather Service Weather Forecast Office Little Rock AR. 2013. *Climate Data.* http://www.srh.noaa.gov/lzk/?n=wxcntl3.htm (accessed June 12, 2013).

NatureServe. 2002. *Number of Extince Species in Each State.* http://www.natureserve.org/consIssues/ivoryBilled_table1.htm (accessed December 19, 2013).

NOAA. 2012. *NOAA's Drought Information Center, the Palmer Drought Severity Index.* http://www.drought.noaa.gov/palmer.html (accessed June 12, 2013).

NOAA NCDC. 2013a. *Climate Data Online: Text and Map Search.* http://www.ncdc.noaa.gov/cdo-web/#t=secondTabLink (accessed May 2013).

NOAA NCDC. 2013b. *Historical Palmer Drought Indices.* September 4, http://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers.php (accessed May 15, 2013).

NOAA NCDC. 2013c. *Plot Time Series.* http://www.ncdc.noaa.gov/temp-and-precip/time-series/index.php (accessed June 2013).

NOAA NCDC.n.d. *Climate of Arkansas*. National Climatic Data Center. http://hurricane.ncdc.noaa.gov/climatenormals/clim60/states/Clim_AR_01.pdf (accessed May 15, 2013).

Northeast Arkansas RSWMD. 2011.*January 1, 2011 Annual Update of the Year 2004 Solid waste Management Plan.* Paragould: Northeast Arkansas Regional Solid Waste Management District.

NRCS. 2011. *Active Irrigation Projects.* http://www.ar.nrcs.usda.gov/programs/watersheds_irrigation_active.html (accessed June 18, 2013).

NRCS. 2012. "Arkansas Annual Report 2012." *NRCS Arkansas.* http://www.ar.nrcs.usda.gov/news/annual_report_2012.html (accessed July 15, 2013).

NRCS. 2013a. *Arkansas NRCS Conservation Programs.* http://www.nrcs.usda.gov/wps/portal/nrcs/main/ar/programs/ (accessed September 17, 2013).

NRCS. n.d. *Arkansas, Major Land Resource Areas.* http://www.ar.nrcs.usda.gov/soils/mo16_mlra.html (accessed March 2013).

Oklahoma Water Resources Board. n.d. *Red River Compact Commission.* http://www.owrb.ok.gov/rrccommission/graphics/reach_2_5.jpg (accessed June 14, 2013).

PRISM Climate Group. 2004. Corvallis: Oregon State University.

Pugh, A.L., D.A. Westerman. 2014. *Mean Annual, Seasonal, and Monthly Precipitation and Runoff in Arkansas, 1951-2011.* US Geological Survey Scientific Investigations Report 2014-5006. Reston, VA: USGS.

Ramsar Convention. 2013. *Ramsar Sites Information Service.* http://ramsar.wetlands.org/Database/SearchforRamsarsites/tabid/765/Default.aspx (accessed June 28, 2013).

Red River Compact Commission. 1978. *Red River Compact.* Red River Compact Commission,

Region 6 EPA. *Arkansas Site Status Summaries.* 2013. http://www.epa.gov/region6/6sf/6sf-ar.htm (accessed June 15, 2013).

Renken, R. A. 1998. *Arkansas, Louisiana, Mississippi HA 730-F*. Groundwater Atlas of the United States, HA 730, by US Geological Survey. Reston, VA: US Geological Survey.

Robison, Henry W., and Thomas M. Buchanan. 1988. *Fishes of Arkansas.* Fayetteville: University of Arkansas Press.

Rogers, Aaron W. 2013. *Encyclopedia of Arkansas History and Culture - White River.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2310&type=Category&item=Water&parent=Transportation&grandparent= (accessed March 18, 2013).

Rural Heritage Development Initiative. 2008. *Arkansas Delta Soil and Soul.* http://arkansasdelta.org/ (accessed June 19, 2013).

Saucier, R. T. 1994. *Geomorphology and Quaternary geologic history of the Lower Mississippi Valley, Volume I.* Vicksburg, MS: U.S. Army Corps of Engineers, Waterways Experiment Station.

Scott, H. Don, James A. Ferguson, Linda Hanson, Todd Fugitt, and Earl Smith. 1998. *Agricultural Water Management in the Mississippi Delta Region of Arkansas. Research Bulletin 959.* Fayetteville: University of Arkansas.

Sharif, S. U., et al. 2008a. *Distribution and variability of redox zones controlloing spatial variability of arsenic in the Mississippi River Valley alluvial aquifer, southeastern Arkansas.* Journal of Contaminant Hydrology: 49-67.

Sharif, S. U., R. K. Davis, K. F. Steele, K. Burmshik, T. M. Kresse, and J. A. Fazio. 2008b. *Inverse geochemical modeling of groundwater evolution with emphasis on arsenic in the Mississippi River Valley alluvial aquifer, Arkansas, USA*. Journal of Hydrology: 41-55.

Sharif, S. U., et al. 2011. *Surface complexation modeling for predicting solid phase arsenic concentrations in the sediments of the Mississippi River alluvial aquifer, Arkansas, USA.* Applied Geochemistry: 496-504.

Shoults, Lenore. 2011. *Encyclopedia of Arkansas History and Culture - Pearl Rush.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=6576 (accessed March 18, 2013).

Shrum, Bill. 2012. *Stuttgart (Arkansas County)*. Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=820 (accessed September 17, 2013).

Southeast Arkansas RSWMD. 2011. *Regional Solid Waste Management Plan Update for Southeast Arkansas Regional Solid Waste Management District.* Pine Bluff: Southeast Arkasnas Regional Solid Waste Management District.

Steele, K. F., S. S. Hill, T. W. Nichols, H. D. Scott, P. Vendrell, and H. S. Lin. 1994. *Completion Report - ground water monitoring project for Arkasnas phase III.* MSC-197, Fayetteville, AR: Arkansas Water Resources Center.

Stewart-Abernathy, Leslie C. 2011a. *Cherokee.* http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Stewart-Abernathy, Leslie C. 2011b. *Encyclopedia of Arkansas History and Culture - Steamboats.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=4466&type=Category&item=Water&parent=Transportation&grandparent= (accessed March 18, 2013).

Stone, Nathan, Larry Dorman, and Hugh Thomforde. 2010. *Baitfish Industry*. Arkansas Encyclopedia of History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=3641 (accessed September 5, 2013).

Stroud, Hubert B. 2011. *Encyclopedia of Arkansas History and Culture: Crowley's Ridge*. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=12&type=Category&item=Six+Natural+Divisions&parent=Geography&grandparent=Land+and+Resources (accessed March 15, 2013).

Stroud, Hubert B. 2012. *Encyclopedia of Arkansas History and Culture: Mississippi Alluvial Plain.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=444&type=Category&item=Six+Natural+Divisions&parent=Geography&grandparent=Land+and+Resources (accessed March 15, 2013).

Terry, J. E., C. T. Bryant, A. H. Ludwig, and J. E. Reed. 1986. *Water-Resources Appraisal of the South-Arkasnas Lignite Area.* Arkansas Geological Commission Information Circular 28-D, Arkansas Geological Commission.

The Nature Conservancy. 2013. *Arkansas Places We Protect.* http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/arkansas/placesweprotect/index.htm (accessed March 22, 2013).

Turner, Ellen E. 2001. *Crowley's Ridge: An Upland in the Lowlands.* Little Rock: Butler Center.

University of Arkansas at Little Rock Institute for Economic Advancement. 2002. *Index for Arkansas State and Counties Population and Social/Economic Characteristics by County 1990 Census of Population and Housing*. http://iea.ualr.edu/arkansas-census-data.html?id=174:index-for-arkansas-state-and-counties&catid=1 (accessed June 18, 2013).

University of Arkansas Divison of Agriculture. 2012. *Economic Contribution of Arkansas Agriculture.* Little Rock: University of Arkansas Division of Agriculture.

University of Georgia - Center for Invasive Species and Ecosystem Health. 2013. *Invasive Plant Atlas of the United States.* www.invasiveplantatlas.org (accessed December 20, 2013).

US Census Bureau. 1993. *1992 Economic Census Area Profile, Arkansas.* Economic Census. http://www.census.gov/epcd/www/92profiles/AR_92PRF.TXT (accessed May 29, 2013).

US Census Bureau. 2003. *Arkansas: 2000 Population and Housing Unit Counts.* Washington DC: US Census Bureau.

US Census Bureau. 2011a. *Urban Area Criteria for the 2010 Census*. Federal Register, 76 (164): 53033-53043.

US Census Bureau. 2011b. *EC0700A1, All Sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007 Economic Census*. American FactFinder. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_00A1&prodType=table (accessed March 26, 2013).

US Census Bureau. 2012a. *Arkansas 2010: Population and Housing Unit Counts.* Washington, DC: US Department of Commerce.

US Census Bureau. 2012b. *Table 20. Large Metropolitan Statistical Areas - Population 1990 to 2010. www.census.gov*. http://www.census.gov/compendia/statab/2012/tables/12s0020.pdf (accessed March 12, 2013).

US Census Bureau. n.d.a. *DP05 ACS Demographic and Housing Estimates 2007-2011 American Community Survey 5-year Estimates*. American FactFinder. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_11_5YR_DP05&prodType=table (accessed March 2013).

US Census Bureau. n.d.b. *DP03 - Selected Economic Characteristics, 2007-2011 American Community Survey 5-year Estimates.* http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_11_5YR_DP03 (accessed March 18, 2013).

US Census Bureau. 1996. *1992 Census of Transportation, Communitcations, and Utilities - 1993 Commodity Flow Survey Arkansas.* TC92-CF-4, Washington DC: US Department of Commerce.

US Congress. 1992. *Clean Vessel Act of 1992*. Digest of Federal Laws of Interest to the U.S. Fish and Wildlife Service. http://www.fws.gov/laws/lawsdigest/clenves.html (accessed July 12, 2013).

US Department of Commerce. 1994. *1992 Census of Agriculture, Volume 2 Subject Series, Part 3 Ranking of States and Counties.* Washington, DC: US Department of Commerce.

US Department of Commerce Bureau of the Census. 1977. *1974 Census of Agriculture Volume 1 Part 4 Arkansas State and County Data.* Washington DC: US Department of Commerce.

US Department of Commerce Bureau of the Census. 1984. *1982 Census of Agriculture Volume 1 Geographic Area Services Part 4 Arkansas State and County Data.* Washington DC: US Department of Commerce.

US Department of Commerce Bureau of the Census. 1989. *1987 Census of Agriculture Volume 1 Geographic Area Series Part 4 Arkansas State and County Data.* Washington, DC: US Government Printing Office.

USACE. 2011. *Value to the Nation State Level Report - Arkansas.* http://www.corpsresults.us/recreation/fastfacts/stateReport.cfml?State=12 (accessed October 2013).

USACE. 2013. *Regulatory In-lieu Fee and Bank Information Tracking System (RIBITS).* https://rsgisias.crrel.usace.army.mil/ribits/f?p=107:158:2210333181022334::NO:RP:P27_BUTTON_KEY:1 (accessed November 18, 2013).

USACE Institute for Water Resources. 2011. *Waterborne Commerce of the United States, Calendar Year 2011, Part 2-Waterways and Harbors Gulf Coast, Mississippi River System and Antilles.* Alexandria, VA: USACE.

USACE Institute for Water Resources. n.d. *Locks by Waterway Lock Commodity CY 1993 - 2012*. Waterborne Commerce Statistics Center. http://www.navigationdatacenter.us/lpms/cy2012comweb.htm (accessed November 19, 2013).

USACE Little Rock District. 1987. *Arkansas State Water Plan Upper White River Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

USACE Little Rock District. 1988. *Arkansas State Water Plan, Arkansas River Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

USACE Little Rock District. 2012. *Three Rivers, AR.* US Army Corps of Engineers Southwestern Division. http://www.swd.usace.army.mil/Portals/42/docs/FY13%20Three%20Rivers%20Study,%20AR.pdf (accessed November 19, 2013).

USACE Memphis District. 2012. *Arkansas Projects.* http://www.mvm.usace.army.mil/Portals/51/docs/missions/projects/Projects%20By%20State/AR_Projects.pdf (accessed March 20, 2013).

USACE Memphis District. 2013. *Arkansas projects*. Memphis District Projects. http://www.mvm.usace.army.mil/Portals/51/docs/missions/projects/Projects%20By%20State/WEB%20Pages%20ARKANSAS.pdf (accessed November 19, 2013).

USACE Vicksburg District. 1984. *Arkansas State Water Plan Special Report in the Grand Prairie Agricultural Water Supply*. Little Rock: Arkansas Soil and Water Conservation Commission.

USACE Vicksburg District. 2013. *Vicksburg District Mitigation Banks.* US Army Corps of Engineers Vicksburg District. http://www.mvk.usace.army.mil/Portals/58/docs/regulatory/District_%20Mitigation_%20Banks.pdf (accessed July 2013).

USDA National Agricultural Statistical Service. 2006.*Census of Aquaculture (2005)* . Washington DC: USDA National Agricultural Statistical Service.

USDA National Agricultural Statistical Service. 2009.*2007 Census of Agriculture Arkansas State and County Data Volume 1 Geographic Area Series Part 4.* Washington DC: USDA.

USDA National Agricultural Statistics Service. 2007. *2007 Census of Agriculture State Profile, Arkansas.* Washington, DC: USDA National agricultural Statistics Service.

USFS. 2013. *Forest Inventory Data Online (FIDO).* http://apps.fs.fed.us/fia/fido/index.html (accessed September 13, 2013).

USFWS. 2007. *Best Management Practices for Fayetteville Shale Natural Gas Activities.* Conway: US Fish and Wildlife Service.

USFWS. 2013a. *National Wildlife Refuge System.* http://www.fws.gov/southeast/refuges/refuges-by-state.html#arkansas (accessed September 16, 2013).

USFWS. 2013b. *Endangered Species Act: Overview*. http://www.fws.gov/endangered/laws-policies/index.html (accessed March 13, 2013).

USFWS; US Department of Commerce Bureau of the Census. 1993. *1991 National Survey of Fishing, Hunting, and Wildlife-associated Recreation, Arkansas.* Washington, DC: US Government Printing Office.

USFWS; US Department of Commerce Census Bureau. 2013. *2011 National Survey of Hunting, Fishing, and Wildlife-associated Recreation - Arkansas.* Washington, DC: US Fish and Wildlife Service.

USGS. 2005. *Water Use Data for Arkansas.* http://waterdata.usgs.gov/ar/nwis/water_use?wu_year=ALL&wu_area=County&wu_county=ALL&wu_category=AQ&submitted_form=introduction (accessed September 9, 2013).

USGS. 2009. *USGS Water Use Data for Arkansas.* http://waterdata.usgs.gov/ar/nwis/wu (accessed July 8, 2013).

USGS. 2012. *2008 Minerals Yearbook, Arkansas.* USGS.

USGS. 2013a. USGS. ftp://nhdftp.usgs.gov/DataSets/Staged/States/FileGDB/HighResolution/NHDH_AR_931v210.zip (accessed October 19, 2013).

USGS. 2013b. *Surface-water monthly statistics for the nation.* http://waterdata.usgs.gov/nwis/monthly/?referred_module=sw (accessed June 19, 2013).

USGS. 2013c. *USGS Water Quality Data for Arkansas.* http://waterdata.usgs.gov/ar/nwis/qw (accessed July 25, 2013).

USGS. 2013d. *NAS - Non Aquatic Species.* http://nas.er.usgs.gov/default.aspx (accessed December 19, 2013).

Westerfield, P. W. 1994. *Potentiometric-surface maps of the Cockfield and lower Wilcox Aquifers in Arkansas, 1991.* US Geological Survey Water-Resources Investigation Report 93-4137, USGS.

Westerman, D.A, K.R. Merriman, J.L. De Lanois, and Charles Berenbrock. 2013. *Analysis and Inundation Mapping of the April-May 2011 Flood at Selected Locations in Northern and Eastern Arkansas and Southern Missouri.* Scientific Investigations Report 2013-5148, Reston: US Geological Survey.

White River RSWMD. 2011. *2011 Regional Solid Waste Management Plan, Regional Needs Assessment, Annual Waste Tire Report, Annual Recycling Program Report.* Batesville: White River Regional Solid Waste Management District.

White, Mel.2011. *Birds*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=4510 (accessed November 2013).

White, Mel. 2010. *Mississippi Flyway*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=5926 (accessed November 2013).

Williams, C. Fred. 2012. *Agriculture*. Arkansas Encyclopedia of History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=385 (accessed September 5, 2013).

Woods, Alan J, T Foti, S. Chapmen, J. Omnerick, J. Wise, E. Murray, W. Prior, J. Pagan Jr., J. Comstock, M Radford. 2004. *Ecoregions of Arkansas (color poster with map, descriptive text, summary tables, and photographs).* Reston, VA: US Geological Survey.

Zbinden, Van. 2011. *St. Louis Southwestern Railway*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=5104 (accessed August 20, 2013).

ARKANSAS WATER PLAN UPDATE
TASK NO. 6 - WEST-CENTRAL ARKANSAS WATER RESOURCES PLANNING REGION

AUGUST 11, 2014

ARKANSAS WATER PLAN UPDATE
TASK NO. 6 - WEST-CENTRAL ARKANSAS
WATER RESOURCES PLANNING REGION

Prepared for

Arkansas Natural Resources Commission
101 East Capitol Avenue, Suite 350
Little Rock, AR 72201-3813

Prepared by

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, Arkansas 72211

FTN No. 03015-0003-001

August 11, 2014

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF APPENDICES

LIST OF FIGURES

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF ACRONYMS

ADEM	Arkansas Department of Emergency Management
ADEQ	Arkansas Department of Environmental Quality
ADH	Arkansas Department of Health
ADPCE	Arkansas Department of Pollution Control and Ecology (now ADEQ)
AECC	Arkansas Electric Cooperative Corporation
AGFC	Arkansas Game and Fish Commission
AHTD	Arkansas State Highway and Transportation Department
ANHC	Arkansas Natural Heritage Commission
ANO	Arkansas Nuclear One
ANRC	Arkansas Natural Resources Commission
APCEC	Arkansas Pollution Control and Ecology Commission
ARPMC	Arkansas Plant Materials Center
ARRA	American Recovery and Reinvestment Act
ASWCC	Arkansas Soil and Water Conservation Commission (now ANRC)
AWAG	Arkansas Watershed Advisory Group
AWP	Arkansas Water Plan
BCE	Before Common Era
BMP	Best Management Practice
CAW	Central Arkansas Water
CCA	Copper Chromated Arsenate
CE	Common Era
cfs	Cubic feet per second
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
CWA	Clean Water Act
DO	Dissolved Oxygen
E. coli	Escherichia coli
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
GCGW	Governor's Commission on Global Warming
gpm	Gallons per minute
gpd	Gallons per day
HUD	United States Department of Housing and Urban Development
L&D	Lock and Dam
mgd	Million gallons per day
mg/L	Milligrams per liter
MKARNS	McClellan-Kerr Arkansas River Navigation System
MS4	Municipal Separate Storm Sewer System
NCDC	National Climatic Data Center

n.d.	No date
NFIP	National Flood Insurance Program
NLRE	North Little Rock Electric
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRC	United States Nuclear Regulatory Commission
NRCS	United States Department of Agriculture Natural Resources Conservation Service
NWR	National Wildlife Refuge
NWS	National Weather Service
PADD	Planning and Development District
PAH	Polynuclear aromatic hydrocarbons
PCB	Polychlorinated biphenyl
PCP	Pentachlorophenol
PDSI	Palmer Drought Severity Index
RCRA	Resource Conservation and Recovery Act
RSWMD	Regional Solid Waste Management District
SDWA	Safe Drinking Water Act
SFHA	Special Flood Hazard Area
SGCN	Species of greatest conservation need
SPL	State priority list
TDS	Total dissolved solids
TMDL	Total maximum daily load
TOC	Total organic carbon
TSS	Total suspended solids
U of A	University of Arkansas at Fayetteville
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
USFS	United States Forestry Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WAWRPR	West-central Arkansas Water Resources Planning Region
WIP	Western Interior Plains
WMA	Wildlife Management Area
WRDA	Water Resources Development Act

1.0 INTRODUCTION

The Arkansas Natural Resources Commission (ANRC) is responsible for and preparing and periodically updating a statewide water resources planning document. The previous update of the Arkansas State Water Plan (AWP) was completed in 1990. In 2012, ANRC initiated an update of the 1990 State Water Plan to be completed in 2014.

This document was prepared as part of the 2014 update of the AWP, Project Task 6. This document provides background information about the West-central Arkansas Water Resources Planning Region (WAWRPR) that will be used in the 2014 AWP update. The WAWRPR is one of five state planning regions being addressed in the 2014 AWP update. The information in this document will serve as background for ongoing discussion and analysis of state water supply, water demand, and alternatives for meeting the water resources needs in this planning region. This background information includes a description of the history of the planning region, its physical characteristics, natural resources, water resources, demographics, and economy. Finally, the regulatory and institutional framework for water resources management in this planning region is outlined.

2.0 GEOGRAPHY AND HISTORY

This section provides a general description of the geography of the WAWRPR, a brief history of the regional culture, and an overview of historical water resources management.

2.1 Geography

The WAWRPR encompasses approximately 7,800 square miles in central Arkansas (Figure 2.1). This region is bounded on the west by Oklahoma. The rest of the boundary of WAWRPR roughly corresponds to the hydrologic boundary of the Arkansas River basin upstream of Little Rock, following county boundaries to facilitate the use of data (e.g., economic, census, and water use data) aggregated at the county level. Eleven full counties and part of Pulaski County fall within the planning region. Table 2.1 lists these counties, the area of each county that is in the planning region, and the corresponding percentage of the county in the planning region. Major cities in the WAWRPR include Fort Smith, Little Rock, North Little Rock, Conway, and Russellville.

2.2 History

The WAWRPR has historically been a region of significance due in large part to the Arkansas River. The Arkansas River valley has supported Native Americans, transported European explorers, and held an important strategic value in American expansion to the west and during the Civil War. Today, the Arkansas River serves as a major economic transportation corridor as well as providing a level of flood protection in the areas contributing to the Arkansas River valley. The cultural history of the region is outlined below. The history of water resources development in the planning region is summarized separately.

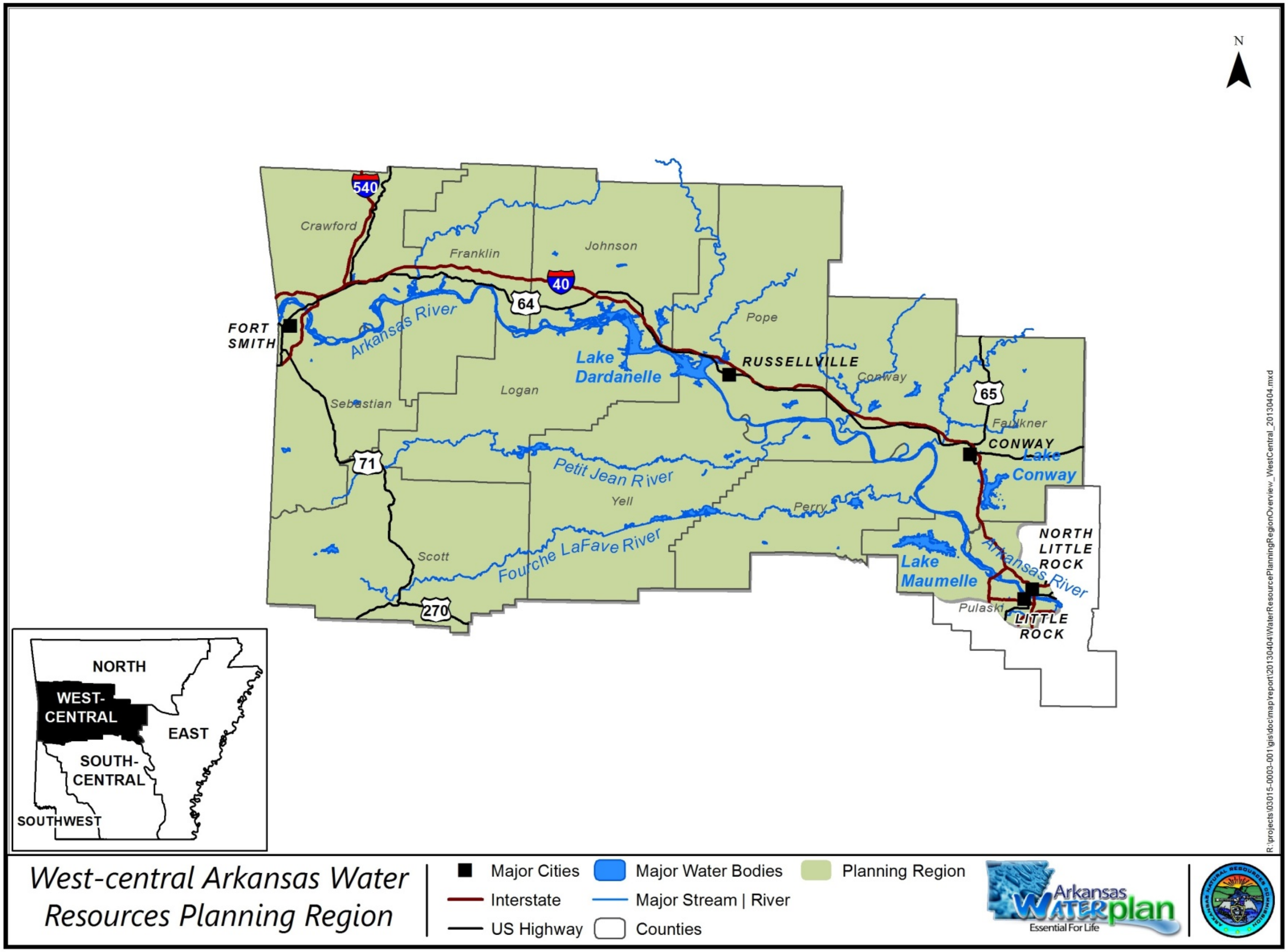

Figure 2.1. Map of the WAWRPR.

Table 2.1. Counties in the WAWRPR.

County	County Area in WAWRPR (square miles) (US Census Bureau 2012a)	Percentage of County Area in WAWRPR
Conway	552.25	100%
Crawford	593.09	100%
Faulkner	647.88	100%
Franklin	608.86	100%
Johnson	659.80	100%
Logan	708.13	100%
Perry	551.40	100%
Pope	812.55	100%
Pulaski	325.75	41%
Scott	892.32	100%
Sebastian	531.91	100%
Yell	929.98	100%
Total	**7813.92**	

2.2.1 Cultural

Native Americans likely settled the WAWRPR prior to European exploration and settlement, however there is no archeological evidence in the region of the presence of sophisticated native cultures from the Woodland Period (1000 BCE to 1000 CE) or Mississippian Period (900 to 1600 CE) (Early 2011). Just prior to European exploration of the region in the mid-1500's, Native Americans of the Caddo, Quapaw, and Osage cultures inhabited the WAWRPR (Bell 2013, Department of Arkansas Heritage 2013). Around 1815, Cherokee moved into the Arkansas River valley from eastern Arkansas (Stewart-Abernathy 2011a). In the 1830s, one of the "Trail of Tears" routes followed the Arkansas River through Arkansas. This route was used by a number of tribes, including the Choctaw, Chickasaw, Muscogee, Seminole, and Cherokee (Sloan 2011).

The Arkansas River valley was an important travel route for both Native Americans, and the first Europeans in the region (Foti 2011a). Hernando de Soto's Spanish expeditionary forces were the first Europeans in the region, arriving in 1541. Hernando de Soto's expedition is believed to have travelled along the Arkansas River from Fort Smith almost to its mouth

(Key 2012). The French explorer Henri de Tonti visited the area in the early 1700's (Department of Arkansas Heritage 2013). In the 1780's LaHarpe led the first French expedition up the Arkansas River to near present-day Morrilton (Key 2012). European settlements existed in the region as early as the 1790s (Bell 2013).

In 1817, American troops began construction of Fort Smith on the Arkansas River. The purpose of the fort was to house troops to keep peace between the resident Osage tribe and the immigrant Cherokee tribe moving into the Arkansas River valley. This planning region is included in the Arkansas Territory established in 1819 (Boulden 2012). After the establishment of the Arkansas Territory, European settlement in the region increased. In 1821, the territorial capital moved to Little Rock, which became the state capital when Arkansas became a state in 1836 (Bell 2013). Fort Smith became an important stop for settlers traveling farther west (Boulden 2012). By the late 1850's the Butterfield Overland Express route extended through Arkansas, travelling west from Memphis along the Arkansas River and south from Missouri, both connecting in Forth Smith (Foti 2011a)

The Arkansas River was of strategic importance during the Civil War. Given this, and the location of the state capital, battles and skirmishes were common in the region during the Civil War (Bell 2013, Gleason 2011).

Into modern times, the Arkansas River valley has remained an important transportation corridor. This, and other amenities present in the region, makes it one of the major regions in the state for population growth and industrial development (Foti 2008).

2.2.2 Water Resources Development

The development of the water resources located in the WAWRPR have included multi-purpose construction projects that serve as a major transportation artery, provide some level of flood control, supply local communities with safe drinking water sources, provide power in the form of electricity and nuclear power, and provide recreational opportunities.

2.2.2.1 Waterborne Transportation

The Arkansas River has been an important transportation artery through the WAWRPR since before Europeans arrived. Early European travelers in the region used flatboats and keelboats on the Arkansas River. Around 1822, the first steamboats began operating on the Arkansas River in the planning region (Stewart-Abernathy 2011b). In 1946 Congress passed the Rivers and Harbors Act authorizing the building of the McClellan-Kerr Arkansas River Navigation System (MKARNS) to provide waterborne transportation on the Arkansas River from the Mississippi River upstream to Catoosa, Oklahoma (Figure 2.2). In addition to transportation the MKARNS plan was to provide hydropower, flood control, and recreation. The system was, and still is, overseen by the US Army Corp of Engineers (USACE). In 1958, construction began on the MKARNS, in 1968 navigation was opened to Little Rock, and in 1971 it was completed to the Port of Tulsa in Catoosa, Oklahoma (Goss 2012). The Arkansas River continues to be a major commercial transportation corridor. The MKARNS averages 12 million tons of commodities shipments annually. Based on prices obtained from the USACE Institute for Water Resources and the National Agricultural Statistics Service, the value of the commodities shipped averages from $2 to $3 billion per year (USACE Little Rock District n.d.).

Other rivers in the planning region were also historically used for transportation including the Fourche La Fave River. In 1879 the US Congress approved deepening the channel for navigation and in 1889 this river was navigable as far upstream as Alpin, in Perry County (Lancaster 2011a).

2.2.2.2 Flood Control

Rivers in the WAWRPR are prone to flooding. During the period from 1833 through 1969, there were 42 major flood events on the Arkansas River. Rivers in this planning region were affected by both the Floods of 1927 and 1937 (Branyan 2012, Lancaster 2011a, Goss 2012). Reservoirs were constructed by the USACE in the region in the 1940s as part of a comprehensive plan for flood control and development of water resources in the Lower Arkansas River Valley. These included Blue Mountain Lake on the Petit Jean River, and Nimrod Lake on the Fourche La Fave River (Lancaster 2011a, 2011b, USACE n.d.).

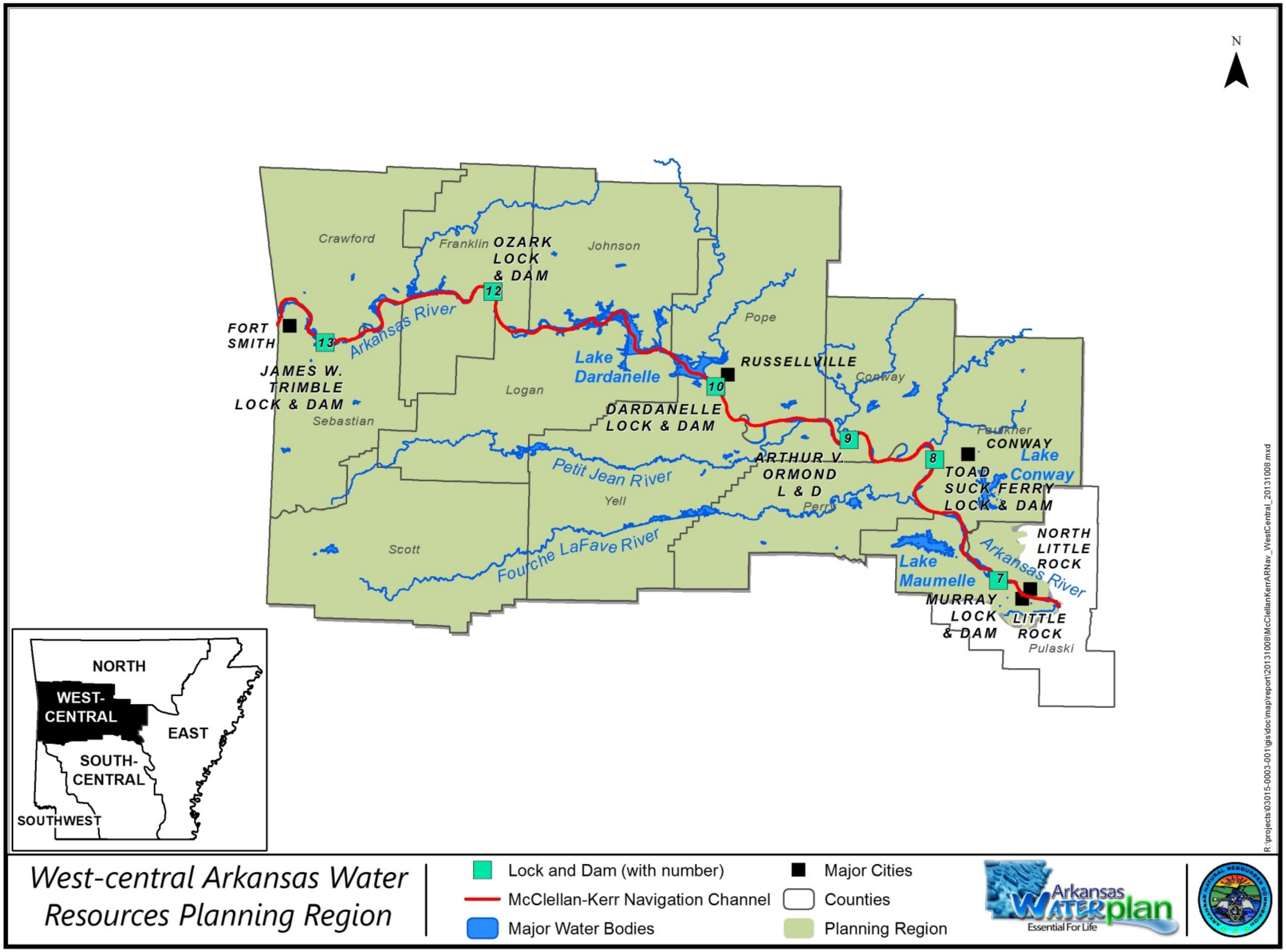

Figure 2.2. McClellan-Kerr Arkansas River Navigation System (MKARNS).

The MKARNS also contributes to flood control on the Arkansas River (Goss 2012). According to the USACE's Little Rock District, flood damages prevented within the District as a result of the Arkansas River Basin projects totaled over $187 million in 2011, and cumulative damages prevented through 2011 total approximately $1.9 billion (Oklahoma Waterways Branch 2012). The WAWRPR is almost completely contained within the jurisdiction of the Little Rock District of the USACE, with the exception of the southeast corner of Faulkner County, which is in the Memphis District, and small portions along the southern edge of the planning region that are part of the Vicksburg District.

In 1879, the US Congress created the Mississippi River Commission to oversee flood control along the entire Mississippi River. Between 1905 and 1915, the Arkansas General Assembly passed laws creating a flood control program for the Mississippi River Valley region of the state. The majority of these levee districts were created in the East Arkansas Water Resources Planning Region, but one district, District Number 1 of Faulkner County, was created in the WAWRPR in 1905. The levee associated with the Faulkner County levee district extends from Toad Suck Ferry Lock and Dam to Tupelo Bayou along the Arkansas River.

Subsequent to the original Mississippi River Commission, levees have been constructed and levee districts created along the Arkansas River. There are 42 levees along the Arkansas River in Arkansas that protect more than 753,180 acres of residential and farm land, much of which is located in the WAWRPR (USACE 2012).

2.2.2.3 Water Supply

In the 1950's, several large water supply reservoirs were constructed in the region. These include Lake Winona, constructed in 1938, and Lake Maumelle, constructed in 1958, as water supply lakes for Little Rock and North Little Rock, and Lake Fort Smith, completed in 1936, and Lake Shepherd Springs, completed in 1954, serving as water supply for the Fort Smith area (Tradewind n.d.). In 2006, construction was completed on the removal of the Lake Shepherd Springs dam and the enlargement of the Lake Fort Smith dam resulting in a single combined and much larger Lake Fort Smith.

Smaller water supply reservoirs in the planning region include Lake Brewer, constructed in 1982 and located in Conway County on Cypress Creek, to serve as the primary water supply for the City of Conway (Conway Corporation 2007), the Huckleberry Creek Reservoir, constructed in 1996 to serve as the primary water supply for the City of Russellville, and James Fork Creek Reservoir completed in 1992.

2.2.2.4 Hydropower

Arkansas has the potential to produce a significant amount of its electrical energy from hydroelectricity, however only 3% of the electricity produced in 2006 was from hydroelectric sources. There are four hydroelectric power plants in the WAWRPR, all of them on the Arkansas River, as presented in Table 2.2.

Table 2.2. Hydroelectric plants in the WAWRPR (Reynolds 2012).

Plant	County	River	Year Completed	Agency
Ozark	Franklin	Arkansas	1973	USACE
Ellis	Crawford/Sebastian	Arkansas	1988	AECC
Murray	Pulaski	Arkansas	1988	NLRE
Whillock	Conway	Arkansas	1993	AECC

AECC Arkansas Electric Cooperative Corporation.
NLRE North Little Rock Electric.
USACE United States Army Corps of Engineers.

2.2.2.5 Nuclear Power

The WAWRPR includes Arkansas' only nuclear power plant, Arkansas Nuclear One (ANO), located on the Arkansas River at Lake Dardanelle, in Russellville. ANO began operating in December of 1974 using water from the Arkansas River for cooling. It is owned by Entergy Arkansas and operated by Entergy Nuclear.

2.2.2.6 Waterfowl and Aquatic Habitat Conservation

Individuals and federal and state agencies have realized the importance of the wetlands, forests, and stream and rivers in the WAWRPR for support of wildlife. Just after the turn of the Twentieth Century, preservation of migratory waterfowl game birds became a national priority.

The Arkansas Game and Fish Commission (AGFC) began establishing wildlife management areas (WMAs) in the region after World War II. In 1957, the Holla Bend National Wildlife Refuge (NWR), overseen by the US Fish and Wildlife Service (USFWS), was established along a bend in the Arkansas River that was cut off when the river was straightened for flood control. The refuge provides a winter home for millions of duck and geese, but also brings in thousands of migratory songbirds in the spring that use the refuge as a resting area (USFWS n.d.a.). National wildlife refuges and state wildlife management areas and natural areas continued to be established to conserve aquatic habitats in the WAWRPR throughout the Twentieth Century (Table 2.3).

Table 2.3. National Wildlife Refuge and State Wildlife Management Areas in the WAWRPR.

Name	Type	Area (acres)	Counties	Year established	Management	Purpose
Bell Slough	WMA	2,040	Faulkner	1951		Migratory bird habitat, hunting
Camp Robinson	WMA	26,675	Faulkner, Pulaski	--	AGFC	
Ed Gordon/Pt. Remove	WMA	8,694	Conway, Pope	--	AGFC	Migratory bird habitat
Galla Creek	WMA	3,329	Pope, Yell	--	AGFC	
Harris Brake	WMA	3,769	Perry	--	AGFC	
Holla Bend	NWR	7,000+	Pope, Yell	1957	USFWS	Migratory bird habitat
Mt. Magazine	WMA	120,000	Logan, Yell	--	AGFC	
Muddy Creek	WMA	146,206	Montgomery, Scott, Yell	--	AGFC	
Petit Jean River	WMA	15,502	Yell	--	AGFC	
Piney Creeks	WMA	176,000	Johnson, Pope	1967	AGFC	Protect species, provide recreation
Ring Slough	WMA	83	Perry	--	AGFC	
Winona	WMA	160,000	Perry	--	AGFC	
Goose Pond	Natural area	392	Pope, Conway	1981	ANHC, AGFC	Protect wetland ecosystem and waterfowl habitat
Cove Creek	Natural area	228	Faulkner	1976	ANHC	Protect riparian and upland habitats

In 1968, the US Congress created the National Wild and Scenic Rivers System to preserve free-flowing rivers with outstanding recreational, cultural, and/or natural features (Arkansas Natural Heritage Commission 2012). In 1992, portions of three rivers in the WAWRPR were added to the National Wild and Scenic Rivers System (Table 2.4).

Table 2.4. Wild and scenic rivers in the WAWRPR (Interagency Wild and Scenic Rivers Council n.d.).

River	Total Length (miles)	Wild (miles)	Scenic (miles)	Recreational (miles)	County
Big Piney Creek	45.2	0	45.2	0	Pope
Hurricane Creek	15.5	2.4	13.1	0	Franklin
Mulberry River	56.0	0	19.4	36.6	Franklin

2.2.2.7 Arkansas River Basin Compact

In 1955, the US Congress authorized Oklahoma and Arkansas to begin negotiating a compact to resolve disputes over rights to water in the Arkansas River and its tributaries, as well as preventing future disputes. In 1970, after 15 years of negotiations, the states of Arkansas and Oklahoma signed an agreement concerning water apportionment in the Arkansas River Basin along the Arkansas-Oklahoma border. In addition to the Arkansas River, the compact addresses water resources of the Lee Creek Watershed and Poteau River Watershed in the WAWRPR. In this compact, the two states agree that Arkansas has the rights to water in both subbasins within the state's borders. Within the Poteau River Watershed, Arkansas water use is limited by the compact so annual yield to Oklahoma is not depleted by more than 60%. Oklahoma's use of the Arkansas River is limited by the compact so that annual yield to Arkansas is not depleted by more than 60%. There are no use restrictions specified for Lee Creek waters in the compact for other either state. (Arkansas River Compact Committee 1970). This compact is described in greater detail in Section 6.1.8.

3.0 PHYSICAL CHARACTERISTICS

This section summarizes the physical characteristics of the WAWRPR. This includes the physiography, geology, climate, and land use, as well as descriptions of the ecological, surface water, and groundwater resources within the planning region.

3.1 Physiography

Arkansas is typically divided into two major physiographic regions; the Interior Highlands in the northeast and the Gulf Coastal Plain in the south and east. These regions are further divided into smaller physiographic provinces based on topography and geology. The “fall line” is where these two physiographic regions meet.

The WAWRPR is located in the Interior Highlands physiographic region. Physiographic provinces of the Interior Highlands that occur in this planning region include the Ozark Plateaus and the Ouachita Mountains. (Figure 3.1) (Arkansas Geological Survey n.d.). A tiny portion of the Gulf Coastal Plain is found in this planning region. Because it comprises such a small part of the planning region, the physiography of the Gulf Coastal Plain will not be described in this document. Descriptions of this physiographic province can be found in the background reports for other planning regions.

3.1.1 Ouachita Mountain Province

The Ouachita Mountain physiographic province accounts for the majority of the area in the WAWRPR. The physigraphic subdivisions of the province that are present in the planning region are the Arkansas River Valley and Fourche Mountains. The Arkansas River Valley physiographic subdivision accounts for the majority of the area in the WAWRPR (Figure 3.1). The valley is up to 40 miles wide, and contains a variety of physiographic features, including narrow ridges similar to the Fourche Mountains, and flat-topped mountains similar to the Boston Mountains, broad hilly plains, and alluvial bottomlands (Foti 2011a, 2011b). To the north of the Arkansas River, the physigraphy of the valley is characterized by low hills eroded from ancient

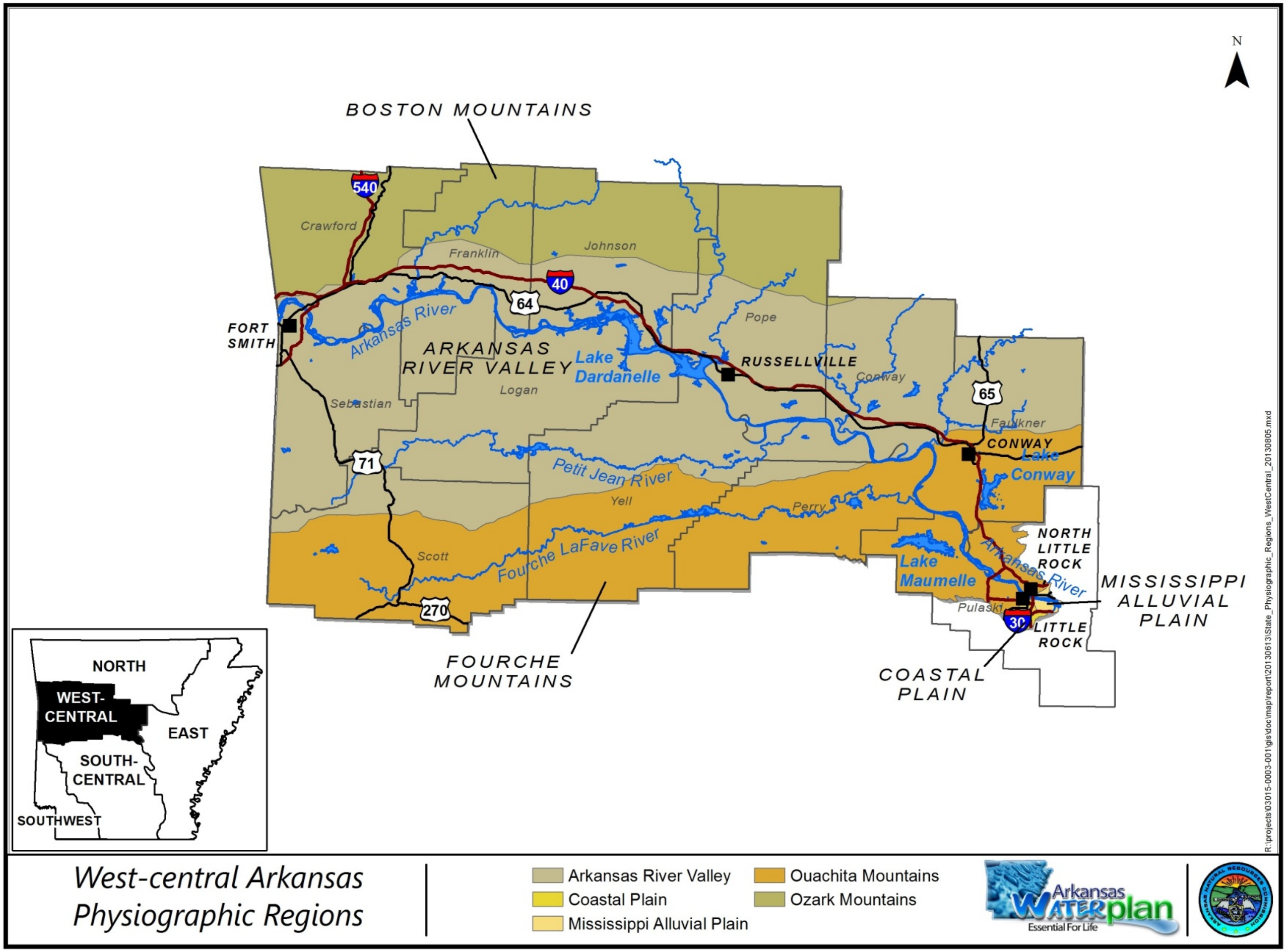

Figure 3.1. Physiography of the WAWRPR.

plateaus, similar to the Ozark Mountains, but lower in elevation (Foti 2011a, Woods et al. 2004). Along the Arkansas River and to the south, the physiography of the valley is characterized by level plains interspersed with high mountains (Foti 2011a).Elevations of valleys generally are 500 feet, declining to around 250 feet above sea level along the Arkansas River at the eastern boundary of the planning region (Woods et al. 2004). Mt. Magazine, the highest point in the state at 2,823 feet, is in the Arkansas River Valley, as are Mount Nebo and Petit Jean Mountain. These prominent “mountains” are known by geologists as monadnocks, isolated, prominent hills, often formed by fluvial erosion, and generally found in a flat plain. Physiographic features in the valley are generally oriented east to west, and the river valley slopes generally to the east.

The Fourche Mountains make up the entire southern portion of the planning region and contain several major ridges including the Poteau Mountains, which crest at just less than 2,500 feet (Foti 2011c). The Fourche Mountains are one of the dominant range geophysical features of western Arkansas. These mountains consist of sedimentary rock that has been folded to create generally parallel ridges and valleys that have east-west orientation. Most of the mountain ridges are narrow, with steep slopes, sharps crests, and narrow valleys. Valley floors are broad and often at high elevations. Principal streams in the Fourche Mountains flow eastward.

3.1.2 Ozark Plateaus Province

The Boston Mountains physigraphic subdivision consists of the higher southern edge of the Ozark Plateaus province and makes up the northern boundary of the planning region (Figure 3.1). These mountains are primarily flat-topped, summit ridges representing the original erosion surface of the plateau. Great stream dissection has occurred, creating steep sided mountains and deep narrow valleys. There are several cliffs and bluffs. Elevations typically range from 200 feet above sea level in the valleys to 1,900 feet above sea level in the highlands. However, elevations of up to 2,300 feet above sea level occur (Woods et al. 2004). The mountains descend rather sharply to the Arkansas Valley.

3.2 Geologic Setting

Geologic formations underlying the WAWRPR range in stratigraphic order from the earliest deposited layers of the Ordovician in the Fourche Mountains to Quaternary Alluvium in the Arkansas River Valley. Figure 3.2 displays the surface geology of the planning region.

Generally, the hydrogeology of the Interior Highlands can be described as an area of consolidated formations which yield relatively low volumes of water to wells. The low specific capacity in these wells is a direct result of the lithological nature of the strata itself. The consolidated formations typically are confined with most of the water yielded to wells coming through secondary porosity found in fractures and bedding plains. The Atoka Formation is significant as a source of shallow domestic wells in the Ouachita Mountains and Arkansas River Valley, but yields are typically small and therefore, limited for other purposes. The best source of groundwater, with respect to quantity, is the Arkansas River Valley alluvium. Groundwater resources of the WAWRPR are further described in Section 3.8.

3.2.1 Geology of the Boston Mountains

The Boston Mountains are characterized by outcropping Pennsylvanian-age sedimentary rocks composed mainly of sandstone and shale, with some limestone units occurring near the base. The massive Atoka Formation, over 1,500 feet thick, is the most prominent geologic formation (Figure 3.2). The Ozarks, which include the Boston Mountains, in general have experienced extensive erosion and have deeply dissected stream valleys throughout. The sedimentary rocks of the Ozarks generally are nearly flat-lying and dip toward the south. Gentle, low-amplitude folds have been observed in the Ozarks (McFarland 2004). The majority of the faults in the Ozarks are normal faults, with displacement generally occurring downward on the southern side of the fault. The rocks of the Ozarks were deposited on a relatively shallow continental shelf that was exposed at numerous times during the Paleozoic resulting in erosional surfaces throughout the stratigraphic sequence (McFarland 2004, Renken 1998, Imes and Emmett 1994, Manger 1983).

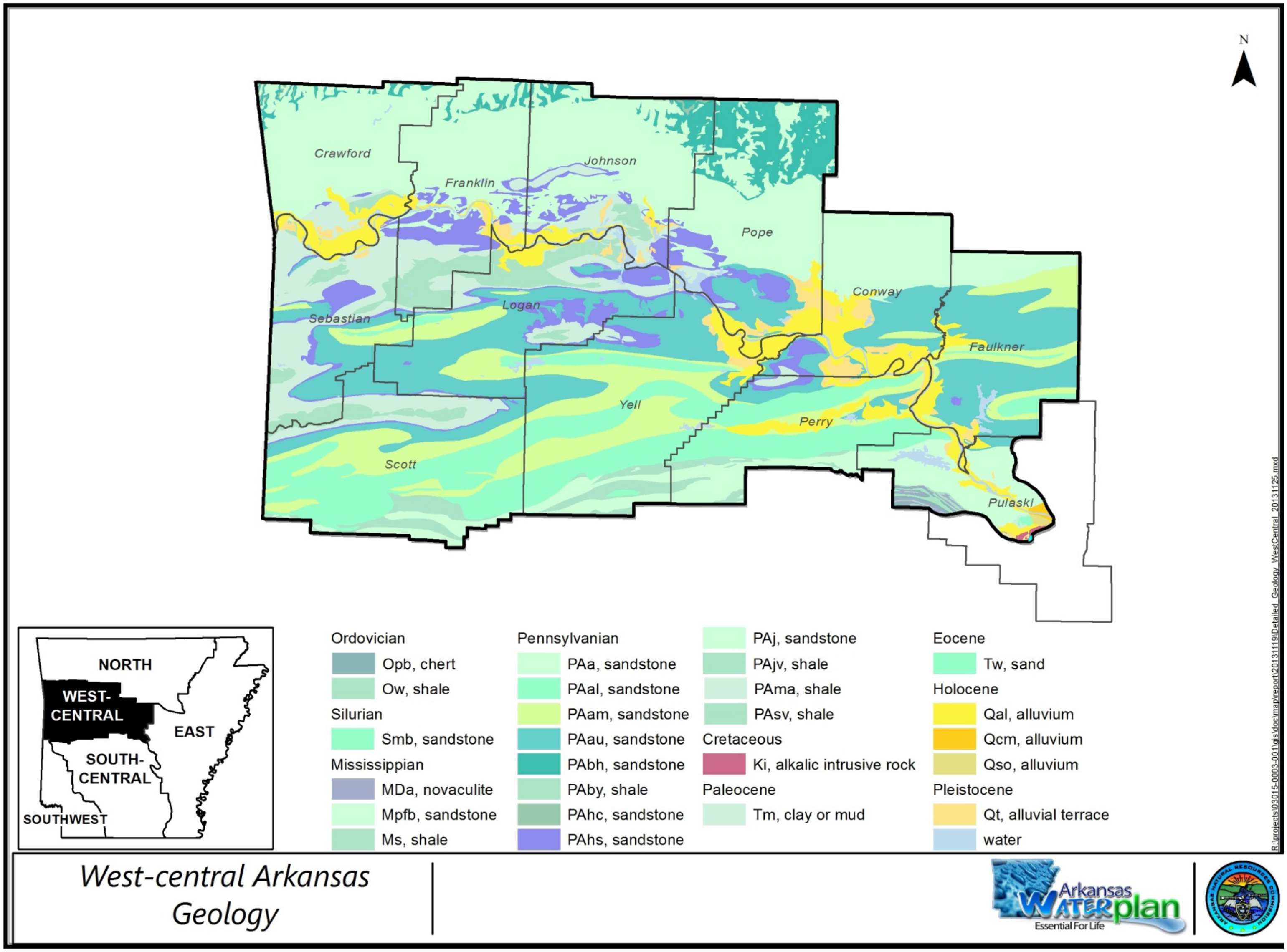

Figure 3.2. Surface geology of the WAWRPR (Haley et al. 1993).

3.2.2 Geology of the Arkansas River Valley

The Arkansas River Valley section of the Ouachita Mountain province lies within the Arkoma Basin between dipping rocks of the Boston Mountains to the north and the highly folded rocks of the Ouachita Mountains to the south of the Arkansas River. The Arkoma Basin (Figure 3.3) is a structural low trending east-west across central Arkansas that was created by compression from the Ouachita orogeny (Adamski, Freiwald and Davis 1995). The structural geology of the area consists of relatively broad synclinal folds with relatively narrow intervening anticlinal folds that trend east-west (McFarland 2004).

The geology of the Arkansas River Valley is dominated by Pennsylvanian age clastic sediments that were deposited on the margin of a continental shelf primarily by deltas and subsequently reworked by marginal marine processes (McFarland 2004). The sedimentary section in the Arkoma Basin is reported to range in thickness from 3,000 to 35,000 feet (Manger and Lloyd 2008). The western part of the Arkansas River Valley is composed of the Savanna Sandstone, Paris Shale, Spadra Shale, and Harthshorne Sandstone is all significant. Coal is important in the Paris and Spadra Shale. The central and eastern portions of the valley are dominated by the alternating sandstone and shale of the Hartshorne and Atoka Formation. There are numerous natural gas fields in this region, producing a dry gas. Currently, the Arkoma Basin is the focus of a major unconventional gas play targeting the Fayetteville Shale. All counties in the planning region are considered a part of the Fayetteville Shale Geologic Formation. Conway and Faulkner Counties house active gas well sites (Figure 3.4).

Alluvial deposits overlie consolidated rocks along the Arkansas River and its major tributaries and comprise terrace and floodplain deposits, which occur along the river in discontinuous segments three to 40 miles in length and one to five miles wide across the river valley (Kresse et al. 2013). In some locations, the alluvium and terrace deposits are absent and the river is bordered by consolidated rocks of the Interior Highlands (Cordova 1963, Bedinger, Emmett and Jeffery 1963). Tops of older terraces lie 50 feet or more above the present floodplain and consist of interbedded gravel, clay, and sand. Younger terrace deposits lie 20 to 40 feet above the present floodplain and are composed of a coarsening downward sequence of clay, sand, and gravel; floodplain alluvial deposits consist of gravel, sand, silt, and clay. The alluvial

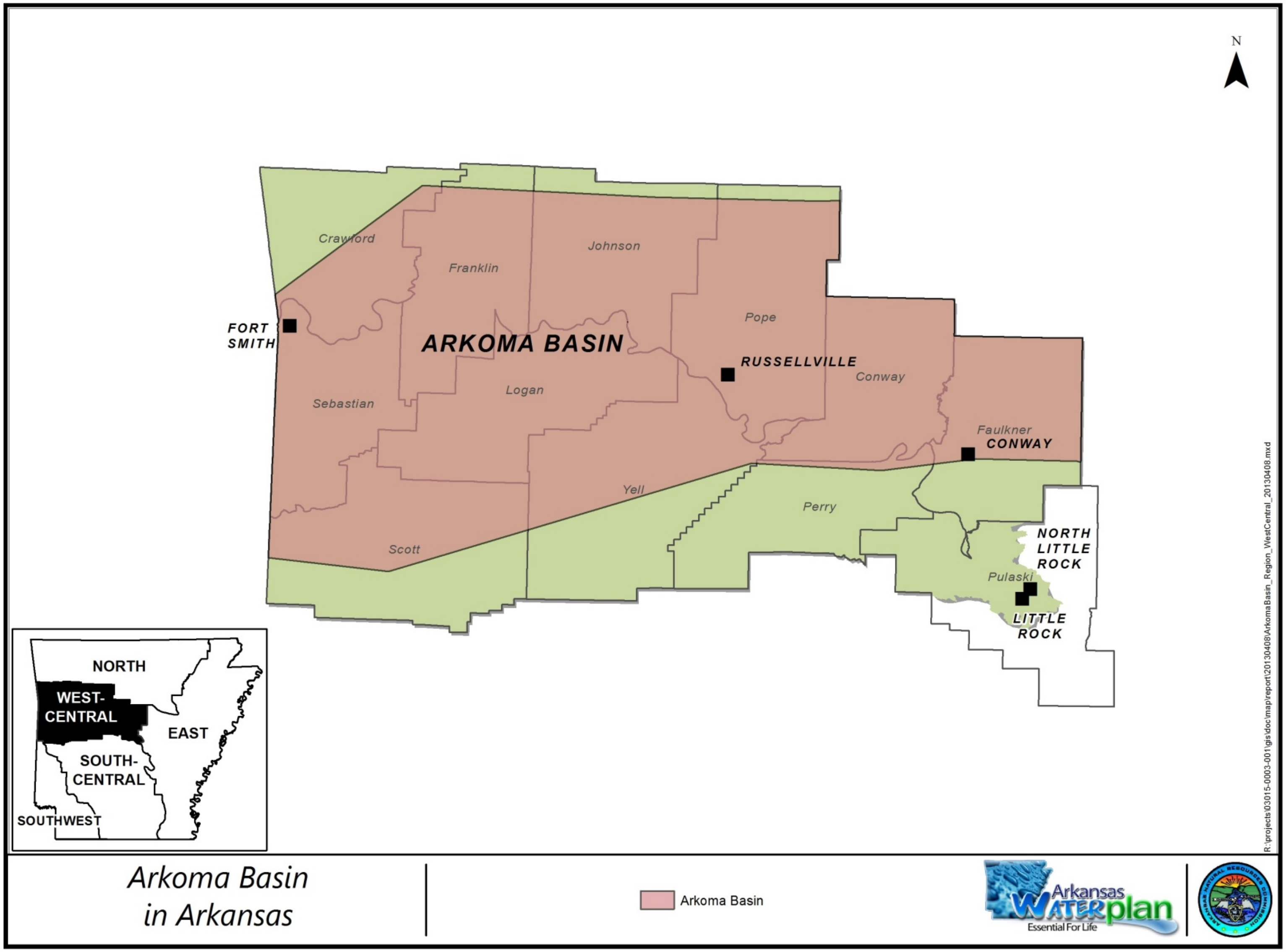

Figure 3.3. Location of Arkoma Basin in the WAWRPR.

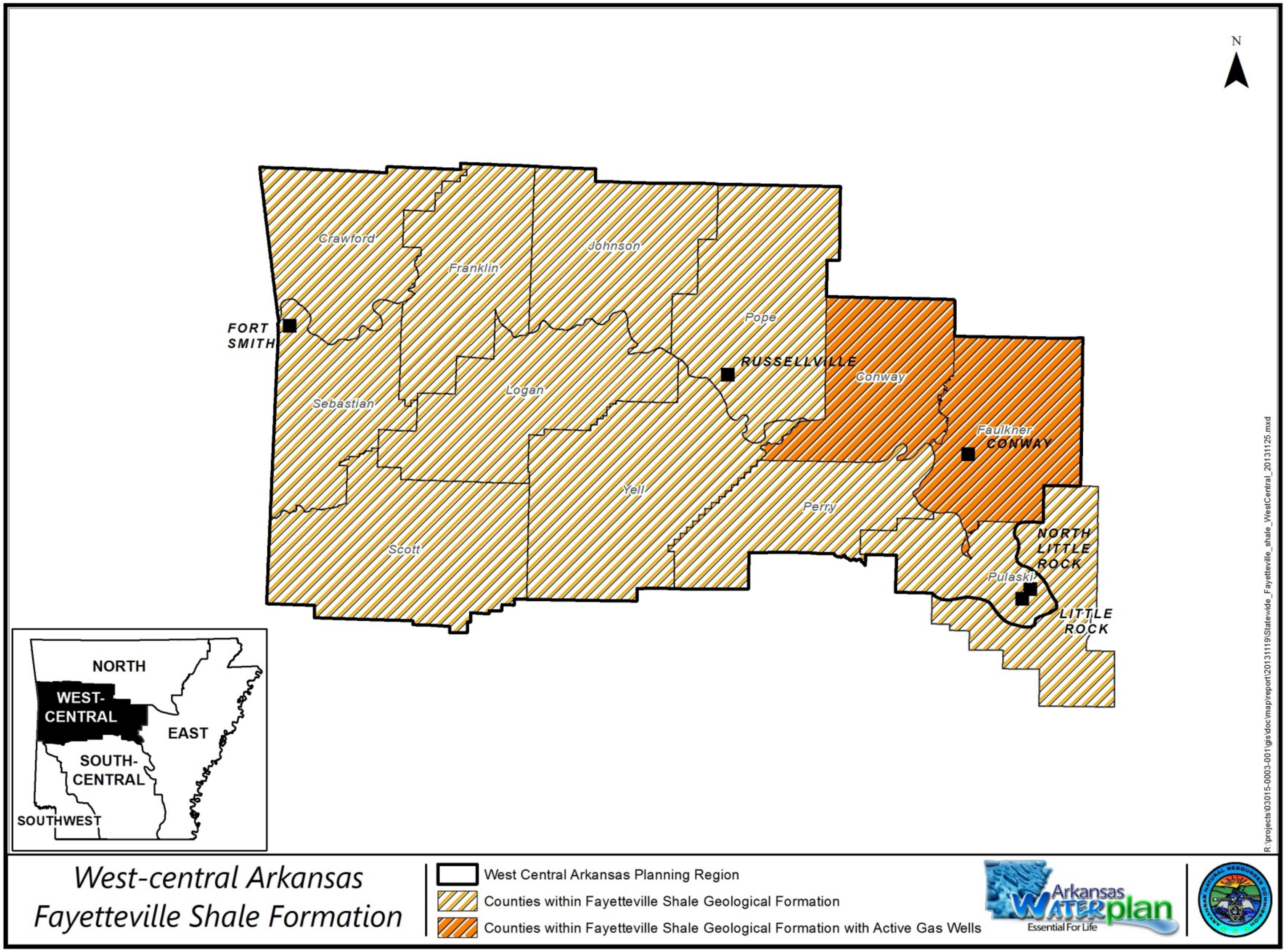

Figure 3.4. Location of Fayetteville Shale Formation in the WAWRPR.

deposits typically are about 40 feet thick in the area near Fort Smith and thicken downstream to about 80 feet near Little Rock (Cordova 1963). The alluvium represented several environments of deposition and characteristic deposits—point bar, swale, channel fill, natural levee, and back swamp—which can be distinguished on the basis of lithologic character and topographic expression.

3.2.3 Geology of the Fourche Mountains

The sedimentary rocks of the Fourche Mountains consist of a thick sequence of shale, chert, sandstone, conglomerates, novaculite, and volcanic tuff deposited during the Paleozoic Era within an elongate, subsiding trough (Renken 1998). The rock types exposed are sandstones and shales of the Atoka Formation. The Jackfork Sandstone is particularly important in the major mountain ridges. The Stanley Shale is the most widespread formation (Figure 3.2).

The Ouachita Mountains are true geosynclinal mountains formed from strata deposited in deep water settings and uplifted and deformed by the compressional events associated with continental collision. The general structure of the Ouachita Mountains is a broad uplift with complex folds and numerous complex faults (McFarland 2004, Manger 1983). Sediments of the Ouachita Mountains are well indurated and generally well cemented as a result of deep burial, intense compression, and complex rock-forming history (Renken 1998).

3.3 Ecoregions

Ecoregions are areas within which ecosystems and the type, quality, and quantity of environmental resources are generally similar. The US Environmental Protection Agency (EPA) has defined 9 Level IV Ecoregions within the WAWRPR (EPA 2013a) (Figure 3.5). The Arkansas Valley, which makes up the central and largest part of the planning region, includes four of the nine ecoregion subdivisions. Characteristics of all of the ecoregions in the WAWRPR are summarized in Table 3.1.

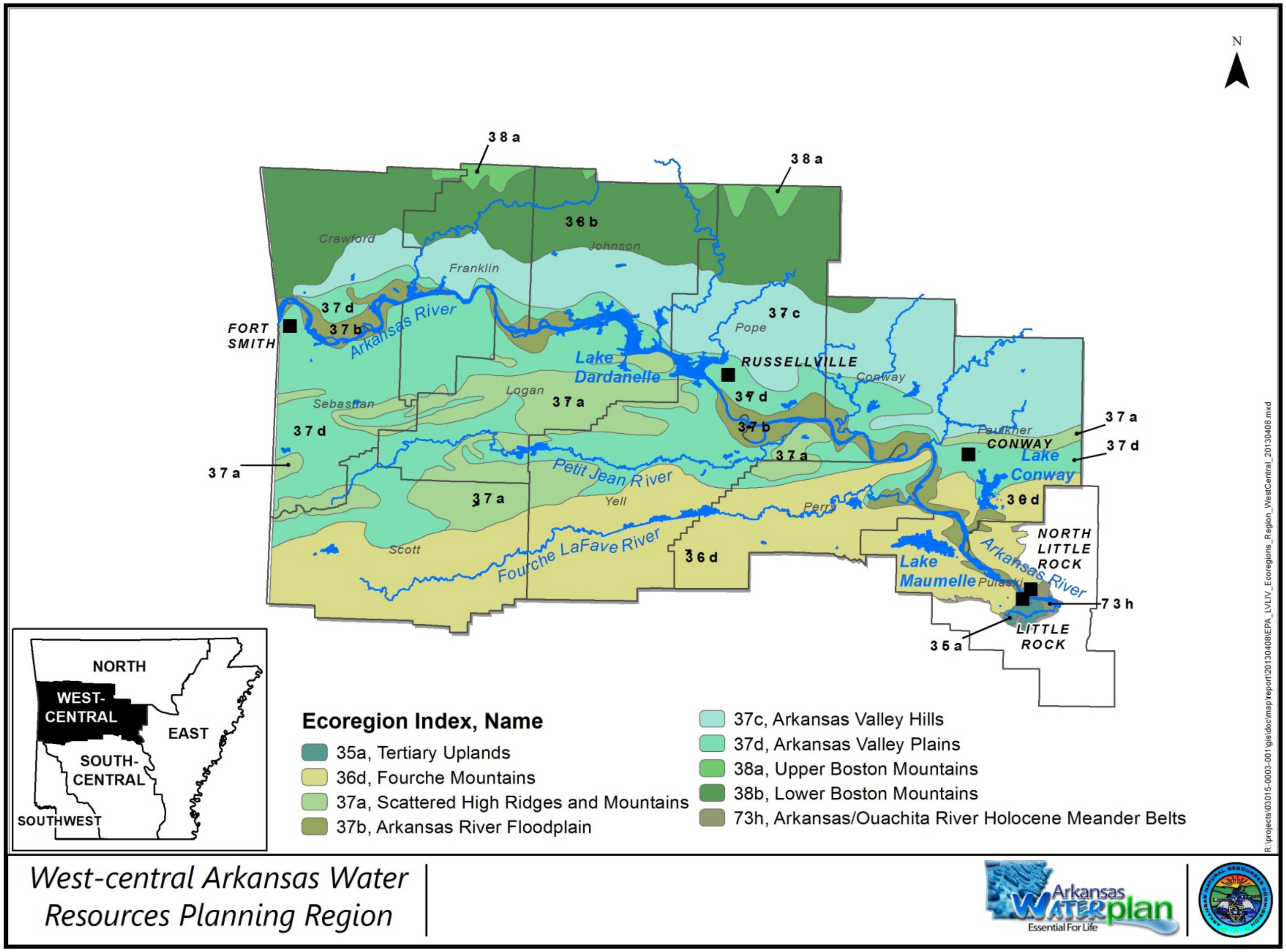

Figure 3.5. EPA-defined Level IV ecoregions of the WAWRPR (Woods et al. 2004).

Table 3.1. Ecoregions in the WAWRPR (Weakley et al. 2013, Woods et al. 2004).

Level III Ecoregion	Level IV Ecoregion	Native Vegetation	Hydrology	Other
Arkansas Valley	Scattered High Ridges and Mountains	Oak-hickory and oak-hickory-shortleaf pine forests	High to average stream gradients	Magazine Mountain, the highest point in Arkansas, is in this ecoregion
Arkansas Valley	Arkansas River Floodplain	Southern floodplain forest i.e., bottomland oaks, sycamore, willow, green ash, pecan, and others	Low gradient streams	Some native forest land remains in the frequently flooded areas.
Arkansas Valley	Arkansas Valley Hills	Oak-hickory and oak-hickory-pine forests	Low gradient streams	
Arkansas Valley	Arkansas Valley Plains	Historically a unique prairie, savanna, woodland collection; currently oak-hickory and oak-hickory-pine forests	Average to low gradient streams	In the rain shadow of Fourche Mountains; Cherokee Prairie (Franklin County) remnant native prairie
Boston Mountains	Upper Boston Mountains	Oak-hickory forest	High gradient streams; low to no flow during summer; pools fed by interstitial flow occur	Water quality in streams typically exceptional, distinctive freshwater communities
Boston Mountains	Lower Boston Mountains	Oak-hickory-pine forest	High gradient streams; low to no flow during summer; pools fed by interstitial flow occur	Water quality in streams typically exceptional, distinctive freshwater communities
Ouachita Mountains	Fourche Mountains	Oak-hickory-pine forest	High gradient streams	Water quality in streams typically exceptional
South-Central Plains	Tertiary Uplands	Oak-hickory-pine, mixed shortleaf pine-loblolly pine, and upland deciduous forests; bottomland forest along rivers	Low gradient streams; low to no flow in summer with the exception of spring-fed streams in sandhills.	Waterfowl habitat; oil and gas are produced in the region
Mississippi Alluvial Plain	Arkansas/ Ouachita River Holocene Meander Belts	Bottomland hardwood forest and woodland; northern limit of palmetto and Spanish moss	Flat floodplain; existing Arkansas River channel; low gradient streams	In the WAWRPR this area is the active Arkansas River

In the Fourche Mountains, steep east to west trending ridges are present which result in primarily north and south-facing slopes. Differences in temperature and moisture on the north and south facing slopes influence the plant communities present. On steep north-facing slopes magnolia and sugar maple occur, while on south-facing slopes, short-leaf pine is the predominant natural vegetation. Overall, oak-hickory-pine forest is the dominant natural vegetation. Streams in the Fourche Mountains have high gradients, and substrates are made up of gravel, cobbles, boulders, or bedrock (ASWCC 1987, Woods et al. 2004). Fish communities in these streams are dominated by sensitive species (Woods et al. 2004).

The Boston Mountains, one of the Ozark Mountain plateaus where folding and faulting has occurred, but the strata is much less deformed than in the Ouachita Mountains. Oak-hickory-pine forest is the dominant natural vegetation. Pine is more common here than in the other ecoregions within the planning region, being particularly wide-spread on south and west facing sandstone slopes. Water quality in this ecoregion is generally exceptional. Fish communities in Boston Mountain streams tend to be diverse and may include sensitive species (Woods et al. 2004). The Boston Mountains contain habitat for a number of cave species (Anderson 2006).

The Arkansas Valley ecoregion includes floodplains, terraces, hills, plains, and scattered mountains. Natural vegetation in the uplands is a mix of woodland, forest, savanna, and prairie. In the lowlands, bottomland hardwoods are the dominant natural vegetation (Anderson 2006). Oak-hickory forest and oak-hickory-pine forest are the most common forest communities in this ecoregion. The area south of the Arkansas River, in the western portion of the ecoregion, where soils are thinner and drier, was historically prone to wildfires, resulting in large areas of savanna and prairie, and the presence of fire-adapted forest communities in the uplands (Woods et al. 2004). The Cherokee Prairie Natural Area, the largest tall grass prairie remnant in Arkansas is located in the Arkansas River Valley just north of Charleston in Franklin County. Streams in the Arkansas Valley have the lowest gradients in the planning region (Anderson 2006). Fish communities typically include a number of sensitive species (Woods et al. 2004).

3.4 Aquatic Biodiversity

While the aquatic habitats in the WAWRPR have been modified in the past, particularly with the construction of the MKARNS, there is still considerable aquatic biodiversity in this planning region. Within the Ouachita ecoregion, which includes the Arkansas River valley, is home to at least 190 native species of fish, which is 18% of all native freshwater fishes on the continent (The Nature Conservancy 2006). Of the 268 aquatic and semi-aquatic animal species that have been identified as being of greatest conservation need in Arkansas, 116 are present in the WAWRPR (Anderson 2006). Figure 3.6 provides a summary of the aquatic and semi-aquatic animal species of greatest conservation need found within the planning region. Of the over 180 aquatic and semi-aquatic plant species tracked by the Arkansas Natural Heritage Commission (ANHC), 50 occur in the WAWRPR (ANHC 2013). Of the 42 Arkansas endemic species (found nowhere else in the world), 10 occur in the planning region (Figure 3.7) (Anderson 2006). While endemic and threatened and endangered species are present in the planning region, none of the waterbodies of the WAWRPR have been designated as state Ecologically Sensitive Waterbodies (APCEC 2011). Additional information on threatened and endangered species in the planning region is provided in Section 5.6.

The water resources of the WAWRPR are important waterfowl habitat. The planning region is located in the Mississippi River bird migration corridor, and the Arkansas River and associated wetlands are important habitat for migrating and wintering waterfowl and shorebirds. Audubon Arkansas has classified Lake Dardanelle and the Holla Bend National Wildlife Refuge as Important Bird Areas (Audubon Arkansas n.d.). Up to 100,000 ducks have been seen at once in the Holla Bend National Wildlife Refuge during the winter. Fourteen species of ducks and four species of geese visit this refuge each winter. Bald Eagles also use the refuge in the winter (Spurgeon 2011).

3.5 Climate

The climate of the WAWRPR is classified as humid subtropical with long summers, relatively short winters, and a wide range of temperatures. Parts of this planning region experience a milder climate, allowing the cultivation of crops unique to this region, such as wine grapes in Franklin County (Buckner 2011). Information on temperature, precipitation, evaporation, and climate trends were obtained from the National Oceanographic and Atmospheric Administration National Climatic Data Center (NOAA NCDC) and the PRISM Climate Group, and are discussed below. The State of Arkansas is divided into nine climate divisions, the WAWRPR is represented by climate divisions 4 and 5 (Figure 3.8).

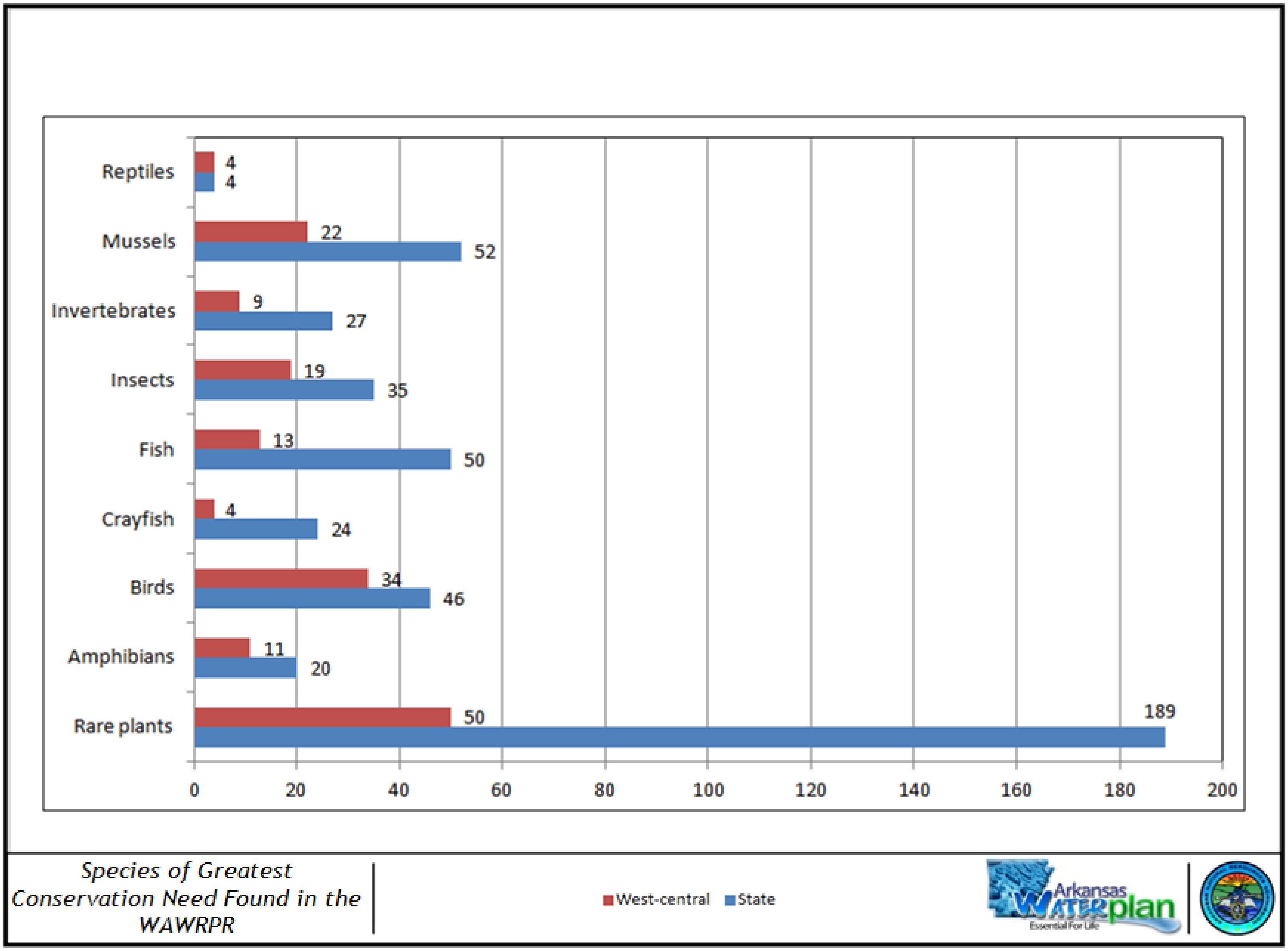

Figure 3.6. Species of greatest conservation need found in the WAWRPR (Anderson 2006, ANHC 2013).

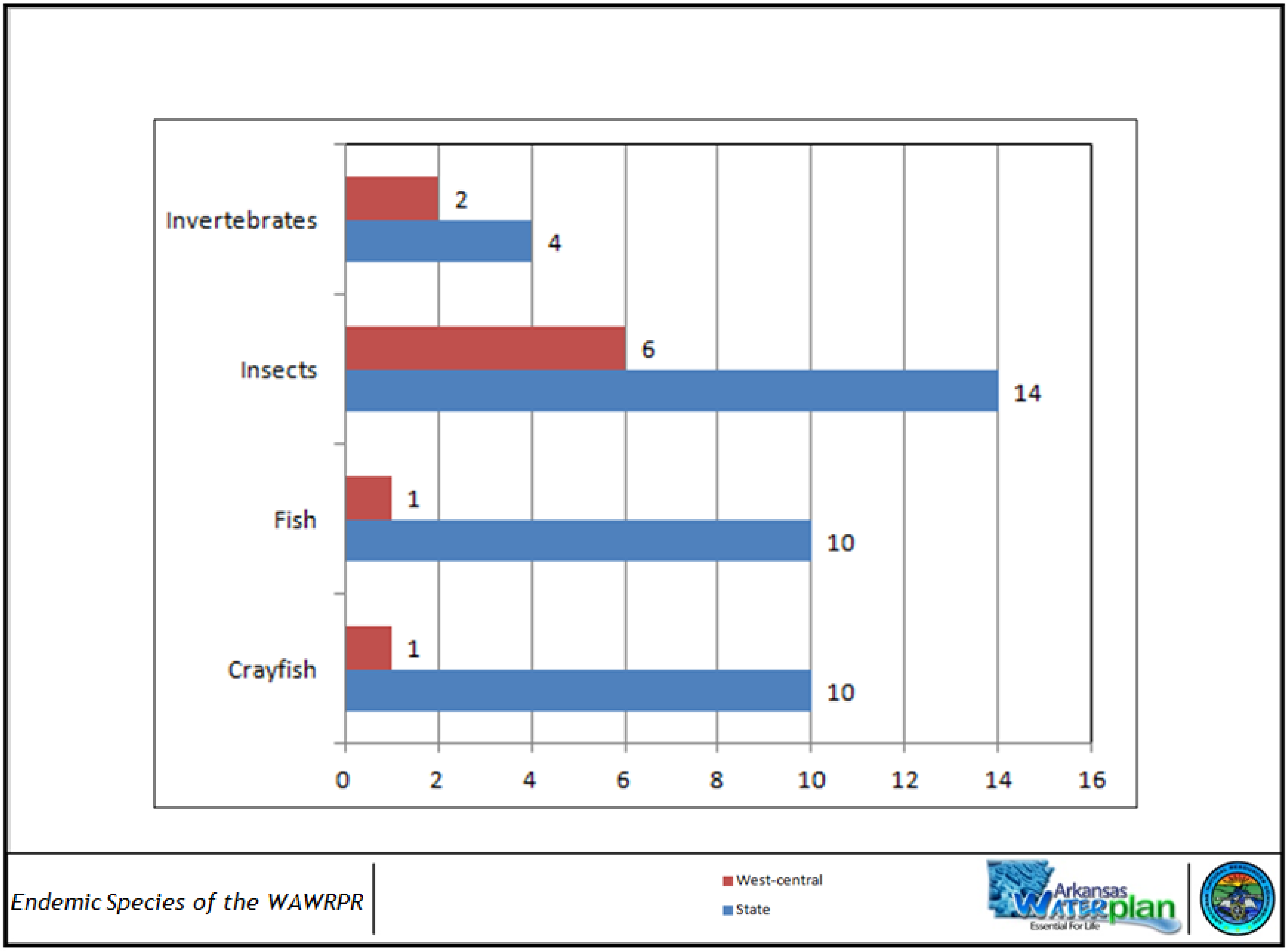

Figure 3.7 Endemic species of the WAWRPR (Anderson 2006).

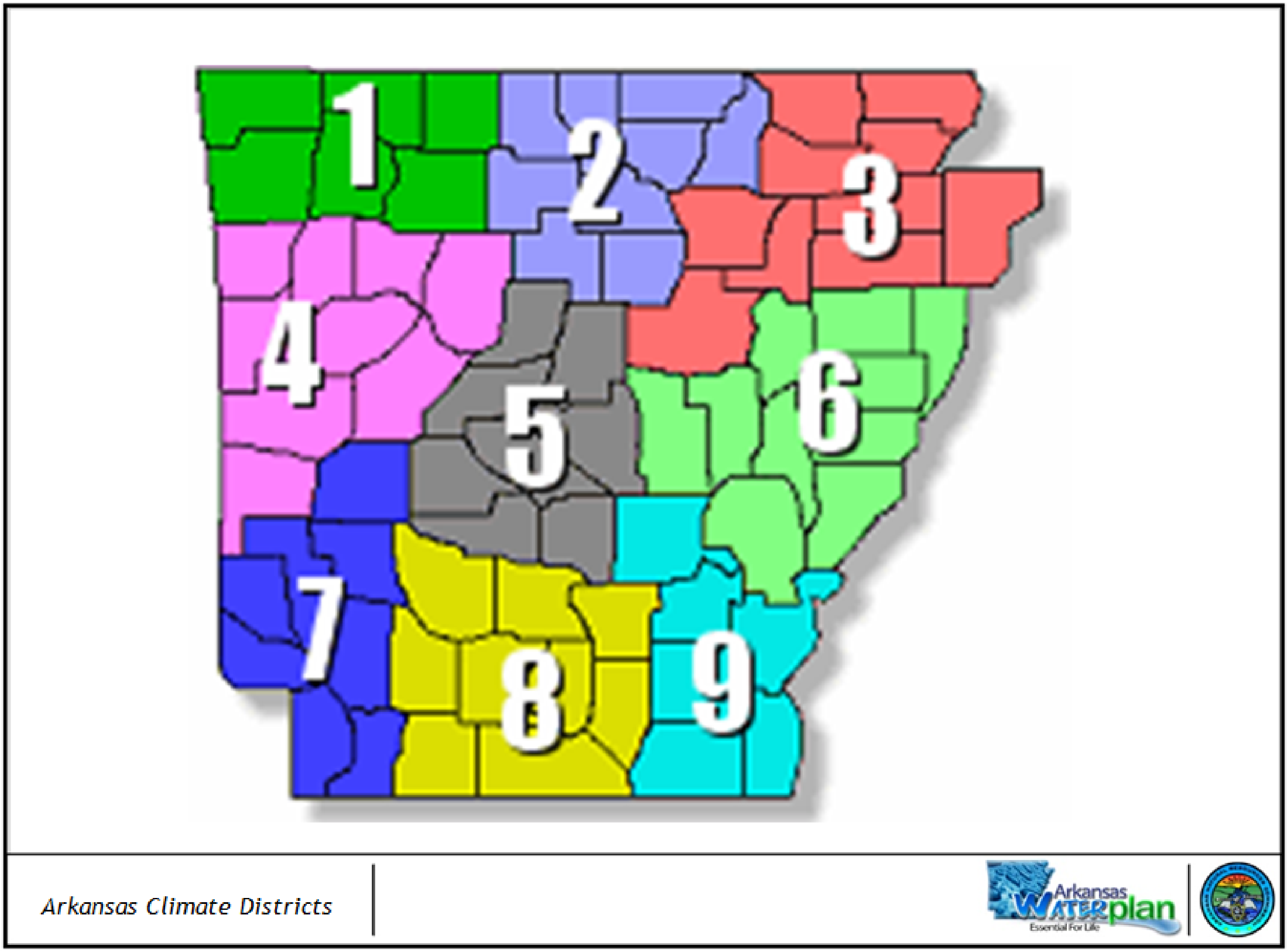

Figure 3.8. Arkansas climate divisions (NOAA NWS 2013).

3.5.1 Temperature

Average monthly high air temperatures in this planning region range from 92 degrees Fahrenheit in the summer to 49 degrees Fahrenheit in the winter (Figure 3.9). Normal monthly minimum air temperatures range from 69 degrees Fahrenheit in the summer to 29 degrees Fahrenheit in the winter. The average difference between normal monthly maximum and minimum air temperatures is 22 degrees Fahrenheit. A map of the average annual maximum daily temperatures for this planning region is provided on Figure 3.10 and demonstrates the wide variation within this particular planning region as compared to the rest of the State. The record high temperature in Arkansas is 120 degrees and was recorded on August 10, 1936 in Ozark, Franklin County, located in the Arkansas River Valley (Buckner 2011).

The growing season in this planning region ranges from 180 days in the mountains to 230 days in the river valley (Woods et al. 2004). Extremes in air temperatures may vary from winter lows around 0 degrees Fahrenheit, usually caused by Canadian air masses, to summer highs above 100 degrees Fahrenheit. Extreme temperatures may occur for short periods of time at any location within the WAWRPR.

3.5.2 Precipitation

Average annual precipitation in the WAWRPR ranges from approximately 47 inches to greater than 60 inches, see Figure 3.11. The variation in the average annual rainfall across the planning region indicates a slight general decrease from east to west, but more prominent is the lower average annual precipitation in the central portion of the planning region as opposed to the north and south. The western portion of the WAWRPR lies in the rain shadow of the Ouachita Mountains, and is influenced by dry winds from Oklahoma (Foti 2011a). In this planning region, the highest precipitation amounts occur in areas of higher elevations. Average monthly precipitation for the period from 1981 through 2010 is shown on Figure 3.12. Precipitation is well distributed throughout the year with the driest months being August and January respectively.

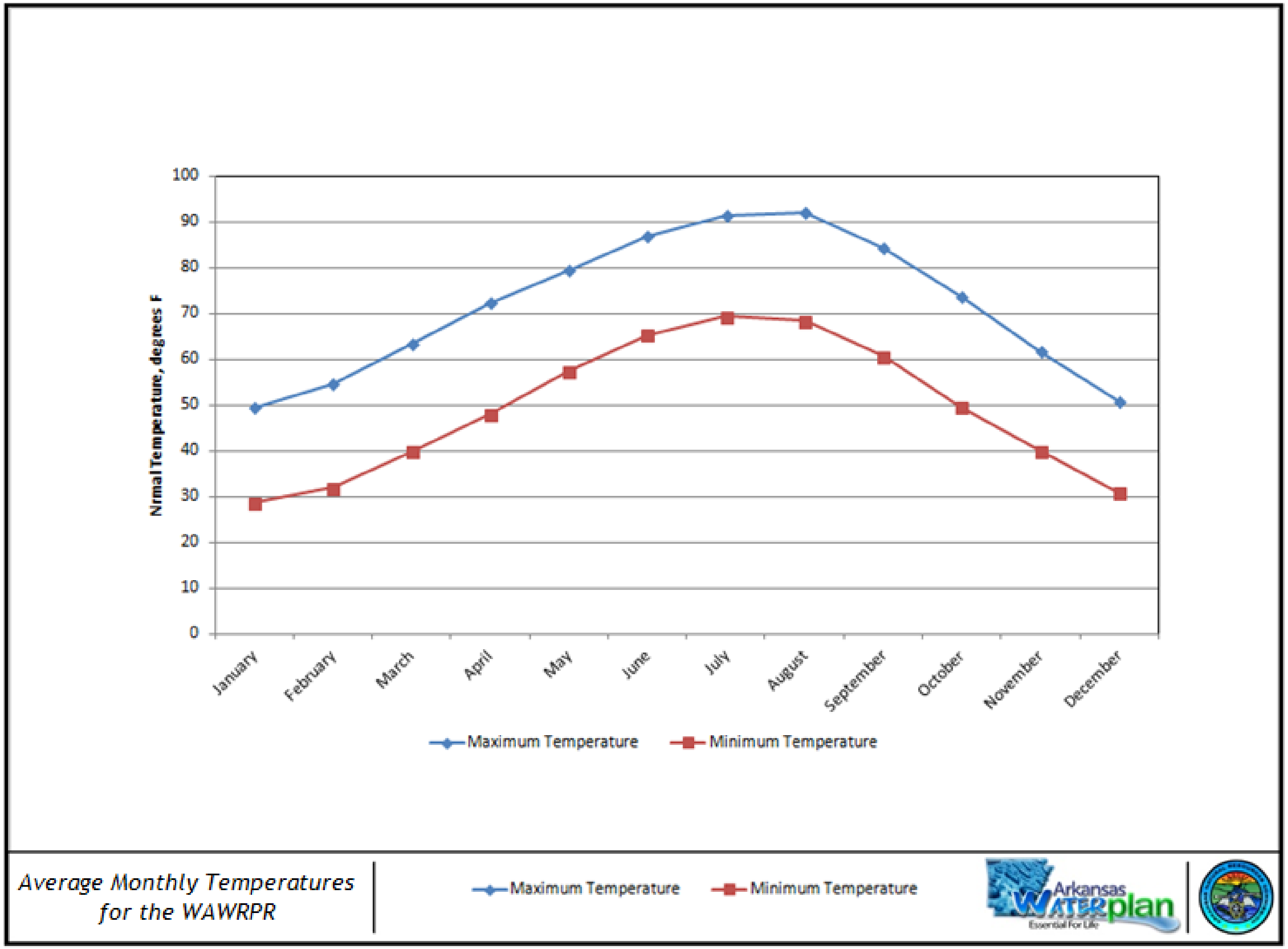

Figure 3.9. Average monthly (Maximum/Minimum) temperatures for the WAWRPR (PRISM Climate Group 2004).

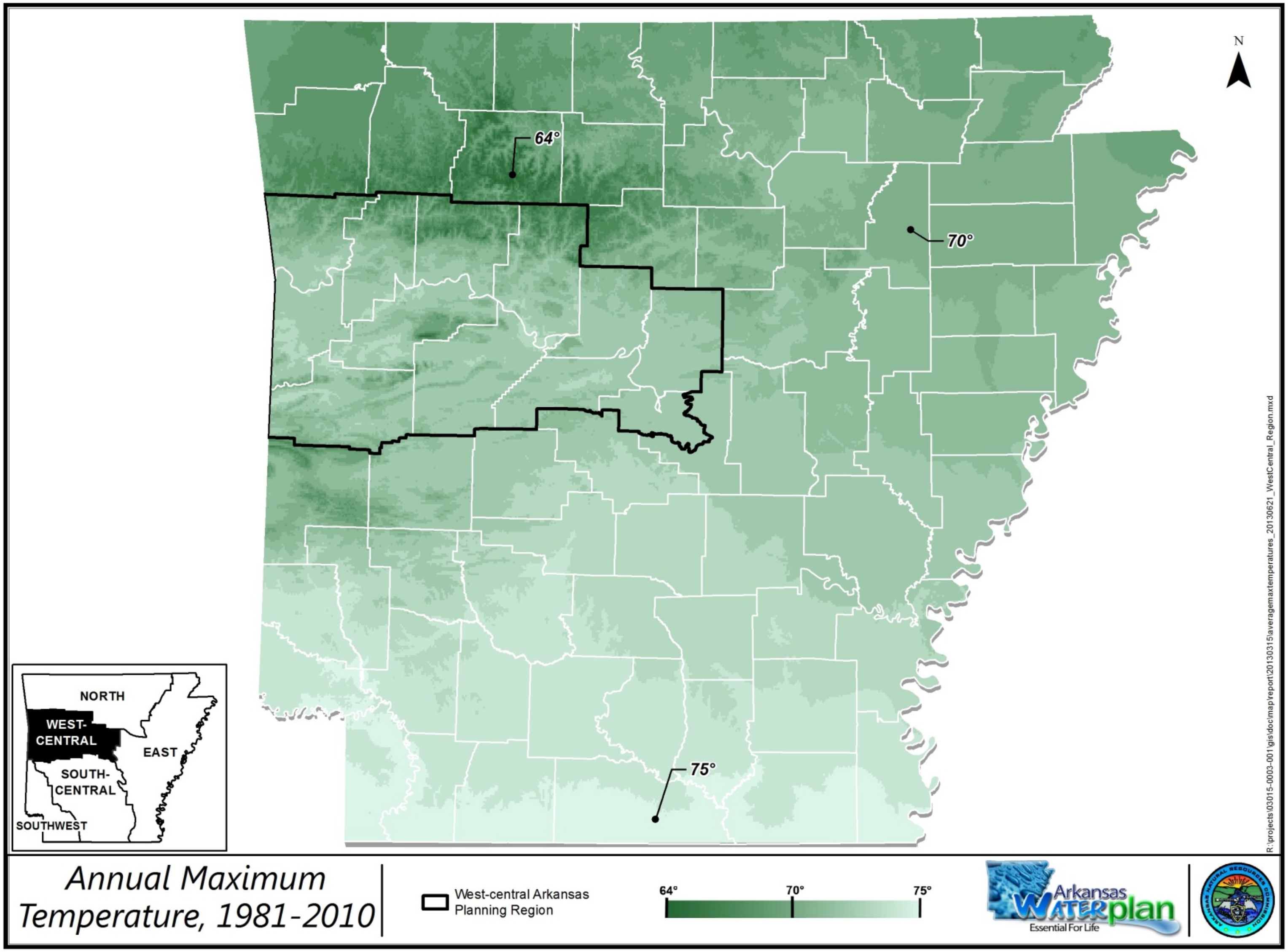

Figure 3.10. Average annual maximum temperatures (°F) across the WAWRPR (PRISM Climate Group 2004).

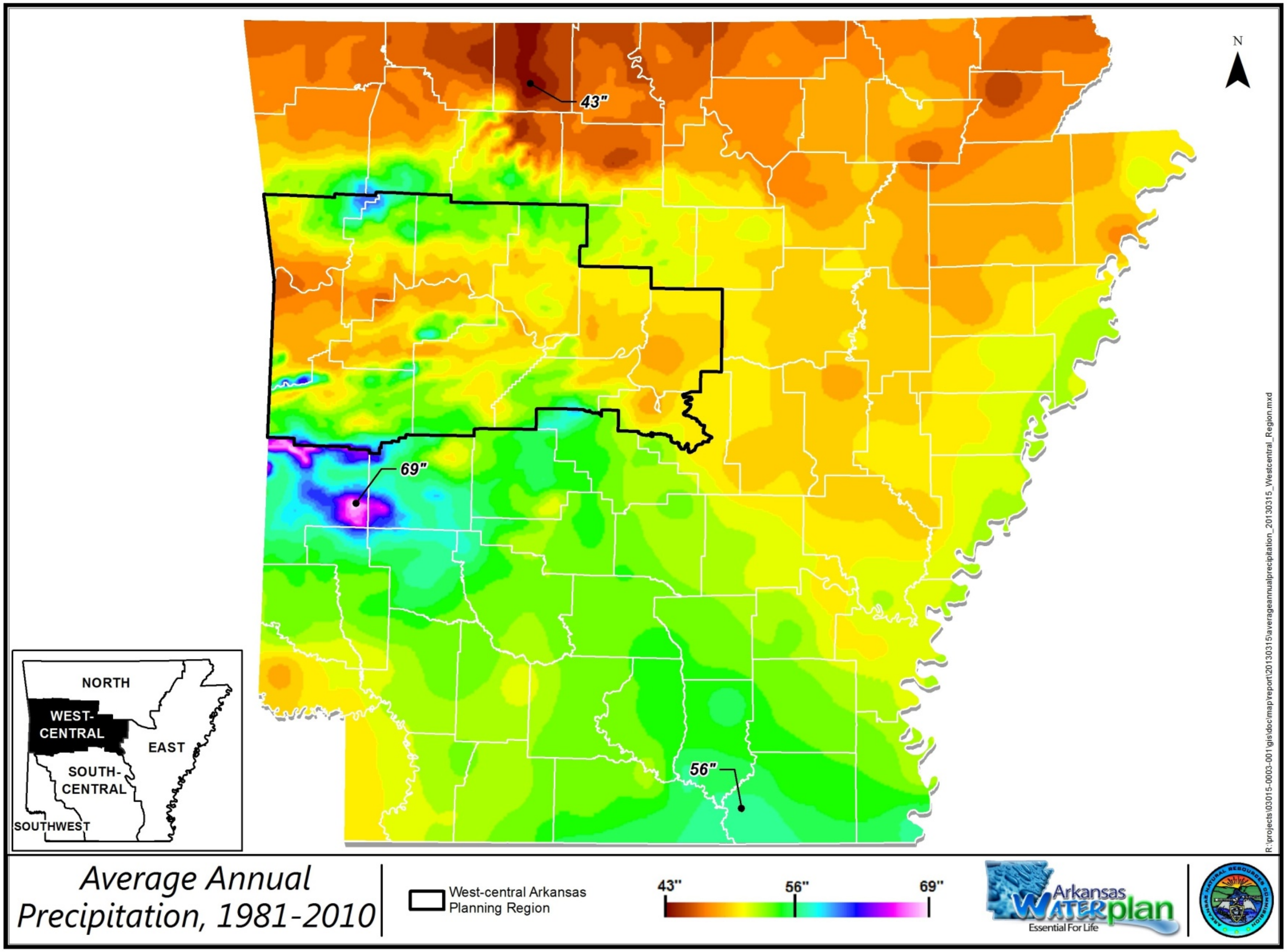

Figure 3.11. Average annual precipitation (inches) for the WAWRPR (PRISM Climate Group 2004).

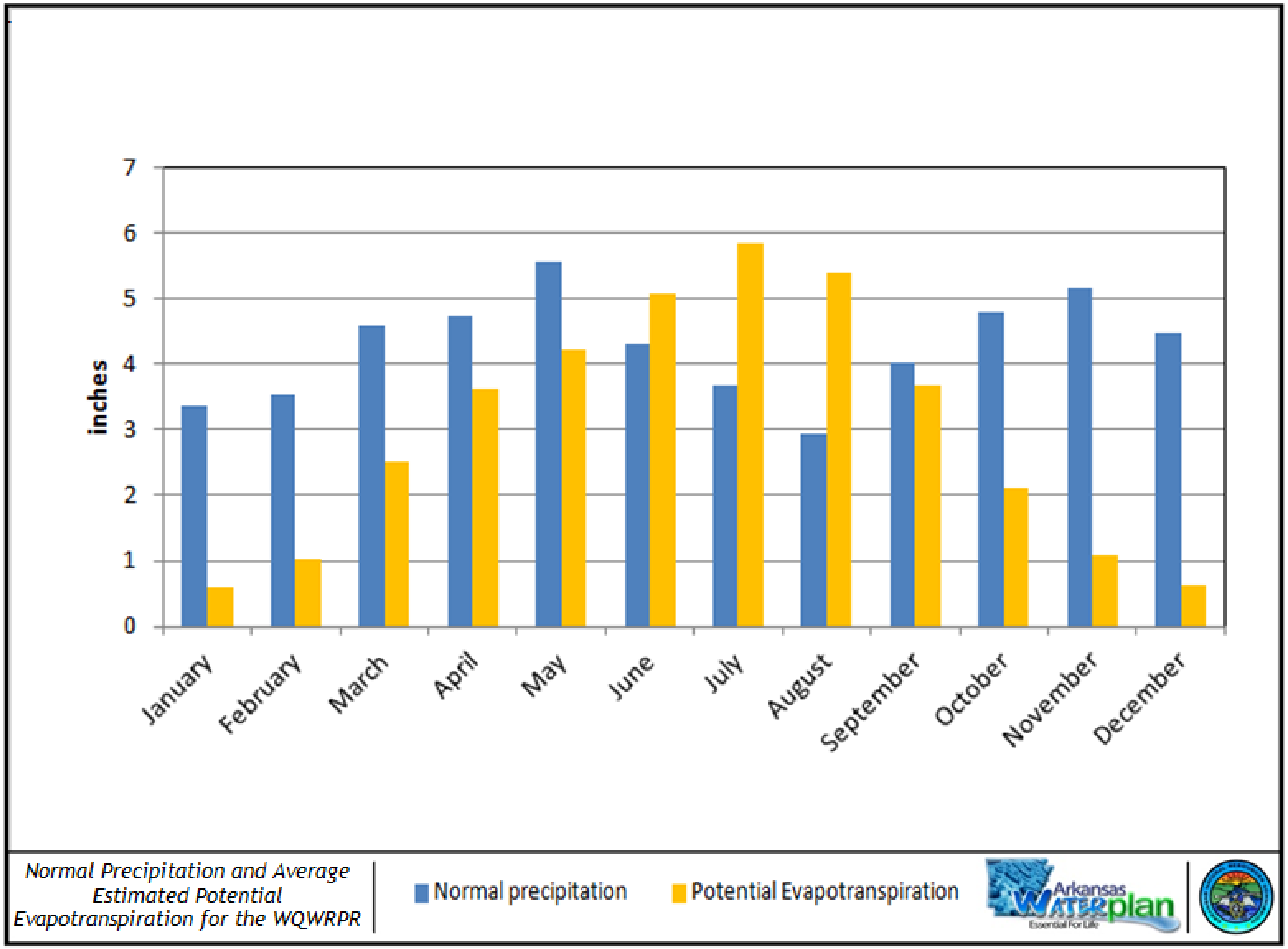

Figure 3.12. Normal precipitation and average estimated potential evapotranspiration for the WAWRPR (1981 – 2010) (PRISM Climate Group 2004, NOAA NCDC 2013b).

3.5.3 Evaporation

Evaporation is the process by which water changes from liquid in soil or waterbodies to gaseous water vapor. When the conversion from liquid to water vapor occurs on leaves, the process is called transpiration. Evapotranspiration is the combination of these processes. The amount of evapotranspiration is controlled primarily by sunlight, but is influenced by humidity and wind (Scott et al. 1998).

Potential evapotranspiration is the maximum rate at which water in soil and on plants would change to water vapor, assuming there is no shortage of water to be changed. Actual evapotranspiration is usually less than the potential. Potential evapotranspiration is difficult to measure, but can be estimated from the meteorological measurement, pan evaporation. Pan evaporation is the rate of evaporation of water from a specific style of open pan at a weather station. In humid climates, like in the WAWRPR, potential evapotranspiration is similar to pan evaporation. In this planning region, the ratio of potential evapotranspiration to pan evaporation is assumed to be 0.85. Evaporation exhibits less variation from year to year and place to place than precipitation (Scott et al. 1998).

There is one weather station in the WAWRPR where pan evaporation has been measured consistently since 2000, Blue Mountain Dam, located in Yell County. Monthly average potential evapotranspiration estimated from available pan evaporation measurements at this weather station for the period 1981 through 2010, and the normal precipitation, are provided on Figure 3.10.

The estimated potential evapotranspiration measured at this site is greater than the normal precipitation for three months out of the year, June through August, however, in general, this planning region has a natural excess of water.

3.5.4 Drought

The WAWRPR does experience drought. One of the tools NOAA uses to determine when drought conditions exist is the Palmer Drought Indices. These indices are based on the differences of precipitation and temperatures from normal. The Palmer Drought Severity Index (PDSI) also takes into account the length of time that drought conditions last. PDSI values less than zero indicate drought conditions. An index of -2 indicates moderate drought, -3 indicates severe drought, and -4 indicates extreme drought (NOAA 2012). Figures 3.13 and 3.14 show time series plots of PDSI values for the two Arkansas climate divisions that cover the majority of the WAWRPR, divisions 4 and 5 (see Figure 3.6 for a map of Arkansas climate divisions). Periods of multiple consecutive years classified as drought have occurred frequently in the planning region. Drought conditions occur more frequently in Climate Division 5, which covers the eastern portion of the planning region than in Climate Division 4, which includes the western portion of the planning region. The entire WAWRPR experienced a period of severe to exceptional drought that began in 2010 and has only recently lessened in portions of the planning region (NOAA NCDC 2013a).

3.5.5 Climate Variability

In 2007, the Governor's Commission on Global Warming (GCGW) was established to, among other tasks; evaluate the potential impacts of global warming on the state citizens, natural resources, and economy. The literature review conducted by the GCGW identified the following climate change effects that could be anticipated for the WAWRPR: (GCGW 2008)

- Increased incidence of severe weather events,
- Increased incidence of flooding,
- Increased incidence of drought, and
- Changes in climatic zones.

Plots of annual average temperature and historic annual precipitation from 1895 to 2013 for the Arkansas climate divisions in the WAWRPR are shown on Figures 3.15 and 3.16, respectively. The temperature data appear to exhibit a cycle of change, where temperatures in the first half of the 20th century were warmer than the second half, but appear to be warming again in the early 21st century (Figure 3.15). The US Department of Agriculture (USDA) develops a plant hardiness zone map which shows annual average minimum winter temperature. The 2012 update of the USDA map shows warmer minimum temperatures in the state as compared to the 1990 zone map, which follows the cycle shown on Figure 3.15 (Clark and Karklis 2012).

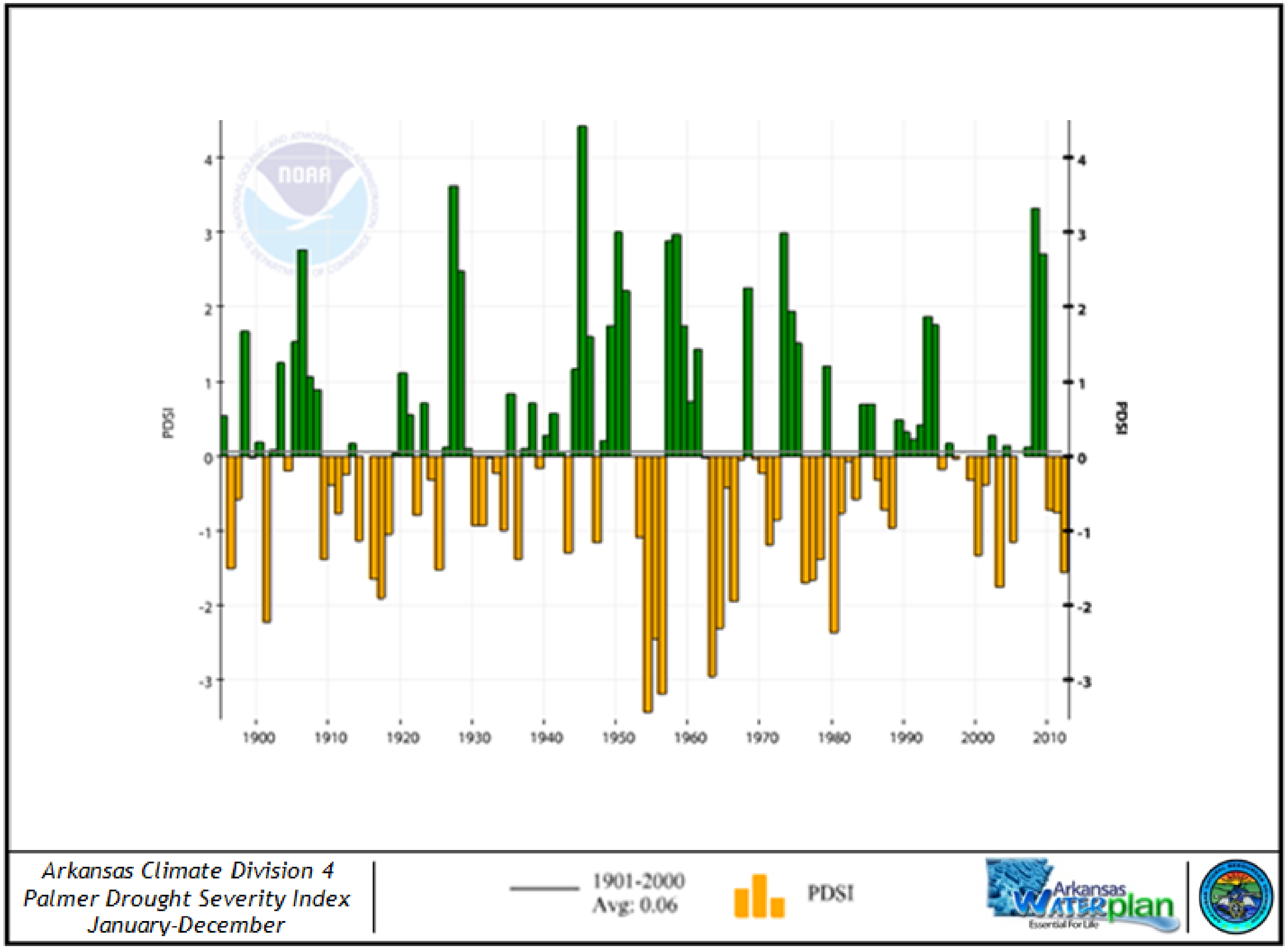

Figure 3.13. Historic PDSI values for climate division 4 in the WAWRPR (NOAA NCDC 2013a).

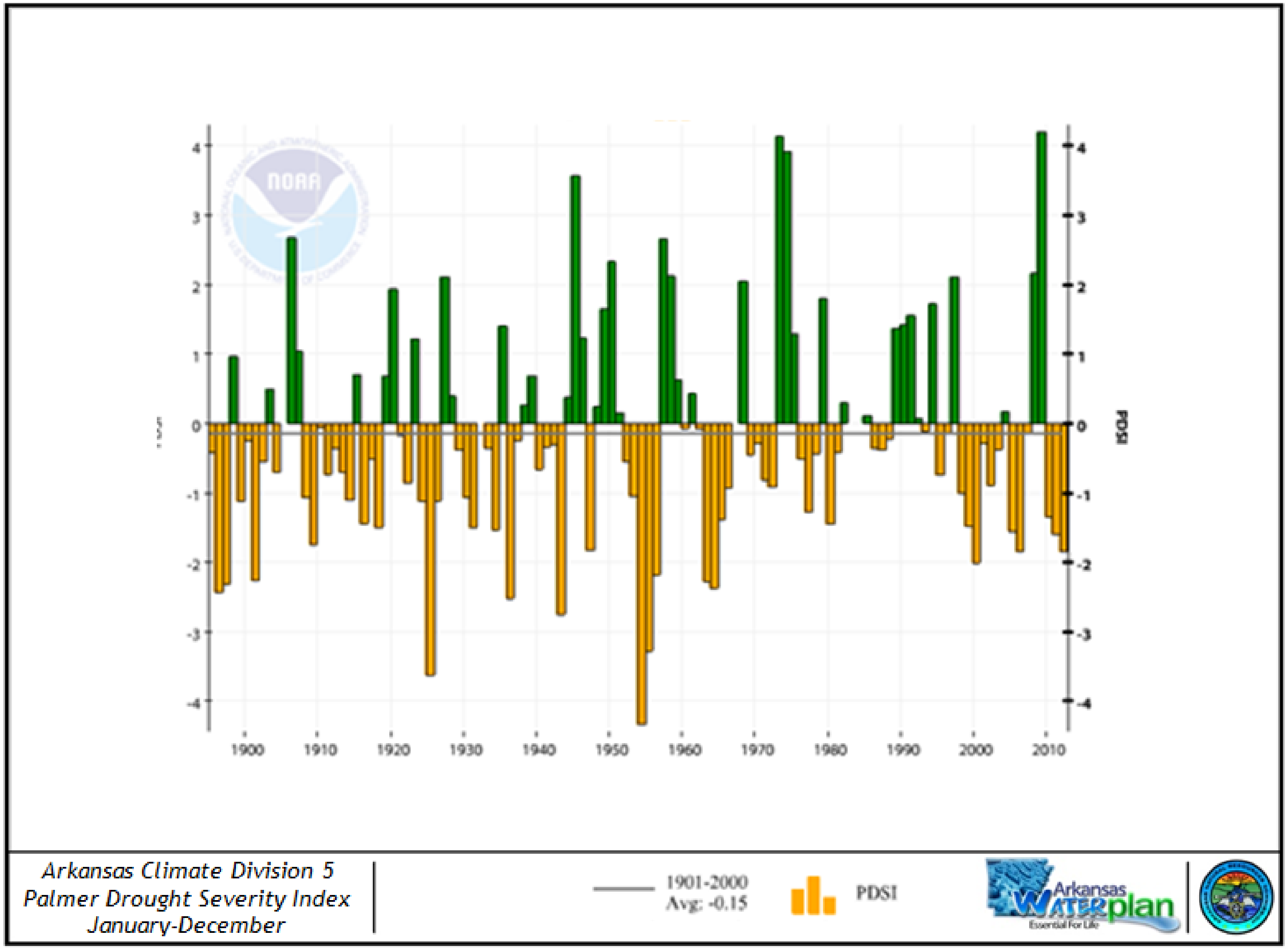

Figure 3.14. Historic PDSI values for climate division 5 in the WAWRPR (NOAA NCDC 2013a).

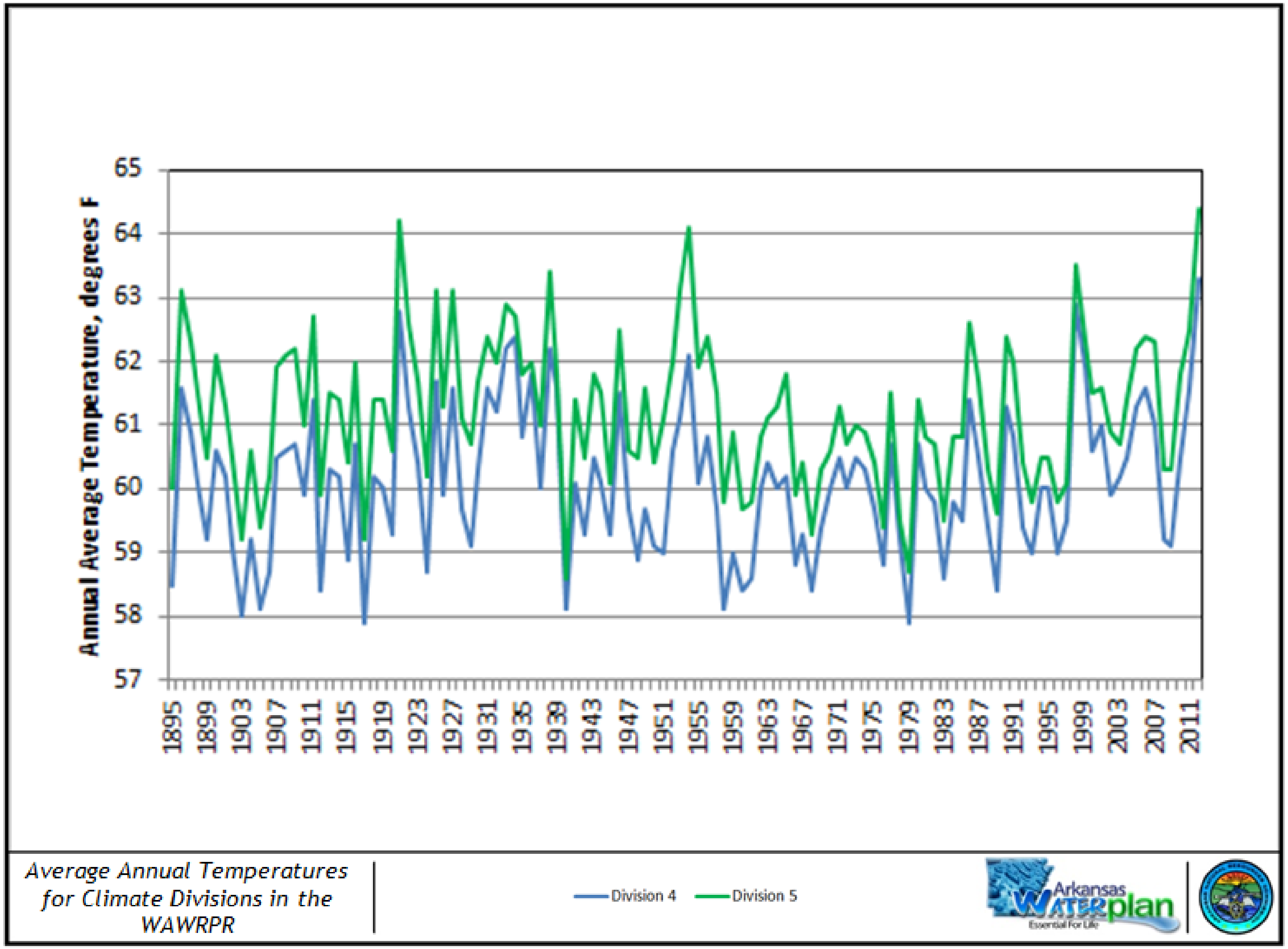

Figure 3.15. Average annual temperatures for climate divisions in the WAWRPR (NOAA NCDC 2013b).

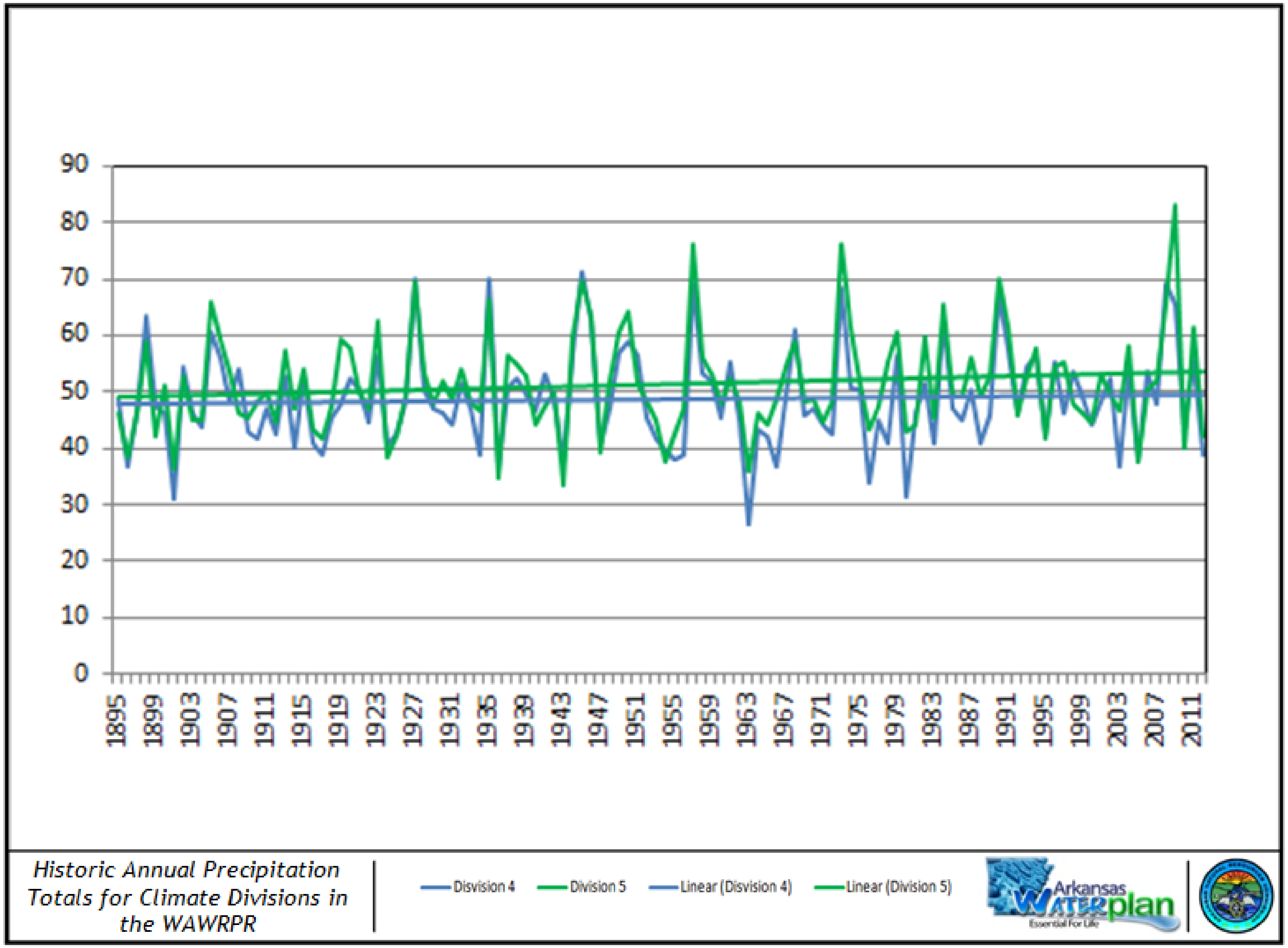

Figure 3.16. Historic annual precipitation totals for climate divisions in the WAWRPR (NOAA NCDC 2013b).

Precipitation totals for Climate Divisions 4 and 5, presented on Figure 3.16, appear to exhibit a slight long-term increasing trend as depicted by the linear trend lines. A detailed analysis of long-term precipitation trends across the state is being prepared as part of the 2014 water plan update.

3.6 Land Use

Land use in the WAWRPR is summarized on Figure 3.17 and mapped on Figure 3.18. Major land use categories are discussed in the sections below, including present day extent, and changes since the 1990 AWP.

3.6.1 Forest

Over 61% of WAWRPR was forested land in 2006 (the most recent year for which detailed land cover data is available). The USDA Forest Service (USFS) 2012 forest land inventory for the counties of the WAWRPR indicates there are over 3.4 million acres of timber. Table 3.2 provides a county summary of the forest land acreage reported. Yell and Scott counties include over 450,000 acres each, which accounts for approximately 28% of the forest land in the planning region. The majority of the forest land in these counties is part of the Ouachita National Forest. Pulaski and Sebastian counties account for the least amount of forestland, which is indicative of the higher population and urban centers in these counties The majority of the forest land in the planning region counties (98%) is classified by the USFS as timberland, or commercial forest land (USFS 2013).

Table 3.2 also includes the forest land areas from the 1977 Resource Inventory Data System reported by county in the 1990 AWP reports. These data are from different sources, so their comparability is uncertain. However, in comparing these areas, there may have been a slight increase in the amount of forest land in the planning region counties during the period since the 1990 AWP update. Some counties appear to have experienced increases in forest area, while other experienced declines in forest area.

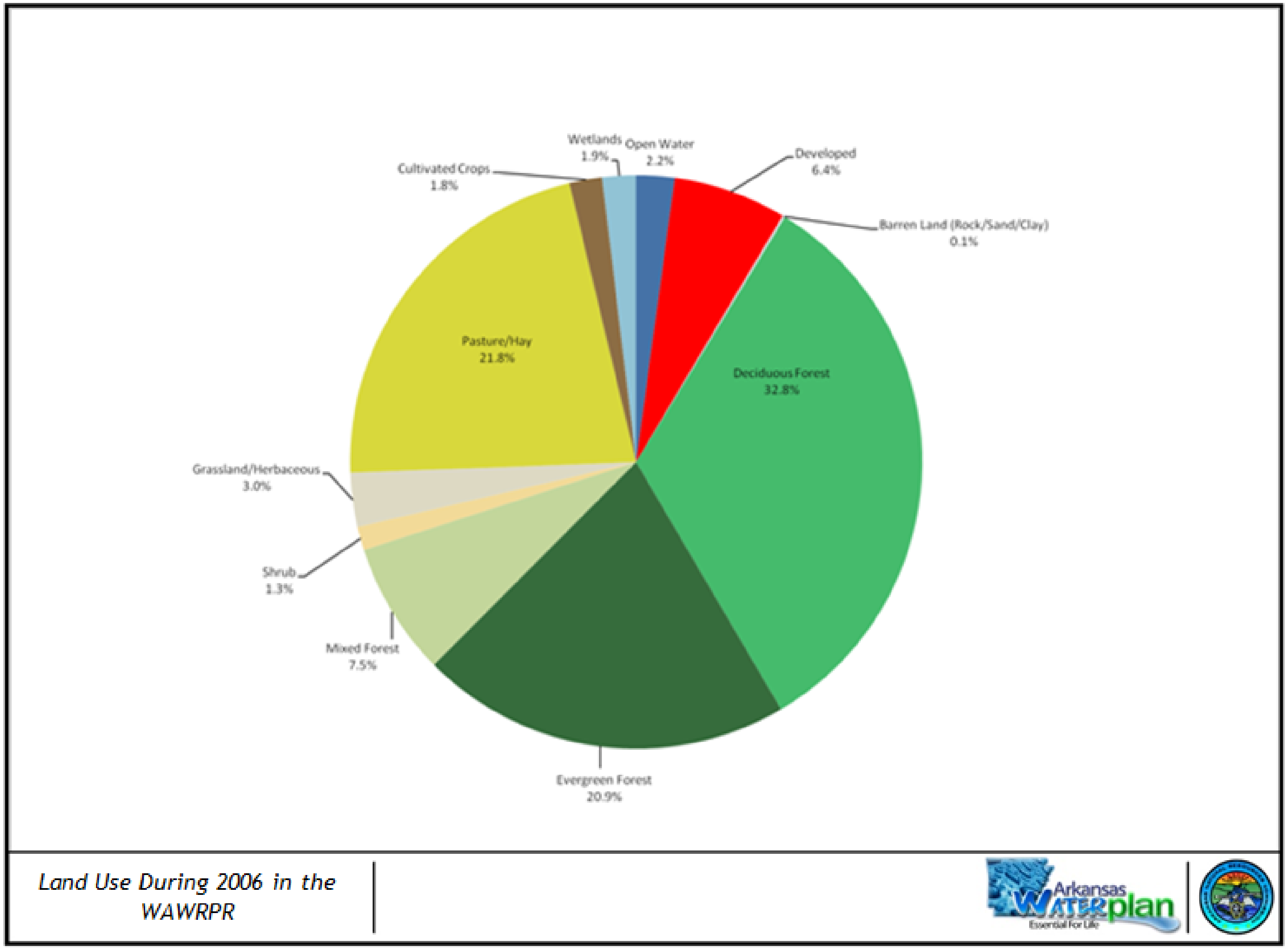

Figure 3.17. Land use during 2006 in the WAWRPR (Fry et al. 2011).

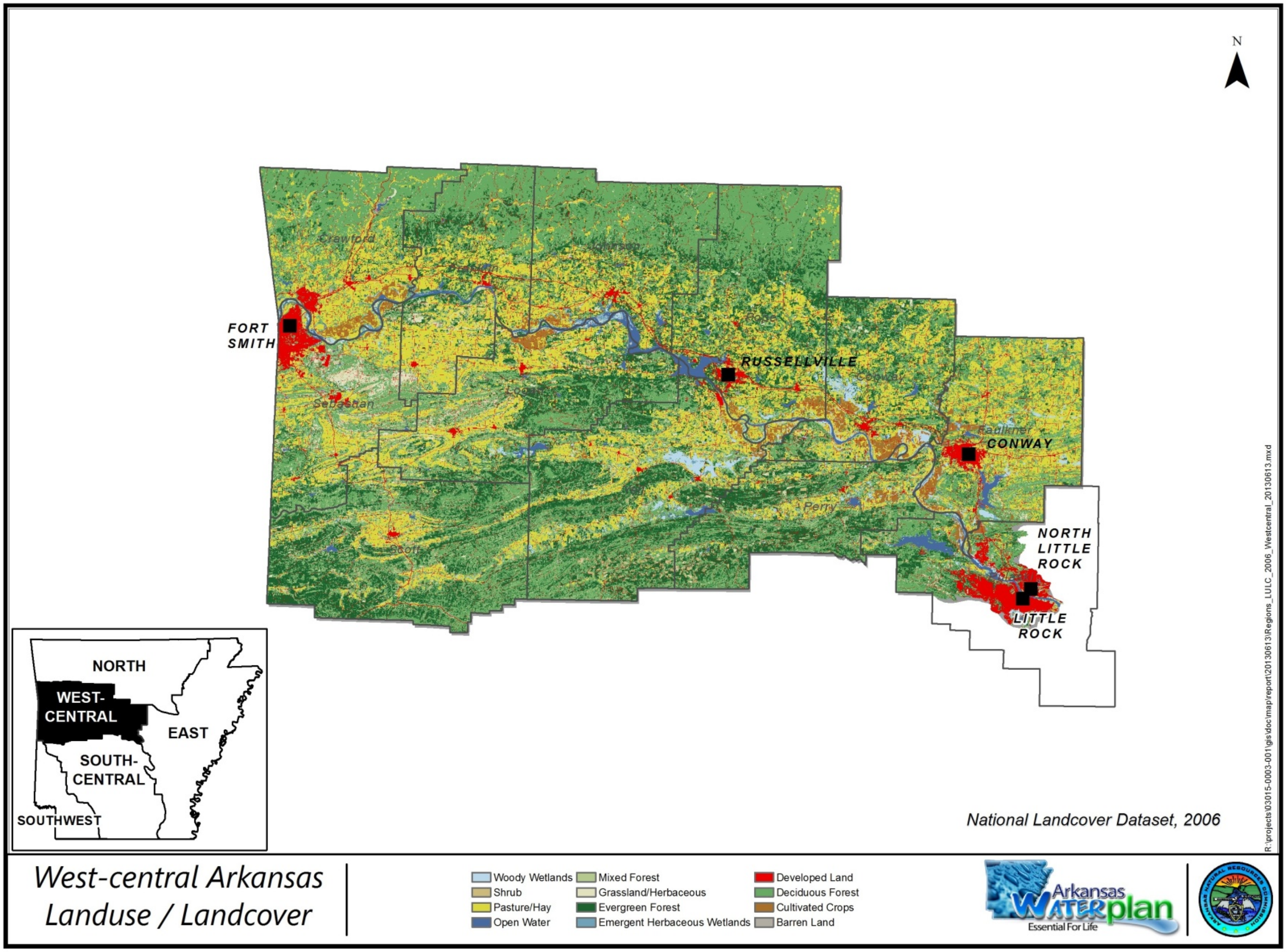

Figure 3.18. Land use map of the WAWRPR (Fry et al. 2011).

Table 3.2. Forest acreage by county in the WAWRPR.

County	1990 AWP Forest Land (acres)	2012 Forest Land[e] (acres)	Change
Conway	159,930[a,b]	196,120	+
Crawford	224,032[a,b]	208,511	-
Faulkner	161,452[a]	219,793	+
Franklin	181,250[a,b]	219,399	+
Johnson	326,628[a]	309,141	-
Logan	232,451[a]	266,414	+
Perry	286,677[a,c,d]	267,630	-
Pope	344,242[a,b]	384,897	+
Pulaski*	199,139[a,d]	234,669	+
Scott	455,108[a,b]	464,581	+
Sebastian	130,917[a]	158,539	+
Yell	412,986[a,b]	482,884	+
Total	**3,114,272**	**3,412,578**	**+**

* Note: the acreage reported is for the entire county, but part of this county is in other planning regions.
a. USACE Little Rock District 1988a
b. USACE Little Rock District 1988b
c. ASWCC 1987a
d. ASWCC 1987b
e. USFS 2013

3.6.2 Agriculture

Agriculture land accounts for the next largest proportion of the planning region at approximately 24% (Figure 3.17). Pasture and haylands account for the majority of this land use category (93%). In the 2007 Census of Agriculture, the total of pasture in the counties within the planning region was 906,330 acres, with 546,276 acres of cropland (USDA National Agricultural Statistics Service 2009). In the WAWRPR livestock production, associated with pasture and haylands, accounts for the bulk of the agricultural activity in the planning region. In the 1990 AWP, the acreage reported for pasture was 1.5 million, with 284,382 acres of cropland. Because these data are from different sources, their comparability is uncertain (See Table 3.3). Comparing pasture and cropland areas from the 1987 and 2007 Census of Agriculture indicates there has been a slight decline in pasture area in the counties of the WAWRPR since 1990, but no significant change in the amount of cropland (US Census Bureau 1989, USDA National Agricultural Statistics Service 2009).

Table 3.3. Comparison of agriculture land use of the WAWRPR.

County	Cropland (acres)			Pasture (acres)		
	1987 Census of Agriculture[a]	**1990 AWP**	**2007 Census of Agriculture[a]**	**1987 Census of Agriculture[b]**	**1990 AWP**	**2007 Census of Agriculture[b]**
Conway	65,115	42,997	76,615	107,050	133,261	88,745
Crawford	45,940	21,520	42,777	92,069	105,912	64,417
Faulkner	63,498	39,469	55,546	183,130	157,933	112,162
Franklin	39,204	7,069	42,002	148,371	198,379	102,253
Johnson	28,359	10,214	31,930	93,777	88,111	64,091
Logan	47,835	19,469	53,636	155,019	194,986	94,013
Perry	23,543	17,442	28,163	52,886	43,775	35,700
Pope	40,055	18,890	51,935	125,862	139,179	86,233
Pulaski*	86,400	62,868	55,575	48,896	35,264	30,576
Scott	22,079	0	26,017	102,356	121,008	59,729
Sebastian	23,627	19,652	27,314	114,552	143,178	73,058
Yell	64,059	24,792	54,766	152,468	150,537	95,353
Total	549,714	284,382	546,276	1,376,436	1,511,523	906,330

* Note: the acreage reported is for the entire county, but part of this county is in other planning regions.
a Note: sum of “harvested cropland” and “other cropland” reported in census
b Note: sum of “pastureland, all types” and “cropland used only for pasture” reported in census

The acreage of cropland harvested in the planning region counties in 2007 was only slightly greater than reported for 1987. Approximately 12% of the cropland in the counties of the planning region was irrigated in 2007. Both the percentage and the acreage of irrigated cropland in 2007 is double what it was in 1987 (US Census Bureau 1989, USDA National Agricultural Statistics Service 2009).

The crop items with the largest acreage within the planning region counties in 2007 were forage, soybeans, and wheat (USDA National Agricultural Statistics Service 2009). There are several counties in the planning region that grow select crops a little more unique to their area. These include grapes (Franklin County), peaches (Johnson County), peas and cantaloupes (Scott County), field and grass seed (Perry County), and sod (Sebastian County) (USDA National Agricultural Statistics Service n.d.). Soybeans and cotton were identified in the 1990 AWP as the two crops with the largest acreages in the Arkansas River basin (USACE Little Rock District 1988).

3.6.3 Developed Land

Developed land accounts for over 6% of the land area in the planning region. Several large urban areas are located within the WAWRPR, including Fort Smith, Russellville, Conway, and portions of Little Rock and North Little Rock. These urban areas have expanded since the 1990s. Table 3.4 compares areas for urban and built-up lands in the counties of the WAWRPR reported in the 1990 AWP, and from the most recent land use data set. These data indicate that developed land has increased in all of the counties of the planning region. Some of the differences in these numbers are likely the result of differences in the methodologies for classifying land use, however, population changes in these counties suggest that not all of the increase is due to differences in methodology (See Section 4.1).

Table 3.4. Comparison of urban/built-up area reported for counties in the WAWRPR (USACE Little Rock District 1988, Fry et al. 2011).

County	Urban/Built-up from 1990 AWP (acres)	Urban/Built-up 2006 (acres)
Conway	4,233	19,250
Crawford	18,228	23,951
Faulkner	18,216	34,778
Franklin	2,710	19,726
Johnson	2,911	22,502
Logan	7,760	20,505
Perry	2,746	15,860
Pope	14,815	27,146
Pulaski*	65,955	108,721
Scott	0	21,701
Sebastian	37,694	42,636
Yell	0	24,708
Total	**175,268**	**381,484**

* Note: the acreage reported is for the entire county, but part of this county is in other planning regions.

3.6.4 Wetlands

Open water and wetlands each account for 2% of the land area in the WAWRPR. The amount of wetlands that existed in the Arkansas River Basin at the time of the 1990 AWP update was estimated to be approximately 50,000 acres (USACE Little Rock District 1988). Based on the 2006 land cover dataset, 95,826 acres of wetlands are within the WAWRPR (note that the

WAWRPR is a smaller area than the Arkansas River Basin of the 1990 AWP) (Fry et al. 2011). This suggests that there has been an increase of wetland area in the region since the 1990 AWP update.

3.6.5 Public Land

There are over 2.4 million acres of public lands in the planning region, including parks, wildlife refuges and management areas, wilderness areas, and military installations, see Table 3.5 (AGFC 2009, AHTD 2006). Almost half of the WAWRPR (48%) is public land. The majority of the public land is National Forest, which accounts for approximately one-third of the area of the planning region.

Table 3.5. Public lands in the WAWRPR (AGFC 2009, AHTD 2006).

Public Land Use	Acreage	Count	Percent of Total Public Land
National Forest	1,782,717	2	73.7%
National Wildlife refuges	5,895	1	0.2%
Wildlife management areas	506,916	30	21.0%
State Park	9,575	7	0.4%
Military land	74,470	2	3.1%
National Parks	25	1	0.0%
Wilderness Areas	39,513	5	1.6%
TOTALS	2,419,111	48	100%

3.7 Surface Water

There are over 2,084 miles of streams and over 100,000 acres of impoundments in the WAWRPR (ADEQ 2012d, ASWCC 1981). The Arkansas River, which flows through this planning region, is one of the state's major rivers and is an important waterborne transportation route. Other principal water courses in the planning region include the Fourche La Fave and Petit Jean Rivers, both tributaries of the Arkansas River (refer to Figure 2.1).

3.7.1 Rivers and Streams

The Arkansas River is the primary river flowing through the center of WAWRPR. It traverses the planning region generally from east to west, making up the largest physiographic region, the Arkansas River Valley (Figure 3.1). The Arkansas River originates in Colorado, entering Arkansas from Oklahoma at Fort Smith, as the boundary between Crawford and Sebastian Counties. The Arkansas River flows to the east as far as Clarksville, in Johnson County, where it turns more to the southeast. The Arkansas River leaves the planning region at Little Rock, in Pulaski County. The Arkansas River receives runoff from the entire planning region. The portion of the Arkansas River in this planning region is entirely contained in the MKARNS, including Lock & Dams 7 through 10, 12, and 13 (See Figure 2.2).

The Fourche La Fave River originates in the planning region, in the Fourche Mountains, in Scott County. The Fourche La Fave River flows eastward until it empties into the Arkansas River in Perry County.

The Petit Jean River also originates in the planning region, in the Fourche Mountains, at the confluence of several streams near Waldron, in Scott County (Lancaster 2011b). The river flows eastward until it empties into the Arkansas River as the boundary between Yell and Conway Counties.

The historical average annual surface runoff in the WAWRPR ranges from 10 inches in the far north-western area of the planning region to 15 inches in the southern area of planning region (Figure 3.19). Seasonal variation in surface runoff mirrors seasonal variation in precipitation (Pugh and Westerman 2014).

Average monthly flows for selected streams in the WAWRPR are shown on Figure 3.20. At all of the stations, streamflow is highest during the winter to spring months, which is consistent with the normally higher precipitation during this same period (see Figure 3.9). A map displaying the locations of the US Geological Survey (USGS) gages used is on Figure 3.21. As would generally be expected, all of the stations report streamflow is generally lowest during the summer months, particularly August. This is due to the decrease in precipitation and an increase in evapotranspiration that occurs during the growing season (USACE Little Rock District 1988). Many streams in the planning region flow only after rainfall, having little or no base flow. As a result, many of the small streams in this planning region are dry at least part of the year (Woods et al. 2004).

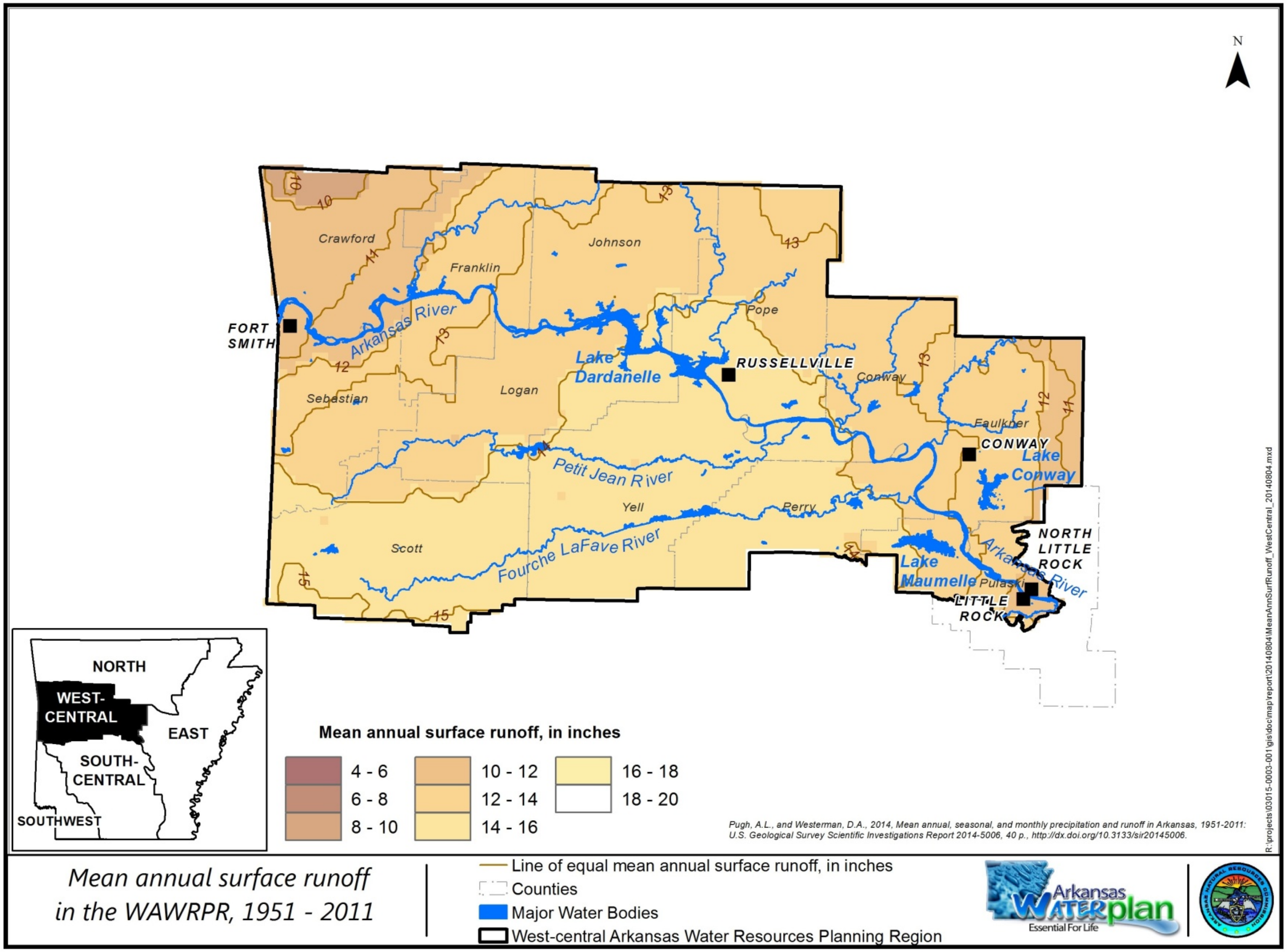

Figure 3.19 Average annual surface runoff in the WAWRPR, 1951 to 2011 (Pugh and Westerman 2014).

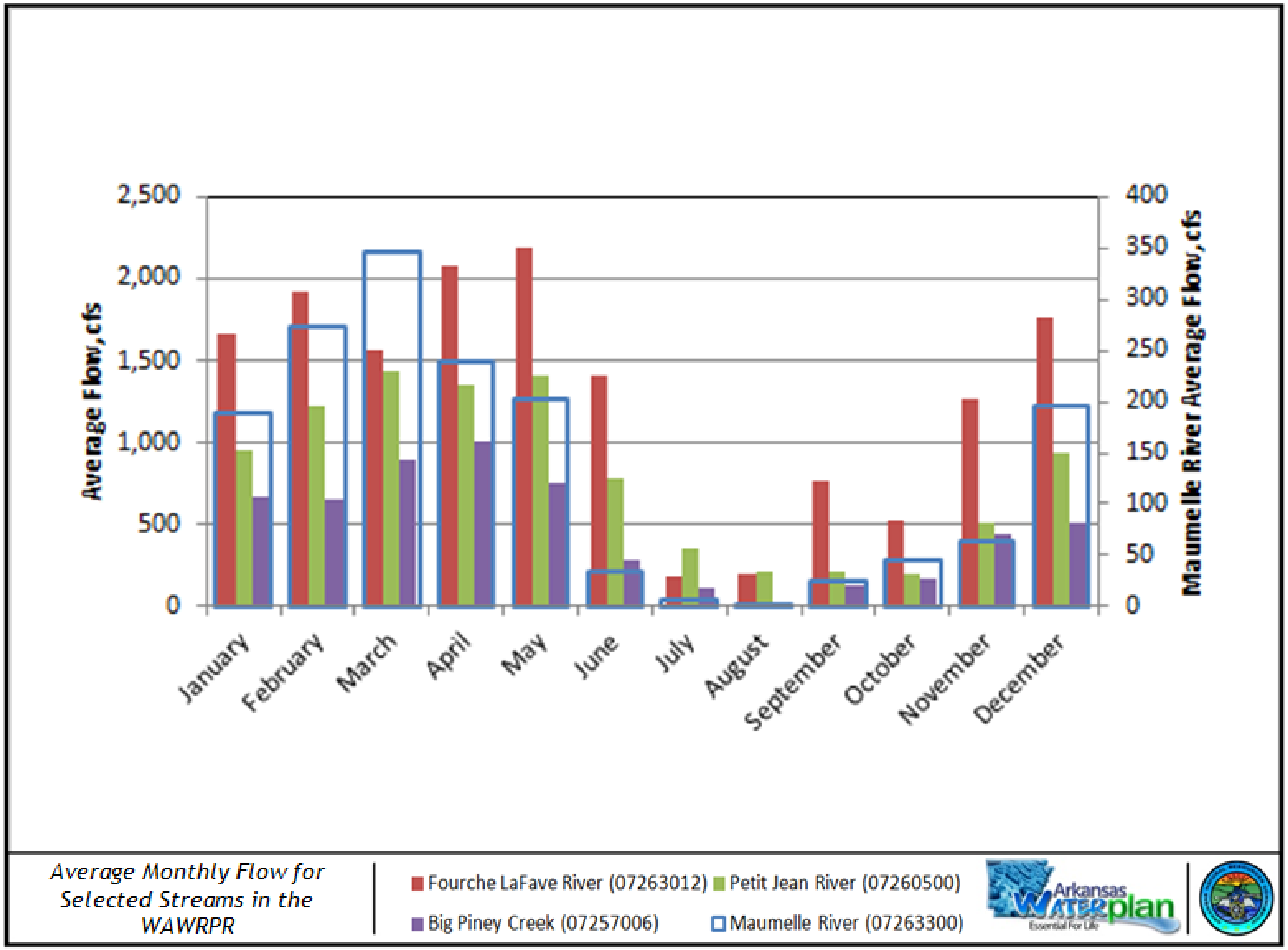

Figure 3.20. Average monthly flow for selected streams in the WAWRPR (USGS 2013a).

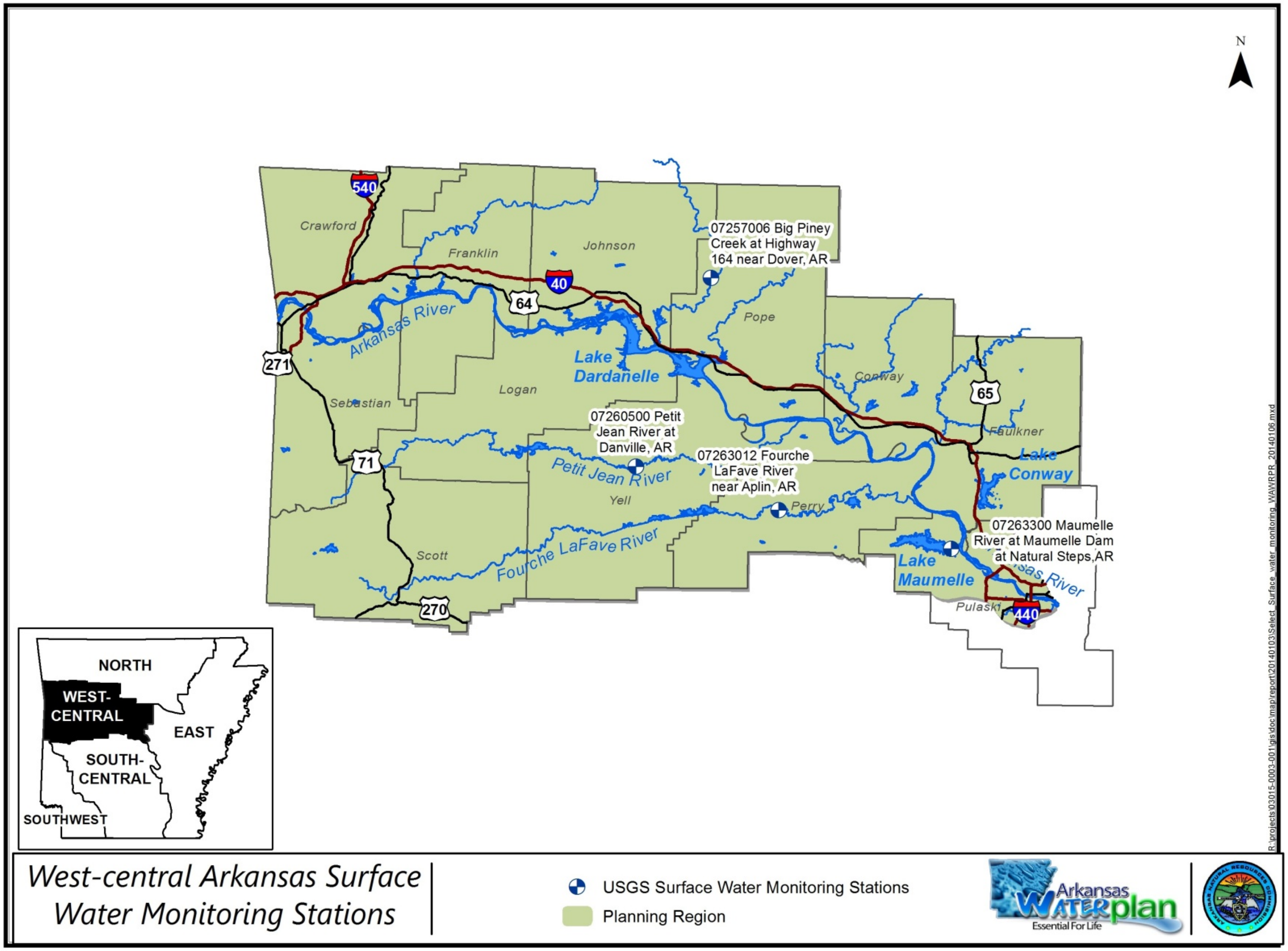

Figure 3.21. Select USGS surface water gage stations.

3.7.2 Lakes and Impoundments

In 1981 there were over 100,000 acres of lakes and impoundments in the planning region, with the largest being the Dardanelle and Ozark impoundments on the Arkansas River. Some of the other notable impoundments in the planning region include Blue Mountain Lake, Nimrod Lake, and Lake Fort Smith. The majority of the smaller impoundments are used for agricultural purposes, such as for livestock. Table 3.6 gives a summary of impoundments in the region. An updated state-wide inventory of impoundments is being prepared for the 2014 water plan update.

The Arkansas Department of Environmental Quality (ADEQ) has identified 21 significant publicly owned lakes in the planning region. These are lakes that are at least 100 acres and have access designed to enhance public use (ADPCE 1990). Information for the significantly publicly owned lakes within the WAWRPR is summarized in Table 3.7.

Table 3.6. Summary of lakes and impoundments in the WAWRPR (ASWCC 1981).

	Number of Lakes and Impoundments	Area (acres)	Capacity (acre-feet)
Conway County	3,015	3,509	10,626
Crawford County	2,322	2,264	62,861
Faulkner County	4,072	3,298	27,995
Franklin County	1,990	2,408	25,101
Johnson County	1,379	2,641	18,282
Logan County	2,898	1,403	10,890
Perry County	1,085	2,250	29,422
Pope County	2,741	3,230	15,322
Pulaski County [1]	806	13,798	236,921
Scott County	2,867	1,910	12,234
Sebastian County	1,805	1,466	24,305
Yell County	2,382	1,267	11,819
USACE	2	6,460 (conservation pool)	53,650 (conservation pool)
USACE[2]	2	44,900 (top of power pondage)	679,500 (top of power pondage)

Table 3.6. Summary of lakes and impoundments in the WAWRPR (continued).

	Number of Lakes and Impoundments	Area (acres)	Capacity (acre-feet)
USFS	5	343	4,173
Parks & Tourism	3	168	1,024
AGFC	9	11,404	85,820
Total[3]	**27,381**	**96.259**	**1,256,295**

1 Not included entirely in the WAWRPR.
2 Arkansas River Impoundments.
3 Totals based on power pondage area and capacity

Table 3.7. Information for significant publicly owned lakes/reservoirs in the WAWRPR (ADEQ 2012d).

Name	County	Lake type	Surface area (acres)	Average Depth (feet)	Capacity (acre-feet)	Purpose[1]
Lake Dardanelle	Johnson, Logan, Pope, and Yell	Reservoir	34,300	14	480,200	N/P/R
Ozark Lake	Franklin	Reservoir	10,600	14	148,400	N/P/R
Lake Maumelle	Pulaski	Reservoir	8,900	23	204,700	WS
Lake Conway	Faulkner	Reservoir	6,700	5	33,500	A
Nimrod Lake	Yell	Reservoir	3,550	8	28,400	FC/R
Blue Mountain Lake	Logan	Reservoir	2,910	9	26,190	FC/R
Lake Fort Smith	Crawford	Reservoir	1,390	66	91,420	WS
Harris Brake Lake	Perry	Reservoir	1,300	6	7,800	A
Brewer Lake	Conway	Reservoir	1,165	20	23,300	WS
Overcup Lake	Conway	Reservoir	1,025	4	4,100	A
Hinkle Lake	Scott	Reservoir	965	5	14,475	A
Beaver Fork	Faulkner	Reservoir	900	10	9,000	R
Atkins Lake	Pope	Reservoir	750	5.5	4,125	A
Lee Creek	Crawford	Reservoir	634	11	6,974	WS
Nolan	Sebastian	Reservoir	350	9	3,150	A
Sugarloaf	Sebastian	Reservoir	250	12	2,000	A
Cove Lake	Logan	Reservoir	160	10	1,600	R
Lake Bailey	Conway	Reservoir	124	8	992	R
Horsehead Lake	Johnson	Reservoir	100	16	1,600	R
Spring Lake	Yell	Reservoir	82	23	1,886	R
Shores Lake	Franklin	Reservoir	82	10	820	R

1 A = Angling (fishing), FC = Flood Control, N = Navigation, P = Power, R = Recreation, WS = Water Supply

The physiography and geology of the WAWRPR is conducive to dam construction as groundwater resources in the region are limited. As a result, a large number of the streams in the planning region are dammed and their flow regulated. These include the Arkansas River, Petit Jean River, Lee Creek, Frog Bayou, Little Clear Creek, Little Mulberry Creek, Galla Creek, Ouachita Creek, Tupelo Bayou, West Fork Point Remove Creek, East Fork Point Remove Creek, Fourche La Fave River, Upper Poteau River, Sixmile Creek, Cypress Creek (in Conway County), Maumelle River, and Flat Rock Creek (in Sebastian County).

3.7.3 Waterborne Transportation

Waterborne transportation of commodities occurs in the WAWRPR on the Arkansas River, which is part of the MKARNS through the entire length of the planning region (Figure 2.2). The MKARNS system includes 18 locks spanning 450 miles and 420 feet of elevation change. In the WAWRPR there are six MKARNS lock and dam facilities: W.W. Trimble Lock and Dam No. 13 in Barling, Ozark-Jeta Taylor Lock and Dam No. 12 in Ozark, Dardanelle Lock and Dam No. 10 in Russellville, Arthur V. Ormond Lock and Dam No. 9 in Morrilton, Toad Suck Ferry Lock and Dam No. 8 in Conway, and Murray Lock and Dam No. 7 in Little Rock (Goss 2012). All of the lock and dams are maintained and operated by the Little Rock USACE. The MKARNS navigation channel is maintained to 9 feet. In 2005 Congress authorized construction of a 12 foot navigation channel along the entire length of the MKARNS, but funding has been limited. Therefore, the 12 foot navigation channel will not be maintained until a complete funding package is provided by Congress. There are two public ports on the MKARNS in the planning region, at Fort Smith and Little Rock, and one private owned multi-modal port, Five Rivers Distribution, at Van Buren. In addition to the locks and dams, channel stabilization structures, and routine dredging are required to maintain the MKARNS navigation channel. Commercial navigation on the MKARNS is generally feasible year-round.

3.7.4 Wetlands

Several types of wetlands exist in the WAWRPR, including mountaintop depressions and sandstone glades, which can be found along the mountaintop areas in the Ozark National Forest.

Several floodplain wetland types and wetlands associated with impoundments also occur in the planning region. Wet tallgrass prairie has also historically occurred in the planning region (Arkansas Multi-Agency Wetland Planning Team 2001).

3.7.5 Surface Water Quality

Surface water quality in the Boston Mountains region of the WAWRPR is exceptional overall, with concentrations of most biochemical and nutrient characteristics being very low. Water quality in the Arkansas River Valley region is influenced more by land use that geology. While the overall water quality in this region is generally good, dissolved oxygen levels tend to be lower than in the Boston and Fourche Mountains, while turbidity, nutrients, and biochemical oxygen demand tend to be higher. Water quality in the Fourche Mountains surface waters tends to be exceptional, with low mineral, nutrient, and biochemical parameter concentrations (Woods, et al. 2004). Surface water quality issues within the WAWRPR are discussed in detail in Section 5.5.

3.8 Groundwater

In general, groundwater of the WAWRPR is of good quality. Compared to the Gulf Coastal Plain, the Interior Highlands have less reported groundwater use. This usage has been attributed to the prevalent use of surface water, less agriculture, lower population and industry densities, lower yield from geologic formations, and lack of detailed reporting in the Interior Highlands. The various aquifers of the Interior Highlands generally occur in shallow, fractured, and discontinuous bedrock. These bedrock characteristics result in lower porosity, lower storage, and lower yields than the laterally extensive, coarse-grained, and unconsolidated sediments of the Gulf Coastal Plain. The dominant use of groundwater in the Interior Highlands is domestic supply, with minor industrial, small-municipal, and commercial-supply uses (Kresse et al. 2013). A discussion on the groundwater quality in the WAWRPR is presented in Section 5.

3.8.1 Aquifers

There are two recognized aquifers in the WAWRPR, which are listed in Table 3.8 and mapped on Figure 3.22. These aquifers are considered minor and are only important as local sources of water. Kresse and others (2013) provide a comprehensive review of the aquifers of Arkansas to include the geologic setting, hydrologic characteristics, water levels, water use, and water quality. Much of the information presented in this section was summarized from the Kresse and others (2013) report.

Within the Ouachita province, fractured Paleozoic rocks of the Ouachita Mountains comprise the Ouachita Mountains aquifer (Kresse et al. 2013). Unconsolidated alluvial deposits underlying some areas of the Arkansas River also serve as a source of groundwater supply. The Arkansas River Valley alluvial aquifer is one of the most productive aquifers in the Interior Highlands and is capable of producing greater than 500 gallons per minute (gpm) for both municipal and irrigation use (Kresse et al. 2013).

The Boston Mountains Plateau and a portion of the Arkansas River Valley belong to the Western Interior Plains (WIP) confining unit and there are no formally recognized aquifers. However, there are several shallow, undifferentiated, and saturated rocks of limited extent that serve as groundwater supply for domestic and small community purposes (Adamski, Freiwald and Davis 1995).

Table 3.8. Nomenclature, geologic age, and use of aquifers in the WAWRPR.

Major Division	Province	Section	Formation or Group of Formations	Geologic Age	Hydrogeologic Unit Name	Aquifer Use[1]
Interior Highlands	Ouachita Province	Arkansas Valley	Arkansas River Valley Alluvium	Quaternary	Arkansas River Valley alluvial aquifer	PS, IR, D
		Ouachita Mountains	Boggy Formation Savanna Formation McAlester Formation Hartshorne Sandstone Atoka Formation Johns Valley Shale Jackfork Sandstone	Pennsylvanian	Ouachita Mountains aquifer	D
	Ozark Plateaus	Boston Mountains	Atoka Formation Bloyd Formation Hale Formation Imo Shale Pitkin Limestone Fayetteville Shale Batesville Sandstone Ruddell Formation Moorefield Formation	Mississippian and Pennsylvanian	Western Interior Plains Confining System	D

[1]IR= irrigation, PS = public supply, IN = industrial, D = domestic. Listed in order of highest use by volume. Primary use in capital letters; secondary use in small caps.

3.8.1.1 Western Interior Plains Confining Unit

The Boston Mountains Plateau and a portion of the Arkansas River Valley are represented by a group of formations referred to as the Western Interior Plains (WIP) Confining Unit. These formations are comprised primarily of fractured shale, sandstone, and siltstone rocks of Mississippian and Pennsylvanian age that are characterized by low porosity, permeability, and yields. While there are no formally recognized aquifers, there are numerous shallow, undifferentiated, and saturated rocks of limited extent that are used for domestic and small community supply (Kresse et al. 2013).

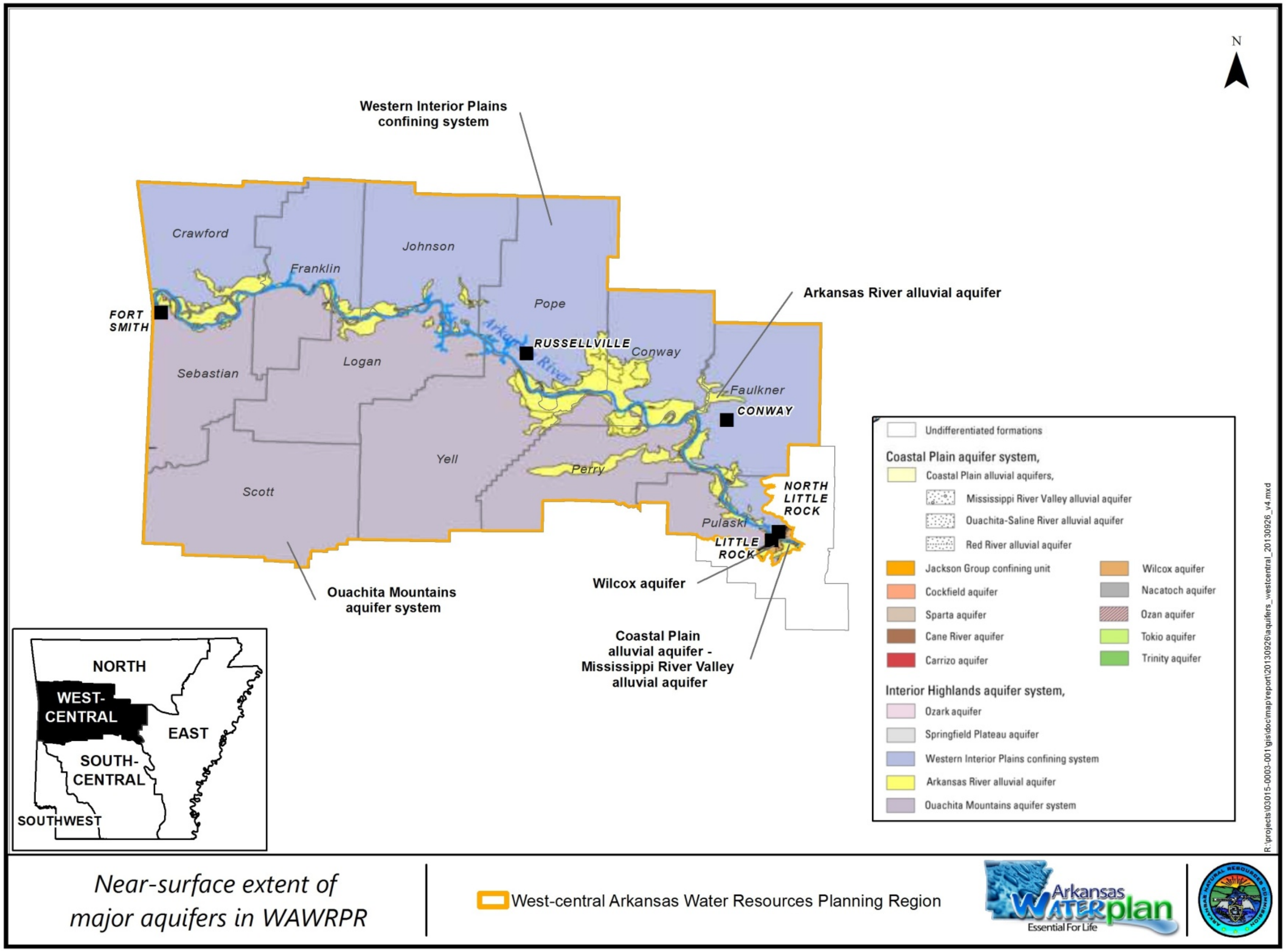

Figure 3.22. Aquifers of the WAWRPR (Kresse et al. 2013).

For this system, recharge occurs as precipitation that infiltrates the ground in upland areas and percolates to the water table. Groundwater flow paths are defined by small-scale topographic features where flow occurs from elevated areas to valley floors terminating in small stream systems. Groundwater storage in these aquifers is limited primarily to fractures and faults. Typical well yields range from 1 to 5 gpm, and thicker sandstone units in the eastern part of the WIP system commonly yield 5 to 10 gpm. It is not uncommon for wells in the WIP system to go dry during pumping, especially during dry periods. Water levels in the WIP confining system range from near land surface to approximately 50 feet below ground surface. Seasonal fluctuations are about 10 feet, with drawdowns from pumping increasing fluctuations to as much as 45 feet (Kresse et al. 2013).

3.8.1.2 Arkansas River Valley Alluvial Aquifer

Unconsolidated alluvial deposits underlying some areas of the Arkansas River valley are able to store large volumes of groundwater and are an important source of municipal water supply. Groundwater in the Arkansas River Valley alluvial aquifer is largely unconfined. Recharge to the aquifer is primarily by downward percolation of precipitation, in addition to leakage from the river (Bedinger, Emmett and Jeffery 1963; Kilpatrick and Ludwig 1990). In most places 30 to 60 feet of saturated sand and gravel is present, and the saturated thickness of the aquifer generally increases with distance downstream from Fort Smith. Wells completed in the sands and gravels in the lower part of the Arkansas River Valley alluvial aquifer are capable of yielding 300 to 700 gpm of water and are used predominantly for irrigation and municipal water supply (Bedinger, Emmett and Jeffery 1963; Kilpatrick and Ludwig 1990). Water levels range from approximately 5 to 30 feet below the ground surface (Kilpatrick and Ludwig 1990).

3.8.1.3 Ouachita Mountains Aquifer

A thick sequence of Paleozoic rock formations in the Ouachita Mountains serves as an important source of groundwater supply for domestic users, in addition to a limited number of small commercial- and community-supply systems. The shallow saturated section of the combined formations in the Ouachita Mountains is referred to as the Ouachita Mountains aquifer

(Kresse et al. 2013). Formations comprising the aquifer are predominated by thick sequences of shale, siltstones, sandstones, and other quartz formations (i.e., chert, novaculite), with minor occurrences of carbonates and other rocks.

For this system, recharge occurs as precipitation that infiltrates the ground in upland areas and percolates to the water table. Groundwater flow paths are defined by small-scale topographic features where flow occurs from elevated areas to valley floors terminating in small stream systems. Groundwater storage in these aquifers is limited primarily to fractures and faults. Quartz formations such as the Bigfork Chert and Arkansas Novaculite are very brittle and prone to dense fracturing, and most researchers working in the Ouachita Mountains identified the Bigfork Chert as the most productive aquifer in the region (Albin 1965; Halberg, Bryant and Hines 1968; Stone and Bush 1984; Cole and Morris 1986; Kresse and Hays 2009).

Yields from wells completed in the Ouachita Mountains aquifer have a fairly large range depending on individual formations and lithology, but are typically low throughout the aquifer. Albin (1965) noted that most wells in the Ouachita Mountains aquifer yielded less than 10 gpm, and yields greater than 50 gpm were rare; however, one well completed in the Bigfork Chert was recorded as yielding 350 gpm (Kresse et al. 2013). In spite of the upper range for reported yields and other hydrologic characteristics for various formations constituting the Ouachita Mountains aquifer, caution was expressed by all authors for planning and management purposes that groundwater should not be considered as a source of supply for municipal growth and economic development unless the required quantity was small (Albin 1965; Halberg, Bryant and Hines 1968; Stone and Bush 1984).

Most wells in the Ouachita Mountains aquifer are less than 100 feet deep, but can range up to approximately 700 feet deep, with static water levels generally less than 20 feet below land surface, and flowing-artesian wells found throughout the region (Albin 1965, Kresse and Hays 2009). Pumping water levels may be as much as 150 feet below land surface in deeper wells. Seasonal water-level fluctuations in wells generally are less than 10 feet; however, larger fluctuations are common in abnormally wet or dry years because the groundwater reservoirs generally have small storage capacities and are recharged by rapid infiltration of local precipitation (Albin 1965).

3.8.2 Groundwater Quality

In general, ground water quality in the WAWRPR is considered good. Groundwater chemistry in the planning region is primarily calcium-bicarbonate. Water quality characteristics of the aquifers in the planning region are described below.

3.8.2.1 Western Interior Plains Confining Unit

In general groundwater in the undifferentiated aquifers of the WIP is of good quality. Groundwater from the undifferentiated aquifers of the WIP system is typically a strongly calcium-bicarbonate to sodium bicarbonate water type. Groundwater with elevated iron, sulfate, and chloride may be encountered in localized areas (Kresse et al. 2006, 2012). Constituent concentrations were attributed to the rock type, groundwater residence times (degree of water rock interaction), and microbially mediated processes. Nitrate concentrations are relatively low in WIP aquifers.

3.8.2.2 Arkansas River Valley Alluvial Aquifer

Groundwater in the Arkansas River Valley alluvial aquifer is of overall good water quality. Groundwater from this aquifer is characterized by a strongly calcium-bicarbonate type water and wide variations in the dissolved-solids content (Bedinger, Emmett and Jeffery 1963; Kresse et al. 2006, 2013). Groundwater is subject to reducing conditions in various parts of the aquifer that control the distribution and concentration of nitrate, iron, and sulfate.

3.8.2.3 Ouachita Mountains Aquifer

Water quality and type generally are defined by the two major rock types in the Ouachita Mountains: quartz rocks (sandstone, chert, and novaculite) and shale. Groundwater from quartz formations tend to have low pH values, low dissolved solids concentrations, and are very soft water of a mixed water type representative of precipitation concentrated by evapotranspiration processes. Groundwater from shale rock in the system is characterized by strongly calcium- to sodium-bicarbonate water type, with varying constituent concentrations defined by residence time along the flow path. Sulfate and chloride concentrations tend to be elevated in some areas for groundwater from shale formations. No spatial relation was noted, however, for the distribution of iron concentrations, and high and low concentrations occurred in shale and quartz formations. Iron is abundant in numerous mineral forms in sedimentary rocks throughout Arkansas, and elevated iron in the Ouachita Mountain aquifer were attributed to microbially mediated processes (Kresse et al. 2013).

3.9 Groundwater-Surface Water Connections

During normal and low river stages, the water-table surface slopes toward the Arkansas River and larger tributary streams. Local water-table highs are common beneath the more permeable surface materials where recharge rates are high. During high river stages, the groundwater gradient is reversed near the river, and water-table troughs form along each side of the river. Locally, pumping can modify the shape of the water table. Pumping for irrigation has little pronounced effect, because irrigation wells are widely spaced and pumpage is small. However, withdrawals for municipal supply are near continuous and are concentrated in small areas. Bedinger and others (1963) noted that pumping at the Atkins municipal well field had a pronounced effect on the groundwater table. The well fields of Ozark and Dardanelle, which are near the river, had cones of depression extending from the well fields to the river, inducing recharge from the river. Studies by Kresse and others (2006) of influx of river water into the Dardanelle well field suggests that the alluvial aquifer may not be hydraulically connected with the river in some sections. Studies by Bedinger and others (1963) and Kresse and others (2013) indicate that any appreciable influx of water will potentially occur from the Arkansas River only where wells are in close proximity to the river and pumping is on a continual basis (municipal use, rather than seasonal pumping for irrigation).

4.0 SOCIO-ECONOMIC CHARACTERISTICS

The socio-economic characteristics of the WAWRPR include demographics, income and employment, and industry. This section describes these characteristics within the planning region and how they have changed since the 1990 AWP update. In addition, the waste generated by the communities and industries in the WAWRPR are discussed since the management of these wastes may have the potential to impact water quality in the planning region.

4.1 Demographics

Demographic information from the 2010 US census for the counties within the WAWRPR are presented below. This data includes population totals and changes, the percentage of people living in urban and rural areas, populations above or below selected ages, and populations based on race. The information collected from the 2010 census is compared to the information from the 1990 census to identify the changes that have occurred in the population of the planning region since the 1990 AWP update. Although the 1990 AWP update reported demographic data from the 1980 census, the 1990 census data better represents conditions at the time of the previous AWP update.

4.1.1 2010 Population

Population data for the counties within the WAWRPR from the 2010 census is mapped on Figure 4.1 and summarized in Table 4.1 and. The 2010 population of the planning region was over 876,000 (US Census Bureau 2012a). The counties with the largest populations, all over 100,000, are Pulaski, Sebastian, and Faulkner Counties. While not all of Pulaski County is included in the planning region, a large part of the cities of Little Rock and North Little Rock, and therefore a large part of the population, are located within the planning region. The counties with the smallest populations, less than 20,000, are Perry, Scott, and Franklin Counties.

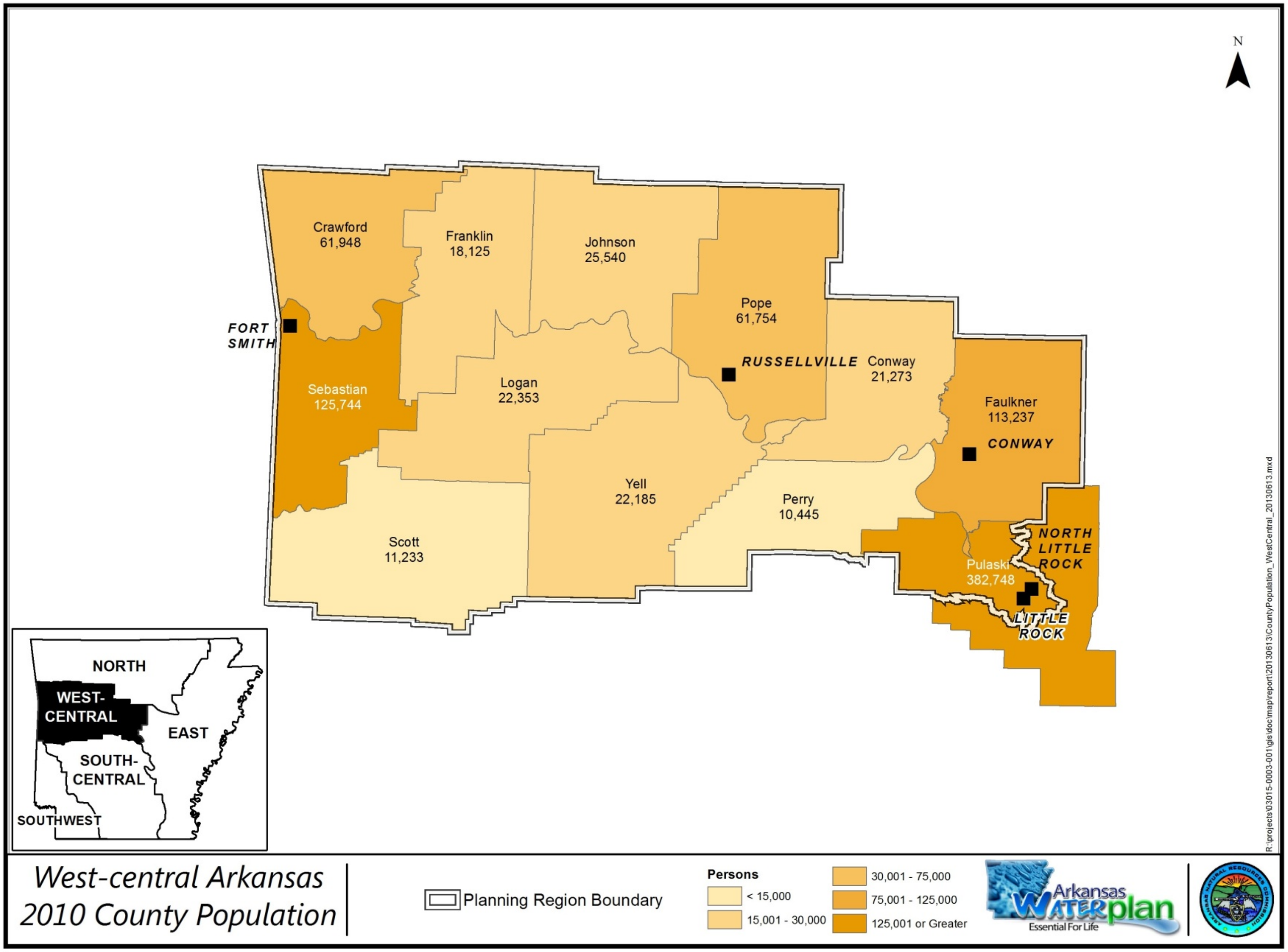

Figure 4.1. Population total from the 2010 census for counties in the WAWRPR.

Parts of two Large Metropolitan Statistical Areas are located within the WAWRPR; Fort Smith, and Little Rock-North Little Rock-Conway (US Census Bureau 2012b). Three Urbanized Areas are located in the planning region; Conway, Fort Smith, and Little Rock, along with nine areas identified as Urban Clusters in the 2010 census (Figure 4.2) (US Census Bureau 2011a). The majority of the population (nearly 68%) live in urban areas (Table 4.1). The percentage of people living in urban areas varied from 0% in Perry County, to close to 90% in Pulaski County (US Census Bureau 2012a).

Table 4.1. County populations in the WAWRPR (US Census Bureau 2003, 2012a).

	Total Population			Percent urban population		
County	**1990**	**2010**	**Change 1990 to 2010**	**1990[+]**	**2010**	**Change in percent urban population 1990 to 2010**
Conway	19,151	21,273	11%	32.1%	29.5%	-2.6
Crawford	42,493	61,948	46%	41.9%	48.0%	6.1
Faulkner	60,006	113,237	89%	43.5%	61.2%	17.7
Franklin	14,897	18,125	22%	19.0%	17.4%	-1.6
Johnson	18,221	25,540	40%	23.6%	28.6%	5.0
Logan	20,557	22,353	9%	30.7%	29.0%	-1.7
Perry	7,969	10,445	31%	0%	0%	0
Pope	45,883	61,754	35%	43.3%	45.5%	2.2
Pulaski*	349,660	382,748	9%	87.9%	87.7%	-0.2
Scott	10,205	11,233	10%	29.2%	29.6%	0.4
Sebastian	99,590	125,744	26%	79.8%	79.2%	-0.6
Yell	17,759	22,185	25%	20.4%	20.9%	0.5
Totals	**706,391**	**876,585**	**24%**	**67.5%**	**67.7%**	**0.2**

* Part of this county is in another planning region.
[+] These percentages calculated using the current urban area definition, not the 1990 definition (US Census Bureau 2003, 2012a)

Demographic data on race in the WAWRPR are summarized in Table 4.2. The WAWRPR is not racially diverse, having a 70% White non-Hispanic population. The Black, Hispanic, and Asian populations make up 18%, 7%, and 2% of the population respectively, with all other races accounting for less than 1% of the population respectively. Demographic data on age, education level, and sex are summarized in Table 4.3. In this planning region, almost two-thirds of the population is made up of people between the ages of 18 and 65 years of age, 27% of the adults are high school graduates, and 20% have college degrees.

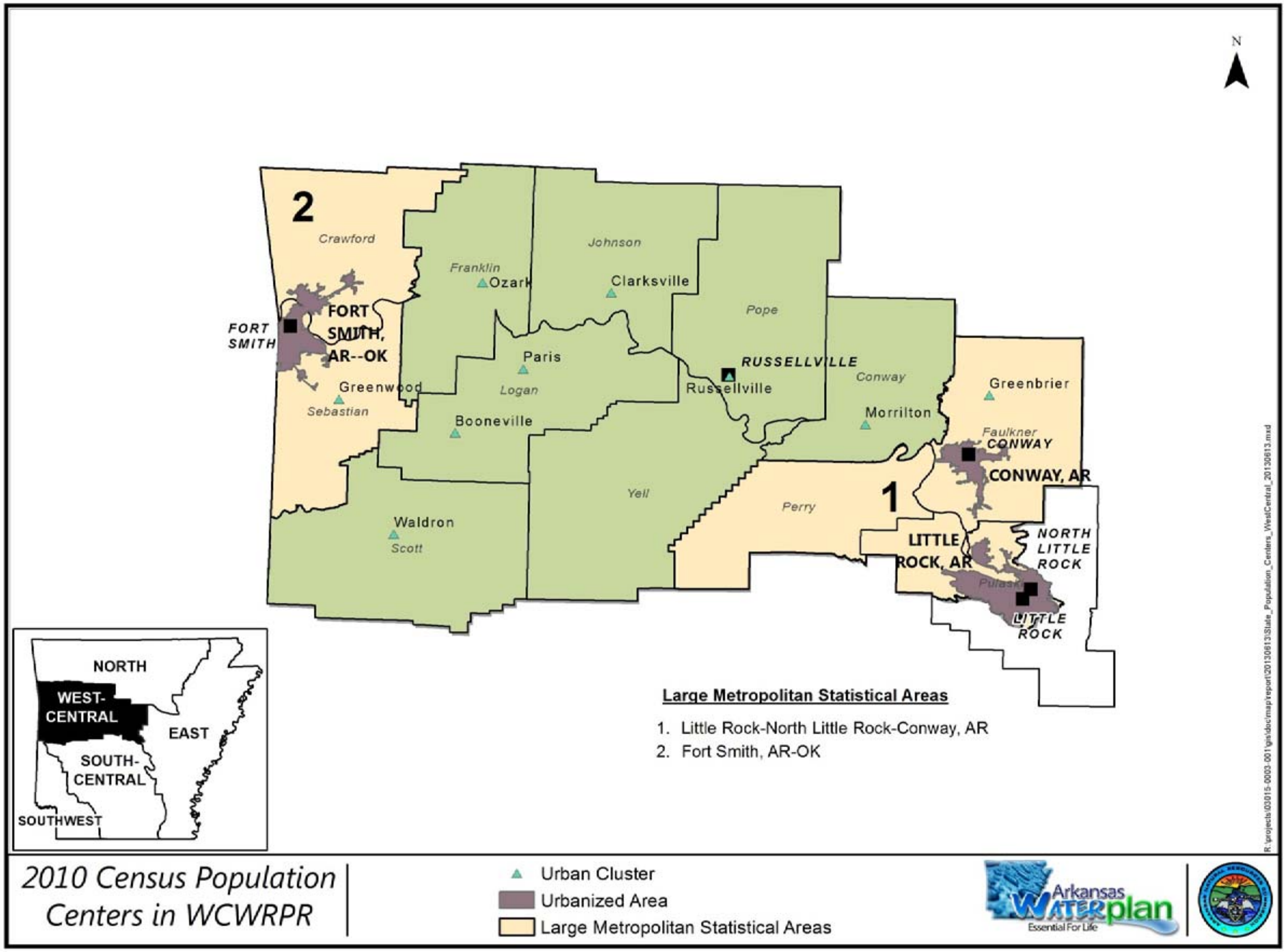

Figure 4.2. Large metropolitan statistical areas for 2010 urban areas and urban clusters in the WAWRPR.

Table 4.2. Demographic summary for counties in the WAWRPR (US Census Bureau 2012a).

County	White Non-Hispanic	Black	Hispanic	Asian	American Indian	Pacific Islander	Other Single Race	Multiple Race
Conway	17,533	2,376	757	76	147	4	10	370
Crawford	53,770	696	3,760	874	1,331	19	38	1,460
Faulkner	93,326	11,495	4,435	1,266	612	42	109	1,952
Franklin	16,997	124	371	162	183	24	3	261
Johnson	21,328	336	3,094	175	209	17	19	362
Logan	20,608	285	510	361	228	4	4	353
Perry	9,779	196	247	17	59	2	3	142
Pope	53,667	1,748	4,168	597	397	18	36	1,123
Pulaski*	211,697	133,242	22,168	7,425	1,267	155	515	6,279
Scott	9,587	51	782	379	190	3	3	238
Sebastian	91,585	7,848	15,445	5,039	2,186	69	82	3,490
Yell	17,020	288	4,230	278	127	2	7	233
Total	**616,897**	**158,685**	**59,967**	**16,649**	**6,936**	**359**	**829**	**16,263**
Percent	**70%**	**18%**	**7%**	**2%**	**<1%**	**<1%**	**<1%**	**2%**

*Part of this county is in another planning region.

Table 4.3. Additional demographic characteristics of counties in WAWRPR (US Census Bureau n.d.a., n.d.b.).

County	Total female population	Total population under 18 years	Total population over 65 years	High school graduates	College graduates
Conway	10,740	5,145	3,592	6,209	1,987
Crawford	31,377	16,350	8,233	14,068	5,252
Faulkner	57,614	27,742	11,318	20,873	17,154
Franklin	9,148	4,431	3,007	4,991	1,515
Johnson	12,881	6,329	3,749	6,466	2,614
Logan	11,155	5,491	3,842	6,470	1,699
Perry	5,262	2,402	1,747	3,157	840
Pope	31,144	14,241	8,113	13,191	7,796
Pulaski*	198,810	92,185	45,908	69,368	79,162
Scott	5,570	2,883	1,915	2,993	819
Sebastian	64,111	31,882	16,518	25,953	15,395
Yell	11,115	5,831	3,417	5,827	1,507
Total	**448,927**	**214,912**	**111,359**	**179,566**	**135,740**
Percent	**51%**	**24%**	**13%**	**27%**	**20%**

*Part of this county is in another planning region.

4.1.2 Changes from 1990

The population of the planning region and the percentage of the population located in urban areas in 1990 and 2010 are presented in Table 4.1. Also included are the changes in total population and the changes in the percent of urban population over the 20 year period, from 1990 to 2010. The change in population in the planning region is also represented by Figure 4.3. The population of the WAWRPR in 2010 was over 876,000, an increase of over 170,000, or 24%, since 1990 (US Census Bureau 2012a). All of the counties in the WAWRPR experienced a population increase between 1990 and 2010. These increases ranged from 9% in Logan and Pulaski Counties, to 89% in Faulkner County. The most significant increase in total population occurred in Faulkner County, where the population increased 89% between 1990 and 2010; followed by Crawford and Johnson counties with increases of 46% and 40% respectively. Similarly, the change in the percent of the urban population from 1990 to 2010 in Faulkner County was the largest at nearly 18%, which was followed by Crawford and Johnson counties at 6% and 5% respectively. Despite the large Faulkner County population increase, within the WAWRPR the majority of the counties within the planning region experienced very little change in the percent of the population living in the urban settings. The overall increase from 1990 to 2010 of the percent of the population living in urban areas in the planning region is very small, only 0.2%, while the change in the overall population for the same time period is 24%. But overall, the majority of the population (nearly 68%) continues to live in urban areas.

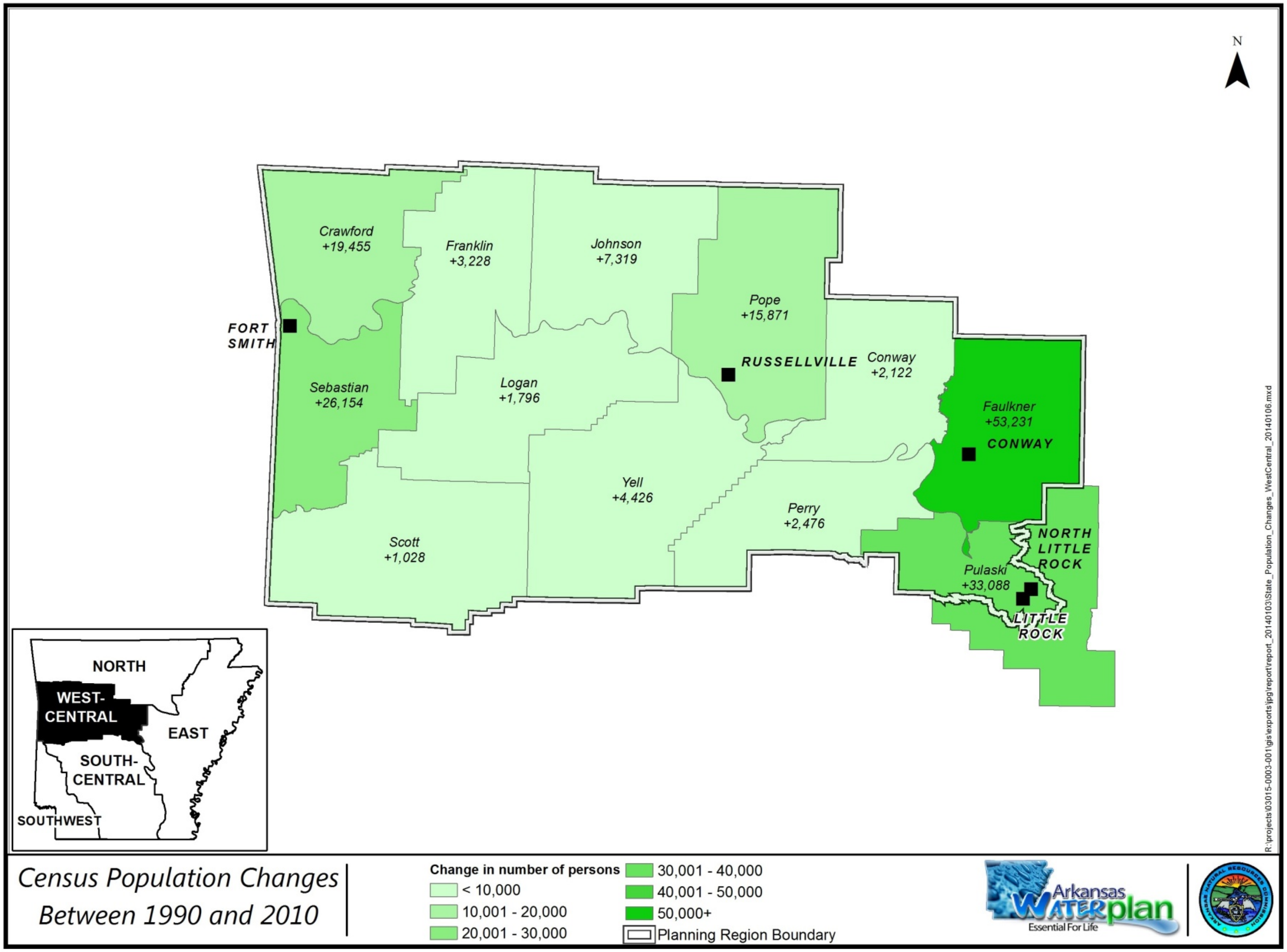

Figure 4.3. Population change from 1990 to 2010 in the WAWRPR.

4.2 Income and Employment

The income and employment data available by county from the US Census Bureau is presented below in Table 4.4 to characterize the current income and employment levels within the WAWRPR. Data from 1989 and 1990 are also presented for comparison, to provide insight into changes that have occurred in the planning region since the 1990 AWP update.

Table 4.4. Income and employment characteristics for counties in WAWRPR (US Census Bureau n.d.a.).

County	Median household income		Families with income below the poverty level		Population with income below poverty level		Unemployment	
	1989	2007-2011	1990	2007–2011	1990	2007–2011	1990	2007-2011
Conway	$20,538	$31,890	12.6%	15.3%	16.5%	21.9%	7.0%	9.3%
Crawford	$21,574	$40,409	13.1%	13.7%	16.3%	17.6%	6.3%	6.7%
Faulkner	$23,663	$47,649	9.8%	9.7%	13.8%	15.4%	6.9%	7.5%
Franklin	$18,408	$34,819	16.4%	17.0%	20.4%	20.1%	7.1%	9.9%
Johnson	$18,225	$31,400	15.6%	15.1%	20.1%	19.9%	8.7%	6.9%
Logan	$18,992	$38,447	16.0%	11.1%	19.3%	15.6%	6.7%	8.8%
Perry	$17,626	$42,514	14.4%	10.7%	20.3%	14.4%	7.4%	5.1%
Pope	$22,326	$40,325	12.5%	14.8%	15.4%	18.9%	6.4%	7.6%
Pulaski*	$26,883	$45,897	10.5%	12.5%	14.1%	16.7%	5.3%	8.1%
Scott	$16,470	$38,910	18.4%	18.1%	21.9%	22.8%	6.4%	8.7%
Sebastian	$24,037	$40,680	10.0%	14.7%	13.1%	19.5%	5.6%	6.6%
Yell	$19,647	$37,477	14.3%	14.5%	17.1%	18.5%	5.3%	7.3%
Average	**$20,699**	**$39,201**	**13.6%**	**13.9%**	**17.4%**	**18.4%**	**6.6%**	**7.7%**
Statewide Average	$21,147	$40,149	14.8%	13.8%	19.1%	18.4%	6.8%	5.0%

4.2.1 Current Income and Employment Levels

Median household incomes reported by the US Census Bureau in the 2007 – 2011 American Community Survey (ACS) for the counties included in the WAWRPR are shown in Table 4.4. The average median household income for the planning region is $39,201, which is just below the state-wide median household income of $40,149, but is the second highest of the five planning regions. Johnson County had the lowest median household income in the planning region at $31,400 and Faulkner County had the highest median household income in the planning region at $47,649. Six of the 12 counties in the planning region had median household incomes greater than the state-wide median household income, while six counties were below the state-wide median household income (US Census Bureau n.d.).

The 2007-2011 Community Survey shows that the counties in the WAWRPR have families and population with income below the poverty level consistent with the overall state-wide averages. The average percentage of families with income below poverty level in the planning region is 13.9% and the state-wide average for Arkansas as a whole is 13.8%. Similarly, the average percentage of the population with income below poverty level in the planning region is 18.4%, which equals the percentage of Arkansas population with income below the poverty level. Although the planning region as a whole seems to be consistent with the state average for families and population with income below the poverty level, the range across the counties represented in the planning region is 9.7% in Faulkner County to 18.1% in Scott County for families, and 14.4% in Perry County to 22.8% in Scott County for overall population, living below the poverty level (US Census Bureau n.d.a.).

Unemployment across the planning region ranges from 5.1% in Perry County to 9.9% in Franklin County. The overall planning region average for unemployment is 7.7%. The overall state unemployment rate is 5%, which is below the rate for all of the counties and the planning region as a whole. Perry County, which had the lowest percentage of population with income below the poverty level (14.4%) and the second lowest percentage of families with income below the poverty level (10.7%), also had the lowest unemployment rate in the region, 5.1%.

4.2.2 Changes in Income and Employment from 1990

Information on income and employment from the 1990 census (1989 data) for the counties included in the WAWRPR is included in Table 4.4. This information demonstrates a general downturn in the economic status of the population in the planning region. While the median household income has increased from the 1990 data to the current data, the percentage of families and overall population living below the poverty level have increased, as has the percentage of unemployment. Statewide the percentage of families and people with income below the poverty level has decreased as has the unemployment percentage, however the changes in the West-central Arkansas planning region are opposite of what has occurred with the state as a whole.

4.3 Economic Drivers

A variety of industries make up the economic drivers in the WAWRPR, contributing to both the regional and the state economy. These industries vary in their demands on regional water resources. There have been changes in the types of industries present in the planning region since the 1990 AWP update; including the expansion of the natural gas industry. This section describes the current industries operating in the planning region, using information from the most recent US Economic Census, the US Census Bureau, Census of Agriculture, industry annual reports, and economic analyses. Information from these sources was used to describe the economic landscape in 1990 and to compare the current conditions to those at the time of the 1990 AWP update.

4.3.1 Current Regional Economic Drivers

Agriculture (including timber), tourism, manufacturing, education, government and resource extraction are important economic drivers in the WAWRPR (Association of Arkansas Counties 2013). In addition to the agriculture economic sector, livestock agriculture and timber generate revenue and jobs in the manufacturing, real estate, wholesale trade, and transportation and warehousing economic sectors (U of A Divison of Agriculture 2012). Tourism generates revenue and jobs in several economic sectors including recreation, accommodation and food services, retail trade, and real estate. Transport of commodities on the Arkansas River in the planning region is important to both the regional and the state economy. The economic impact of agriculture, tourism, and waterborne commodity transportation in the WAWRPR are discussed in detail in the following sections. Part of the Fayetteville Shale Play is located within the WAWRPR, and influences the economy of the region.

The US Census Bureau conducts an economic census every 5 years. This includes information on the value of sales, and the number of people employed in each economic sector by county. The value of sales and receipts reported for the counties within the WAWRPR in the 2007 economic census is summarized on Figure 4.4. Manufacturing and wholesale trade are the economic sectors with the greatest value in the region.

The number of people employed in the WAWRPR by economic sectors, as reported in the 2007-2011 American Community Survey (ACS) and the 2007 economic census are summarized in Figure 4.5. The economic sectors for which employment is reported in these two sources are slightly different. However, both sources indicate that health care and education, manufacturing, and retail trade provide the majority of employment in the WAWRPR. In these three economic sectors, Pulaski County and Sebastian County account for at least two-thirds of the reported totals.

4.3.1.1 Agriculture

Agriculture is the largest industry in the State of Arkansas and is a prevalent and growing industry within the WAWRPR. As noted in Section 3.6, agriculture is the second largest land use in the planning region, preceded only by forested land, and pasture land is the largest land use classification within the agricultural land use designation. The market value of the agricultural products sold in the planning region in 2007 was over $1 billion (USDA National Agricultural Statistics Service 2009).

Agriculture is the main industry for several counties in the planning region (Association of Arkansas Counties 2013). Crops and livestock cultivated in the region include soybeans, rice, assorted fruit and vegetables, beef cattle, hogs, and poultry. Timber production is important for two of the counties in the planning region (Association of Arkansas Counties 2014). Another regionally important agricultural industry in the WAWRPR is winemaking, with several vineyards located in Franklin County.

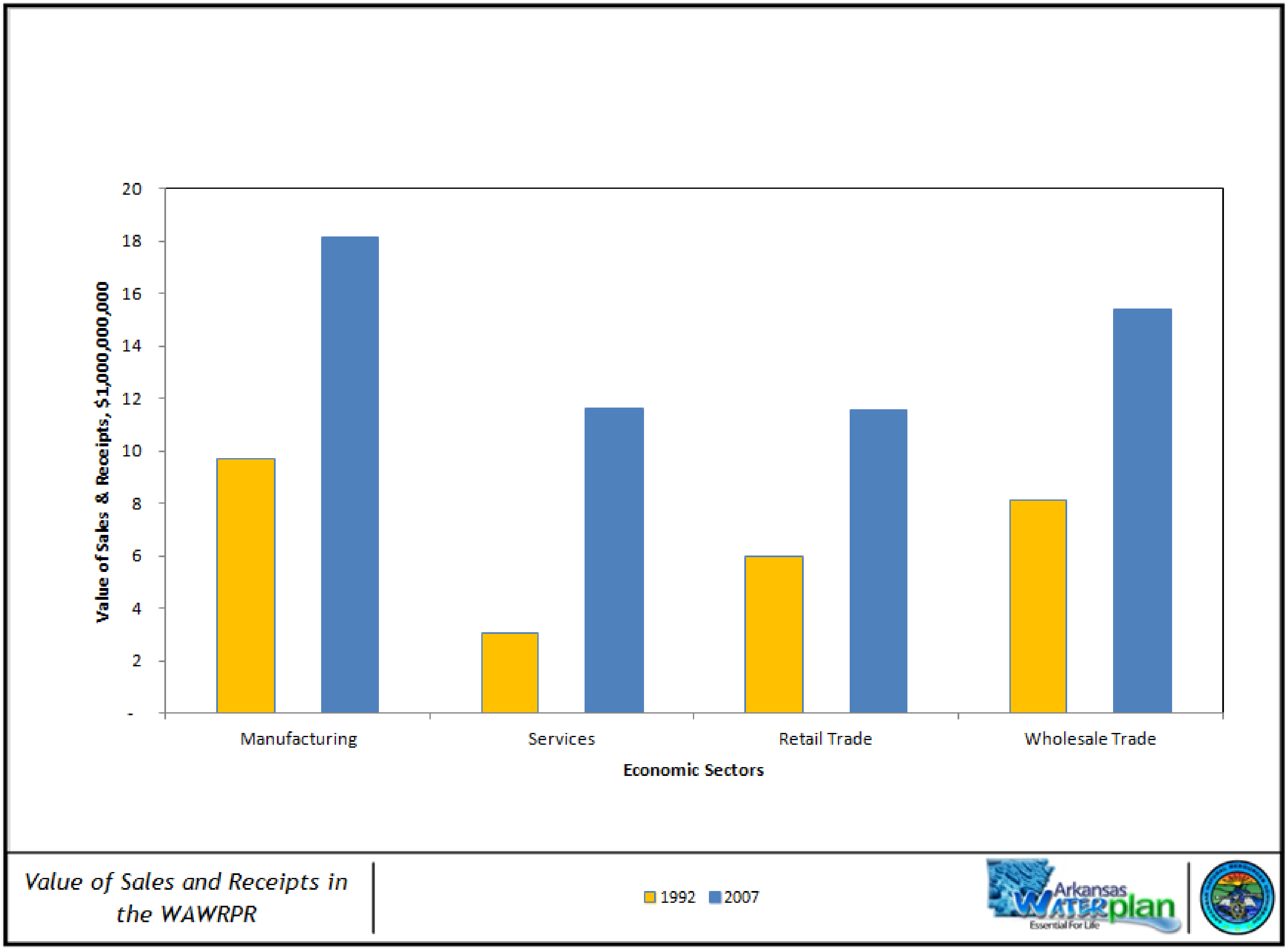

Figure 4.4. Value of sales and receipts in the WAWRPR (US Census Bureau 1992, US Census Bureau 2011b, USDA NASS 2007).

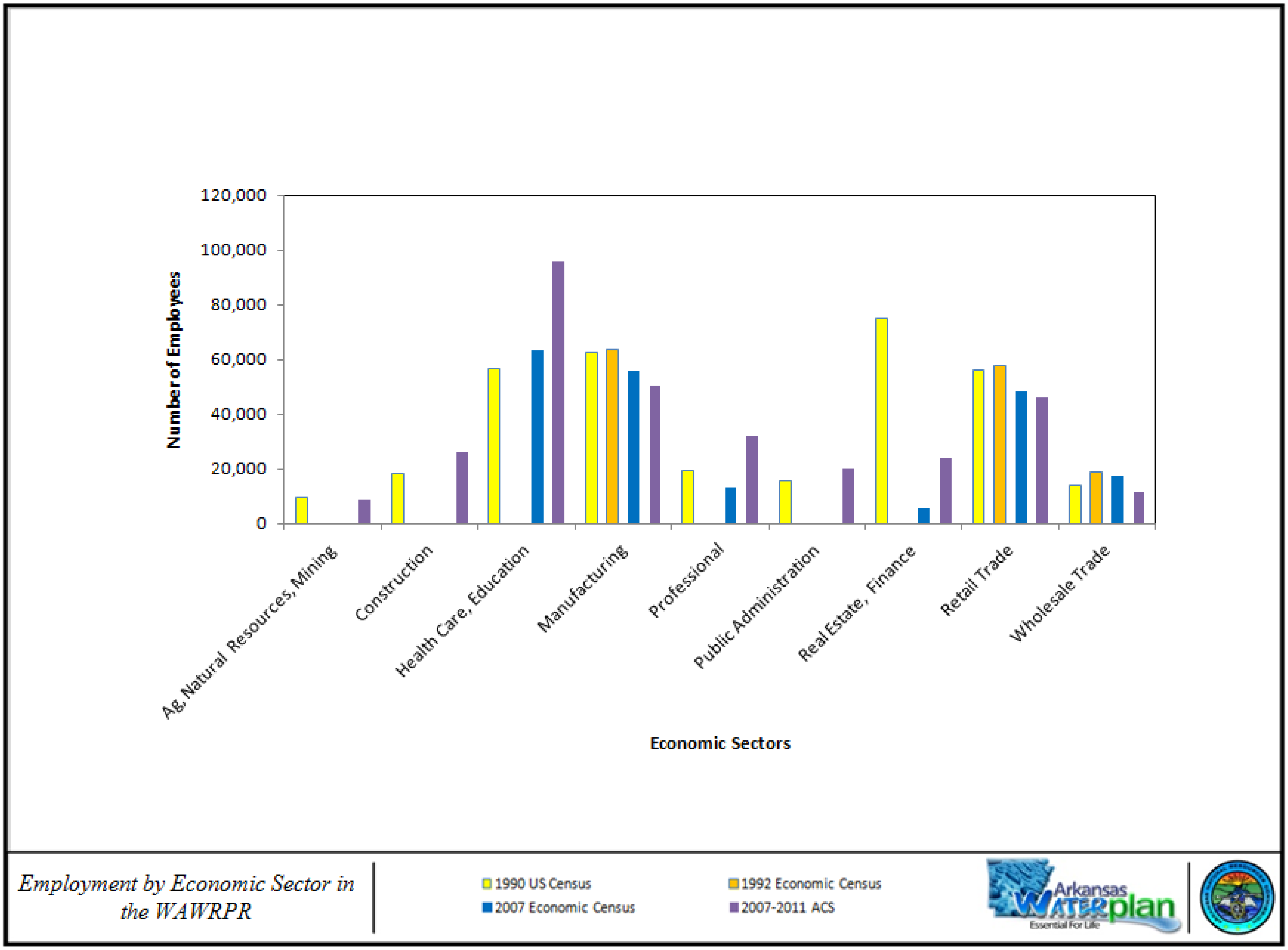

Figure 4.5. Employment by economic sectors in the WAWRPR (US Census Bureau 1992, 2011b, University of Arkansas at Little Rock Institute for Economic Advancement 2002).

4.3.1.2 Tourism

The Arkansas Department of Parks and Tourism estimated that tourism contributed over $2.9 million to the planning region economy in 2012, and is presently the state's 2nd largest industry (Table 4.5), however, the economic impact of recreation and outdoor activities is captured under several different economic sectors, making it difficult to represent.

Table 4.5. Tourism and its economic impact in the counties in the WAWRPR (Arkansas Department of Parks and Tourism 1991, 2012).

.

County	Visitors		Jobs		Total Expenditures, $1,000		State tax revenue, $1000		Local tax revenue, $1,000		Payroll, $1,000	
	1990	2012	1990	2012	1990	2012	1990	2012	1990	2012	1990	2012
Conway	64,691	97,720	189	246	$9,070	$21,846	$426	$1,343	$109	$500	$1,642	$3,886
Crawford	170,407	172,911	482	394	$23,183	$40,309	$1,090	$2,507	$278	$699	$4,196	$6,651
Faulkner	281,339	350,146	790	951	$37,968	$81,429	$1,784	$4,995	$456	$1,368	$6,872	$15,185
Franklin	28,747	58,482	86	151	$4,130	$13,918	$194	$861	$50	$305	$748	$2,565
Johnson	73,521	111,703	231	296	$11,118	$25,217	$523	$1,545	$133	$494	$2,012	$4,795
Logan	22,437	41,514	69	107	$3,309	$10,802	$156	$685	$40	$314	$599	$1,806
Perry	22,431	57,909	61	112	$2,938	$15,729	$138	$942	$35	$521	$532	$2,249
Pope	360,377	552,779	1,025	1,204	$49,261	$133,649	$2,315	$5,855	$591	$1,886	$8,916	$19,924
Pulaski	2,998,431	5,653,505	10,169	12,972	$488,767	$1,612,014	$22,972	$63,066	$5,865	$27,674	$88,467	$335,126
Scott	23,330	21,473	69	61	$3,301	$5,741	$155	$351	$40	$141	$598	$997
Sebastian	900,006	1,190,136	2,867	2,779	$137,809	$345,209	$6,477	$12,443	$1,654	$4,226	$24,943	$56,035
Yell	18,943	46,449	56	103	$2,695	$12,855	$127	$774	$32	$346	$488	$1,751
Total	4,964,660	8,354,727.	16,094	19,376	$773,549	$2,318,718	$36,357	$95,367	$9,283	$38,474	$140,013	$450,970

Recreational opportunities on the Arkansas River expanded with the construction of the MKARNS, in part through the commercial economic contribution to the planning region and by establishing the linear corridor, which encouraged the development of parks, camping areas, hiking and biking trails, and river access for boating and fishing. The Arkansas River continues to be an important resource in the planning region recreationally as marinas in the Little Rock / North Little Rock are being planned, the expansion of trails along and across the river continues, and city riverfronts are redeveloped, including Clarksville, Fort Smith, Little Rock, and North Little Rock.

The planning region boasts a number of state parks, including those at Lake Dardanelle, Lake Fort Smith, and Wooly Hollow, that provide opportunities for water-based recreation such as hunting, fishing, boating, and bird watching. The planning region also includes 11 wildlife management areas, 6 wilderness areas, and over 21 public lakes allowing ample opportunities for water-based recreation through the planning region. ADEQ has designated 335 miles of streams in the planning region as Extraordinary Resource Waterbodies for "scenic beauty, aesthetics, broad scope recreation potential, and intangible social values" (Figure 4.6) (APCEC 2011). Over 106 miles of streams in the planning region are designated as Natural and Scenic Waterways (Figure 4.6). Portions of Big Piney Creek, Hurricane Creek, and the Mulberry River are designated National Wild and Scenic Rivers. Two counties within the planning region, Pulaski and Sebastian, were ranked in the top five counties within the state with the highest total tourism travel expenditures during 2012. (Table 4.5). USACE has estimated economic impacts of recreation associated with the reservoirs located in the WAWRPR. Overall, the two USACE reservoirs and the MKARNS generate over 1,900 jobs, and over $175 million in revenue and wages from recreation (Table 4.6).

Table 4.6. Economic benefits from USACE reservoirs in the WAWRPR in 2012 (USACE 2011).

USACE reservoir	Visitors per year	Sales per year	Number of jobs as a result of lake visits	Labor Income
Blue Mountain Lake	405,025	$7,867,000	144	$2,740,000
Lake Dardanelle (navigation pool)	1,304,569	$31,899,000	550	$11,261,000
Davie D. Terry Lake (navigation pool)*	1,256,852	$36,013,000	490	$14,122,000
John Paul Hammerschmidt Lake (navigation pool)	473,808	$12,370,000	191	$4,564,000
Murray Pool (Arkansas River)	461,504	$14,979,000	202	$5,801,000
Nimrod Lake	226,048	$4,698,000	90	$1,587,000
Ozark Lake (navigation pool)	519,159	$13,656,000	213	$5,092,000
Winthrop Rockefeller Lake (navigation pool)	74,187	$1,514,000	25	$533,000
Toad Suck Ferry Pool (Arkansas River)	146,983	$5,191,000	70	$2,022,000
Total	4,868,135	$128,187,000	1975	$47,722,000

* Part of this reservoir is in another planning region.

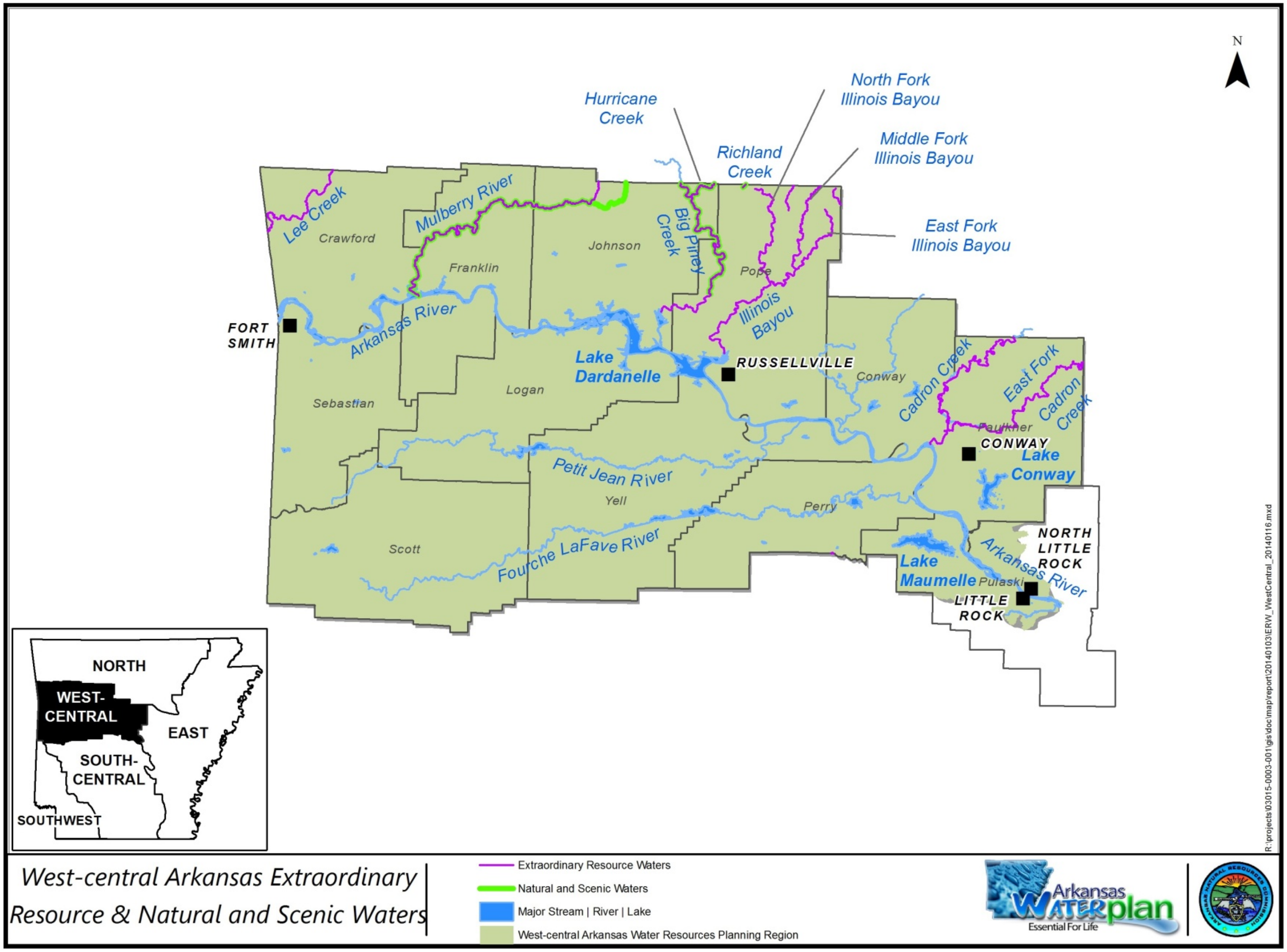

Figure 4.6. Designated extraordinary resource waters and natural and scenic waterways in the WAWRPR.

The 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, published by the USFWS and the US Census Bureau does not provide county or regional data, however, it is apparent that fishing, hunting, and wildlife-watching are significant economic activities as well as activities in which a significant part of the Arkansas population participates. Economic contributions from wildlife recreation in Arkansas are summarized in Table 4.7. In the State of Arkansas there are over 555,000 anglers, 363,000 hunters, and over 852,000 wildlife-watching participants. In 2011, expenditures related to wildlife recreation in Arkansas totaled $1.8 billion (US Fish and Wildlife Service; US Department of Commerce Census Bureau 2013).

Table 4.7. Economic contributions from wildlife recreation in Arkansas.

Activity	Total Expenditures (Million $)		2011 Retail Sales (Million $)[c]	2011 State/Local Tax Revenue (Million $)	2011 Federal Tax Revenue (Million $)
	1991[a]	2011[b]			
All Hunting	$85.0	$1,018.8	$877.4	$99.2	$99.5
Waterfowl Hunting	Nr	$288.0	$236.7	$29.1	$23.9
Sport Fishing	$216.9	$495.6	$508.0	$49.4	$49.8
Wildlife Watching	NR	$216.1	NR	NR	NR

a USFWS, US Department of Commerce Bureau of the Census 1993
b USFWS, US Department of Commerce Census Bureau 2013
c AGFC 2013b

4.3.1.3 Waterborne Commodity Transport

Waterborne transportation of commodities directly and indirectly contributes to the economic growth of the State, and the EAWRPR, through economic value, employment, and earnings (Nachtmann 2002). A recent study determined that the total economic impact of river transportation of commodities on the Arkansas economy is $811 million annually (Arkansas Waterways Commission 2013). The MKARNS, which traverses the entire planning region, averages 12 million tons of commodities shipments annually, with an estimated value of $2 to $3 billion per year (USACE 2012). The Arkansas River continues to be an important resource in the planning region economically as expansion of regional freight management in Fort Smith and Van Buren is being investigated.

4.3.1.4 Fayetteville Shale Natural Gas Production

The recent expansion of the natural gas industry in the planning region, specifically the Fayetteville Shale, has had direct economic effects from drilling wells to the increased need for supporting activities including construction, transportation, storage, and distribution. Within the planning region, the Fayetteville Shale includes the counties of Conway, Faulkner, Franklin, Johnson and Pope. Extensive natural gas exploration and production has been occurring in these counties, with the exception of Johnson County where there has been limited activity. The economic impacts of the industry expansion have reached Arkansas residents via mineral leases and subsequent royalty payments, and jobs with higher than average pay. Within the planning region, Conway, Faulkner, and Pope Counties experienced a rate of payroll employment growth from 2001 to 2010 that was higher than the state average. Drilling permit fees and severance tax revenues from the Fayetteville Shale activities have generated more than $92 million for the State from 2004 to 2011. During 2012, and continuing through 2013, sustained low natural gas prices have reduced the expected expenditures of the exploration and production companies and could have significant economic impacts beyond the counties included in the Fayetteville Shale area (Center for Business and Economic Research 2012).

4.3.1.5 Coal Production

The WAWRPR is home to commercially viable coal deposits. Historically, coal mining occurred in six counties in the planning region. Currently there are active coal mines in Sebastian, Scott, and Johnson Counties (Arkansas Geological Survey 2012). In 2011, approximately 99,200 tons of coal was produced by the mines in the planning region, contributing $307 million to the state GDP, directly and indirectly employing 3,030 people and providing $172 million in wages, and contributing $21 million in state and local taxes (National Mining Association 2013, Arkansas Geological Survey 2014).

4.3.1.6 Timber

The timber industry contributes to the economy of the WAWRPR. Pine plantations are located throughout the panning region. In 2012, the USDA Forest Service (USFS) reported over

3 million acres of timberland in the counties of the planning region (Table 4.8) (USFS 2013). In addition, there are sawmills at Russellville and Plumerville, a paper mill at Morrilton, and lumber manufacturing facilities at Ola and Waldo, as well as container plants in Fort Smith, Conway, and Russellville (Cottingham 2011). Statewide, paper mills, sawmills, paperboard container manufacturing, sanitary paper product manufacturing, and logging contribute 16,300 jobs, $880 million in wages, $971 million in labor income, and $1,736 million in value added to the state economy (U of A Divison of Agriculture 2012). The market value of the forest products sold in the planning region in 2007 was $2.5 million (USDA National Agricultural Statistics Service 2009).

Table 4.8. Timberland acreage within the counties of the WAWRPR (USFS 2013, Hines and Vissage 1988).

County	Timberland (acres)		Forest Industry Owned (acres
	1988	**2012**	**1988**
Conway	163,872	191,787	14,200
Crawford	211,633	208,511	0
Faulkner	168,401	219,793	0
Franklin	231,221	219,399	0
Johnson	285,208	303,070	0
Logan	242,474	254,233	12,100
Perry	260,832	267,630	135,800
Pope	353,727	367,614	11,200
Pulaski	201,803	234,669	41,400
Scott	442,655	458,490	5,700
Sebastian	149,593	140,605	0
Yell	401,521	476,793	78,100
Total	3,112,940	3,342,594	298,500

Water use in the timber industry is primarily during processing. Timberlands are not generally irrigated. Timberlands can impact water quality through erosion of forest roads, stream crossings, and harvested areas; and runoff of chemicals used in timber management.

4.3.2 Changes in Region Economy since 1990

Figure 4.4 also shows the value of sales and receipts reported in the 1992 economic census. Note that the 1992 economic census reported values only for the manufacturing, services, retail trade, and wholesale trade sectors. The 2007 value for services shown on Figure 4.4 is a summation of values reported for economic sectors that reportedly were in included in the 1992 value for services (US Census Bureau 2011c). It appears that all of the economic sectors have experienced expansion.

Employment data from the 1990 census and 1992 economic census are included in Figure 4.5. The economic sectors used to report employment are slightly different for the two sources and the different time periods shown in Figure 4.5. While these differences make direct comparisons uncertain, using the information from different sources during similar time periods allows us to have greater confidence when identifying changes over time. It appears that employment in manufacturing, real estate and finance, and retail trade has declined since the 1990 AWP update. Other economic sectors, such as construction, and health care and education, appear to be employing more people now than in the early 1990s. Overall, however, it appears that the same economic sectors provided the majority of employment in the region in 1990 as do now; manufacturing, health care and education, and retail trade.

4.3.2.1 Agriculture

The market value of the agricultural products sold in the planning region in 1992 was over $639 million compared to over $1 billion in 2007. Although the planning region has seen a 36% decrease in designated cropland from 1992 to 2007, the number of farms, the value of the crops, and the value of the livestock have increased 19%, 71%, and 97% respectively (USDA National Agricultural Statistics Service 1992, 2007).

4.3.2.2 Tourism

Table 4.5 provides a summary of the tourism travel expenditures in 1990 and 2012 (preliminary values) for the counties within the planning region (Arkansas Department of Parks and Tourism 2012). In all counties the travel expenditures have increased from 1990 to 2012. Increases range from 74% to 435%. In Pulaski County alone, there has been increase in the total number of visitors of over 2.6 million. The economic contribution of hunting and fishing in the state has also increased since 1990 (Table 4.7).

4.3.2.3 Waterborne Commodity Transportation

On the MKARNS, a total of 8.8 million tons was transported during 1990 (Bolton 1995). Information on the value of commodities transported on the MKARNS in 1990 was not available (US Census Bureau 1996). Information on the types of commodities shipped is discussed below.

During the period from 1971 through 1994, sand and gravel made up the majority (38%) of the commodities transported on the MKARNS (Bolton 1995). In 2011, sand and gravel accounted for only around 5% of the shipping, while agricultural products (including grains, soybeans, and animal feed) made up 30% of the shipping (Table 4.9). Exported grains and soybeans accounted for an average of 21% of the commodities shipped on the MKARNS during the period from 1971 through 1994 (Bolton 1995). This is similar to 2011, when exported grains and soybeans accounted for 25% of the shipping on the MKARNS.

4.3.2.4 Fayetteville Shale Natural Gas Production

At the time of the 1990 AWP update, the Fayetteville Shale Natural Gas Play was not active in Arkansas. A new horizontal fracturing technique established in the late 1990s in the natural gas industry made it possible to extract natural gas from shale formations. Beginning in the mid-2000s, gas production began in the Fayetteville Shale formation in Central Arkansas, including Conway, Faulkner, Franklin, Johnson and Pope Counties. The introduction of this new industry in the region has had a very positive impact on the economy, providing new employment opportunities and also boosting other industries in the region, including transportation, hospitality, education, and finance (Center for Business and Economic Research, U of A 2012). The development of the Fayetteville Shale natural gas is the largest change in the regional economy since 1990.

4.3.2.5 Coal Production

Arkansas coal production was lower in the 1990s than currently. In 1990, 69,100 tons of coal was produced in the planning region. Underground mining of coal expanded in the early 21st Century (Arkansas Geological Survey 2014). Information on the economic impact of coal mining in the 1990s was not found.

4.3.2.6 Timber

Table 4.8 includes information on the acreage of timberland in 1988. The acreage of timberland in the planning region counties is slightly greater in 2012 than in 1988. In 1988, timber industry owned 298,500 acres in the planning region counties (Table 4.8). The market value of forest products sold in the planning region counties in 1987 was $641,000 (USDA National Agricultural Statistics Service 1992).

As today, in the 1990s, forestry was an important economic driver in the state, contributing over $4 billion annually to the state economy (Gray 1993). Lumber and wood products companies dominated the manufacturing sector of the state economy during this period (Advameg, Inc. 2010). Roundwood production in the state increased between 1990 and 2005 but declined to levels similar to 1990 between 2005 and 2009 (Brandeis et al. 2011).

4.4 Waste Generation and Disposal

Industries and communities produce wastes that must be properly managed to protect water quality, which contributes to water availability for the water users of the state. ADEQ is the state agency responsible for regulating solid waste, hazardous waste, and wastewater. These three waste streams are managed through separate permitting programs overseen by the EPA. Arkansas Nuclear One (ANO), located in the planning region, is regulated by the U.S. Nuclear Regulatory Commission (NRC), which includes the management of nuclear materials and waste (US Nuclear Regulatory Commission 2013). Waste management in the WAWRPR is quantified below, along with changes in waste management that have occurred since the 1990 AWP Update.

4.4.1 Solid Waste

All of three and part of one Regional Solid Waste Management Districts (RSWMDs) are located in the WAWRPR. Information on solid waste generation and disposal for each of these districts is summarized in Table 4.9 and illustrated on Figure 4.7. For the most part, the RSWMDs report that their solid waste disposal facilities and collection services are sufficient to meet demand. However, a number of illegal dump sites have been identified that could pose local threats to water quality (Sebastian County RSWMD 2011, West River Valley RSWMD 2011, Faulkner County RSWMD 2011, Pulaski County RSWMD 2011).

Table 4.9. Solid waste generation and disposal information for RSWMDs in the WAWRPR.

RSWMD Name	Number of counties in RSWMD	Number of Counties in planning region	Number of landfills in planning region	2010 Solid Waste Generated In-district (tons)	2010 Solid Waste Disposed In-district (tons)	Number Illegal Dump Sites Identified 2010
Sebastian	1	1	1	189,261	189,261	1
West River Valley	9	9	3	122,077	120,059	53
Faulkner	1	1	2	102,092	88,430	13
Pulaski*	1	1	4	901,037	910,037	0
Total	**12**	**12**	**10**	**1,314,467**	**1,307,787**	**67**

*Part of this district is located in another planning region.

There have been significant changes in the solid waste arena since 1990, driven by the need to protect water quality. Subtitle D of the 1991 amendment of the Resource Conservation and Recovery Act (RCRA) introduced specifications for how landfills were to be constructed and managed to protect groundwater quality. In addition, the new regulations required monitoring of groundwater quality around landfills (EPA 2012a, ADEQ 2011). This led to sweeping changes in solid waste management across the country and in Arkansas (APCEC 2011).

At the same time, state regulations set up programs to fund cleanup of groundwater contamination from landfills, and for collection and recycling of batteries and waste oil, both of which pose risks to surface and groundwater quality when disposed of improperly. Around 1995, the Arkansas General Assembly established a policy to eliminate illegal dumping, another threat to surface and groundwater quality. State legislation to implement this policy was passed in 1997. In 2005, state legislation was passed that resulted in the development and implementation of a comprehensive mercury minimization program for the state. Mercury is a surface water quality issue throughout the state (ADEQ 2011). State programs initiated since 1990 for the collection and recycling of electronics, and collection of household hazardous wastes also protect water quality.

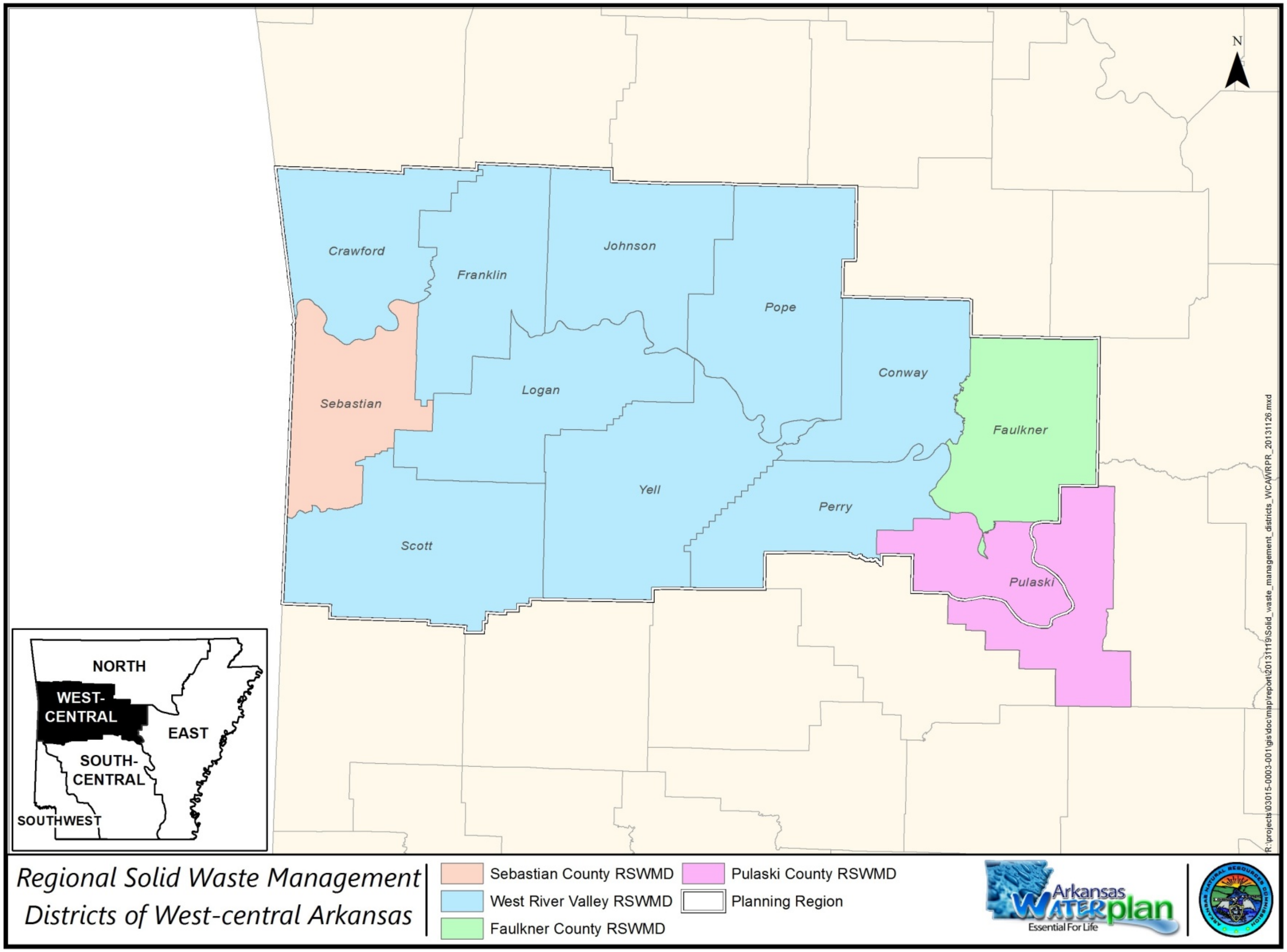

Figure 4.7. Solid Waste Management Districts in the WAWRPR.

4.4.2 Hazardous Waste

There are 160 permitted hazardous waste generators in the counties within the WAWRPR (Table 4.10). The majority of these facilities are located in Pulaski County, which is only partially located in the planning region, followed by Sebastian and Faulkner counties. Forty-eight of the facilities in the counties within the WAWRPR are classified as large quantity generators, meaning they generate at least 1,000 kilograms of hazardous waste per month (EPA 2012b). One hundred twelve of the facilities are classified as small quantity generators, meaning they generate between 100 and 1,000 kilograms of hazardous waste per month (EPA 2012c). One of the 10 facilities in the state that generated the most hazardous waste in 2011 is located in the WAWRPR (EPA 2012d). There is one hazardous waste treatment/storage/disposal facility in the region, in Pulaski County (ADEQ 2012a).

Table 4.10. Permitted hazardous waste generators in counties in the WAWRPR (ADEQ 2012a).

County	Large Quantity	Small Quantity
Conway	0	3
Crawford	5	2
Faulkner	3	15
Franklin	0	1
Johnson	1	4
Logan	1	1
Perry	0	0
Pope	5	4
Pulaski*	25	63
Scott	0	0
Sebastian	8	18
Yell	0	1
Total	**48**	**112**

*Part of this county is in another planning region

Hazardous waste generation data is compiled annually, but this program was not implemented in Arkansas until after 1990. Information from 1990 on the number of hazardous waste generators is also not readily available. Therefore, a comparison with 1990 conditions is not made in this document.

4.4.3 Wastewater and Stormwater

There are over 3,000 point sources permitted to discharge wastewater and stormwater in the WAWRPR (Table 4.11). Nearly half of these are located in Pulaski County. These discharges are permitted by ADEQ through the federal National Pollutant Discharge Elimination System (NPDES). Industrial, municipal, and domestic wastewater discharges are permitted through NPDES as well as discharges of stormwater and runoff associated with industrial sites, municipalities (MS4s), and temporary construction sites. Please refer to Section 6 for more details on wastewater regulations and permitting in Arkansas.

Table 4.11. NPDES permitted discharges in the WAWRPR (ADEQ 2013a, 2013b, 2013c, 2013d)

County	NPDES Industrial	NPDES Municipal	NPDES Domestic	NPDES Large MS4	NPDES Small MS4	NPDES Construction Stormwater[1]	NPDES Industrial Stormwater	NPDES Other[2]	Total
Conway	10	2	1	0	0	51	16	5	85
Crawford	13	5	4	0	3	83	67	5	180
Faulkner	27	7	23	0	2	278	77	4	418
Franklin	7	3	2	0	0	31	27	2	72
Johnson	19	3	1	0	0	51	39	1	114
Logan	6	4	3	0	0	39	26	4	82
Perry	3	2	1	0	0	14	3	2	25
Pope	18	5	5	0	0	84	66	5	183
Pulaski*	109	15	67	1	8	844	434	19	1497
Scott	3	1	1	0	0	22	9	1	37
Sebastian	38	10	2	0	2	229	150	6	437
Yell	8	4	1	0	0	29	11	6	59
Total	261	61	111	1	15	1755	925	60	3189

*Part of this county is in another planning region.
[1]Construction stormwater permits are temporary.
[2]Includes filter backwash, process water, agricultural, cooling water, toxics, and saltwater discharges.

Approximately 143 surface water bodies in the planning region receive wastewater discharges. Several of these water bodies receive wastewater discharges from more than one point source (ADEQ 2008).

Table 4.12 compares the number of NPDES permits for municipal, domestic, and industrial wastewater reported for the WAWRPR in the 1990 state-wide water quality assessment with the current numbers for the same categories of NPDES permits. Overall, the number of permitted wastewater discharges in the planning region has increased over 180% since the 1990 AWP update, with the biggest change being in industrial permitting. Note that the state-wide water quality assessment reports do not include permits for municipal, industrial, or construction stormwater runoff. The first industrial and construction stormwater runoff NPDES permits were issued by ADEQ in 1992 (ADEQ 2013b, 2013c). ADEQ did not issue permits for small municipalities' stormwater runoff until 2004 (ADEQ 2013d).

Table 4.12. Numbers of NPDES wastewater permits reported for the WAWRPR in 1990 and 2013 (ADEQ 2013a, ADPCE 1990).

Permit type	1990	2013	Change
Industrial	44	261	217
Municipal	42	61	19
Domestic	65	111	46
Cooling water	8	3	-5
Filter backwash	1	25	24
Process water	0	18	18
Agricultural	0	0	0
Other	14	13	-1
Total	174	492	318

5.0 WATER RESOURCES ISSUES

Water resources issues in the WAWRPR include concerns about the amount of water that is available, how the water is used, and the chemical and biological quality of water resources. In addition, there are concerns in the region about how water is managed in terms of flood control, water supply infrastructure, commodity transport, and wastewater treatment infrastructure. These issues are discussed and, to some extent, quantified below. Changes in regional water resources issues since the 1990 AWP update are also discussed.

5.1 Flooding

Flooding is common in the WAWRPR along the Arkansas River and its tributaries, with the flash flooding events likely to occur in the Ouachita Mountain streams and tributaries to the Arkansas River, and in the urban centers located along the Interstate 40 corridor. Since 1957, there have been 34 major disaster declarations involving flooding in the State of Arkansas. According to the Arkansas Department of Emergency Management (ADEM), some or all of the counties included in the West-central Region of Arkansas have been included in 14 flooding disaster declarations between 2003 and 2010 (ADEM 2010).

A recent significant flood event in the planning region occurred in the spring of 2004 when heavy precipitation fell in the western half of the State that contributed to flash flooding along the Arkansas River and subsequently saw the Arkansas River rise to, and remain at, flood stage for nearly the entire month of May (ADEM 2010)

The most recent significant flood event in the planning region occurred in May 2013. A record flood stage was recorded along the Fourche La Fave River in Yell County, with the river stage rising from 2.34 feet prior to the storm event to 32.6 feet at its peak. USGS estimated that the storm event was between and 100-year and 500-year event (USGS 2013b). Six deaths were attributed to this flood (5News Web Staff 2013).

5.2 Wetland Loss

Significant wetland loss has occurred in Arkansas making it the inland state having lost the most wetlands in the nation (Dahl 1990). The most significant losses were in the eastern part of the state in the Mississippi Delta area, however, the WAWRPR has not been exempt from wetland losses. This planning region has lost wetlands through conversion to agricultural lands and silviculture practices. Other wetland losses have occurred through the disruption of the connectivity between the wetland and adjacent rivers by modifications for flood control and commercial navigation, such as MKARNS (Adams et al. 2007). Wetland losses appear to continue in Arkansas but at a significantly reduced rate, while wetland mitigation and restoration projects continue to take place in the planning region, such as the Seven Lakes Wetland Project in Yell County (NRCS n.d.b.)

5.3 Water Supply

Arkansas is generally thought of as a water-rich state, and the WAWRPR has experienced little or no serious water supply issues outside of drought. The planning region has a much greater abundance of accessible surface water resources than groundwater resources.

5.3.1 Surface Water

Many of the municipalities in the WAWRPR utilize surface water impoundments for their water supply. This includes, but is not limited to, the cities of Fort Smith, Clarksville, Alma, Ozark, Russellville, Conway, and Little Rock, as well as many of the surrounding cities and towns. Typically surface water supply is only an issue during periods of drought (Winthrop Rockefeller Foundation 2008).

Presently, water supply in Central Arkansas (through Central Arkansas Water) is meeting the needs of its citizens, and is projected to meet demands for 60 years (Wiest 2011). Some members of the Mid-Arkansas Water Alliance have pursued the use of water from Lake Ouachita. Central Arkansas Water had secured future water rights for its users for DeGray Lake, and recently sold some of those rights to the City of Hot Springs. This deal has caused issue among users of Central Arkansas Water, who believe those water rights should have been saved rather than sold (Petrimoulx 2013).

Lake Fort Smith was expanded in 2006 to include Lake Shepherd Springs, providing a water supply to meet the needs of the Fort Smith region to 2060 (The City Wire 2009).

Currently, the Arkoma Basin is the focus of a major unconventional gas play targeting the Fayetteville Shale. A new horizontal fracturing technique established in the late 1990s in the natural gas industry has made it possible to extract natural gas from shale formations. Beginning in the mid-2000s, production began in the Fayetteville Shale formation in Central Arkansas, including several counties within the WAWRPR. The hydrofracking process uses large volumes of surface water, and development of the Fayetteville Shale has increased regional water demand..

5.3.2 Groundwater

In the WAWRPR there are three primary groundwater resources that are considered with regard to water supply. These include the Western Interior Plains (WIP) Confining Unit and Ouachita Mountains aquifer and the Arkansas River Valley alluvial aquifer.

5.3.2.1 Water Level Monitoring

There is little official routine monitoring of groundwater levels in the aquifers underlying the WAWRPR. The USGS monitors water levels at one USGS master well located in the planning region, in Faulkner County (T. Fugitt, ANRC, personal communication 9/4/2013). The ANRC collects data on groundwater in areas where water-level problems are a known issue (Kresse et al. 2013). ANRC is not currently collecting data on groundwater levels in the WAWRPR (ANRC 2013).

5.3.2.2 WIP Confining Unit and Ouachita Aquifer

In the WIP confining unit, owing to poor well yields and limited groundwater resources, water use is limited to domestic, small community, and non-irrigation agricultural supply. The greatest use of groundwater from the Ouachita Mountains aquifer is for domestic-supply purposes. Since domestic and water supply systems producing less than 50,000 gallons per day (gpd) are not required to report groundwater use, there is no way to accurately quantify the number of domestic and livestock wells in use in these regions. As of 2010, water use from 13 wells completed in the Atoka Formation of the WIP confining unit was reported. These wells were primarily used for public supply at parks, schools, stores, and some commercial business (Kresse et al. 2013).

Although Albin (1965) noted that wells in the Ouachita Mountains yielding greater than 10 gpm were considered "large-yield wells", some wells commonly can yield between 10 and 50 gpm—yields more than sufficient for many community-supply systems. A review of community supply wells from the Arkansas Department of Health identified 72 wells used by various entities including camps and other recreational areas, conference centers, rest areas, stores, and even sources of public supply; and five separate communities using wells completed in the Atoka, Bigfork Chert, Stanley Shale, and Arkansas Novaculite Formations for purpose of public supply, demonstrating that many formations constituting the Ouachita Mountains aquifer are capable of supplying volumes sufficient to supply small communities (Kresse et al. 2013).

5.3.2.3 Arkansas River Valley Alluvial Aquifer

Groundwater from the Arkansas River Valley alluvial aquifer is, and historically has been, an important source of irrigation and municipal supply. Currently, only the cities of Dardanelle and Maumelle, Arkansas, are using the Arkansas River Valley alluvial aquifer as a source of municipal supply water. In the past, the cities of Atkins, Morrilton, Dardanelle, and Ozark used the aquifer for municipal supply. Of these four cities, only Dardanelle has continued and expanded the use of the aquifer as its sole municipal water source. Bedinger and others (1963) outlined use from these four cities during 1959 and calculated the remaining development potential of the Arkansas River Valley alluvial aquifer based on aquifer thickness, extent, and average yields. Atkins pumped about 162,000 gpd during 1959 from three wells yielding approximately 75 to 250 gpm each; Dardanelle used three wells yielding about 300 gpm and pumped approximately 225,000 gpd; Morrilton used four wells yielding 200-500 gpm and averaged approximately 681,000 gpd; and Ozark used five wells to pump an average of approximately 300,000 gpd. Assuming natural recharge to the aquifer of 10 inches per year, Bedinger and others (1963) calculated that throughout the Arkansas River Valley, one could potentially pump 130 million gpd (mgd) without over of groundwater storage or induction from the river. In 1959, groundwater was pumped at average rate of 3.2 mgd, or less than 3 % of the amount regionally available from natural recharge.

The City of Dardanelle, Arkansas, continues to depend solely upon groundwater for municipal supply, and recent drilling efforts are part of plans for continued long-term use of this aquifer. A review of data from 2003 through 2009 revealed total withdrawals increasing from 1.1 to 2.2 mgd from nine wells completed at depths ranging from approximately 60-69 feet in the Arkansas River alluvial aquifer and each well pumping at approximately 200 gpm – three times the number of wells used in 1959. In 2010, the City of Dardanelle completed construction of a horizontal interceptor well system 300 feet from the river (a 13 by 16 feet caisson installed 45 feet below ground level with five 12-inch diameter lateral screens ranging from 150 to 250 feet in length) that produced more than 2.5 mgd in 2010. The collector well system has replaced the nine production wells as primary supply since January 2011, though these nine wells are maintained as backup supply (Kresse et al. 2013). By 2012, the City reported the capability of pumping greater than 3.0 mgd (Smith 2012). As such, with improved directional-drilling techniques and innovative well design, the City of Dardanelle has demonstrated that groundwater from the Arkansas River Valley alluvial aquifer may contain great potential as a valuable and productive water supply in other areas along the extent of the aquifer. Total reported use for the City of Dardanelle in 2010 was 2.03 mgd.

In Maumelle, Arkansas, pumping from the Arkansas River Valley alluvial aquifer began in 1941, when the Maumelle Ordnance Plant installed two wells to provide production water; water use continued through March 1945 when the plant was deactivated. In 1972, the City of Maumelle converted those wells for municipal supply and installed two additional wells. Nine additional wells were installed to provide water for the growing municipality from 1995 through 2012. Maumelle, which pumped from 13 wells completed in the Arkansas River Valley alluvial aquifer at the time of this report, reported an average use of 2.74 mgd in 2010.

In addition to the important use as a source of municipal supply water, the Arkansas River Valley alluvial aquifer continues to be a valuable source of irrigation water for cropland along the Arkansas River. For 2010, the reported use for irrigation from the Arkansas River Valley alluvial aquifer was 2.6 mgd, which was pumped from 34 wells supplying approximately 2,960 acres of cropland (T. Holland 2013). Kresse and others (2013) noted that in the City of Van Buren, dry-land farming was common throughout the area, and irrigation occurred only where water-producing sands and gravels of sufficient thickness occurred in the complex depositional environment of the meandering Arkansas River Valley alluvial deposits.

5.4 Waterborne Commodity Transport Infrastructure

As discussed in Section 3.7.3, in the WAWRPR, the Arkansas River (as part of MKARNS) is used for the transport of goods and materials. Maintenance of this waterway, and the associated public port facilities, which is a significant economic driver in the region and the State, is a constant and expensive activity. USACE is responsible for planning, improving and maintaining the river system to provide for flood control, navigation and recreation. The USACE operates most of the locks and dams and administers the Section 10 and Section 404 federal permit programs (Arkansas Waterways Commission 2013).

The Arkansas Waterways Commission, whose mission is to develop, promote, and protection the commercially navigable waterways of Arkansas for waterborne transportation and economic development to benefit the people of Arkansas, reported the following on the Arkansas River:

- The USACE (Tulsa District and Little Rock District) have a backlog of critical maintenance issues (maintenance that if not conducted will cause failure in 5 years or less) on MKARNS, estimated at $38 million (Arkansas Waterways Commission 2013). The USACE’s total operation and maintenance budget for MKARNS-AR for Fiscal Year 2013 (October 2012 – September 2013) was approximately $25 million (USACE 2012).
- A project to deepen the MKARNS navigation channel to a minimum of 12 feet was authorized by the US congress in 2005, and the work was initiated. However, funding for the project has been sporadic and was not appropriated in 2012 or 2013. As a result, work on this project has ceased.

5.5 Water Quality Issues

Federal law requires states to assess the water quality of the waters of the state (both surface water and groundwater) and prepare a comprehensive report documenting the water quality, which is to be submitted to EPA every two years. ADEQ is the agency in Arkansas responsible for enforcing the water quality standards and preparing the comprehensive report for submittal to EPA. This section discusses surface water and groundwater quality issues that have been identified in the WAWRPR. These issues include non-attainment of surface water quality standards, non-attainment of drinking water standards and water quality guidelines in groundwater, fish consumption advisories, nonpoint source pollution of surface water and groundwater, and contaminants of emerging concern.

5.5.1 Water Quality Monitoring

To assess water quality, it is necessary to collect water quality data through monitoring programs. Monitoring of water quality in the planning region occurs under a range of programs, including routine ambient, special project, and research-oriented monitoring. Multiple agencies are responsible for the various water quality monitoring programs, and numerous entities assist with monitoring activities. Surface water and groundwater monitoring programs in the planning region are outlined below.

5.5.1.1 Surface Water

ADEQ monitors water quality of surface waters through several programs. ADEQ relies on chemical data from its ambient water quality monitoring network to assess whether surface waterbodies are meeting their designated uses. Biological surveys are also conducted on a site-specific basis to further document whether an aquatic life use is being attained. There are 129 surface water ADEQ water quality monitoring station locations in the WAWRPR (ADEQ 2013e). Twenty-four of these monitoring stations are part of the Ambient Water Quality Monitoring Network (ADEQ 2004). Monthly water quality data are collected at these stations (ADEQ 2012d). There are 22 stream water quality monitoring stations in the WAWRPR that are part of the Roving Water Quality Monitoring Network (ADEQ 2004). These stations are sampled bimonthly over a two year period every six years (ADEQ 2012d). Twenty-seven of the water quality monitoring stations are on lakes, and the remaining are being sampled as part of special studies in the region.

ADEQ publishes a biennial report in order to comply with Section 305(b) of the federal Clean Water Act (CWA). This report includes water quality data collected by ADEQ as well as other available sources. It also lists impaired waters and proposed actions to correct water quality problems (ADEQ 2013f).

The USGS also monitors water quality in the region. There are 8 continuous USGS water quality monitoring stations in the WAWRPR although 5 of the stations are in Pulaski County (USGS 2013c). The locations of surface water quality monitoring stations in the WAWRPR are displayed on Figure 5.1.

Through its nonpoint source management program, ANRC oversees water quality monitoring programs in 10 nonpoint source priority watersheds. Two of these watersheds, Lake Conway Point Remove Watershed and Poteau River Watershed, are located in the planning region. These programs involve universities, contractors, and nonprofit organizations. Parameters monitored by these programs typically include nutrients and sediment, turbidity, and/or total suspended solids.

The monitoring and reporting requirements for surface water used for human consumption are authorized by both federal and state regulations. A summary of these requirements can be found in Chapter 5 of *Arkansas Public Water System Compliance Summary*, “Microbial Disinfection By-Products Rules” (ADH 2012). Only 15 public water supply systems in the WAWRPR do not use surface water as their water source, and two of those are under the direct influence of surface water (ADH n.d.). Depending on the treatment methods used and the number of customers served by the public water supply utilizing surface water, the monitoring requirements for the source water will vary and may include turbidity, *Escherichia coli* (*E. coli*), cryptosporidium, total organic carbon (TOC), and alkalinity.

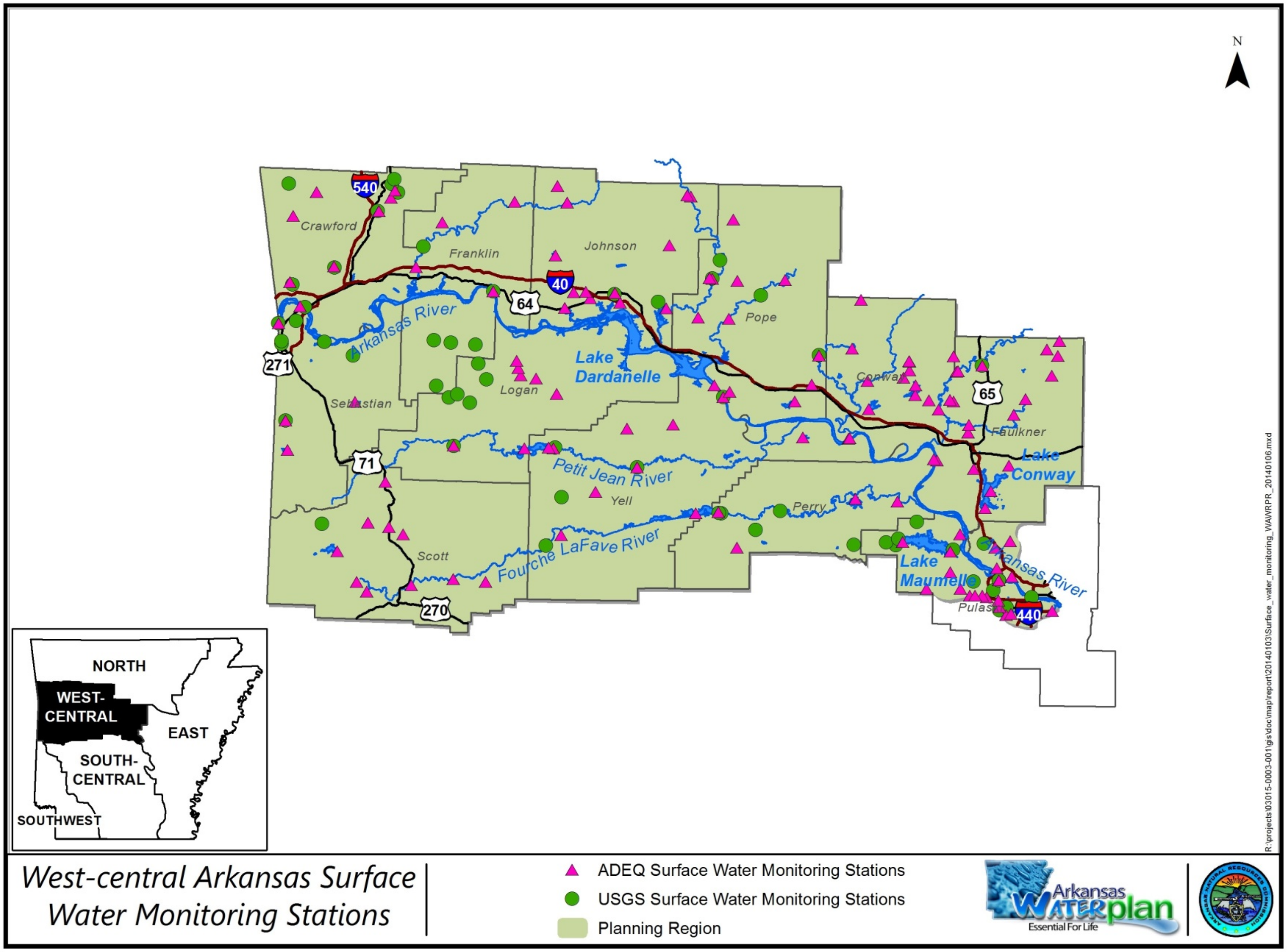

Figure 5.1. Surface water quality monitoring stations in the WAWRPR.

5.5.1.2 Groundwater

In the WAWRPR, groundwater quality monitoring is performed through a number of programs ranging from ambient to research-oriented and mandated monitoring. Multiple agencies are responsible for the various groundwater monitoring programs, and numerous entities assist with monitoring activities. Divisions of ADEQ administer mandated groundwater monitoring programs at various sites that are regulated by state and federal programs. The purpose of this monitoring is to evaluate potential and actual impacts to groundwater resulting from human activities and natural phenomenon (ADEQ 2008).

ADEQ developed the Arkansas Ambient Ground Water Monitoring Program in 1986, which currently consists of 12 monitoring areas and approximately 250 wells and springs throughout the state (ADEQ 2012d, Kresse et al. 2013). Two monitoring areas are within the WAWRPR, Frontal Ouachitas and North Central (Figure 5.2). The Frontal Ouachita Monitoring Area is located along the Pulaski and Saline County boundaries within the planning region. Samples are collected largely from the Ouachita Mountains aquifer for analysis of inorganic constituents and nutrients to evaluate impacts from multiple land uses. The monitoring wells are affected by agricultural, industrial, or a combination of both sources. The North Central Monitoring Area includes portions of Conway and Faulkner Counties. Samples are collected from the Atoka and Hale formations, above the Fayetteville Shale. This monitoring area was established in 2010 to address concerns related to natural gas development in the Fauetteville Shale gas play. Samples are collected on a three-year rotational basis and include a comprehensive suite of analytes. Data are presented in various ADEQ publications available on their website and in the EPA's STORET database (ADEQ 2012d).

The University of Arkansas (U of A) has conducted a significant amount of groundwater research that has resulted in scientific data and information necessary to understand, manage, and protect water resources within the state (Kresse et al. 2013). Hard-copy or digital reports, theses, dissertations, and journal articles are available at the U of A Mullin's Library, Arkansas Water Resources Center technical library, or through various online sources.

The Arkansas Department of Health (ADH) is the primary state agency for the federal Safe Drinking Water Act (SDWA) and is responsible for monitoring public water-supply wells.

ADH maintains a statewide database that consists of 1,300 wells (Kresse et al. 2013). Every three years, these wells are sampled for inorganic, organic (including pesticides, herbicides, synthetic organic compounds, and volatile organic compounds), and radiochemical contaminants. The Total Coliform Rule of the SDWA requires sampling on monthly basis, where the number of samples required is dependent upon the population size. Nitrate monitoring is performed on a yearly basis unless a sample greater than or equal to 50 % of the maximum contaminant level is detected and prompts the need for increased frequency. Additionally, the Disinfection Byproduct Rule of the SDWA requires monitoring of trihalomethanes and haloacetic acids (byproducts of chlorine and other disinfectants used to treat drinking water) on a quarterly or annual basis. While all of the programs above collect samples from treated drinking water, ADH also collects samples from untreated water sources (surface and groundwater) that include bacteria, particulates, algae, organics, pathogens, total organic carbon on a weekly or monthly basis as required by the SDWA (ADEQ 2008).

The USGS has 24 groundwater wells or springs scattered throughout the state that they monitor, with one of these sites located in the planning region (Faulkner County) (Figure 5.2). Samples are collected on a five-year rotational basis and analyzed for a variety of constituents including nutrients, metals, organics, radioactivity, and selected primary and secondary drinking water standard constituents (Kresse et al. 2013). In addition, the USGS samples many other wells and springs for purposes of water quality and quantity investigations or as part of other monitoring programs, such as the National Water Information System. Data from these investigations and monitoring programs are presented in reports or available for download online at the Arkansas Water Science Center (http://ar.water.usgs.gov/) or similar USGS websites (ADEQ 2009a, Kresse et al. 2013).

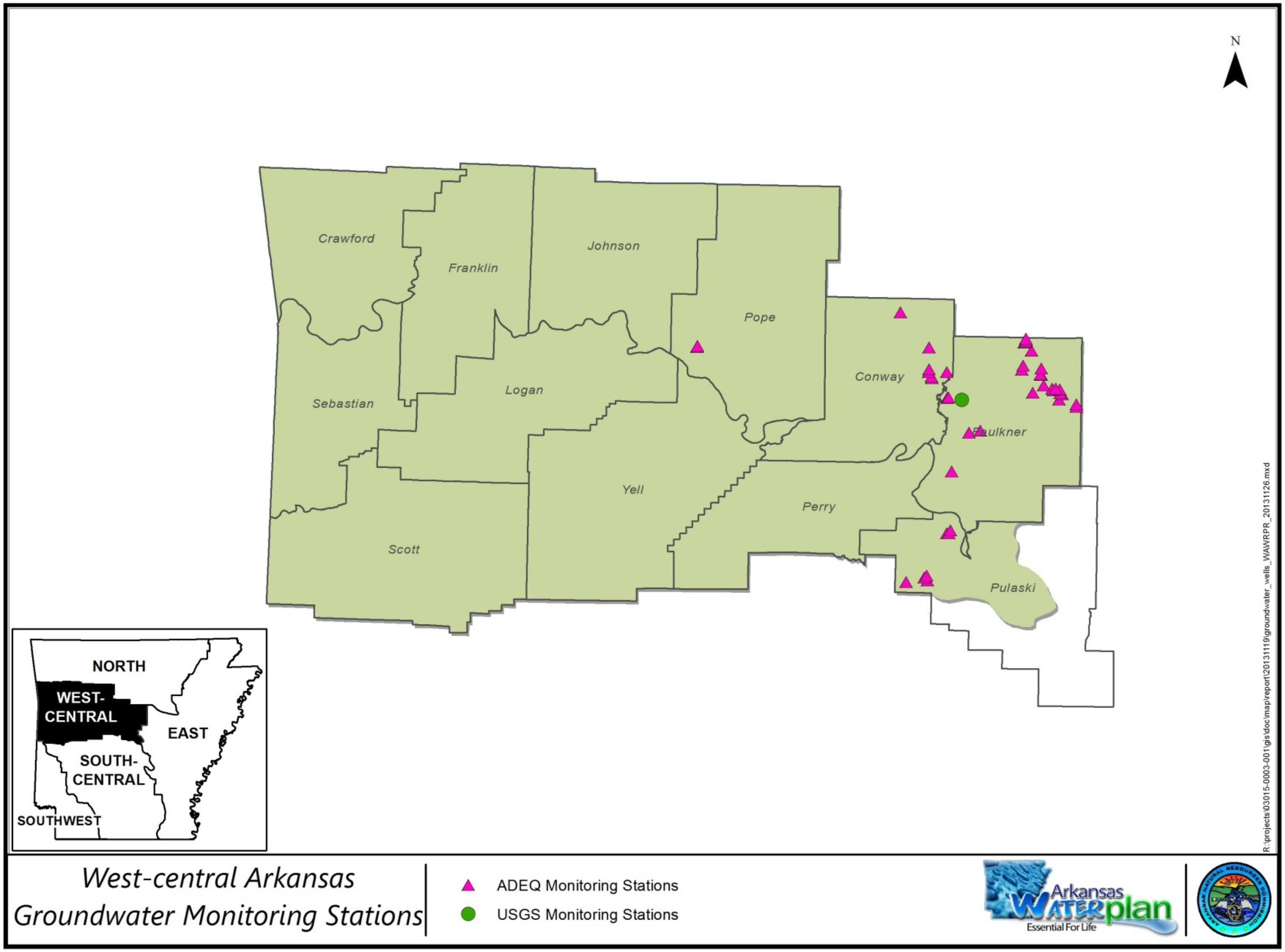

Figure 5.2. Ambient groundwater quality monitoring sites in the WAWRPR.

5.5.2 Non-attainment of Surface Water Quality Standards

In 2008, around 1,378 of the 1,781 miles of waterways in the WAWRPR were assessed for water quality. Of the miles assessed, 394 miles did not meet numeric water quality criteria or did not support all of their designated uses, along with 9,521 acres of lakes and impoundments. Siltation/turbidity, low dissolved oxygen, minerals (chloride, sulfate, and total dissolved solids [TDS]), and metals were the causes of impaired water quality in the majority of the stream miles assessed (Table 5.1) (ADEQ 2008, 2009). A detailed list of WAWRPR stream impairments is included in Appendix A. Beryllium, mercury, and siltation/turbidity were the sources of impairment for lakes in the planning region. Figures 5.3 through 5.5 show locations of impaired waterbodies in the WAWRPR.

In the Arkansas River Valley, soil types in much of the area are highly erosive and tend to easily go into colloidal suspension which can cause long-lasting high turbidity values (ADEQ 2008). It should be noted that while a waterbody may be impaired due to sediment, there is no numeric water quality standard for sediment. Arkansas has a numeric water quality standard for turbidity but not total suspended solids (TSS); thus turbidity is the chemical parameter that is assessed to determine if sediment impairment exists. There is currently no other method that is consistently used by EPA or ADEQ to measure sediment or siltation in water.

Table 5.1 Summary of impaired waters in the WAWRPR (ADEQ 2009)

Pollutant	Miles of impaired stream	Acres of impaired lakes
Beryllium	39.5	2,675
Chlorides	17.6	0
Copper	42.7	0
Dissolved Oxygen	180.0	0
Pathogens	68.2	0
pH	52.9	0
Siltation/Turbidity	91.1	2,900
Total Dissolved Solids (TDS)	28.4	0
Zinc	34.0	0
Mercury	8.7	3,946
Sulfates	6.6	0
Total Phosphorus	6.6	0
Ammonia	3.0	0
Nitrate	13.0	0

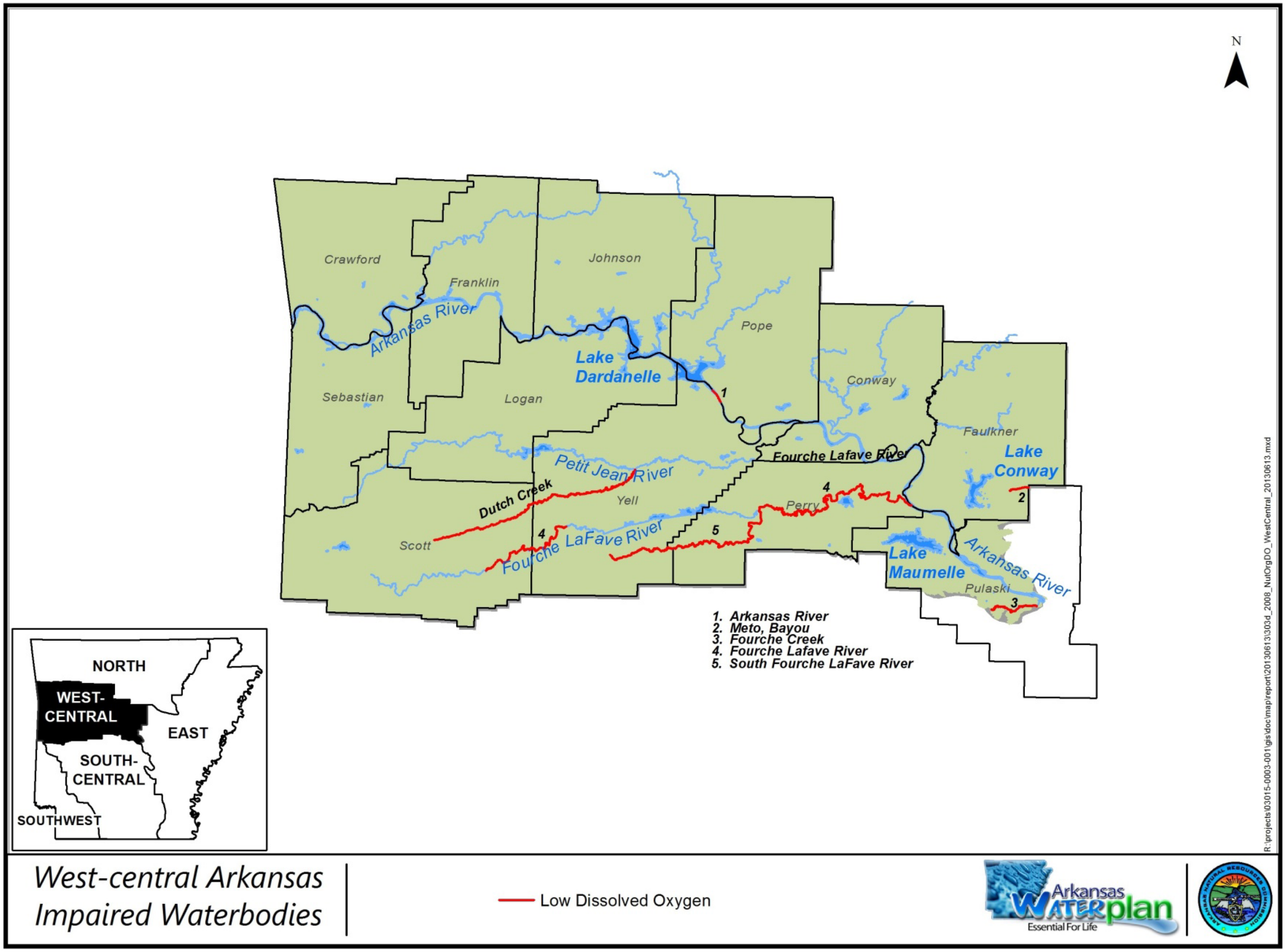

Figure 5.3. Waterbodies in the WAWRPR listed as impaired due to low dissolved oxygen on the 2008 303(d) list.

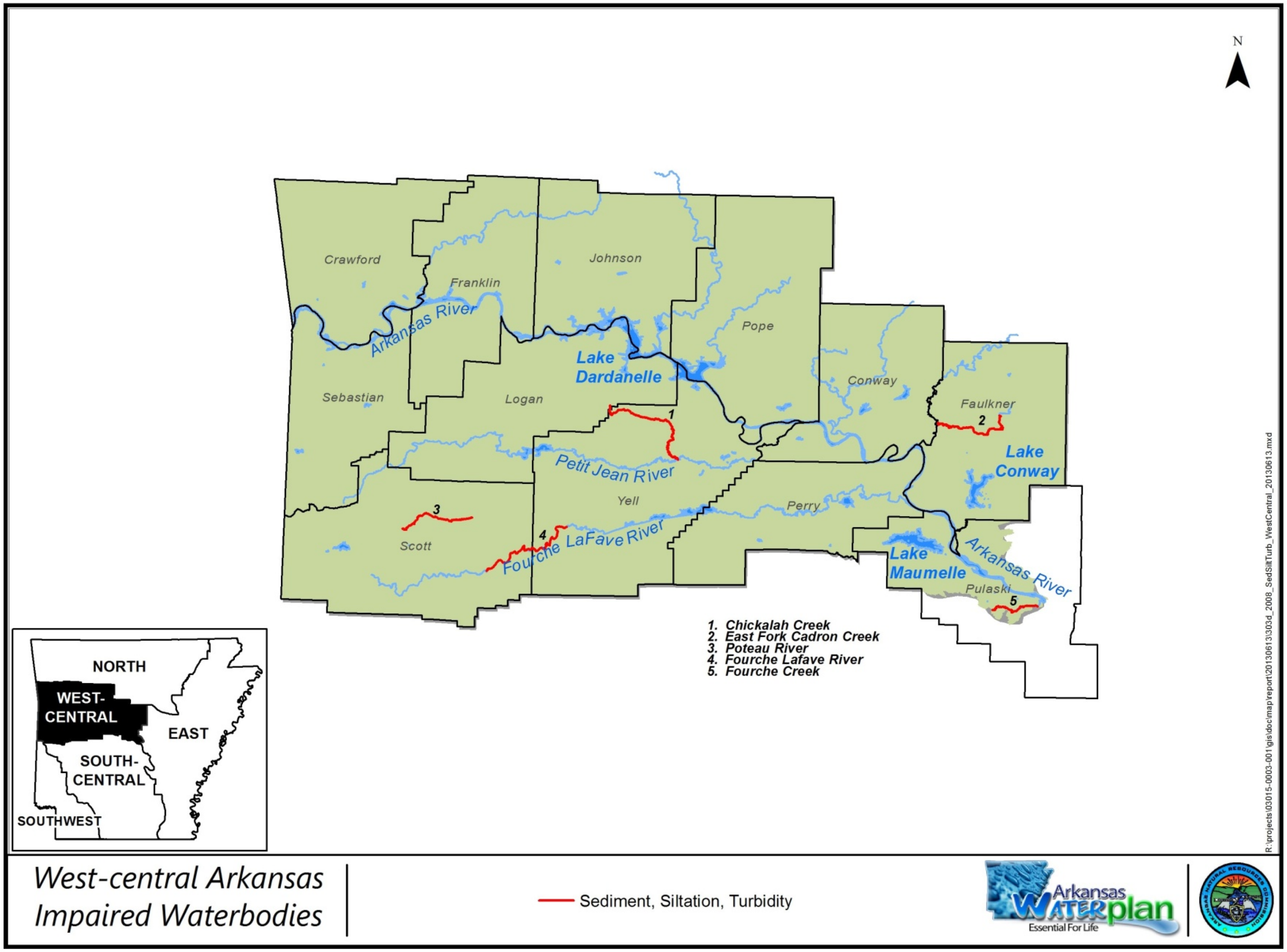

Figure 5.4.Waterbodies in the WAWRPR listed as impaired due to siltation / turbidity on the 2008 303(d) list.

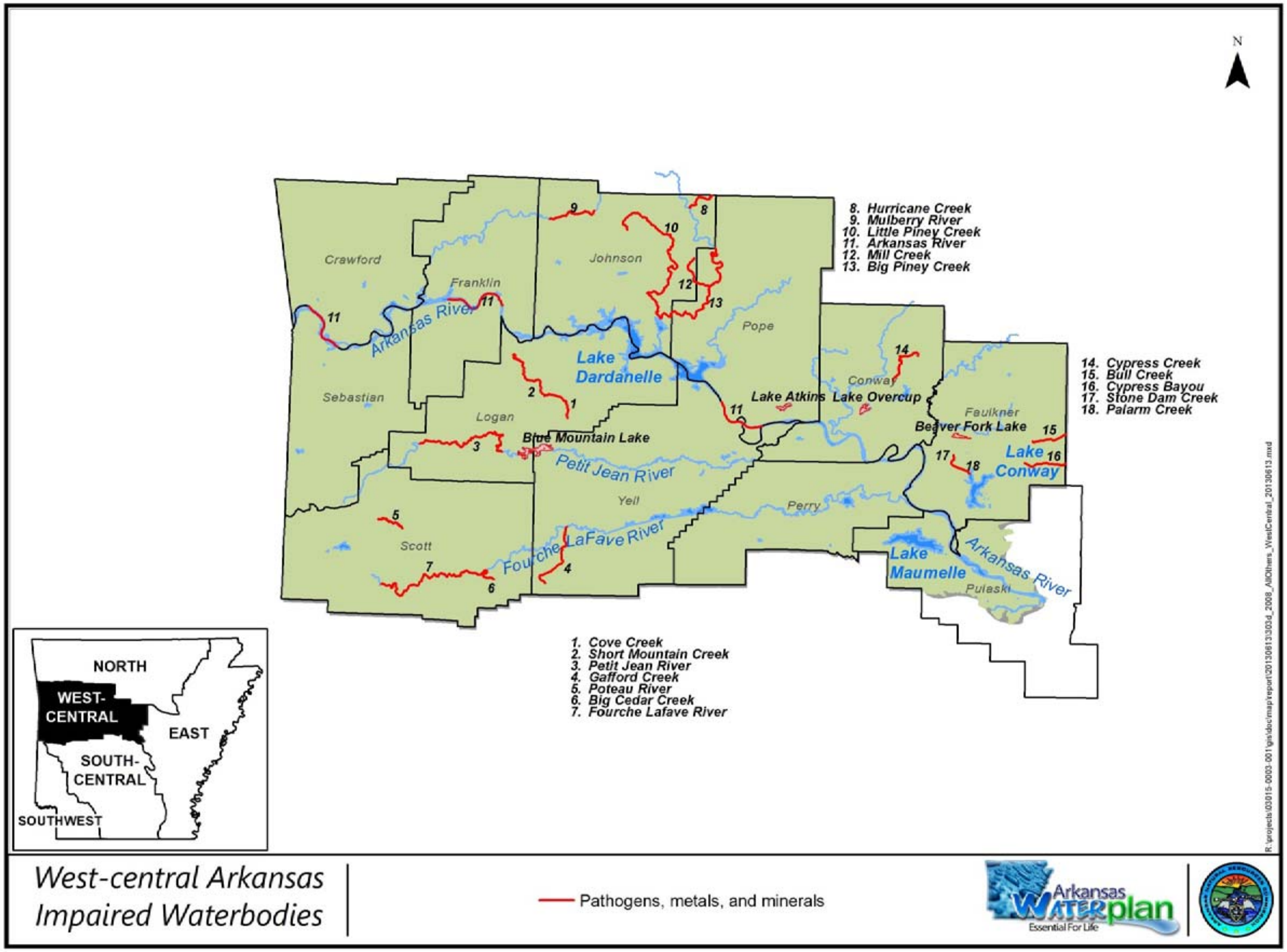

Figure 5.5. Waterbodies in WAWRPR classified as impaired due to pathogens, metals, and/or minerals on the 2008 303(d) list.

In cases where exceedances of water quality criteria are preventing the attainment of a designated use, a total maximum daily pollutant load (TMDL) must be developed. A TMDL is the maximum amount of a pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant, resulting in the waterbody being listed as impaired. A TMDL allows for the allocation of pollutant loads between point sources and nonpoint sources discharging to the waterbody, as well as a margin of safety. TMDL reports have been prepared for a number of waterbodies in the WAWRPR addressing sediment/turbidity, minerals, metals, nutrients, and low dissolved oxygen (Table 5.2).

Table 5.2. TMDLs for waterbodies in WAWRPR (ADEQ 2012b)

Waterbody	Impaired Uses	Pollutants	TMDL Status
Cadron Creek	Aquatic life	Turbidity	Final 1/05/2006
Dry Fork lake	Fish consumption	Mercury	Final 9/17/2002
Fourche La Fave River	Fish consumption	Mercury	Final 9/17/2002
Lake Nimrod	Fish consumption	Mercury	Final 9/17/2002
Stone Dam Creek	Aquatic life, domestic water supply	Ammonia, Nitrate	Final 11/01/2003
Whig Creek	Aquatic life, domestic water supply	Nitrate	Final 12/08/2000
Whig Creek	Aquatic life, domestic water supply	Copper	Final 11/01/2003
White Oak Creek	Aquatic life	Turbidity	Final 1/06/2006
Spring Lake (Yell County)	Fish consumption	Mercury	Final 1/16/2007
Cove Creek Lake	Fish consumption	Mercury	Final 9/17/2002
Mulberry River	Aquatic life	pH	Final 8/01/2008
Shepherd Springs Lake	Fish consumption	Mercury	Final 9/17/2002
Poteau River near Fort Smith	Aquatic life	Turbidity	Final 12/29/2005
Poteau River near Waldron	Aquatic life	Phosphorus, Copper, Zinc	Final 1/10/2006

5.5.3 Nutrient Surplus Areas

Controversy over phosphorus concentrations in streams that cross the Arkansas-Oklahoma border, primarily the Illinois River, prompted actions in Arkansas to reduce nutrients in these streams. One of these actions was the declaration of eight watersheds in Arkansas as Nutrient Surplus Areas. Two of these watersheds – Upper Arkansas River (Lee Creek) and Poteau River are in the WAWRPR (Figure 5.6). This designation requires that nutrient

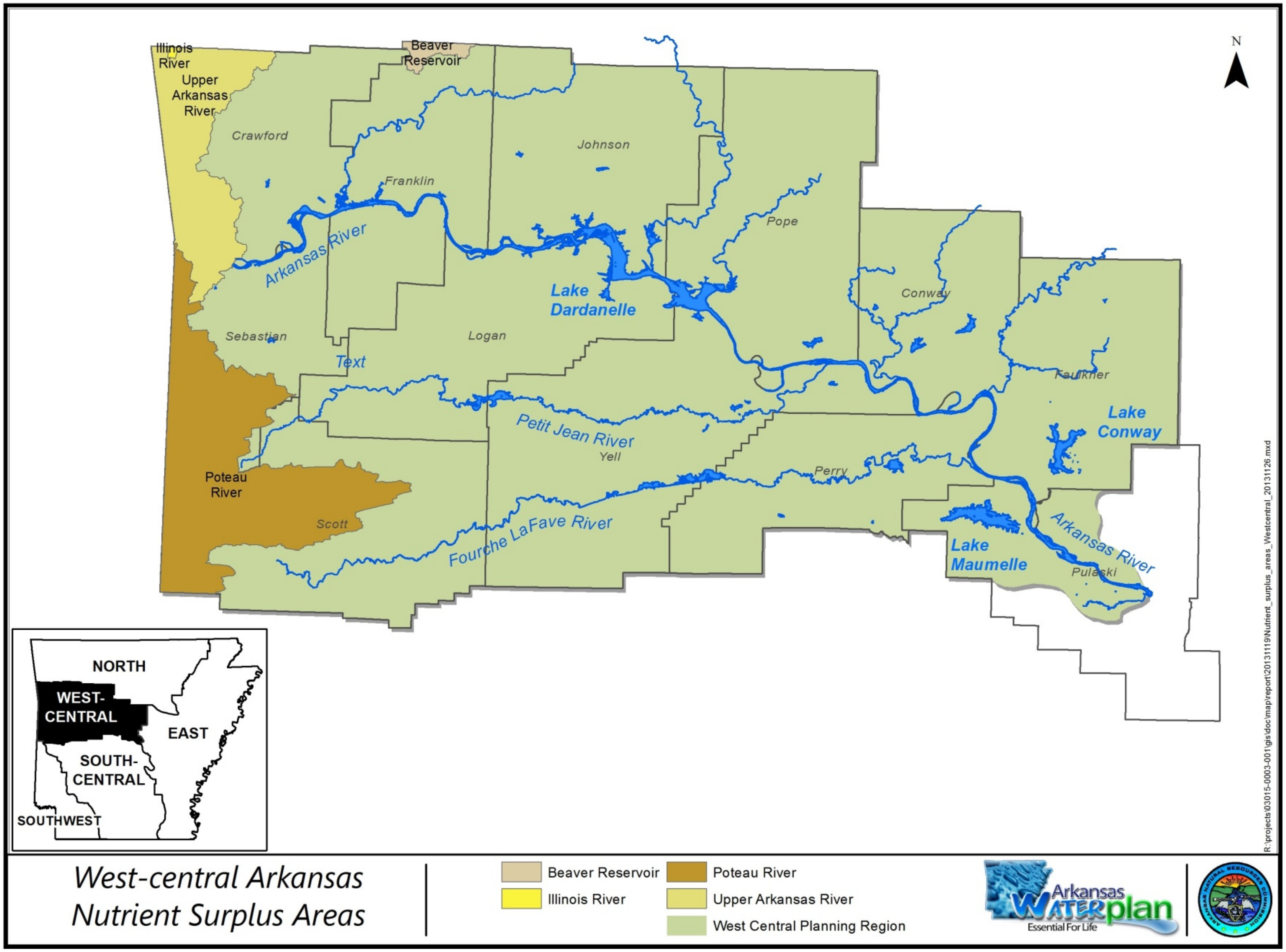

Figure 5.6. Nutrient surplus areas in the WAWRPR.

management practices be used in these areas to help to reduce nitrogen and phosphorus levels in the surface and ground water. Nutrient management training and planning is also required.

The Upper Arkansas River watershed is designated as a Nutrient Surplus Area because the State of Oklahoma has designated Lee Creek downstream of the Arkansas border as a scenic river, and set phosphorus limits for scenic rivers at 0.037 mg/L (Oklahoma Statute § 82-1451 et seq., Oklahoma Water Resources Board 2013). The U.S. Supreme Court has ruled that a downstream state's water quality requirements must be met at the state line.

The Poteau River in Oklahoma does not have a numeric phosphorus criterion. However, the Oklahoma Water Resources Board has set phosphorus limits for Lake Wister, into which the Poteau River drains after leaving Arkansas (Oklahoma Water Resources Board 2013). Therefore, the Poteau River watershed in Arkansas is designated as a Nutrient Surplus Area.

5.5.4 Non-attainment of Drinking Water Quality Standards and Water Quality Guidelines by Groundwater

No groundwater quality standards have been set by state agencies in Arkansas; although there are state regulations to protect groundwater quality (see Section 6). However, groundwater used as a drinking water source is required to meet state and federal drinking water quality standards. Other groundwater users, such as farmers and industries, have developed guidelines that they use to determine if groundwater quality is suitable for their uses.

Groundwater quality in the WAWRPR is discussed in the following sections by dividing the planning region into three distinct resources areas. The Western Interior Plains (WIP) Confining Unit, which lies north of the Arkansas River valley, the Arkansas River Valley alluvial aquifer, in the central portion of the planning region, and the Ouachita Mountains aquifer, located south of the Arkansas River valley.

5.5.4.1 Western Interior Plains Confining Unit

Due to the limited groundwater resources of the area, there is very little groundwater quality data available for the WIP Confining Unit. Of the few groundwater quality studies published, most focus on the WIP Confining Unit in the northern portion of the Arkansas River

Valley. Recent groundwater studies that were conducted to evaluate impacts of development of the Fayetteville Shale gas play to water quality in central Arkansas provide the most comprehensive evaluation of the WIP aquifers (Kresse et al. 2006, 2012). These studies include the portion of the Arkansas River Valley in the WAWRPR. The studies found no evidence of groundwater contamination associated with natural gas extraction activities in the study area (Kresse et al. 2012).

Groundwater with elevated iron, sulfate, and chloride may be encountered in localized areas, and occasionally exceed Federal secondary drinking water standards (Kresse et al. 2006; 2012). Constituent concentrations were attributed to the rock type, groundwater residence times (degree of water rock interaction), and microbially mediated processes.

Nitrate concentrations in the WIP aquifers are relatively low; however, elevated nitrate concentrations were associated with shallow sandstone aquifers overlain by sandy soils. In these areas, the soil is more permeable and aquifers are more susceptible to surface-derived contamination (Kresse et al. 2013). Since the Boston Mountains Plateau and Arkansas River Valley are not considered karst terrains, less impact from surface derived contaminates would be expected due to diffuse recharge allowing for natural attenuation to occur to a greater extent in the unsaturated zone.

5.5.4.2 Arkansas River Valley Alluvial Aquifer

Groundwater in the Arkansas River Valley alluvial aquifer is of overall good water quality, with the exception of elevated iron concentrations, which often requires treatment for use as a municipal supply system. Chloride concentrations can be slightly elevated in backswamp areas or where influenced by influx of water from the Arkansas River but rarely exceeded the Federal secondary drinking water regulation of 250 milligrams per liter (mg/L) (Kresse et al. 2013). Groundwater from this aquifer is characterized by a strongly calcium-bicarbonate type water and wide variations in the dissolved-solids content (Bedinger, Emmett and Jeffery 1963; Kresse et al. 2006; 2013). Groundwater is subject to reducing conditions in various parts of the aquifer that control the distribution and concentration of nitrate, iron, and sulfate.

Nitrate concentrations ranged from 0.01 to 67 mg/L, with a median of 1.1 in sample data reviewed by Kresse and others (2013). Twelve percent of the samples had concentrations exceeding the Federal maximum contaminant level of 10 mg/L. The median concentrations for all other aquifers in Arkansas, with the exception of the Springfield Plateaus and Ozarks aquifers, were less than 0.3 mg/L. The shallow depths and relatively high recharge values of the Arkansas River Valley alluvial aquifer are consistent with increased vulnerability to surface (for example, fertilizer and manure) and near-surface (for example, septic tanks) sources of nitrogen. The greatest density of elevated nitrate concentrations were along the western extent of the aquifer (Crawford County) and eastern extent (Yell, Pope, Conway, and Faulkner Counties), compared to lower concentrations in the central part of the aquifer in Franklin, Logan, and Johnson Counties. The lower concentrations of nitrate in the central part of the aquifer are theorized to result from natural denitrification processes in the aquifer (Kresse et al. 2013).

5.5.4.3 Ouachita Mountains Aquifer

Groundwater quality in the Ouachita Mountains aquifer is good with respect to Federal primary drinking water standards. Problems in regard to taste, staining, and other aesthetic properties are related to elevated levels of iron, which is a common complaint among domestic users. Water quality and type generally are defined by the two major rock types in the Ouachita Mountains: quartz rocks (sandstone, chert, and novaculite) and shale. Groundwater from quartz formations tend to have low pH values, low dissolved solids concentrations, and are very soft water of a mixed water type representative of precipitation concentrated by evapotranspiration processes. Groundwater from shale rock in the system is characterized by strongly calcium- to sodium-bicarbonate water type, with varying constituent concentrations defined by residence time along the flow path. Sulfate and chloride concentrations tend to be elevated in some areas for groundwater from shale formations. No spatial relation was noted, however, for the distribution of iron concentrations, and high and low concentrations occurred in shale and quartz formations. Iron is abundant in numerous mineral forms in sedimentary rocks throughout Arkansas, and elevated iron in the Ouachita Mountain aquifer were attributed to microbially mediated processes (Kresse et al. 2013).

5.5.4.4 Groundwater Contamination

Elevated nitrate concentrations are associated with all three aquifer systems. In these areas, the soil is more permeable and aquifers are more susceptible to surface-derived contamination. The relatively high median concentration of nitrate in the Arkansas River Valley alluvial aquifer especially compared to other aquifers in Arkansas, with the exception of the Springfield Plateaus and Ozarks aquifers in northern Arkansas, is indicative of the vulnerability of groundwater contamination from fertilizer, manure, and septic tanks. Hydraulic fracturing and associated impact on water quality is a concern of many citizens; however, a recent study conducted by Kresse and others (2012) found groundwater quality throughout the region to be consistent with natural processes.

5.5.5 Fish Consumption Advisories

There are active fish consumption advisories due to mercury for several waterbodies in the WAWRPR. Details of these advisories are given in Table 5.3. The locations of these water bodies are shown on Figure 5.7.

5.5.6 Contaminants of Emerging Concern

There is growing interest, nationally and in Arkansas, in the occurrence of a group of chemicals called contaminants of emerging concern, which include pharmaceuticals, personal care products (e.g., soap and shampoo), natural and synthetic hormones, surfactants, pesticides, fire retardants, and plasticizers primarily in surface waters, but also starting to be measured in groundwater across the nation. The risks to human health and the environment from the majority of these chemicals are unknown, which is why they are referred to as “contaminants of emerging concern.” Contaminants of emerging concern have been detected in surface waters in Arkansas (Galloway et al. 2005). Detection, however, does not indicate there is an effect.

Table 5.3. Fish consumption advisories in the WAWRPR (ADH, AGFC, ADEQ 2011, ADEQ 2012d).

Waterbody	Miles Affected	Pollutant of Concern	Restrictions for high risk groups[1]	Restrictions for general public
Fourche La Fave River – from Nimrod Dam to South Fourche	8.7	Mercury	Should not eat largemouth bass (16 inches or longer)	Eat no more than 2 meals per month of largemouth bass (16 inches or longer)
Nimrod Lake	N/A	Mercury	Should not eat largemouth bass (16 inches or longer)	Eat no more than 2 meals per month of largemouth bass (16 inches or longer)
Cove Creek Lake	N/A	Mercury	Should not eat largemouth bass (12 inches or longer)	Should not eat largemouth bass (over 16 inches). No more than 2 meals per month of largemouth bass (12-16 inches)
Lake Sylvia	N/A	Mercury	Should not eat largemouth bass (16 inches or longer)	Eat no more than 2 meals per month of largemouth bass (16 inches or longer)
Dry Fork Lake	N/A	Mercury	Should not eat largemouth bass (16 inches or longer)	Eat nor more than 2 meals per month of largemouth bass (16 inches or longer)
Shepherd Springs Lake	N/A	Mercury	Should not eat black bass (16 inches or longer)	Should not eat black bass (over 20 inches). No more than 2 meals per month of black bass (16-20 inches)
Spring Lake (Yell Co.)	N/A	Mercury	Should not eat largemouth bass (16 inches or longer)	Eat no more than 2 meals per month of largemouth bass (16 inches or longer)

[1] pregnant or breastfeeding women, women who plan to become pregnant, and children under 7 years of age.

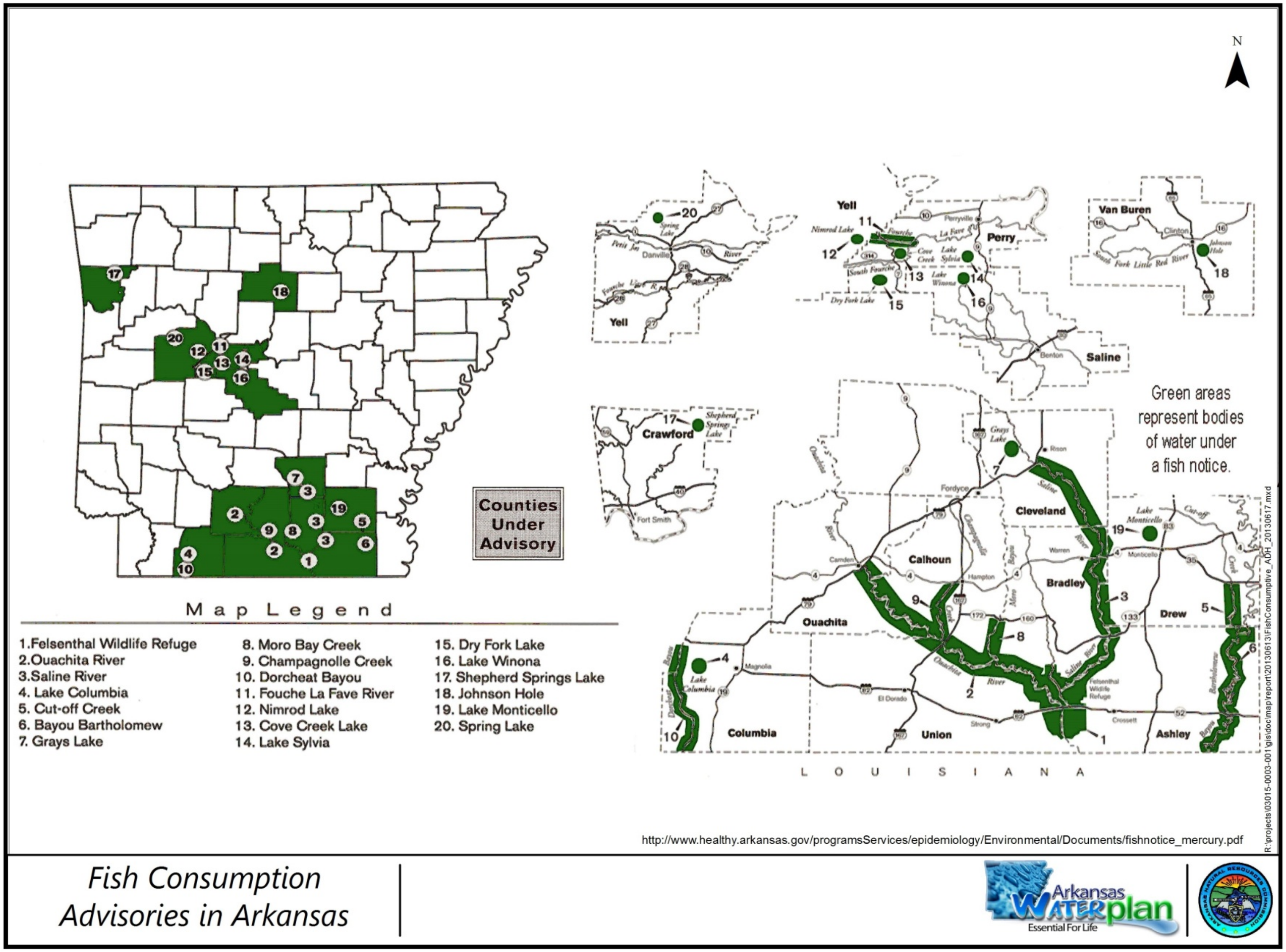

Figure 5.7. Waterbodies in the WAWRPR for which fish consumption advisories have been issued (ADH, AGFC, ADEQ 2011)

5.5.7 Nonpoint Source Pollution

Nonpoint source pollution was identified as a water resources issue in the 1990 AWP. Nonpoint source pollution is still a concern with respect to surface water and groundwater quality issues in the WAWRPR.

5.5.7.1 Nonpoint Source Priority Watersheds

Ten watersheds in Arkansas have designated as nonpoint source priority watersheds. These are 8-digit HUC watersheds where impairments or threats to water quality are known to occur. These priority watersheds either have or will have an approved Nine Element Plan and are eligible for Section 319(h) funding from the EPA (ANRC 2011b). Sections of four of these designated watersheds are located in the WAWRPR. These watersheds are displayed on Figure 5.8.

5.5.7.2 Hazardous Waste Remedial Action Priority Sites

Hazardous waste sites and resource extraction activities in the planning region also contribute nonpoint source pollution. There are six sites in the WAWRPR identified as priority for hazardous waste cleanup (i.e., Superfund sites) due to contamination of water resources. These are summarized in Table 5.4 (ADEQ 2013g). There are also eight properties in the state's Brownfields program that are currently being evaluated; one site that is on the State Priority List (SPL) that is monitored; two sites in the Elective Cleanup program; three Class I solid waste landfills; and an unknown number of hazardous waste sites (e.g. Whirlpool in Fort Smith) and leaking underground storage tank sites that are being evaluated or monitored through other regulatory mechanisms.

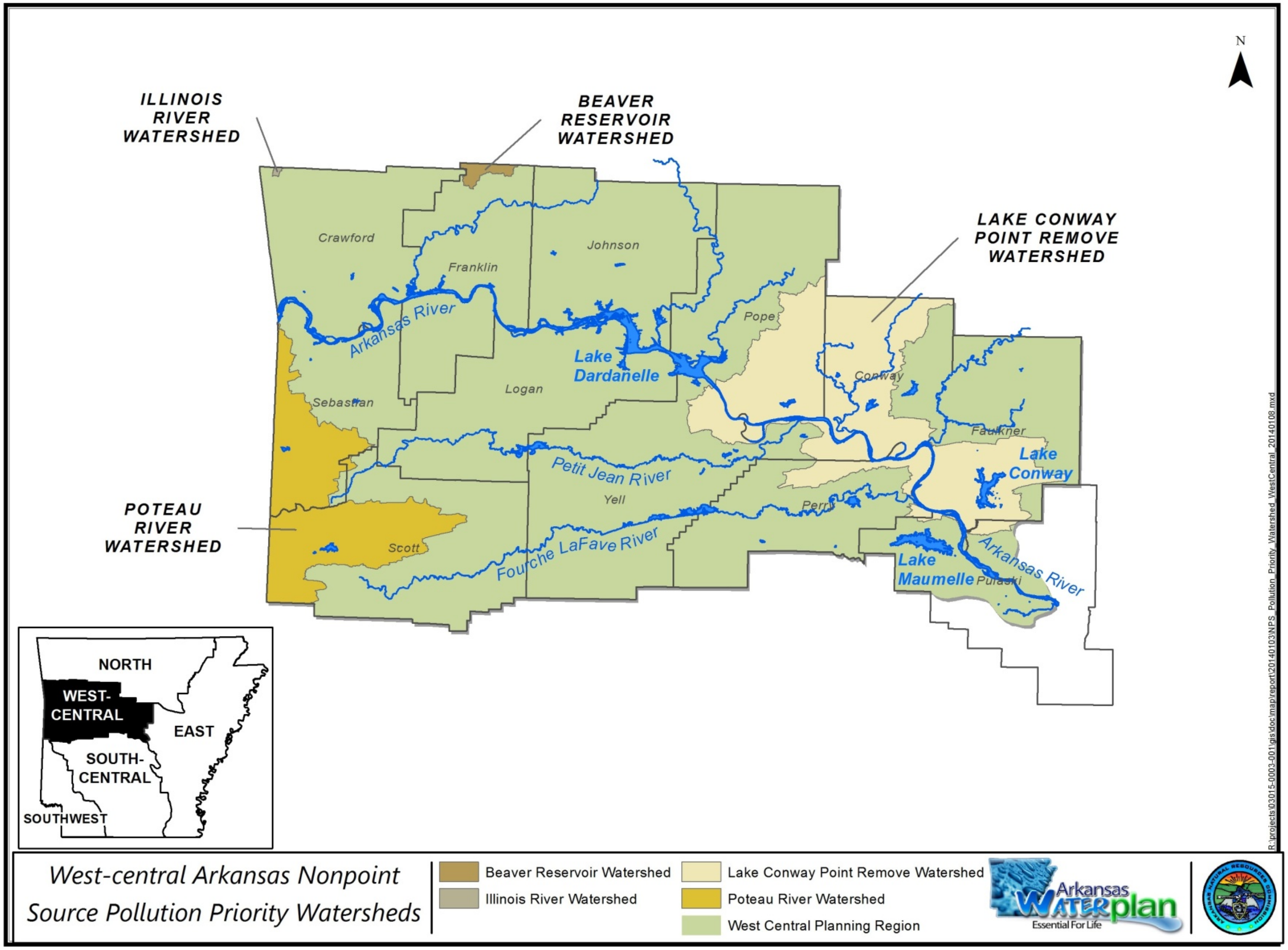

Figure 5.8. Nonpoint source pollution priority watersheds in the WAWRPR.

Table 5.4.Status of Superfund sites in the WAWRPR (ADEQ 2013h).

Site name	EPA ID	Site Location	Pollutants of concern	Contaminated water resources	Remediation Status	List
Industrial Waste Control	ARD980496368	Sebastian County	Methylene chloride, toluene, polynuclear aromatic hydrocarbons (PAHs), heavy metals	Unnamed tributary to Prairie Creek. groundwater	Completed 1991	Removed from National Priority List (NPL) April 2008
Mountain Pine Pressure Treating	ARD049658628	Yell County	Pentachlorophenol (PCP), copper chromate arsenate	Surface water (not specified), groundwater	Completed September 2005	NPL
Jimelco, Little Rock	ARD062144308	Pulaski County	Polychlorinated biphenyl (PCB), hydraulic oil, emthalite	Ditch to Fourche Creek (potential)	Completed May 2009	Removed from SPL June 2013
Plainview Lumber Company	ARD006349187	Yell County	PCP, Copper chromate arsenate (CCA)	Porter Creek & Prairie Creek (potential)	Now listed as part of Mount Pine Pressure Treating Site on NPL	Removed from SPL January 2009
United States Forgecraft	ARD006341747	Sebastian County	Arsenic, lead, cadmium, total chromium, and PAHs	In proximity to Poteau River	Completed 2009	Removed from SPL June 2010
Old Midland Products	ARD980745665	Yell County	PCP, PAHs	Groundwater	Completed 2006	NPL

Note: Highlighted rows indicate sites that were added to the NPL after the 1990 AWP update.

5.5.7.3 Resource Extraction

There is concern that natural gas extraction from the Fayetteville Shale Play could affect groundwater quality. However, a study conducted in 2011 did not find evidence of groundwater contamination associated with natural gas extraction in north-central Arkansas (Warner et al. 2013, EPA 2013c).

5.6 Loss of Aquatic Species

In a 2002 report, NatureServe ranked Arkansas 13th in the nation for the level of reportedly extinct species (NatureServe 2002). In 2005, 369 animal species of greatest conservation need were identified for Arkansas by a team of specialists (Anderson 2006). These species of greatest conservation need include 116 species associated with aquatic and semi-aquatic habitats that occur in the WAWRPR (see Figure 3.6). Figures 5.9 through 5.12 show the numbers of aquatic species of greatest conservation need present in watersheds within the WAWRPR. The greater the number of aquatic species of greatest conservation need present in a watershed, the more important it is to protect and restore water resources and their aquatic habitats in the watershed. The condition of aquatic habitats depend on characteristics such as water levels, flow volumes, and seasonal variability in both. Five aquatic and semi-aquatic animal species present in the planning region are on the federal list of threatened and endangered species (Table 5.5). One, the Arkansas River Shiner, is considered to be extirpated from Arkansas (USFWS n.d.b.).

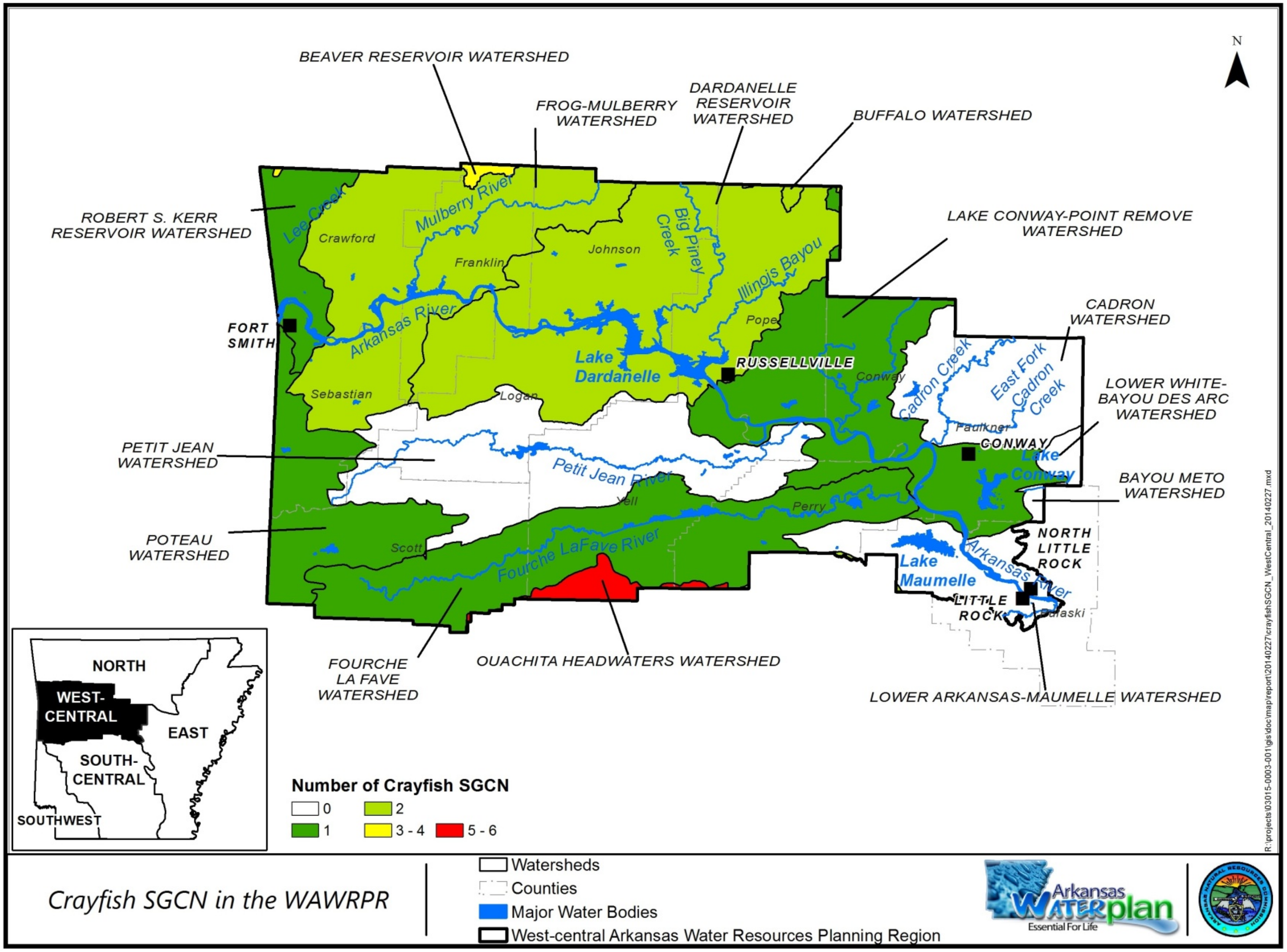

Figure 5.9. Numbers of crayfish Species of Greatest Conservation Need (SGCN) in watersheds of the WAWRPR.

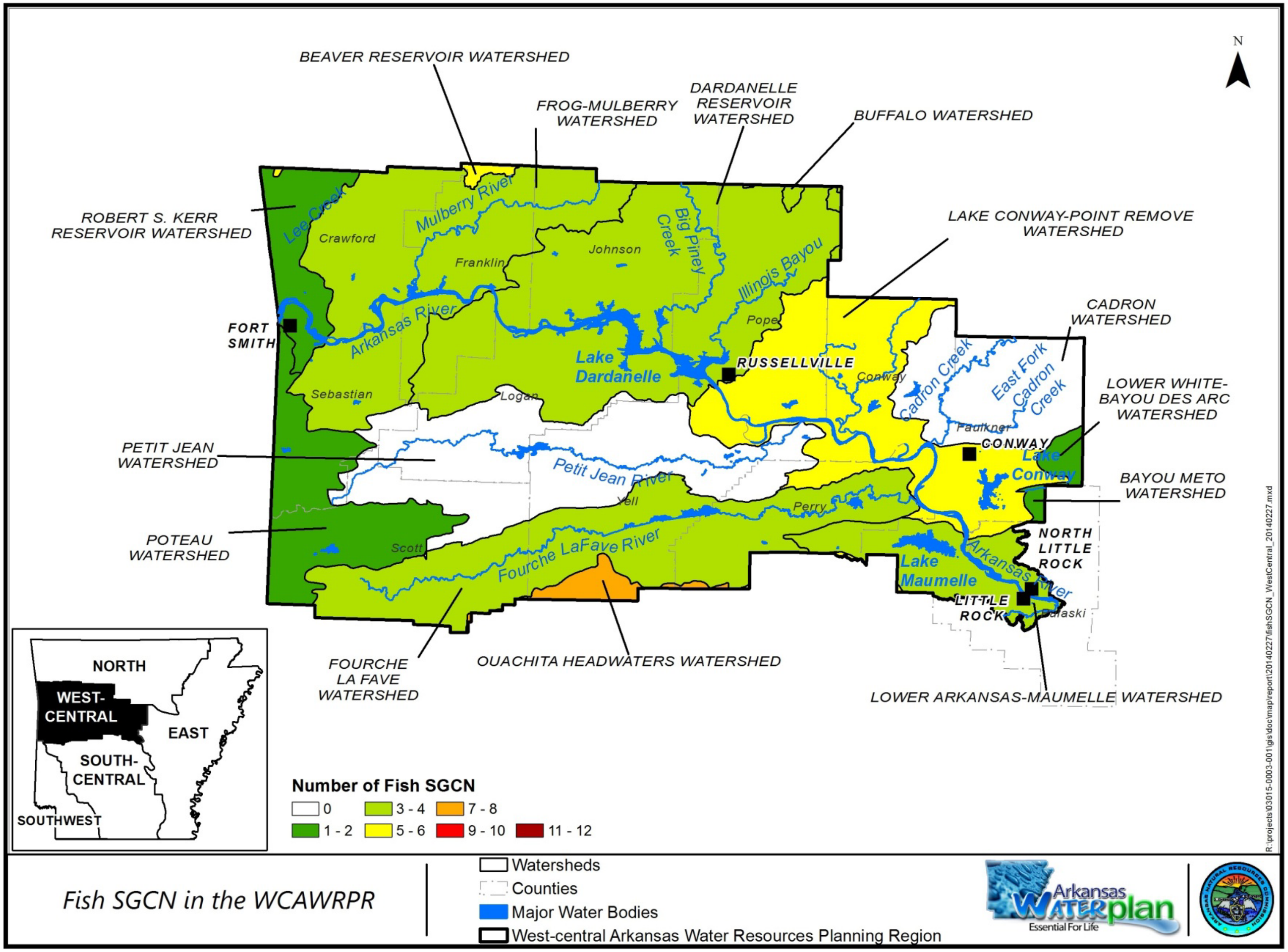

Figure 5.10. Numbers of fish SGCN in watersheds of the WAWRPR.

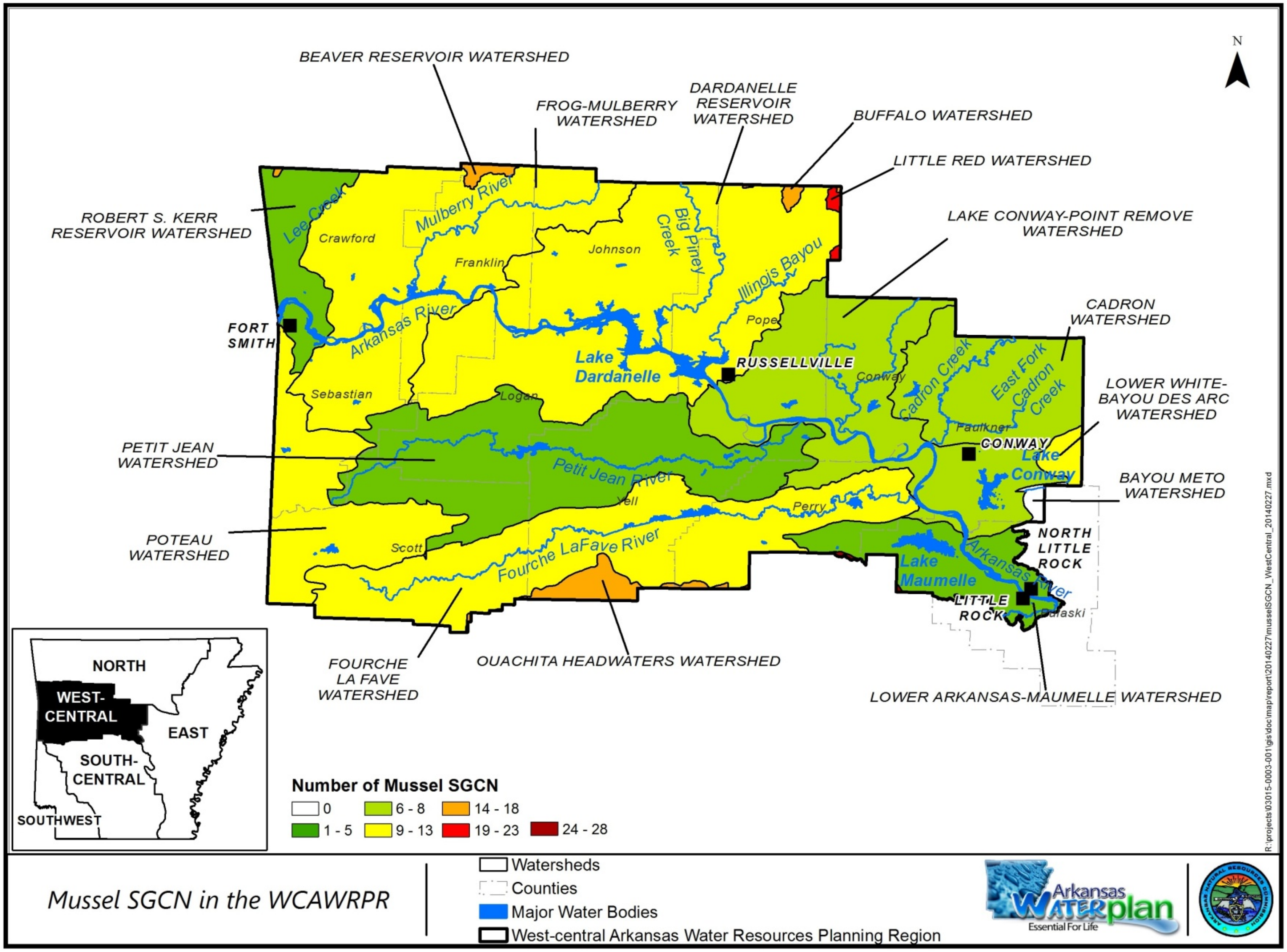

Figure 5.11. Numbers of mussel SGCN in watersheds of the WAWRPR.

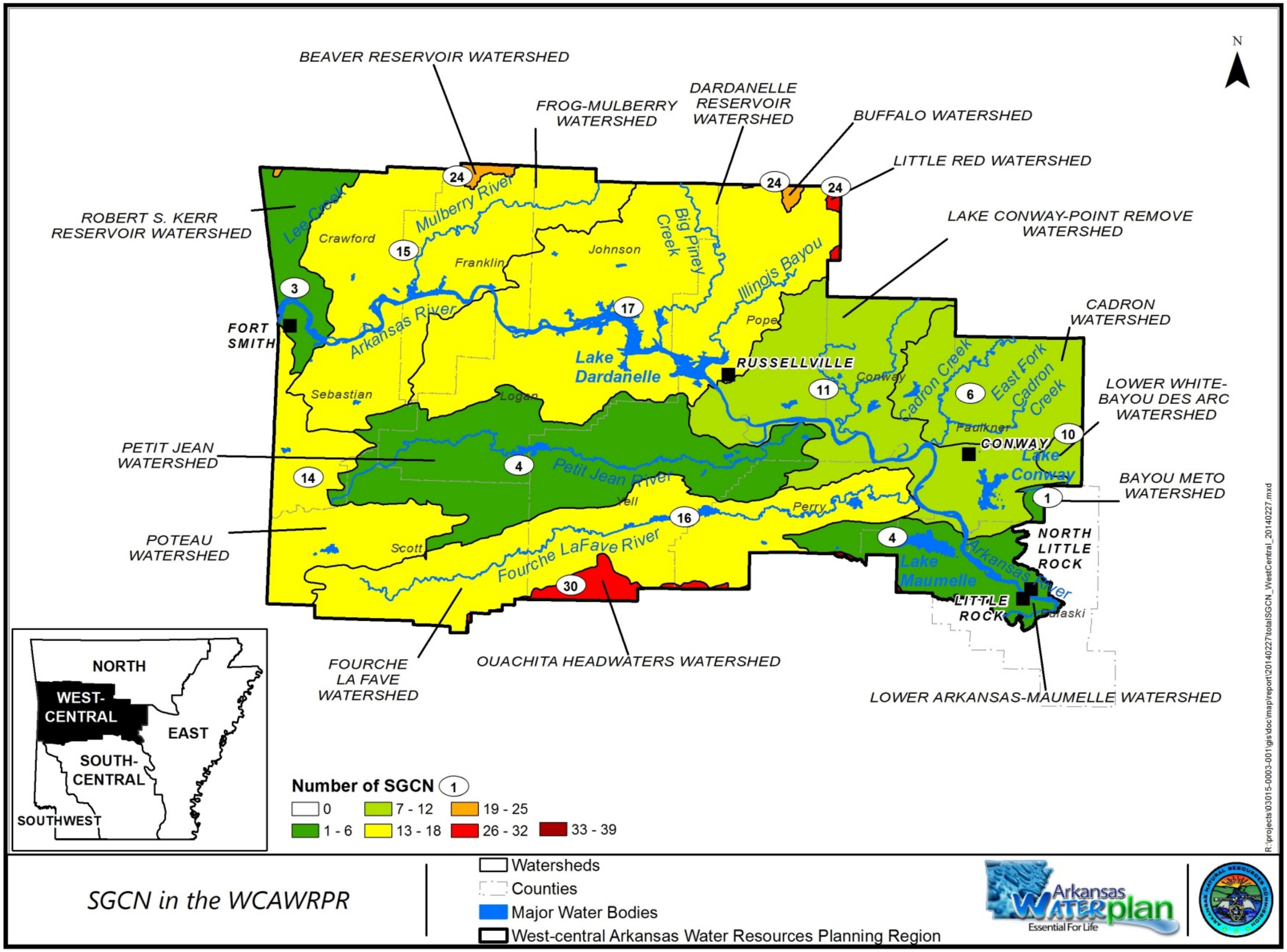

Figure 5.12. Total numbers of crayfish, fish, and mussel SGCN in the watersheds of the WAWRPR.

Table 5.5. Federally listed threatened and endangered species associated with aquatic and semi-aquatic habitats occurring in the WAWRPR (ANHC 2013, Anderson 2006, USFWS n.d.b.)

Common Name	Species Name	Status	WAWRPR habitat
Arkansas River shiner	Notropis girardi	Threatened	Turbid waters of broad, shallow, unshaded creek channels, small to large rivers, with mostly silt and shifting sand bottoms; Larvae seek backwater pools and side channels; extirpated from Arkansas River system
Harperella or piedmont mock bishopweed (herb)	Ptilimnium nodosum	Endangered	rocky/gravelly shoals or cracks in bedrock outcrops beneath the water surface in clear, swift-flowing streams, edges of intermittent pineland ponds; granite outcrop seeps
Scaleshell (freshwater mussel)	Leptodea leptodon	Endangered	Interior highlands division; typically associated with riffles, relatively strong currents, and substrate of mud, sand, or assemblages of gravel, cobble, and boulder; Currently it is more restricted to rivers with relatively good water quality in stretches with stable channels.
Spectaclecase (freshwater mussel)	Cumberlandia monodonta	Endangered	Large rivers with areas sheltered from current, i.e. beneath rock slabs, between boulders
Interior Least Tern	Sterna antillarum athalassos	Endangered	Mud flats, ponds, lakes
Piping Plover	Charadrius melodus	Threatened	Open sand, gravel, beaches; island and river riparian areas

In addition to the animals of greatest conservation need, the ANHC has identified 50 species of rare aquatic and semi-aquatic plants that occur in the WAWRPR. Seven semi-aquatic plant species present in the planning region are on the state threatened and endangered plant species list (Table 5.6). These plant species of concern are affected by water quality, water levels, flow rates, and/or seasonal changes in water levels or flow.

Table 5.6. State-listed threatened and endangered plant species occurring in aquatic and semi-aquatic habitats in WAWRPR (ANHC 2013).

Common Name	Species Name	Status	WAWRPR Counties
Slender rose-gentian	*Sabatia campanulata*	Endangered	Pulaski
Opaque Prairie Sedge	*Carex opaca*	Endangered	Faulkner, Franklin, Logan, Sebastian
White-top sedge	*Rhynchospora colorata*	Endangered	Pulaski
Small-head pipewort	*Eriocaulon koernickianum*	Endangered	Conway, Franklin, Johnson, Logan, Pope, Pulaski
Southern tubercled orchid	*Platanthera flava*	Threatened	Conway, Pulaski
Purple fringeless orchid	*Platanthera peramoena*	Threatened	Faulkner, Pulaski
Spinulose wood fern	*Dryopteris carthusiana*	Threatened	Logan, Yell

In some cases, the presence of non-native aquatic species is believed to affect aquatic biodiversity. There are 30 non-native aquatic animal species known to occur in the planning region (Table 5.7). The majority of the non-native fish species present in the region are sport fish species that have been introduced purposely and are regularly stocked. Some of the non-native fish species are believed to have been released from private aquariums. The impact of many of these species on native species is unknown. Some species, such as carp, are suspected to affect native species as a result of modifying aquatic habitats, e.g., removing vegetative cover and increasing turbidity. Other species, such as non-native sport fish and exotic clams, are suspected to affect native species by competing with them for food and/or habitat (USGS 2013d). There are also 11 species of invasive aquatic plants are known to occur in the planning region (Table 5.8) (University of Georgia - Center for Invasive Species and Ecosystem Health 2013).

Table 5.7. Non-native aquatic species occurring in the WAWRPR.

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
magnificent bryozoan	*Pectinatella magnifica*	East of Mississippi River	a pond in Elm Park, just off of Highway 23	2013	Unknown	Clog water pipes
freshwater jellyfish	*Craspedacusta sowerbyi*	China	Van Buren City Park Lake, Mulberry River, Rock Quarry near Altus, Old coal pit in Hartman, Paris City Lake, Hurricane Creek, Jeffrey Quarry, Kiwanis Pond in Little Rock	1999	Accidental	Unknown
waterflea	*Daphnia lumholtzi*	Africa, Australia, India	Dardanelle Reservoir	1994	Unknown	Competes with native species
a calanoid copepod	*Eurytemora affinis*	Ponto-Caspian region, North American Atlantic and Pacific Coasts, western European coast, parts of Asia	Dardanelle Reservoir, Nimrod Lake	1967, 1982	Accidental	Unknown
Inland Silverside	*Menidia beryllina*	Eastern North America, Mexico	Arkansas River, Dardanelle Reservoir	1987	Stocked	Competes with native species
Rock Bass	*Ambloplites rupestris*	St. Lawrence River, Great Lakes, Hudson Bay, Mississippi River basin in eastern Canada and U.S.	Lee Creek, Mulberry River, Dardanelle River, Big Piney Creek, Horshead Lake	1980, 1997	Stocked	Hybridization, competes with native species
Redbreast Sunfish	*Lepomis auritus*	Atlantic and Gulf Slope drainages	Spring Lake	1966	Stocked	Competes with native species
Unidentified pacu	*Colossoma or Piaractus sp.*	Tropical America	Arkansas River, Lake Valencia, Lakewood Lake #1	1992, 1995	Aquarium release	Unknown
Threadfin Shad	*Dorosoma petenense*	Ohio River, Mississippi River to gulf; Atlantic Slope, Gulf drainages	Jones Creek, Gap Creek	1988	Unknown	Competes with native species
Goldfish	*Carassius auratus*	Eastern Asia, China	Hollis Lake, Lake Conway, Arkansas River, Dardanelle Reservoir	1988	Introduced to propogate species in America	Unknown

Table 5.7. Non-native aquatic species occurring in the WAWRPR (continued).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
Grass Carp	*Ctenopharyngodon idella*	Eastern Asia	Lake Conway, Dardanelle Reservoir, Sixmile Creek, Lake Maumelle, Black Fork, Poteau drainage, Nimrod Lake	1988	Stocked	Competes with native species
Common Carp	*Cyprinus carpio*	Eurasia	Frog Bayou, Hurricane Creek, Lake Conway, Arkansas River, Mulberry Creek, Dardanelle Reservoir, Piney Creek, Fourche LaFave River, Illinois Bayou, Indian Creek, Lake Maumelle, Gap Creek, Poteau drainage, Blue Mountain Lake, Nimrod Lake	1988	Stocked	Destroys vegetation, causes turbidity
Silver Carp	*Hypophthalmichthys molitrix*	Eastern Asia	Lake Conway, Arkansas River	1988	Stocked	Unknown
Fathead Minnow	*Pimephales promelas*	Parts of North America	Dardanelle Reservoir, Lake Maumelle, Gap Creek, Blue Mountain lake	1988	Accidental (baitfish)	Unknown
Northern Pike	*Esox lucius*	Atlantic, Arctic, Pacific, Great Lakes, Mississippi River basins	Jones Creek	1988	Stocked	Reduce prey density
White Catfish	*Ameiurus catus*	Atlantic and Gulf Slope drainages	Flat Cypress Creek, Lake Conway	1988	Stocked	Loss of native species
Brown Bullhead	*Ameiurus nebulosus*	Atlantic and Gulf Slope drainages, St Lawrence-Great Lakes, Hudson Bay, Mississippi River basins	Lake Conway-Point Remove drainage, Fourche La Fave daraigne, Jones Creek, Sugar Loaf Lake, Blue Mountain Lake	1988	Stocked	Reduce prey density

Table 5.7. Non-native aquatic species occurring in the WAWRPR (continued).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
Blue Catfish	*Ictalurus furcatus*	Mississippi River Basin, Gulf Slope	Frog Bayou, Lake Forth Smith, Lake Shepherd Springs, Ozark Lake, Mulberry River, Shores Lake, Big Piney Creek, Horsehead lake, Big Shoal Creek, Cove Lake, Lake Dardanelle, Illinois Bayou, Jonew Creek, Lake Hinkle, Gap Creek, Sugar Loaf Lake, Kingfisher Lake, Blue Mountain Lake, Petit Jean River, Spring Lake	1988, 1997	Stocked	Hybridization
Wiper (Sunshine Bass)	*Morone chrysops x M. saxatilis*	None (artificially hybrid)	Lake Maumelle	1981	Stocked	Backcrossing of several species
Striped Bass	*Morone saxatilis*	St. Lawrence River, Gulf Slope drainage	Arkansas River, Ozark Lake, Dardanelle Reservoir, Blue Mountain Lake, Lake Maumelle, Nimrod Lake	1967, 1984, 1988, 1997	Stocked	Preys on small fish
Walleye	*Sander vitreus*	St. Lawrence-Great Lakes, Arctic, and Mississippi River basins	Lee Creek, Dardanelle Reservoir, Blue Mountain Lake, Nimrod Lake	1950, 1988	Stocked	Preys on native species, depletes the forage base
Cutthroat Trout	*Oncorhynchus clarkii*	Pacific Coast drainages	Arkansas River, North Fork River	1992, 1997	Stocked	Hybridization
Rainbow Trout	*Oncorhynchus mykiss*	Pacific Slope	Arkansas River, North Fork River	1988, 1992, 1997	Stocked	Hybridization, predation of native species
Brown Trout	*Salmo trutta*	Europe, Northern Africa, western Asia	Arkansas River	1997	Stocked	Reduce native fish population
Brook Trout	*Salvelinus fontinalis*	Eastern Canada, Atlantic, Great lakes, Mississippi River Basin	Arkansas River, North Fork River	1992, 1997	Stocked	Loss of native species
Lake Trout	*Salvelinus namaycush*	Canada, Alaska, New England, Great Lakes basin	Arkansas River	1997	Stocked	Loss of native species

Table 5.7. Non-native aquatic species occurring in the WAWRPR (continued).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
Nutria	*Myocastor coypus*	Southern South America	Conway, Crawford, Faulkner, Franklin, Johnson, Logan, Perry, Pope, Pulaski, Sebastian, Yell Counties	1978	Imported for fur farming	Over-grazing of wetland habitats
Asian clam	*Corbicula fluminea*	Southern Asia, Africa, Asian islands, Australia	Arkansas River, Frog Bayou, Illinois Bayou	1974, 1980, 1983, 1985	Food of immigrants	Biofouling, damage to structures, modfication of predator diets
zebra mussel	*Dreissena polymorpha*	Black, Caspian, Azov Seas	Arkansas River, Dardanelle Reservoir, Holla Bend National Wildlife Refuge	1992, 1994, 1995, 1997, 2005	Accidental	Biofouling, decline of native species
Common octopus	*Octopus vulgaris*	Atlantic Ocean	Lake Conway	2003	Aquarium release	N/A

Table 5.8. Invasive aquatic plants occurring in the WAWRPR.

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
Alligatorweed	*Alternanthera philoxeroides*	South America	Perry, Pulaski Counties	1988	Accidental - ballast water	Displace native species, clog waterways, diminished water quality
Brazilian waterweed	*Egeria densa*	South America	Conway, Pulaski Counties	1988	Aquarium release	Displace native species, interferes with recreational activities
Common water hyacinth	*Eichhornia crassipes*	South America	Pope, Pulaski Counties	1999, 2006	Imported - ornamental plant	Reduce light levels, diminished water quality
Hydrilla	*Hydrilla verticillata*	Europe, Old World	Pulaski County	Not Available	Aquarium release	Restrict native species, irrigation, recreation, hydroelectirc production, water flow
Yellow iris	*Iris psedacorus*	Asia, Africa, Europe	Pulaski County	1997	Imported - ornamental plant	Not Available
European water-clover	*Marsilea quadrifolia*	Europe, Asia	Pulaski County	Not Available	Not Available	Not Available
Eurasian water-milfoil	*Myriophyllum spicatum*	North America, Europe, Asia, Africa	Pulaski County	Not Available	Accidental	Displace native species, reduce light levels, reduce habitat for others
Watercress	*Nasturtium officinale*	Not Available	Crawford, Franklin Counties	1988	Not Available	Not Available
Reed canarygrass	*Phalaris arundinacea*	North America, Europe	Sebastian County	Not Available	Escaped cultivars	Excludes other vegetation
Water fern	*Salvinia minima*	Mexico, South America	Pulaski County	Not Available	Not Available	Not Available
Narrow-leaved cattail	*Typha angustifolia*	Not Available	Faulkner County	Not Available	Not Available	Not Available

5.7 Water Infrastructure

Communities throughout the state struggle to provide and maintain drinking water and wastewater infrastructure, including treatment plants and distribution lines. Several communities in the WAWRPR are experiencing growth that is requiring expansion of water supply and wastewater capacity. For example, Lake Fort Smith was expanded to serve the growing water supply needs in the Fort Smith area. The James Fork Regional Water District has expanded over the last 10 years from serving only south Sebastian County to including residents in Scott County, and the cities of Greenwood and Booneville with quality drinking water (James Fork Regional Water District 2014). Central Arkansas Water (CAW) serving the Little Rock metropolitan area, has expanded their Pleasant Valley treatment plant most recently in 2008 from a capacity of 100 mgd to 133 mgd. In 2007, CAW began construction on expanding their water supply distribution north of the Arkansas River to include north Pulaski County and the cities of Jacksonville and Cabot (Central Arkansas Water n.d.a.). In other areas within the planning region, maintaining aging infrastructure with limited financial resources is an issue.

Expansion of water supply service areas, at times, results in conflict between water providers. For example, in 2003, the City of Forth Smith water utility proposed to expand its service area into areas already being served by the James Fork Regional Water District. This expansion was opposed by the James Fork Regional Water District. The two water utilities ended up in litigation over this issue, settling in 2005 (James Fork Regional Water District 2014).

The recent increased focus on nutrients in wastewater discharges is affecting infrastructure in the WAWRPR. Historically, permitted point source discharges in Arkansas were not limited with regard to the amount of nutrients that could be in the wastewater they discharge. Current regulations require that all point source discharges in watersheds of waterbodies included on the Arkansas list of impaired waters due to phosphorus, be limited in the amount of phosphorus that can be present in their discharge. Point source discharges in designated nutrient surplus watersheds can also be subject to limits for phosphorus in their discharge under this regulation (Arkansas Regulations 2.509). Upgrades to remove nutrients from wastewater are often expensive, placing an additional financial burden on utilities. As of

2013, at least 10 municipal facilities in the WAWRPR have current discharge permits that require monitoring the discharge for phosphorus and/or nitrate (ADEQ 2013i).

6.0 INSTITUTIONAL AND REGULATORY SETTING

This section provides a description of the regulatory and institutional framework for water resources management in WAWRPR. It includes general descriptions of federal and state laws, regulations, and programs that deal with water resources management in the region, as well as a listing of federal, state, and local governmental and nonprofit institutions that are involved in water resources management in the region. In addition, the interrelationships between regulations and institutions at the federal, state, and local levels in the planning region are illustrated.

6.1 Legal Framework

The legal framework for management and use of water resources in Arkansas is based on court case law, laws enacted by the Arkansas General Assembly, and rules and regulations enacted by state agencies. Federal laws and regulations also influence the regulation of water resources in the state (ANRC 2011a). The discussion below identifies and summarizes the laws and regulations and associated programs that guide water management in WAWRPR, and summarizes changes that have occurred in this legal framework since the 1990 AWP update.

6.1.1 Federal Laws and Regulatory Programs

Federal policy recognizes that states have primary authority for regulation of water usage within their borders. Therefore, the federal laws, regulations, and associated programs that influences water resources management in the WAWRPR primarily relate to water quality. Federal legislation and programs also deal with other aspects of management of water resources in the region such as conservation and protection of waterbodies, flood control, and navigation.

6.1.1.1 Water Quality

The current federal laws and programs that guide management of water quality in the WAWRPR are summarized in Table 6.1. The Clean Water Act (CWA) of 1972 (most recently amended in 2002) and the Safe Drinking Water Act (SDWA) of 1974 (most recently amended in 1996) are two important pieces of federal water quality legislation that authorize a number of

Table 6.1. Federal laws and regulatory programs that address WAWRPR water quality.

Federal Law	Federal Water Quality Regulatory Programs	Responsible Federal Agency
Clean Water Act	Ambient nutrient water quality standards	EPA
	Biosolids regulations	
	Impaired waters	
	Nonpoint source pollution management	
	NPDES point source permitting	
	NPDES stormwater permitting	
	NPDES pesticide application permitting	
	NPDES confined animal feeding operations permitting	
	State ambient water quality standards	
	State biennial water quality assessment	
	Total maximum daily loads (TMDL)	
	Dredge and fill permitting	USACE
Safe Drinking Water Act	Source water protection	EPA
	Underground injection wells	
Underground storage tank regulations	Underground storage tank program	EPA
Resource Conservation and Recovery Act	Hazardous waste management	EPA
	Solid waste management	
	Subtitle D	
Comprehensive Environmental Response, Compensation, and Liability Act	Hazardous waste site clean up	EPA
Federal Insecticide, Fungicide, and Rodenticide Act	Endangered species protection program	EPA
	Labeling requirements	
	Registration	
Surface Mining Control and Reclamation Act	Mine reclamation	US Department of the Interior (USDI)
	Surface mining control	
Toxic Substances Control Act	Polychlorinated Biphenyls (PCB) Program	EPA
Soil and Water Resources Conservation Act	Conservation Effects Assessment Program	USDA
Arkansas Wilderness Act	National forests	USDA Forest Service
National Forest Management Act		
Weeks Act		
Oil Pollution Act	Oil spill response planning	EPA
Pollution Prevention Act	Pollution prevention planning	EPA
National Environmental Policy Act	Environmental impact analysis of Federal projects, with mitigation	EPA, Council on Environmental Quality

Note: Highlighted laws and programs were promulgated after the 1990 AWP update.

federal water quality programs. Legislation related to forest conservation, such as the Cooperative Forestry Assistance Act, is included here because forests can protect and improve water quality. The EPA is responsible for administering the majority of these laws and programs; however, EPA has delegated some of this authority to state agencies such as ADEQ and the Arkansas Department of Health.

The CWA of 1972 established the NPDES that regulates point source discharges through a permit program. The NPDES program is managed by EPA, but ADEQ has been delegated authority to issue NPDES permits. NPDES permits are based on a combination of technology-based and water quality based standards. Technology-based standards are developed by EPA for certain industry categories based on the performance of pollution control technologies available to the industry without regard for the receiving water body. Water quality based standards are developed after consideration of the designated uses of the receiving water body and the water quality criteria necessary to protect those uses. In 1987, Congress amended the CWA to include nonpoint sources of pollution such as stormwater runoff from industries, construction sites, and municipalities. NPDES permits for the WAWRPR are summarized in Section 4. The 1987 amendments also addressed management of biosolids (sewage sludge). The CWA also requires permits for dredge and fill activities in wetlands, lakes, streams, rivers, and other waters of the US. These permits are issued by the USACE.

The TMDL program was established by the CWA in 1972; however, TMDLs were rarely developed for waterbodies until the 1990s, after environmental groups began suing the EPA over the lack of TMDLs being performed (EPA 2008). The CWA requires that a TMDL study be conducted for waterbodies identified as having impaired water quality. The TMDL study is conducted to determine the maximum amount of a pollutant that a waterbody can receive and still meet ambient water quality standards. This maximum load is split between point sources and nonpoint sources. These loads are then compared to the estimated existing point source and nonpoint source loads to determine the amount of reduction required for the waterbody to meet its water quality standards. The first TMDLs for waterbodies in the WAWRPR were completed in 2000. Prior to this, beginning in the 1980s, ADEQ routinely performed Wasteload Allocation Studies as part of the NPDES permitting process to determine the amount of a pollutant that could be discharged to a waterbody. Since 2000, 15 TMDLs have been completed for waterbodies in the WAWRPR (see Section 5).

In 1998, EPA initiated a program to develop ambient water quality criteria for nutrients, i.e., nitrogen and phosphorus. At the time, nutrients were identified as a leading cause of water quality issues across the nation, including such high profile events as the hypoxic zone in the Gulf of Mexico and algal blooms along the national seacoast. In 2001, EPA published recommended nutrient criteria development plans (EPA 2013c).

The drinking water source water protection program was initiated as a result of the 1996 amendment to the SWDA. The purpose of this program is to prevent the need for increased treatment of drinking water (resulting in increased treatment costs and costs to customers) due to water quality degradation, by protecting the quality of the drinking water source. In the majority of cases, the cost of protecting drinking water sources from pollution is far lower than the cost of upgrading water treatment to remove increased pollution. There are approximately 90 public water utilities in the WAWRPR that are subject to SDWA regulations (ADH n.d.).

Subtitle D of the 1991 amendment of the Resource Conservation and Recovery Act (RCRA) introduced specifications for how landfills were to be constructed and managed to protect water quality. This led to sweeping changes in solid waste management across the country and in Arkansas (ADEQ 2011).

6.1.1.2 Water Resources Management

The federal regulations and programs that address non-water quality aspects of water resources management are summarized in Table 6.2. These include regulations and programs that address flood control, river navigation, wetlands tracking, or water-based recreation. Programs related to drinking water infrastructure are also included in Table 6.2 and discussed below. The dredge and fill permitting program of the CWA both protects water quality and preserves the extent and physical quality of aquatic habitats. Federally appropriated water, such as the water required to maintain navigation on MKARNS, is not available for other uses. Federal water appropriations preempt other beneficial water uses, such as irrigation.

Table 6.2. Federal laws and regulatory programs that address aspects of WAWRPR water resources other than water quality.

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Clean Water Act	Wetland and stream mitigation	USACE	Physical protection of waterbodies, including wetlands
Safe Drinking Water Act	Consumer confidence reports	EPA	Protects/improves public water supply
	Finished water criteria		Protects human health
	Operator certification		Informs the public
Endangered Species Act	Freshwater species protection	USFWS	Mechanism for physical protection of waterbodies that are habitats for endangered species
	Waterfowl protection		
Soil and Water Resources Conservation Act	Census of Agriculture	USDA	Irrigation and agriculture
	Conservation Effects Assessment Program		Water resources protection/improvement
	Natural Resources Inventory		Characterize water resources
National Environmental Policy Act	Environmental Impact Statements and Mitigation	EPA, Council on Environmental Quality	Water resources protection/mitigation
Flood Control Act/Water Resources Development Act	Dam safety	USACE	Water storage, water supply, flood reduction, flow management, restoration of physical aquatic habitat
	Flood control reservoirs		
	Levees		
	Navigation systems		
Arkansas Wilderness Act	National forests	USDA Forest Service	Well managed forestlands improve and protect water resources
National Forest Management Act			
Weeks Act			
Rivers and Harbors Act	Navigation	USACE	Federal navigation systems in Arkansas
	Section 10	USACE	Protects waterbodies, including wetlands
Migratory Bird Hunting and Conservation Stamp Act	Small wetland acquisition program	USFWS	Protects wetlands
Emergency Wetlands Resources Act	National Wetlands Inventory	USFWS	Track wetland resources
Dam Safety and Security Act	National Dam Safety Program	Federal Emergency Management Agency (FEMA)	Protection of lives and property

Table 6.2. Federal laws and regulatory programs that address aspects of WAWRPR water resources other than water quality (continued).

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
National Parks Acts	National Parks	USDI National Park Service	Protection of water resources associated with national parks
Migratory Bird Conservation Act	Acquisition of lands for wildlife refuges	Migratory Bird Conservation Commission	Preservation of water resources for bird habitat
National Wildlife Refuge System Improvement Act	National Wildlife Refuges	USFWS	Preservation of water resources for habitat
Pittman-Robertson Wildlife Restoration Act	Wildlife and sport fish restoration	USFWS	Preservation of water resources for fish and wildlife habitat
National Flood Insurance Act	National Flood Insurance Program	FEMA	Insurance against flood losses
	Floodplain management		Reduction of flood damage
	Flood hazard mapping		Identification of flood hazard areas
None	Climate monitoring	NOAA	Tracking precipitation and evaporation – water availability
	Climate prediction		Future water availability
	Drought status		Enactment of water shortage specific management

Note: Highlighted programs were initiated after the 1990 AWP update

An important federal program for mitigating impacts to wetlands and streams is part of the dredge and fill permitting program of the CWA (Section 404), overseen by the USACE. This mitigation program was initiated in 1990, when the EPA and the USACE signed a memorandum of agreement establishing a process for determining the need for mitigation of impacts to wetlands, streams, and other water resources under the CWA Dredge and Fill Permitting program. This program provides a means for dredge and fill permit applicants to compensate for unavoidable destruction of aquatic habitat by either restoring or creating similar habitat either on site or at another location (EPA 2013d). The program is a mechanism for implementing the federal policy of no-net-loss of wetlands. Revised regulations governing this mitigation program were issued in 2008. Located in the WAWRPR is the privately managed 2,064 acre Cadron

Creek Mitigation Bank and the 160-acre Hartman Bottoms Wetland Mitigation Bank created by the AHTD (NRI Group 2010, Federal Highway Administration n.d., USACE 2013, AHTD 2001).

The Endangered Species Act provides for protection and recovery of imperiled terrestrial, freshwater, and marine plant and animal species (except pest insects) (USFWS 2013)

The 1996 amendments to the SDWA directed EPA and the states to develop requirements for certification of water treatment system operators (EPA 2012e). These amendments also initiated a program that required public water suppliers that operate community water systems to provide annual reports to drinking water utility customers on the quality of their drinking water.

Under the National Flood Insurance Act, flood hazard maps have been completed for much of the WAWRPR, and most of the mapping has been modernized within the last 8 years, with the exception of Perry and Scott Counties (Figure 6.1). Flood hazard maps for Perry County range from 13 to 15 years old. In Scott County, the unincorporated areas have never been mapped, but the Town of Mansfield and City of Waldron have maps that range from 3 to 33 years old. Modernized flood hazard maps typically include updated Special Flood Hazard Areas (SFHAs), and are created in a digital countywide format. For the communities participating in the National Flood Insurance Program (NFIP), the flood hazard maps identify the regulatory SFHA whereby the community floodplain administrator applies the locally adopted and enforced floodplain management ordinance. Participation in the NFIP is voluntary; however non-participation results in federal flood insurance not being available to residents and limits post-disaster financial assistance. The NFIP provides some water quality protection through reducing changes in hydrology by restricting development in the floodplain. All of the counties except Scott County in the planning region participate in the NFIP, as well as around 75 individual communities (FEMA 2013).

The Flood Control Act provided the authority for construction of federal flood control projects, constructed and maintained by the US Army Corps of Engineers. The Water Resources Development Act (WRDA) has superseded the Flood Control Act in 1974.

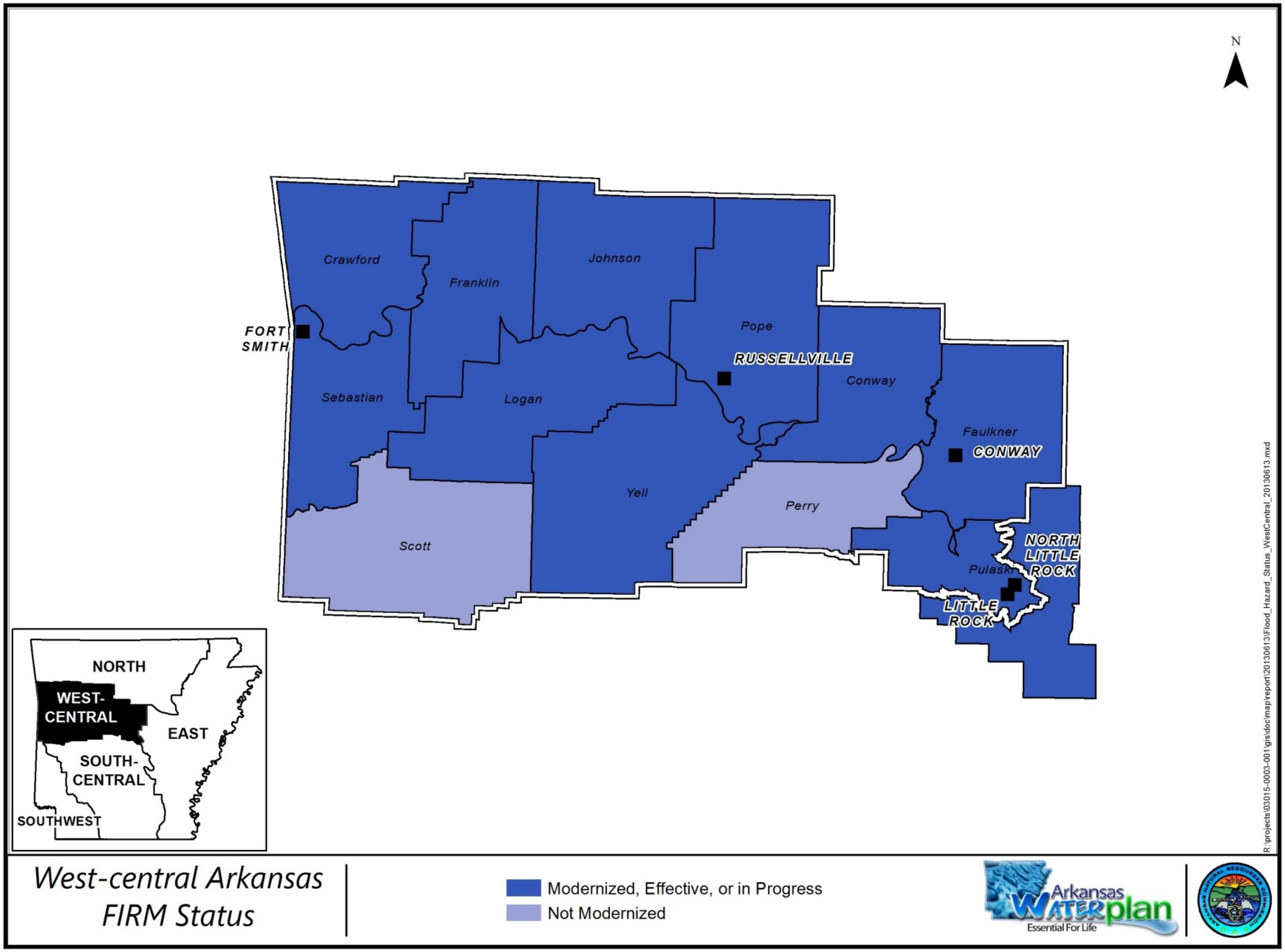

Figure 6.1 Flood hazard map status.

Surface waters in the WAWRPR that are under some degree of federal management include the Arkansas River (MKARNS and Holla Bend NWR), Petit Jean River (Blue Mountain Lake and the Ouachita National Forest), Fourche La Fave River (Nimrod Lake), Mulberry River (Ozark National Forest), Lee Creek (Ozark National Forest), and Poteau River (Ouachita National Forest). Streams considered navigable in the Little Rock District of the USACE include, in addition to the previous list, Illinois Bayou in Pope County, Lee Creek in Crawford County, and the Little Maumelle River in Pulaski County (USACE Little Rock District 2004)

MKARNS was a federal flood control project. In addition, reservoirs were constructed by the USACE in the region in the 1940s as part of a comprehensive plan for flood control and development of water resources in the Lower Arkansas River Valley. These included Blue Mountain Lake on the Petit Jean River, and Nimrod Lake on the Fourche La Fave River (Lancaster 2011a, 2011b). The Holla Bend NWR is located on a bend of the Arkansas River that was cut off during river straightening by the USACE for flood control. The Holla Bend NWR provides a winter home for some of the millions of ducks and geese that use the Mississippi Flyway annually. Federally authorized uses for the portions of the Arkansas River in this planning region include navigation and flood control. However, the Arkansas River is also authorized for hydropower, and provides a variety of additional benefits including water supply, fish and wildlife conservation and recreation.

Federally appropriated water, such as the water required to maintain navigation on MKARNS, is not available for other uses. Federal water requirements preempt other beneficial water uses. The Arkansas River minimum flow at Little Rock (Murray Lock and Dam 7) required for navigation is 3,000 cubic feet per second (cfs).

6.1.2 Federal Laws and Assistance Programs

Federal laws have also established a number of programs to provide technical and financial assistance for water resources management, that are available in Arkansas. Assistance programs for management of water quality and other aspects of water resources are discussed in the following sections.

6.1.2.1 Water Quality

Table 6.3 summarizes current federal assistance programs available in the WAWRPR and the associated federal laws. The majority of the federal assistance programs listed originated through the Farm Bill. The Farm Bill has been amended four times since 1990, most recently in 2013 (National Agricultural Law Center 2012). New conservation programs that are intended to assist farmers in protecting and restoring water quality have been added with each amendment. In 2012, nearly $9 million in funding was provided for water quality practices from Farm Bill programs on over 60,000 acres. Due to the extreme drought that occurred from 2010 through 2012 over 33,000 of the acreage in the conservation programs were in drought specific programs (Table 6.4) (NRCS 2012).

Table 6.3 Federal water quality assistance programs available in the WAWRPR.

Federal Law	Federal Water Quality Funding Assistance Programs	Responsible Federal Agency
CWA	Clean water state revolving fund	EPA
	Nonpoint source pollution management grants	
	Water pollution control program grants	
Comprehensive Environmental Response, Compensation, and Liability Act	Hazardous waste site clean up	EPA
Cooperative Forestry Assistance Act	Forest Stewardship Program	USDA Forest Service
	Forest Legacy Program	
	Urban and Community Forestry Program	
Housing and Community Development Act	Community development block grants programs	US Department Housing and Urban Development (HUD)
Consolidated Farm and Rural Development Act	Water and waste disposal systems for rural communities	USDA Rural Utilities Service
	Water and Waste Disposal Loans and Grants	
	Solid Waste Management Grants	
	Grant Program to Establish a Fund for Financing Water and Wastewater Projects	

Table 6.3 Federal water quality assistance programs available in the WAWRPR (continued).

Federal Law	Federal Water Quality Funding Assistance Programs	Responsible Federal Agency
Farm Bill	Agricultural Water Enhancement Program	USDA Natural Resources Conservation Service (NRCS)
	Conservation Reserve Program (CRP)	USDA Farm Services Agency
	Conservation Innovation Grants Program	NRCS
	Conservation Stewardship Program (CSP)	
	Cooperative Conservation Partnership Initiative	
	Environmental Quality Incentives Program (EQIP)	
	Farm and Ranch Land Protection Program	
	Grassland Reserve Program	
	Grazing Lands Conservation Initiative	
	Mississippi River Basin Healthy Watersheds Initiative	
	National Water Management Center	
	National Water Quality Initiative	
	Organic Initiative	
	Plant Materials Program	
	Watershed protection and flood prevention	
	Wetlands Reserve Program	
	Wildlife Habitat Incentives Program	
American Recovery and Reinvestment Act	Clean water state revolving fund, Clean up of leaking underground storage tanks	Recovery Accountability and Transparency Board
Clean Vessel Act	Funding for pumpout stations and waste reception facilities for recreational boaters	USFWS

Note: Highlighted laws and programs were promulgated after the 1990 AWP update.

A component of the NRCS conservation activities provided for in the Farm Bill is the Plant Materials Program, which hosts a regional Plant Material Center in the WAWRPR, the Arkansas Plant Materials Center (ARPMC). The ARPMC is operated by the NRCS on the Dale Bumpers Small Farm Research Center in Booneville. The ARPMC develops plants and plant science that focuses on the protection and enhancement of water quality through conservation methods specific to the Ozarks and areas into Oklahoma (NRCS Plant Materials Program n.d.).

Table 6.4. NRCS conservation programs summary for 2012 (NRCS 2012).

County	CRP			Drought / EQIP			EQIP (All initiatives and Funding Categories			Drought / Wildlife Habitat Incentive Program			Wetlands Reserve Program		
	Contracts	acres	$ obligated	Contracts	acres	$ obligated	Contracts	acres	$ obligated	Contracts	acres	$ obligated	Contracts	acres	$ obligated
Conway	0	0	0	43	3836.7	$ 824,420	81	13126	$ 2,175,446	1	25	$ 1,251	1	99.14	$ 90,764
Crawford	0	0	0	0	0	$ -	6	1009.2	$ 116,754	4	824	$ 65,293	1	132.5	$ 230,000
Faulkner	0	0	0	48	3886	$ 1,035,232	56	4824.3	$ 1,234,784	7	279.1	$ 31,155	0	0	$ -
Franklin	0	0	0	0	0	$ -	9	700	$ 99,352	0	0	$ -	0	0	$ -
Johnson	0	0	0	0	0	$ -	23	1295	$ 236,784	0	0	$ -	0	0	$ -
Logan	0	0	0	0	0	$ -	16	447.4	$ 240,889	2	482	$ 35,642	0	0	$ -
Perry	1	814.3	$ 17,539	23	2165.3	$ 563,777	30	2901.3	$ 702,037	1	20	$ 4,316	0	0	$ -
Pope	0	0	0	42	4416.5	$ 560,293	79	9263.1	$ 1,415,746	13	1774.7	$ 192,803	0	0	$ -
Pulaski*	0	0	0	0	0	$ -	4	12.7	$ 33,604	1	28	$ 6,772	0	0	$ -
Scott	0	0	0	0	0	$ -	3	259.8	$ 119,659	0	0	$ -	0	0	$ -
Sebastian	0	0	0	0	0	$ -	8	1186.7	$ 125,938	5	879	$ 74,314	0	0	$ -
Yell	0	0	0	47	12001.2	$ 887,795	80	16563.8	$ 1,561,522	7	3273.1	$ 174,535	0	0	$ -
Total	1	814.3	$ 17,539	203	26305.7	$ 3,871,517	395	51589.3	$ 8,062,515	41	7584.9	$ 586,081	2	231.64	$ 320,764

* A portion of this county is located in another planning region

The CWA authorizes EPA to provide federal funding assistance to states and local entities through three funding programs. Through the Clean Water State Revolving Fund, federal funds are provided to ANRC to fund a low interest loan program for wastewater treatment, nonpoint source pollution control, and watershed management projects in the state. Grants for nonpoint source pollution control projects are authorized under Section 319 of the CWA. Finally, Section 106 of the CWA authorizes federal funding assistance to states and interstate agencies through grants for pollution control programs such as discharge permitting and water quality monitoring.

The American Recovery and Reinvestment Act (ARRA) was promulgated in 2009 to save and create jobs during the recession that began in 2008. This act initiated several programs that provide money to states for a range of activities, including improvements to wastewater treatment infrastructure and cleanup of contaminated leaking underground storage tanks (EPA 2013e). Over $25 billion of recovery money was awarded to the Arkansas State Clean Water Developing Loan Fund. ARRA funds were also awarded to two leaking underground storage tank cleanup projects in Crawford County (EPA n.d.). Another ARRA project in the planning region that could be considered a water quality project is the wetland restoration at the Presidential Park in Little Rock (State of Arkansas 2009).

The Clean Vessel Act was promulgated in 1992. This act established a program to provide grants to states to pay for construction, maintenance, operation, or renovation of boat pumpout stations and waste reception facilities (US Congress 1992, ADH 2011). In June 2013 USFWS announced that the Arkansas Department of Health was awarded $1.5 million for construction, purchases, renovations, and the operation and maintenance of pump-out facilities, docks and stations, and assistance in sewage hauling. They will also continue their campaign to increase awareness, understanding and compliance with the goals of the Clean Vessel Act program in its state (Heartland Boating 2013).

Forestry assistance programs are included in Table 6.3 because forest improvement can improve water quality.

6.1.2.2 Water Resources Management

The federal assistance programs that address non-water quality aspects of water resources management are summarized in Table 6.5. These include programs that address flood control, water conservation, water supply systems, fisheries, and aquatic habitat for wildlife. Some of the programs that provide assistance for addressing water quality also address other aspects of water resources management. For example, some Farm Bill programs support practices that conserve water, as well as practices that protect water quality. As a result, there is some duplication in Tables 6.3 and 6.5.

Table 6.5 Federal assistance programs for aspects of WAWRPR water resources other than water quality.

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Safe Drinking Water Act	Drinking water state revolving fund	EPA	Protects human health
Farm Bill	Agricultural Water Enhancement Program	NRCS	Water conservation
	Cooperative Conservation Partnership Initiative	NRCS	Water conservation
	Conservation Innovation Grants Program	NRCS	Water conservation
	Emergency Watershed Protection	NRCS	Flooding reduction, recovery
	Groundwater Decline Initiative	NRCS	Water Conservation
	National Water Management Center	NRCS	Waterbody protection/restoration
	On-farm Energy Initiative	NRCS	Water conservation
	Plant Management Center	NRCS	Watershed management, native plant management
	Watershed protection and flood prevention	NRCS	Flooding management
	Wetlands Reserve Program	NRCS	Physical waterbody protection/restoration
	Wildlife Habitat Incentives Program	NRCS	Physical waterbody protection/restoration
Cooperative Forestry Assistance Act	Urban and Community Forestry Program	USDA Forest Service	Trees in communities reduce stormwater runoff, improving hydrology
	Forest Stewardship Program	USDA Forest Service	Well-managed forestlands improve and protect water resources
	Forest Legacy Program		

Table 6.5. Federal assistance programs for aspects of WAWRPR water resources other than water quality (continued).

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Flood Control Act/Water Resources Development Act	Habitat restoration	USACE	Water storage, water supply, flood reduction, flow management, restoration of physical aquatic habitat
	Flood control and water supply projects		
Housing and Community Development Act	Community development block grants programs	HUD	Protects/improves public water supply
American Recovery and Reinvestment Act	Funding for drinking water state revolving fund	Recovery Accountability and Transparency Board	Protects/improves public water supply
Consolidated Farm and Rural Development Act	Water and waste disposal systems for rural communities	USDA Rural Development	Protects/improves public water supply
	Water and waste disposal loans and grants		
	Household water well system grant program		
	Grant program to establish a fund for financing water and wastewater projects		
	Emergency community water assistance grants		
Land and Water Conservation Fund Act	Matching grants for acquisition and development of public recreation areas and facilities	USDI National Park Service	Preservation of water resources for recreation
Pittman-Robertson Wildlife Restoration Act	Wildlife restoration grant programs	USFWS	Preservation of water resources for fish and wildlife habitat
Sport Fish Restoration Act	Boating infrastructure grants	USFWS	Recreational boating and fishing
	Multistate conservation grants	USFWS	Aquatic habitat research and education
	Sports fish restoration grants	USFWS	Preservation of water resources for fish and wildlife habitat

Note: Highlighted laws and programs were initiated after the 1990 AWP update.

The 1996 amendment of the SDWA established the Drinking Water State Revolving Fund to assist drinking water utilities in financing infrastructure improvements. Using this fund, states can offer utilities low-cost loans and other types of assistance. In the WAWRPR, ARRA funds awarded to the Arkansas Drinking Water State Revolving Fund were awarded to Central Arkansas Water in Little Rock, and Franklin and Sebastian Counties, to maintain compliance with the SDWA (State of Arkansas 2009).

Farm Bill amendments and associated assistance programs were discussed previously in Section 6.1.2. Farm Bill programs address water conservation, flood control, and conservation and restoration of aquatic habitat.

Several water resources projects have been authorized in Arkansas since 1990 under WRDA. Projects located in the WAWRPR that have been authorized through WRDA are described in Table 6.6.

Table 6.6. WRDA projects in WAWRPR initiated after 1990.

Project Name	Location	Description	Authority	Status
Rehabilitation of Federal Flood Control Levees	Arkansas River	Rehabilitation and reconstruction of Federal flood control levees including repairs of deficiencies and replacement of deteriorated drainage structures and appurtenances (fiscal years 1992 – 1996)	WRDA 1990	Unknown[1]
Flood damage reduction, May Branch, Fort Smith	May Branch, Fort Smith	The project for flood damage reduction, May Branch, Fort Smith, Arkansas.	WRDA 2007	Unknown[2]
Pine Mountain Dam, Arkansas	Lee Creek, Crawford County	Construction of Pine Mountain Dam on Lee Creek, Arkansas for water supply and flood control	WRDA 2007	Suspended in 2010[3,4]

[1] http://www.fws.gov/habitatconservation/omnibus/wrda1990.pdf
[2] http://www.gpo.gov/fdsys/pkg/PLAW-110publ114/pdf/PLAW-110publ114.pdf
[3] http://www.gpo.gov/fdsys/pkg/PLAW-110publ114/pdf/PLAW-110publ114.pdf and [4] http://www.thecitywire.com/node/11537#.UoUpKJ3nbcs
(Inquiry on this information sent to USACE on 1/10/14; info may be updated at a later time)

6.1.3 State Laws and Regulations

State water use law is based on a policy where riparian land owners, i.e., persons owning land that abuts a waterbody, have the right to reasonable use of the water within that waterbody. The reasonable use policy means that all landowners along a stream have the right to free and unrestricted use of the stream flow, provided that their use does not negatively affect the availability of water for other riparian users. Similarly, landowners have the right to reasonable use of groundwater under their property, as long as that use does not adversely affect the ability of other landowners to use the groundwater. In addition to water rights related to water withdrawals and consumptive use, Arkansas regulations address water rights related to public recreational uses of surface water such as boating and fishing (ANRC 2011a).

6.1.3.1 Water Use Regulations

In Arkansas, at the state level, regulations and programs authorized by the General Assembly that are related to water use are generally administered by ANRC. In addition, the Arkansas Water Well Construction Commission promulgates rules for construction of water supply wells, and the Arkansas Public Services Commission regulates private water utility fees. State incentive programs for water conservation, as well as funding for water resources development projects, have also been legislated. Table 6.7 summarizes selected Arkansas water use regulations that apply in the WAWRPR.

Table 6.7. State regulations related to water use.

State Water Use Regulations	Subjects Addressed by Regulations	Related State Legislation
Title 3: Rules for the Utilization of Surface Water[1]	Registration of surface water withdrawals	Arkansas Code §15-22-215
	Minimum streamflows	Arkansas Code §15-22-222
	Surface water transfers to non-riparian users	Arkansas Code §15-22-304
	Regulation of dam construction	Arkansas Code §15-22-210 - 214
	Allocation during periods of water shortage	Arkansas Code §15-22-217
Title 4: Rules for the Protection and Management of Groundwater[1]	Registration of groundwater withdrawals	Arkansas Code §15-22-302
	Groundwater protection program	Arkansas Groundwater Protection and Management Act (Arkansas Code §15-22-901 et seq.)
Arkansas Water Well Construction Commission Rules and Regulations[2]	Licensing of water well contractors Construction requirements Well reporting requirements	Arkansas Code §17-50-201 et seq.
Affiliate Transaction Rules[3]	Requirements for utility rates	Arkansas Code §23-2-101 et seq.

Table 6.7. State regulations related to water use (continued).

State Water Use Regulations	Subjects Addressed by Regulations	Related State Legislation
General Service Rules[3]	Standards of service for utilities	
Special Rules Water[3]	Standards of service for water utilities	

1 Enforcement by ANRC
2 Enforcement by Arkansas Water Well Construction Commission
3 Enforcement by Arkansas Public Service Commission
Note: Highlighted legislation was promulgated after the 1990 AWP update

State law requires ANRC to "establish and enforce minimum stream flows for the protection of instream water needs" (Arkansas Code § 15-22-222). Minimum streamflow is defined by Arkansas Code §15-22-202(6) as "…the quantity of water required to meet the largest of [specified] instream flow needs as determined on a case-by-case basis." The needs to be met that are specified in the statute are interstate compacts, navigation, fish and wildlife, water quality, and aquifer recharge. This definition is used to set minimum streamflows by rulemaking under Arkansas Code §15-22-222. Where no minimum flow is set by rule, these factors are used to make a case-by-case determination of minimum flow. ANRC has adopted minimum streamflow by rule for the main stem of the Arkansas River (1990).

The minimum streamflow, set by rule or determined on a case-by-case basis, represents the trigger point for a "shortage" requiring allocation of water use. Because of the critical low flow conditions which may exist at the minimum streamflow level, the 1990 AWP recommended taking steps to reduce water withdrawals before water levels drop to minimum streamflow levels. The ANRC may allocate water among uses during a shortage.

Prior to adoption of Act 593 of 2013, minimum streamflows were classified as a "reserved" use when allocating water during a shortage, along with drinking water use and federal water rights. The legislation removed this reserved status and demoted minimum streamflows to a position below agriculture and industry in the allocation hierarchy, and ahead of hydropower and recreation. The intent was to ensure that agricultural and industrial surface water use is not curtailed during a shortage in an effort to protect instream flow needs (interstate compacts, navigation, fish and wildlife, water quality, and aquifer recharge). This change, especially as it applies a state law limitation on federal interests in navigation, interstate compacts and water quality, including wastewater discharge permits for sewer systems and industries, has not been tested.

In 1985, the Arkansas General Assembly adopted a departure from traditional riparian law by allowing transfer of water for use on non-riparian land. Prior to determining how much water is available to transfer, ANRC must first calculate the amount of water that must remain in the stream. The amount of water that must remain in the stream must be enough to cover: (1) existing riparian water rights as of June 28, 1985; (2) water needs of federal water projects as they existed on June 28, 1985; (3) firm yield of all reservoirs in existence on June 28, 1985; (4) maintenance of instream flows for fish and wildlife, water quality, aquifer recharge requirements, and navigation; and (5) future water needs of the basin of origin as projected in the AWP. The General Assembly limited the amount of excess surface water that may be permitted for non-riparian transfer to 25% of the average annual yield from the watershed after the greatest of the instream needs listed above is met.

Minimum streamflow is often mistakenly equated with fish and wildlife flow requirements. Fish and wildlife flows are one of the five elements of minimum streamflow, which also includes interstate compacts, navigation, water quality, and aquifer recharge. Two different methods are used to calculate fish and wildlife flows for different situations. For case-by-case determinations of minimum flow for use in characterizing shortage and allocating water during a shortage, fish and wildlife flow requirements are estimated using a modified Tennant Method (ASWCC 1988). To calculate fish and wildlife flow requirements when determining the amount of excess water available for transfer to nonriparian users, the “Arkansas Method” (Filipek, Keith and Giese 1987) is used.

Arkansas water law requires that major users of either surface or ground water register with the state, and report the amount of water they use annually. Major water users are those that divert more than one acre-foot of water in a year, or use water from non-household wells with a capacity greater than 50,000 gallons annually.

In 1991, the Arkansas Ground Water Protection and Management Act was signed into law (Arkansas Code §15-22-915), providing ANRC with authority to designate critical groundwater areas, of which none are currently located in the WAWRPR. This law also mandated that ANRC evaluate the condition of the state's aquifers on a biennial basis, and make recommendations concerning safe yield and the designation of critical groundwater areas (ANRC 2011a). ANRC publishes annual reports on the condition of the state's groundwater resources, including recommendations concerning aquifer safe yield and designation of critical groundwater areas.

6.1.3.2 Water Quality Regulations

Water quality regulations are promulgated by the General Assembly, the Arkansas Pollution Control and Ecology Commission (APCEC), the State Board of Health, and ANRC. State regulations and laws, along with associated federal laws that address water quality, are identified in Table 6.8 below.

.

Table 6.8. State regulations that protect water quality in the WAWRPR.

State Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Regulation 1: Prevention of Pollution by Salt Water and Other Oil Field Wastes Produced by Wells in All Fields or Pools[1]	Environmental protection during oil drilling	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 2: Water Quality Standards for Surface Waters of the State of Arkansas[1]	Water quality standards (designated uses and numeric criteria)	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 3: Licensing of Wastewater Treatment Operators[1]	Licensing program for wastewater treatment operators	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 4: Disposal Permits for Real Estate Subdivisions in Proximity to Lakes and Streams[1]	State wastewater permit	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 5: Liquid Animal Waste Systems[1]	State wastewater permit	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act

Table 6.8. State regulations that protect water quality in the WAWRPR (continued).

State Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Regulation 6: Regulations for State Administration of the NPDES Program[1]	Federal wastewater permits (NPDES)	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 15: Open-Cut Mining and Land Reclamation Code[1]	Environmental protection during non-coal mining activities, restoration of non-coal mining sites	Arkansas Open Cut Land Reclamation Act (Arkansas Code §15-57-301 et seq.) Arkansas Quarry Operation, Reclamation, and Safe Closure Act (Arkansas Code §15-57-401 et seq.)	None
Regulation 17: Underground Injection Control Code[1]	Underground injection of wastewater	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Safe Drinking Water Act
Regulation 20: Surface Coal Mining and Reclamation Code[1]	Environmental protection during coal mining activities, restoration of coal mining sites	Arkansas Surface Coal Mining and Reclamation Act (Arkansas Code § 15-58-101 et seq.)	Surface Mining Control and Reclamation Act
Regulation 22: Solid Waste Management[1]	Landfill construction specifications, acceptable materials for landfill disposal, regional solid waste management districts, pollution prevention	Arkansas Solid Waste Management Act (Arkansas Code § 8-6-201 et seq.), Arkansas Pollution Prevention Act (Arkansas Code § 8-10-201 et seq.)	Resource Conservation and Recovery Act, Pollution Prevention Act
Regulation 23: Hazardous Waste Management[1]	Hazardous waste management, pollution prevention	Arkansas Hazardous Waste Act (Arkansas Code § 8-7-201 et seq.), Arkansas Hazardous Materials Transportation Act (Arkansas Code § 27-2-101 et seq.), Arkansas Pollution Prevention Act (Arkansas Code § 8-10-201 et seq.)	Resource Conservation and Recovery Act, Pollution Prevention Act

Table 6.8. State regulations that protect water quality in the WAWRPR (continued).

State Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Regulation 27: Licensing of Landfill Operators and Illegal Dumps Control Officers[1]	Licensing of landfill operators, licensing of illegal dumps control officers	Arkansas Code § 8-6-901 et seq., Illegal Dump Eradication and Corrective Action Program Act (Arkansas Code § 8-6-501 et seq.)	Resource Conservation and Recovery Act
Regulation 29: Brownfields Redevelopment[1]	Clean-up and redevelopment of contaminated sites, clean-up funding	Arkansas Hazardous Waste Act (Arkansas Code § 8-7-201 et seq.), Remedial Action Trust Fund Act, Arkansas Voluntary Clean-up Act (Arkansas Code § 8-7-1101 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Regulation 32: Environmental Professional Certification[1]	Certification program for professionals involved in clean-up of contaminated sites	Phase I Environmental Site Assessment Consultant Act (Arkansas Code § 8-7-1301 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Regulation 34: State water permit regulation[1]	Regulation of systems with the potential to pollute water resources, that are not otherwise regulated	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Rules and regulations pertaining to general sanitation[3]	Groundwater pollution, surface water pollution, sewage treatment	Arkansas Sewage Disposal Systems Act (Arkansas Code § 14-236-101 et seq.)	Clean Water Act
Rules and regulations pertaining to public water systems[3]	Safety of drinking water supplied by public water systems	Arkansas Code § 20-7-101 et seq.	Safe Drinking Water Act
Rules and regulations pertaining to semi-public water systems[3]	Safety of drinking water supplied by semi-public water systems	Arkansas Code § 20-7-101 et seq.	Safe Drinking Water Act
Rules and regulations pertaining to water operator licensing[3]	Licensing for drinking water treatment systems	Arkansas Code § 17-51-101 et seq.	Safe Drinking Water Act

Table 6.8. State regulations that protect water quality in the WAWRPR (continued).

State Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Rules and regulations pertaining to onsite wastewater systems, designated representative, and installers[3]	Permitting of onsite wastewater treatment systems (septic systems), licensing of designated representatives for onsite wastewater treatment systems, licensing of installers of onsite wastewater treatment systems	Arkansas Sewage Disposal Systems Act (Arkansas Code § 14-236-101 et seq.)	Clean Water Act
Rules and regulations pertaining to mobile home and recreational vehicle parks[3]	Water supply, wastewater disposal, solid waste management	Arkansas Code § 20-7-101 et seq.	Clean Water Act, Safe Drinking Water Act, Resource Conservation and Recovery Act
Arkansas regulations on pesticide classification[4]	Pesticide classification	Arkansas Pesticide Control Act (Arkansas Code § 2-16-401 et seq.), Arkansas Pesticide Use and Application Act (Arkansas Code § 20-20-201 et seq.)	Federal Insecticide, Fungicide, and Rodenticide Act
Arkansas regulations on pesticide applicator licensing[4]	Licensing of pesticide applicators	Arkansas Pesticide Use and Application Act (Arkansas Code § 20-20-201 et seq.)	Federal Insecticide, Fungicide, and Rodenticide Act
Arkansas Water Well Construction Commission Rules and Regulations	Specifications for construction of water wells to provide safe drinking water	Water Well Construction Act (Arkansas Code § 17-50-101 et seq.)	Safe Drinking Water Act
Rules and Regulations pertaining to outdoor bathing places[3]	Swim beach water quality	Arkansas Code § 20-7-101 et seq.	Clean Water Act
Marine sanitation[3]	Marine sanitation	Arkansas Code § 27-101-401 et seq.	Clean Vessel Act
Title 12: Rules Governing the Arkansas Wetlands Mitigation Bank Program[2]	Wetland mitigation banks	Arkansas Wetlands Mitigation Bank Act (Arkansas Code § 15-22-1001 et seq.)	Rivers and Harbors Act, Clean Water Act
Title 19: Rules Governing the Poultry Feeding Operations Registration Program[2]	Registration of poultry feeding operations	Arkansas Poultry Feeding Operations Registration Act (Arkansas Code § 15-20-901 et seq.)	Clean Water Act

Table 6.8. State regulations that protect water quality in the WAWRPR (continued).

State Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Title 20: Rules Governing the Arkansas Nutrient Management Planner Certification Program[2]	Training and certification of nutrient management planners	Arkansas Soil Nutrient Management Planner and Applicator Certification Act (Arkansas Code § 15-20-1001 et seq.)	Clean Water Act
Title 21: Rules Governing the Arkansas Nutrient Management Applicator Certification Program[2]	Training and certification of nutrient applicators	Arkansas Soil Nutrient Management Planner and Applicator Certification Act (Arkansas Code § 15-20-1001 et seq.)	Clean Water Act
Title 22: Rules Governing the Arkansas Soil Nutrient and Poultry Litter Application and Management Program[2]	Nutrient surplus areas, nutrient management plans, poultry litter management plans, poultry litter transport	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.), Arkansas Poultry Feeding Operations Registration Act (Arkansas Code § 15-20-901 et seq.), Arkansas Soil Nutrient Management Planner and Applicator Certification Act (Arkansas Code § 15-20-1001 et seq.), Arkansas Soil Nutrient Application and Poultry Litter Utilization Act (Arkansas Code § 15-20-1101 et seq.)	Clean Water Act

Note: Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update.
1 Responsible state agency is ADEQ
2 Responsible state agency is ANRC
3 Responsible state agency is Arkansas Department of Health
4 Responsible state agency is Arkansas State Plant Board

As illustrated in Table 6.8, there are several state regulations covering a range of activities that address water quality. The most basic of these are the regulations that set criteria for water quality of surface waters in the state. These regulations identify the uses that state waterbodies should support, and specify narrative and numeric criteria for surface water quality to ensure that the identified uses can be supported. In Arkansas, numeric water quality criteria for dissolved oxygen, turbidity, temperature, and minerals are ecoregion-based (APCEC 2011). Arkansas is in the process of developing numeric criteria for nutrients in surface water to meet federal requirements (ADEQ 2012c). State numeric water quality criteria for groundwater are in development.

A summary of designated uses assigned to surface waterbodies in the West-central Arkansas Planning Region under Regulation 2 is provided in Table 6.9. The Boston Mountains eco-region, Arkansas River Valley eco-region, and Ouachita Mountains eco-region numeric surface water quality criteria apply in the respective areas of the planning region. Numeric surface water quality criteria for the water bodies in the planning region are listed in Tables 6.10 through 6.12. Figure 6.2 shows the ADEQ Water Quality Planning Segments that are located in the planning region.

Table 6.9. State designated uses for waters in the WAWRPR (APCEC 2011).

Designated Use	Waterbodies
Extraordinary Resource Waters	Archey Creek, Big Piney Cree, Cadron Creek, East Fork Cadron Creek, East Fork Illinois Bayou, Falling Water Creek, Hurricane Creek, Illinois Bayou, Lee Creek, Middle Fork Illinois Bayou, Mulberry River, North Fork Illinois Bayou
Natural and Scenic Waterways	Mulberry River, Big Piney Creek, Hurricane Creek
Ecologically Sensitive Waterbodies	None
Primary Contact Recreation	all streams with watersheds of greater than 10 square miles and all lakes and reservoirs
Secondary Contact Recreation	All waters
Domestic, Industrial, and Agricultural Water Supply	All waters except a portion of the Poteau River and Unnamed tributary to Poteau River at Waldron
Fishery	All lakes and reservoirs
Seasonal Fishery	All waters with watersheds of less than 10 square miles
Perennial Fishery	All waters with watersheds greater than 10 square miles and discharge of at least 1 cfs

Table 6.10 Temperature and turbidity numeric criteria that apply in the WAWRPR (APCEC 2011).

Water body	Temperature (°C)	Turbidity base flow (NTU)	Turbidity all flows(NTU)
Boston Mountain Streams	31	10	19
Lakes & reservoirs	32	25	45
Arkansas River	32	50	52
Arkansas River Valley Streams	31	21	40
Dardanelle Reservoir	35	50	52
Ouachita Mountain streams	30	10	18

Table 6.11. Dissolved oxygen (DO) numeric water quality criteria that apply in the WAWRPR (APCEC 2011).

Water body	DO Primary* (mg/L)	DO Critical+ (mg/L)
Boston Mountain and Ouachita Mountain streams with watershed < 10 square mile	6	2
Boston Mountain and Ouachita Mountain streams with watershed > 10 square mile	6	6
Arkansas River Valley streams with watershed < 10 square mile	5	2
Arkansas River Valley streams with watersheds 10 to 150 square mile	5	3
Arkansas River Valley streams with watersheds 151 to 400 square mile	5	4
Arkansas River Valley streams with watersheds > 400 square mile	5	5
Lakes and reservoirs	5	N/A

* At water temperatures ≤10°C or during March, April and May when stream flows are 15 CFS and greater, the primary season D.O. standard will be 6.5 mg/l.

\+ When water temperatures exceed 22°C, the critical season D.O. standard may be depressed by 1 mg/l for no more than 8 hours during a 24-hour period.

Table 6.12 Numeric water quality criteria for minerals that apply in the WAWRPR (APCEC 2011).

Water body	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
Arkansas River Lock and Dam (L&D) #7 to L&D #10	250	100	500
Cadron Creek	20	20	100
Arkansas River L&D #10 to Oklahoma state line, including Dardanelle Reservoir	250	120	500
Poteau River from Business Highway 71 to state line	120	60	500
Unnamed tributary to Poteau River at Waldron	150	70	660
Boston Mountains Reference Streams	17.3	15	95.3
Arkansas River Valley Reference Streams	15	17.3	112.3
Ouachita Mountain Reference Streams	15	20	142

To protect surface water and groundwater quality, there are state regulations and laws that regulate discharge of wastewater, discharge of stormwater, underground storage tanks, underground injection of fluids, management of livestock, and disposal of solid waste. The state source water and wellhead protection programs address protection of the quality of surface waters and aquifers used as public drinking water supplies. There are 133 active public water supply utilities in the WAWRPR. Of the 133, 12 of these utilities use groundwater from their own wells are subject to the state wellhead protection program. Surface water is the most utilized water supply in the WAWRPR. There are 25 utilities identified as drawing surface water, 94 utilities are purchasing surface water, and 2 doing both for their customers. The utilities using surface water are subject to the state source water protection program (ADH n.d.). The Arkansas Marine Sanitation Act requires all vessels with marine sanitation devices to lock them to prevent direct sewage discharge, increasing the need for operational pumpout facilities.

In 2003, Acts 1059, 1060, and 1061 (Arkansas Code §15-20-901 et seq., §15-20-1001 et seq., §15-20-1101 et seq.) were enacted to encourage wise practices regarding application and management of soil nutrients and poultry litter to protect and enhance the state's surface water quality, while allowing for optimum soil fertility and proper plant growth in the designated nutrient rich watersheds of the State. Several watersheds have been declared nutrient surplus areas in northern and western Arkansas by the State Legislature (Arkansas Code §15-20-1104).

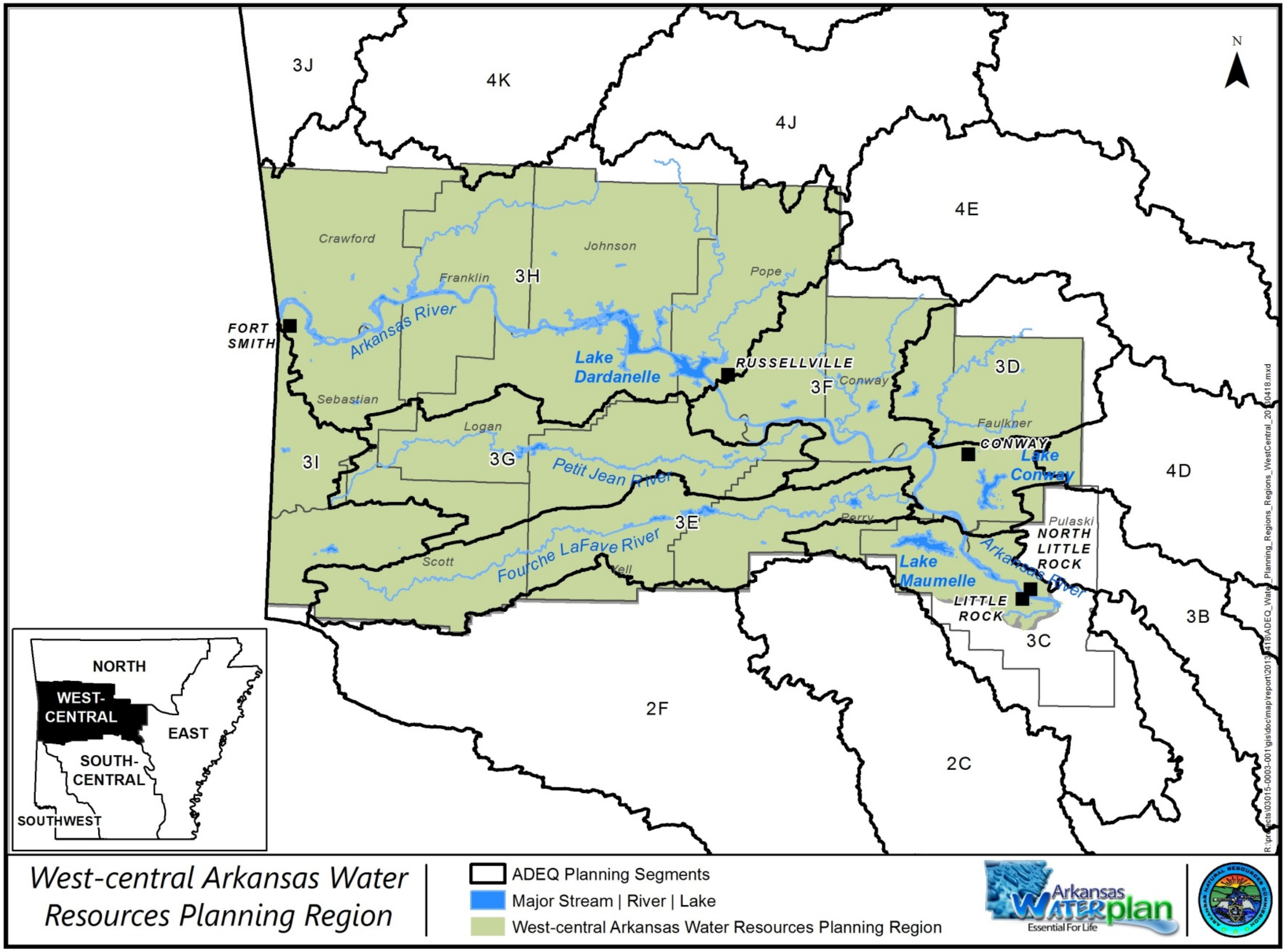

Figure 6.2 ADEQ Water Quality Planning Segments in WAWRPR.

Portions of Crawford County, Sebastian County, and Scott County are included in the designated nutrient surplus areas (Figure 5.8). Within the nutrient surplus areas, land application of any nutrient soil amendments is required to be done in accordance with time, manner, place, and rate restrictions outlined within state regulations. In addition, development of nutrient management plans is required (subject to approval by county conservation districts), all poultry feeding operations are required to develop litter management plans, and nutrient soil amendments are required to be applied by, or under the direction of, a certified nutrient applicator (ANRC 2010).

6.1.3.3 Floodplain Management

Arkansas Code provides that it is the policy of the state to encourage and support actions to prevent and lessen flood hazards and losses. The State has the authority to adopt measures that will discourage development in flood-prone land, assist in reducing damage caused by floods, and improve long-range land management in flood-prone areas (Arkansas Code §14-268-101 et seq.).

Arkansas statute also requires each county, city, or town that is participating in the NFIP to designate a “person to serve as the floodplain administrator to administer and implement the ordinance and any local codes and regulations relating the management of flood-prone areas” (Arkansas Code §14-268-106[a]). The designated floodplain administrator must also be accredited by the ANRC under the commission’s authority regarding flood control. State accreditation of floodplain administrators is regulated under ANRC Title 18 rules. Continuing education for the floodplain administrator is an especially important component of the State’s accreditation program (Arkansas Code §14-268-106, 15-24-102, and 15-24-109).

6.1.3.4 Water Management Regulations

Other state regulations and programs address additional aspects of water resources and their management. Table 6.13 summarizes these regulations, and the associated federal legislation.

Table 6.13 Additional state water resources regulations.

State Water Resources Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Title 6: Water plan compliance review procedures[1]	AWP	Arkansas Code § 15-22-503 and 504	None
Title 7: Rules governing design and operation of dams[1]	Dam safety	Arkansas Code § 15-22-201 et seq.	Water Resources Development Act/Dam Safety and Security Act
Title 12: Rules governing the Arkansas wetland mitigation bank program[1]	Wetland mitigation bank	Arkansas Wetlands Mitigation Act (Arkansas Code § 15-22-1001 et seq.)	Rivers and Harbors Act, Clean Water Act
Rules and regulations of the Arkansas Natural Heritage Commission[2]	Preservation of natural/wild and scenic rivers for recreation	Arkansas Natural and Scenic Rivers System Act (Arkansas Code § 15-23-301 et seq.)	Wild and Scenic Rivers Act
Arkansas Wildlife Resources Regulations[3]	Allowance for fish passage at dams.	Arkansas Code § 15-44-110	
	Screens required on surface water intakes to protect fish	Arkansas Code § 15-44-111	

1 Responsible state agency is ANRC
2 Responsible state agency is Arkansas Natural Heritage Commission
3 Responsible state agency is Arkansas Game and Fish Commission

The Arkansas Wetland Mitigation Banking Program (Arkansas Code §15-22-1002), authorized in 1995, is a state-sponsored initiative that promotes, in cooperation with federal, state, nonprofit, and other interested entities, the restoration, creation, enhancement, and conservation of aquatic resources, including wetlands, streams, and deep-water aquatic habitat. This legislation authorizes ANRC to operate wetland and stream mitigation banks and to sell mitigation "credits" to private, nonprofit, and public entities required to provide mitigation for dredge and fill activities under the Clean Water Act. The "credits" represent the accrual or attainment of aquatic resource function at the mitigation bank site which results from restoration, creation, enhancement, or conservation efforts. The state wetland mitigation bank provides a cost-effective alternative for mitigating impacts. The Corps of Engineers regulates both public and private mitigation banking and is responsible for approving the number of "credits" available within any individual bank. When an individual or entity is required to provide compensatory mitigation for unavoidable loss of function, the Corps of Engineers can approve the purchase of "credits" from the state mitigation bank to satisfy all regulatory mitigation requirements. There are no mitigation banks under this program in the planning region at this time.

6.1.4 State Financial Assistance Programs

Arkansas has several state programs that provide financial incentives and assistance for water resources management. The federal government has also delegated authority to the state to administer federal assistance programs of the Clean Water Act, the Safe Drinking Water Act, and the Housing and Community Development Act.

6.1.4.1 Financial Assistance for Public Water and Wastewater Projects

ANRC is responsible for managing and distributing monies from several federal assistance programs intended to assist communities in constructing and maintaining drinking water and wastewater systems (Table 6.14). There are also state-funded programs that provide financial assistance for drinking water and wastewater (Table 6.15). ANRC also manages these incentive programs. Programs shown in both Table 6.14 and 6.15 utilize both federal and state funds.

Table 6.14. Federal assistance programs for public water projects that are administered by ANRC.

Federal Program	Federal funding source	State Program
Community Development Block Grant Program	Housing and Urban Development	Arkansas Community and Economic Development Program
Drinking water state revolving fund	EPA	Water resources cost share revolving fund program
		Construction assistance revolving loan fund
Clean water state revolving fund	EPA	Water resources cost share revolving loan fund
		Construction assistance revolving loan fund Construction

Table 6.15. State programs for public water system assistance (administered by ANRC).

State Water Use Regulations	State Assistance Programs	Related State Legislation
Title 5: Administrative rules and regulations for financial assistance	Water resources development	Arkansas Water Resources Cost Share Finance Act (Arkansas Code § 15-22-801 et seq.),
	General obligation bond fund	
	Water development fund program	
	Water resources cost share revolving fund program	
	Water, sewer, and solid waste management systems program	
	Water, waste disposal, and pollution abatement facilities general obligation bond fund program	Arkansas Water, Waste Disposal, and Pollution Abatement Facilities Financing Act (Arkansas Code § 15-20-1301 et seq.)
Title 15: Rules governing loans from the safe drinking water revolving loan fund	Safe drinking water revolving loan fund	Arkansas Code §15-22-1101
	Construction Assistance revolving loan fund	Arkansas Code § 15-5-901
Title 16: Rules governing the Arkansas clean water revolving loan fund program	Clean water revolving loan fund	Arkansas Code §15-5-901 et seq.
	Construction assistance revolving loan fund	
Title 23: Rules governing water and wastewater project funding through the Arkansas community and economic development program	Funding for construction or improvement of community treatment facilities for drinking water and waste water treatment	Arkansas Code § 15-5-901 et seq.
Title 5: Administrative rules and regulations for financial assistance	Water resources development general obligation bond fund	Arkansas Water Resources Cost Share Finance Act (Arkansas Code § 15-22-801 et seq.),
	Water development fund program Water resources cost share revolving fund program	
	Water, sewer, and solid waste management systems program	
	Water, waste disposal, and pollution abatement facilities general obligation bond fund program	Arkansas Water, Waste Disposal, and Pollution Abatement Facilities Financing Act (Arkansas Code § 15-20-1301 et seq.)
Title 15: Rules governing loans from the safe drinking water revolving loan fund	Safe drinking water revolving loan fund	Arkansas Code §15-22-1101
	Construction Assistance revolving loan fund	Arkansas Code § 15-5-901
Title 16: Rules governing the Arkansas clean water revolving loan fund program[2]	Clean water revolving loan fund	Arkansas Code §15-5-901 et seq.
	Construction assistance revolving loan fund	

Table 6.15. State programs for public water system assistance (continued).

State Water Use Regulations	State Assistance Programs	Related State Legislation
Title 23: Rules governing water and wastewater project funding through the Arkansas community and economic development program	Funding for construction or improvement of community treatment facilities for drinking water and waste water treatment	Arkansas Code § 15-5-901 et seq.

6.1.4.2 State Financial Incentive and Assistance Programs for Promoting Water Quality and Water Resources Management

ADEQ and ANRC administer a number of incentive and assistance programs related to water resources management (Table 6.16). These include programs to assist with clean-up of hazardous waste contamination, reduction of nonpoint source pollution, and management of solid wastes to protect water quality. In addition, there are state programs to encourage water conservation and preservation of wetlands. All but one of the programs listed in Table 6.16 are funded by state sources. The state nonpoint source pollution management grant program is federally funded under the authority of the Clean Water Act Section 319.

Table 6.16. State incentive and assistance programs that protect water quality.

State Regulation	State Assistance Programs	Related State Legislation	Related Federal Legislation
Regulation 11: Solid Waste Disposal Fees, Landfill Post-Closure Trust Fund, and Recycling Grants Programs[1]	Recycling Fund	Solid Waste Management Recycling Fund Act (Arkansas Code §8-6-601 et seq.)	Resource Conservation and Recovery Act
Regulation 12: Storage Tank Regulations[1]	Petroleum storage tank trust fund	Petroleum Storage Tank Trust Fund Act (Arkansas Code § 8-7-901 et seq.)	Clean Water Act, Underground Storage Tank Regulations, including Energy Policy Act of 2005
Regulation 29: Brownfields Redevelopment[1]	Clean-up funding	Arkansas Hazardous Waste Management Act (Arkansas Code § 8-7-201 et seq.), Remedial Action Trust Fund Act (Arkansas Code § 8-7-501 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act

Table 6.16. State incentive and assistance programs that protect water quality (continued).

State Regulation	State Assistance Programs	Related State Legislation	Related Federal Legislation
Regulation 30: Remedial Action Trust Fund, Site Priority List[1]	Clean-up funding, prioritization of contaminated sites for clean-up	Remedial Action Trust Fund Act (Arkansas Code § 8-7-501 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Title 5: Administrative rules and regulations for financial assistance[2]	Sewer and solid waste management systems program Waste disposal and pollution abatement facilities General obligation bond program Water, waste disposal, and pollution abatement facilities general obligation bond fund program	Arkansas Code § 14-230-101 et seq., § 15-22-601 et seq., § 15-22-701 et seq.	None
Title 10: Rules governing the Arkansas water resource agricultural cost-share program	Arkansas water resources agricultural cost-share program	Arkansas Code § 15-22-913 through 914, § 15-22-507	Title 10: Rules governing the Arkansas water resource agricultural cost-share program
Title 11: Surplus Poultry Litter Removal Incentives Cost-Share Program[2]	Transport of poultry litter from nutrient surplus areas	Surplus Nutrient Removal Incentives Act (Arkansas Code § 15-20-1201 et seq.)	CWA
Title 13: Rules governing the tax credit program for the creation and restoration of private wetland and riparian zones[2]	Wetlands and Riparian Zone Tax Credit Program	Arkansas Private Wetland Riparian Zone Creation and Restoration Incentive Act (Arkansas Code § 26-51-1501 et seq.)	None
Title 14: Rules for implementing the Water Resources Conservation and Development Incentives Act	Groundwater conservation tax incentives	Water Resource Conservation and Development Incentives Act (Arkansas Code § 26-51-1001 et seq.)	Title 14: Rules for implementing the Water Resources Conservation and Development Incentives Act

Table 6.16. State incentive and assistance programs that protect water quality (continued).

State Regulation	State Assistance Programs	Related State Legislation	Related Federal Legislation
Title 23: Rules governing water and wastewater project funding through the Arkansas community and economic development program[2]	Funding for construction or improvement of community treatment facilities for wastewater	None	Housing and Community Development Act
None	Nonpoint source pollution grant program[2]	None	Clean Water Act (Section 319)
Marine Sanitation[3]	Clean Vessel Act Grant Program, Arkansas Marine Sanitation Fund	Arkansas Code §27-101-408, § 19-6-301, § 19-6-490	Clean Vessel Act

Note: Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update.
1 Responsible state agency is ADEQ; 2 Responsible state agency is ANRC 3 Responsible state agency is Arkansas Department of Health

6.1.5 Non-regulatory State Water Management Programs

There are state agency programs for natural resources protection and management that apply to water resources. These include planning, guidance, and incentive programs. These programs do not necessarily have regulations associated with them. However, they guide the activities of state agencies related to water resources. The AWP is one such program. Others are described below.

6.1.5.1 Arkansas Wildlife Action Plan

A state wildlife action plan was prepared by the Arkansas Game and Fish Commission, and approved by USFWS in 2007. This plan prioritizes activities to protect species of concern and their habitats throughout the state. This plan addresses amphibians, birds, fish, crayfish, insects, mammals, mussels, and reptiles. There are 116 species of greatest conservation need identified for Arkansas in this plan that are found in the aquatic and semi-aquatic habitats of the WAWRPR. Within the three primary eco-regions that make up the planning region, habitat restoration/improvement is the most recommend conservation activity for the Arkansas Valley and Ouachita Mountains, while habitat protection is the most highly recommend conservation activity in the Boston Mountains (Anderson 2006).

6.1.5.2 Arkansas Wetland Strategy

A state wetland strategy was ed in 1995 by a team of Arkansas agencies. This strategy consisted of 10 elements that are intended to address conservation and restoration of wetlands, and improving understanding of wetlands, both by the scientific and natural resources community and by the public. Implementation of this strategy resulted in legislation that created the Arkansas Mitigation Banking Program, and the Arkansas Riparian Zone and Wetland Creation Tax Credit Program (Arkansas Multi-agency Wetlands Planning Team 1995).

6.1.5.3 Arkansas Nonpoint Source Pollution Management Plan

ANRC regularly prepares a state nonpoint source pollution management plan. The purpose of this plan to provide a guide and focus for public agencies, nonprofit organizations, interest groups, and other stakeholders to work together to "develop, coordinate, and implement programs to reduce, manage or abate" nonpoint source pollution. The plan is updated every five years. The current plan was updated in 2010.

6.1.5.4 Arkansas Forestry Best Management Practices

The Arkansas Forestry Commission has prepared a booklet of approved guidelines for conducting forest management practices in a way that minimizes water quality impacts. Implementation of these best management practices is voluntary. These management practices are applicable to commercial and private timber operations on public or private land.

6.1.6 Local Regulations

There are also local regulations that influence management of water resources. These can include zoning laws; regulations promulgated by municipalities, counties, water and wastewater utilities; and regulations promulgated by irrigation, drainage, water, and sewer districts.

6.1.7 Regional Water Resources Management Programs

Several agencies and organizations have developed management or restoration programs for areas within the WAWRPR. The purpose of some of these programs is to support a state or federal regulation or policy, such as ambient water quality standards or conservation of rare and endangered wildlife. These programs constitute a framework that provides opportunities for leveraging resources (personnel and funding) to accomplish water resources management goals. Examples of these regional water resources management programs are described below.

6.1.7.1 Nine-element Watershed Plans

Watershed plans are required by the CWA to guide activities for reducing pollution in waterbodies for which TMDLs have been developed. EPA has prepared guidance describing the nine elements that should be included in watershed plans to achieve TMDLs calculated for impaired waterbodies. A nine-element watershed plan must be completed and approved by EPA before restoration projects in the watershed can receive funding from the CWA Nonpoint Source Program (Section 319 funding). The Lake Maumelle Watershed Management Plan is an approved nine-element watershed management plan completed in the planning region (Central Arkansas Water n.d.b).

6.1.7.2 Fayetteville Shale Best Management Practices

A team consisting of multiple agencies has developed best management practices (BMPs) for natural gas activities in the Fayetteville Shale area intended to protect natural resources, including water quality (USFWS 2007).

6.1.7.3 Nonprofit Organizations

There are several nonprofit organizations that have active programs within the WAWRPR. These include The Nature Conservancy, Ducks Unlimited, and others. The Nature Conservancy manages a preserve on the Mulberry River (The Nature Conservancy 2013). Ducks Unlimited, along with multiple partners, have restored wetlands at the Ed Gordon Point Remove WMA near Morrilton and Lake Dardanelle WMA near Russellville, and restored bottomland hardwood forest land and seasonally flooded wetlands at Frog Bayou WMA near Fort Smith (Ducks Unlimited n.d.).

6.1.8 Interstate Water Compacts

The Arkansas River is subject to the Arkansas River Basin Compact. The Arkansas River Basin Compact of 1970 between the States of Arkansas and Oklahoma provides for the administration of the water apportionment agreed to by each of the state partners. The compact describes which state may use specific waters, promotes the orderly development of the river, encourages an active pollution abatement program to further the reduction of pollution, man-made or natural, into the waters of the Arkansas River basin, and facilitates cooperation between the appropriate administrative agencies in each state in the total development and management of the water resources of the Arkansas River Basin. The Arkansas River Basin subject to the compact includes all of the drainage basin of the Arkansas River and its tributaries from just below the confluence of the Grand-Neosho River with the Arkansas River near Muskogee, OK, to a point just below the confluence of Lee Creek with the Arkansas River near Van Buren, AR, and the drainage basin of Spavinaw Creek in Arkansas, but excluding the drainage basin of the Canadian River below Eufaula Dam (Figure 6.3). The compact is further defined by the following Articles (State of Oklahoma 1970).

Article IV: The following apportionment of the waters of the Arkansas River Basin have been agreed upon by the State of Arkansas and Oklahoma:

A. The State of Arkansas shall have the right to develop and use the waters of the Spavinaw Creek Subbasin subject to the limitation that the annual yield shall not be depleted by more than fifty percent (50%).

B. The State of Arkansas shall have the right to develop and use the waters of the Illinois River Subbasin subject to the limitation that the annual yield shall not be depleted by more than sixty percent (60%).

C. The State of Arkansas shall have the right to develop and use all waters originating within the Lee Creek Subbasin in the State or Arkansas, or the equivalent thereof.

D. The State of Oklahoma shall have the right to develop and use all waters originating within the Lee Creek Subbasin in the State of Oklahoma, or the equivalent thereof.

E. The State of Arkansas shall have the right to develop and use the waters of the Poteau River Subbasin subject to the limitation that the annual yield shall not be depleted by more than sixty percent (60%).

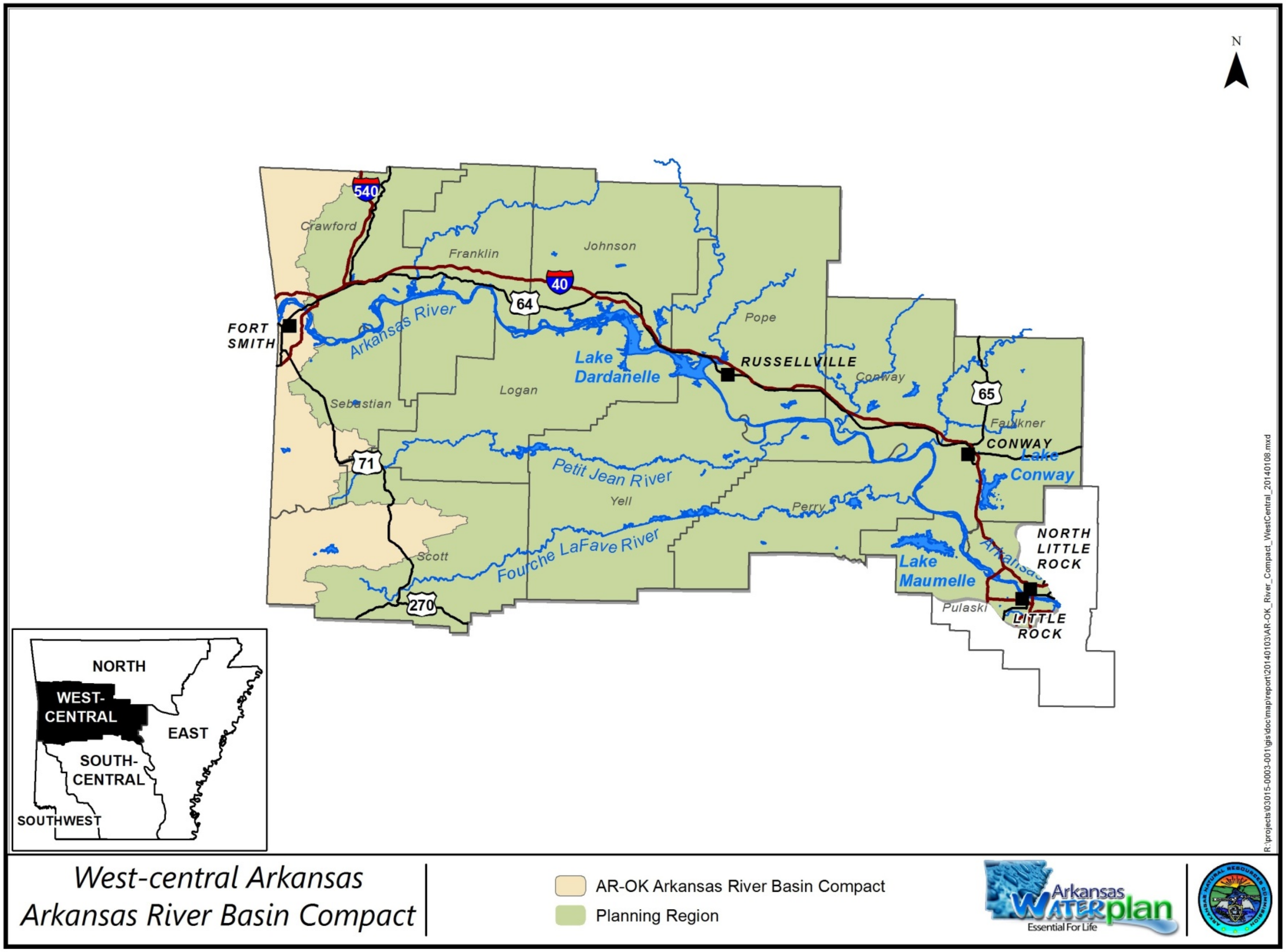

Figure 6.3. Arkansas River Basin Compact boundaries within the WAWRPR.

F. The State of Oklahoma shall have the right to develop and use the waters of the Arkansas River Subbasin subject to the limitation that the annual yield shall not be depleted by more than sixty percent (60%).

Article V:

A. On or before December 31 of each year, following the effective date of this Compact, the Commission shall determine the stateline yields of the Arkansas River Basin for the previous water year.

B. Any depletion of annual yield in excess of that allowed by the provisions of this Compact shall, subject to the control of the Commission, be delivered to the downstream State, and said delivery shall consist of not less than sixty percent (60%) of the current runoff of the basin.

C. Methods for determining the annual yield of each of the sub-basins shall be those developed and approved by the Commission.

Article VI:

A. Each state may construct, own and operate for its needs water storage reservoirs in the other state.

B. Depletion in annual yield of any subbasin of the Arkansas River Basin caused by the operation of any water storage reservoir either heretofore or hereafter constructed by the United States or any of its agencies, instrumentalities or wards, or by a state, political subdivision thereof, or any person or persons shall be charged against the state in which the yield therefrom is utilized.

C. Each state shall have the free and unrestricted right to utilize the natural channel of any stream within the Arkansas River Basin for conveyance through the other state of waters released from any water storage reservoir for an intended downstream point of diversion or use without loss of ownership of such waters; provided, however, that a reduction shall be made in the amount of water which can be withdrawn at point of removal, equal to the transmission losses.

Article VII: The States of Arkansas and Oklahoma mutually agree to:

A. The principle of individual state effort to abate man-made pollution within each state's respective borders, and the continuing support of both states in an active pollution abatement program;

B. The cooperation of the appropriate state agencies in the States of Arkansas and Oklahoma to investigate and abate sources of alleged interstate pollution within the Arkansas River Basin;

C. Enter into joint programs for the identification and control of sources of pollution of the waters of the Arkansas River and its tributaries which are of interstate significance;

D. The principle that neither state may require the other to provide water for the purpose of water quality control as a substitute for adequate waste treatment;

E. Utilize the provisions of all federal and state water pollution laws and to recognize such water quality standards as may be now or hereafter established under the Federal Water Pollution Control Act in the resolution of any pollution problems affecting the waters of the Arkansas River Basin.

Article VIII: Creates the agency to be known as the "Arkansas-Oklahoma Arkansas River Compact Commission," which consists of three Commissioners representing the State of Arkansas and three Commissioners representing the State of Oklahoma.

Article IX: Describes the powers of the Commission.

Articles X – XIII: Further defines the powers and binding authority of the Compact.

6.2 Institutional framework

Governmental responsibility for water resources management in the WAWRPR is split among many agencies on three levels (Federal, State and Local). As a result, management of water resources can require coordination among a number of government entities. In addition, there are a number of nonprofit organizations that participate in water resources management in the planning region.

6.2.1 Federal Agencies

There are more than 15 different federal agencies involved in water resources management in the WAWRPR. These federal agencies are listed in Table 6.17, along with their respective activities in this planning region.

Table 6.17 Federal agencies with water resources related responsibilities in the WAWRPR.

Federal Agency	Responsibility
EPA	• Oversees state agencies in implementation of management and funding programs under o CWA, o SDWA, o Superfund, o Federal Insecticide, Fungicide, and Rodenticide Act, and o Surface Mining Control and Reclamation Act • Conducts TMDL studies and other water quality studies in the

Table 6.17 Federal agencies with water resources related responsibilities in the WAWRPR (continued).

Federal Agency	Responsibility
	state • Implements programs under the Toxic Substances Control Act
Federal Energy Regulatory Commission (FERC)	Oversees environmental matters related to natural gas and hydropower projects in the state
FEMA	Prepares flood hazard maps for the state and encourages State and local governments to guide development decisions away from defined flood hazard risk areas through participation in the National Flood Insurance Program
HUD	Provides funding for water and wastewater infrastructure improvements
NOAA	Participates in monitoring precipitation and climate in the state
NRCS National Water Management Center	• Located in Little Rock • Serves as a water resources information exchange • Provides support and training related to o environmental compliance, o hydrology and hydraulics, o stream geomorphology and restoration, o water quality and quantity, o watershed and dam rehabilitation, and o technology outreach
Nuclear Regulatory Commission	Regulates nuclear power plants in Arkansas to protect the environment, including disaster preparedness planning for flood events
Southwestern Power Administration	Markets and delivers hydroelectric power produced at two USACE hydropower projects in the planning region
USACE (the Little Rock and Memphis Districts are located in the WAWRPR)	• Manages the McClellan-Kerr Navigation System, Blue Mountain Lake, and Lake Nimrod • Manages federal water, navigation, flood control, and hydropower projects in the state • Implements sections of the Clean Water Act related to impacts to navigable waters and wetlands • Constructs flood control, irrigation, and water supply projects authorized by the Water Resources Development Act • Oversees dam safety for federal dams
USDA	• Conducts the Census of Agriculture • Conducts the Natural Resources Inventory • Manages Conservation Effects Assessment Projects (watershed and regional)
USDA Farm Services Agency	Implements the Conservation Reserve Program for erosion control and habitat restoration in the state

Table 6.17 Federal agencies with water resources related responsibilities in the WAWRPR (continued).

Federal Agency	Responsibility
USFS	• Manages the Ozark and Ouachita National Forests and associated surface waters • Forest management incentive programs • Participates in forest inventory • Manages Urban and Community Forestry Program
USDA Rural Development	• Implements UDSA rural utilities financial assistance programs
NRCS	• Implements over 25 Farm Bill erosion control and habitat restoration funding and technical assistance programs in the state • Appraises the status and trends of soil, water, and related resources on non-federal land in the state and assesses their capability to meet present and future demands
USFWS	• Implements the Endangered Species Act and programs to o Promote management of ecosystems, o Promote conservation of migratory birds, o Promote preservation of wildlife habitat, o Promote restoration of fisheries, o Combat invasive species, and o Promote international wildlife conservation • Manages national wildlife refuges in the planning region • Conducts the National Wetland Inventory • Oversees state wildlife planning through the State Wildlife Grant Program
USDI National Park Service	• Manages national parks within the planning region, and their associated water resources • Provides funds for land and water conservation projects
USGS	• Flow and stage monitoring of rivers and streams • Groundwater level monitoring • Water quality monitoring • Groundwater modeling • Water quality modeling • Water data storage and management

6.2.2 Arkansas Agencies

There are over 20 Arkansas agencies involved in water resources management in the WAWRPR. These state agencies are listed in Table 6.18, along with a description of their water resources management responsibilities within the planning region.

Table 6.18. Arkansas agencies and entities with responsibilities related to water resources in the WAWRPR.

State Entity	Responsibility
ADEQ	• Implements state water quality policy and the Clean Water Act NPDES program • Develops and enforces water quality standards • Investigates citizen complaints regarding water pollution • Oversees solid waste management • Operates the hazardous waste management program • Manages contaminated site clean-up and redevelopment programs • Develops and enforces mining and mine site reclamation regulations • Manages the storage tank regulation program • Permits no-discharge facilities and underground injection operations • Water quality monitoring and assessment
ANRC	• Regulates, permits, and tracks water use and dam construction • Monitors climate • Administers federal water resources funding programs • Prepares water resources and nonpoint source pollution management plans • Develops and maintains mitigation banking and restoration incentive programs for aquatic resources • Supports conservation districts • Registers poultry feeding operations • Certifies nutrient management planners and applicators • Promotes public health and safety and minimize flood losses through o training, o education, o technical assistance in floodplain management, and o accrediting floodplain administrators
Arkansas Department of Health (ADH)	• Regulates public water supply systems • Implements the Safe Drinking Water Act source water protection programs • Issues fish consumption advisories • Implements state health rules and regulations that apply to water resources • Regulates septic tanks and licenses septic tank cleaners • outdoor bathing and swimming • Implements state marine sanitation program
Arkansas Department of Parks and Tourism	• Manages the 7 state parks in the region and associated water resources • Prepares comprehensive outdoor recreation plan • Manages outdoor recreation grant program

Table 6.18. State agencies and entities with responsibilities and authority related to water resources in the West-central Arkansas Planning Region (continued).

State Entity	Responsibility

Arkansas Forestry Commission	• Provides guidelines for protection of water resources in forestry operations
	• Monitors use of forestry BMPs
	• Participates in forest inventory
	• Implements forest management incentive programs
	• Implements Urban and Community Forestry program
	• Designates and manages state forests for a variety of purposes, including
	  o watershed protection
	  o erosion and flood control

Arkansas Game and Fish Commission (AGFC)	• Manages protection, conservation and preservation of various species of fish and wildlife in Arkansas through
	  o habitat management,
	  o wildlife management areas,
	  o fish stocking,
	  o hunting and fishing regulations, and
	  o education and outreach programs
	• Prepares state Wildlife Action Plan
	• Implements conservation grant program
	• Manages 9 lakes in the planning region

Arkansas Geological Survey	• Participates in research of, and provides information and education about, state water resources • Mapping • Water well construction records
Arkansas Livestock and Poultry Commission	Regulates disposal of livestock carcasses
Arkansas Multi-agency Wetland Planning Team	Developed the State Wetland Strategy and is the lead for developing state numeric nutrient criteria for wetlands
Military Department Arkansas National Guard	Manages land and surface water resources within the boundaries of Fort Chaffee and Camp Robinson
Arkansas Natural Heritage Commission (ANHC)	• Surveys and conducts research on natural communities in the state • Acquires natural areas for preservation • Manages the Arkansas Natural and Scenic Rivers system

Arkansas Oil and Gas Commission	• Provides technical assistance related to protection of water resources from wastes associated with production of natural gas
	• Issues permits for drilling and operation of
	  o natural gas production wells
	  o injection and disposal wells

Arkansas Pollution Control and Ecology Commission (APCEC)	Environmental policy-making body for the state
Arkansas Public Service Commission	Regulates rates and services of private water utilities, as well as utilities water crossings

Table 6.18. State agencies and entities with responsibilities and authority related to water resources in the West-central Arkansas Planning Region (continued).

State Entity	Responsibility
Arkansas State Board of Health	Promulgates health rules and regulations for the state
Arkansas State Highway and Transportation Department (AHTD)	• Hazardous waste transportation permits • Stormwater management • Develops and implements construction BMPs
Arkansas State Plant Board	Implements • Insecticide, Fungicide, and Rodenticide Act programs, o pesticide registration o user and applicator training o dealer licensing • state pesticide management plan for groundwater protection, • groundwater quality monitoring, and • climate/weather monitoring
Arkansas Water Well Construction Commission	• Regulates development of groundwater through licensing water well contractors and registering drillers and pump installers • Regulates specifications for construction of water wells • Maintains water well construction records
Arkansas Waterways Commission	Studies and promotes navigable waterways for transportation and economic development
University of Arkansas (U of A) Cooperative Extension Service	Provides technical assistance to Arkansans related to water conservation, and protection and restoration of water quality
U of A Water Resources Center	Participates in research related to water resources, and in water resources management projects

6.2.3 Federal - State Organizations

There are at least three federal-state organizations involved in water resources management in the WAWRPR:

- Arkansas-Oklahoma Arkansas River Compact Commission,
- Arkansas Conservation Partnership, and
- Arkansas Watershed Advisory Group.

The Arkansas-Oklahoma Arkansas River Compact Commission administers the Arkansas-Oklahoma Arkansas River Compact, which applies to Lee Creek and Poteau River basins in the WAWRPR (see Section 6.18). The commission is made up of three representatives each from Arkansas and Oklahoma, the director of the state water agency and two residents appointed by the state governor, as well as one federal representative, appointed by the US president (Arkansas River Compact Committee 1970).

The Arkansas Conservation Partnership supports locally-led natural resources conservation through coordination of education, financial, and technical assistance to landowners. Water resources and implementation of Farm Bill programs are two of the six natural resource issues that are the focus of the partnership. Members of the partnership include federal agencies, as well as ANRC, the NRCS, Arkansas Association of Conservation Districts, U of A Cooperative Extension, U of A at Pine Bluff, and Arkansas Forestry Commission. This partnership was formed in 1992 (ANRC 2011b, Cooperative Conservation America n.d.).

The Arkansas Watershed Advisory Group (AWAG) provides technical assistance to form local watershed groups, hosts an annual water quality conference, and facilitates quarterly discussions of voluntary water quality management approaches. AWAG is a consortium of federal and state agencies with private citizens (ANRC 2011b).

6.2.4 Regional and Local Entities

There are numerous regional and local entities in the WAWRPR that are involved in activities related to water resources management. Examples of the types of local and regional entities present in this planning region are shown in Table 6.19, along with descriptions of their activities related to water resources management.

Table 6.19. Some of the regional and local entities involved in water resources management in the WAWRPR.

Regional or Local Entity	Water Resources Involvement
Local Conservation Districts	Work with state and federal agencies to implements measures for the control of erosion and flooding, and conservation of soil and water resources
County Government	Responsible for unincorporated areas, sometimes including floodplain management and zoning
Levee Districts	Provide for the construction and maintenance of levees for flood protection
Arkansas-Oklahoma Arkansas River Compact Commission	Administers the Arkansas-Oklahoma Arkansas River Compact

Table 6.19. Some of the regional and local entities involved in water resources management in the WAWRPR (continued).

Regional or Local Entity	Water Resources Involvement
Regional Planning and Development Districts (PADD) o Central Arkansas PADD o West Central Arkansas PADD o Western Arkansas PADD o White River PADD	• Provide assistance in grant applications • Economic development projects that may include water resources management • Water supply and wastewater infrastructure improvements
Regional Solid Waste Management Districts	Manage collection, disposal, and recycling of solid waste
Universities	Water resources and management research, education, and outreach
Water districts and associations	Water supply planning and management

6.2.5 Nonprofit Organizations

There are several nonprofit organizations that conduct activities in the WAWRPR that are related to water resources management. These organizations are listed in Table 6.20 with a description of their water resources related activities in the planning region.

Table 6.20. Examples of nonprofit groups involved in water resources management in the WAWRPR.

Nonprofit	Water Resources Involvement
Arkansas Farm Bureau	Advocate for agriculture
Arkansas Waterways Association	Promotes and protects Arkansas inland transportation waterways
Arkansas Wildlife Federation	Conservation of aquatic habitat for fish and wildlife
Ducks Unlimited	Conservation and restoration of aquatic habitat for waterfowl
The Nature Conservancy	Mulberry River Preserve Presson-Oglesby Preserve
Watershed organizations (at least 2)	Water resources planning, Sponsor for water quality and quantity projects
Arkansas Environmental Federation	Advocate for industry

6.2.6 Institutional Interactions in Water Resources Management

As noted at the beginning of this section, water resources management in the WAWRPR involves numerous entities at multiple scales. Examples of the interactions among federal, state, and local entities that occur in water resources management in the planning region are presented in Table 6.21.

Table 6.21. Examples of interactions of federal, state, and local entities in water resources management within the WAWRPR.

State Water Resources Responsibility/Program	Involves: Federal Entities	State Entities	Regional or Local Entities
Water use registration	USGS (houses registration database)	ANRC (program lead)	Water utilities
Dam safety	USACE (federal dams) FEMA (oversight)	ANRC (program lead), AGFC (dam builder), Arkansas Department of Parks and Tourism (dam builder)	Water utilities, municipalities, counties (dam builders)
State climate monitoring	NOAA National Weather Service, NOAA National Climatic Data Center, USGS (precipitation monitoring), USACE (climate monitoring),	ANRC (State Climatologist), Arkansas State Plant Board (monitoring)	Community Collaborative Rain, Hail & Snow Network
Safe Drinking Water Act funding	EPA (funding)	ANRC (program lead)	Water utilities, municipalities/ communities, water districts
Water Resources Conservation Tax Incentives	NRCS	ANRC (program lead), U of A Cooperative Extension Service	Conservation districts
Conservation district grants program	None	ANRC (program lead)	Conservation districts
Community development block water and wastewater grants	HUD (funding)	ANRC (program lead), Arkansas Economic Development Commission	Water utilities, wastewater utilities, water districts, sewer districts
Floodplain management	FEMA	ANRC (State liaison)	Levee districts, counties, and municipalities
Nonpoint source pollution management	EPA (funding), NRCS (conservation programs), USFS (BMPs), The Nature Conservancy (projects), USDA Farm Services Agency (conservation program)	ANRC (program lead), Universities, Arkansas Water Resources Center, Audubon Arkansas, U of A Cooperative Extension Service, Arkansas Farm Bureau, ADEQ (TMDLs)	Watershed organizations, Conservative districts, water districts, stream teams, nonprofit organizations
Clean Water Act funding program (including nonpoint source and clean water revolving loan fund)	EPA (funding)	ANRC (program lead)	Watershed organizations, sewer districts, municipalities, nonprofit organizations

Table 6.21. Examples of interactions of federal, state, and local entities in water resources management within the WAWRPR (continued).

State Water Resources Responsibility/Program	Involves: Federal Entities	State Entities	Regional or Local Entities
Wetland and riparian zone tax credit program	None	ANRC (program lead)	Watershed organizations
Wetland and stream mitigation	USACE (lead)	ANRC (state mitigation bank), AHTD, AGFC, ADEQ, ANHC	Local conservation districts, nonprofit organizations, watershed organizations
Non-riparian water use permitting	None	ANRC (program lead)	Water utilities
Arkansas Recovery Act water and wastewater funding	Recovery Accountability and Transparency Board	ANRC (program lead)	Water utilities, wastewater utilities, water districts, sewer districts
State water utility funding	None	ANRC (program lead)	Water utilities, water districts
State wastewater utility funding	None	ANRC (program lead)	Wastewater utilities, sewer districts
NPDES discharge permits	EPA (oversight, guidance)	ADEQ (program lead)	Dischargers
Underground injection control	EPA	ADEQ (program lead), Arkansas Oil and Gas Commission (program lead)	Dischargers
Wastewater pretreatment program	EPA	ADEQ (program lead)	Dischargers
Water quality standards	EPA	APCEC (regulations), ADEQ (implementation, enforcement), ANRC (groundwater standards), Multi-agency Wetland Planning Team (nutrient criteria for wetlands)	Local government, regulated entities, interest groups
Water quality assessment	EPA (oversight, guidance), USGS (data), USACE (data)	ADEQ (implementation)	None
TMDLs	EPA (oversight, guidance), USGS (data), USACE (data)	ADEQ (program lead)	None
Storage tank regulation	EPA	ADEQ (program lead)	None
Solid waste management	EPA (oversight)	ADEQ (program lead)	Regional solid waste management districts
Landfill post-closure trust fund	None	ADEQ (program lead)	Regional solid waste management districts
Hazardous waste management	EPA	ADEQ (program lead), AHTD (transport)	Interest groups

Table 6.21. Examples of interactions of federal, state, and local entities in water resources management within the WAWRPR (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
Remedial action trust fund	None	ADEQ	Interest groups
Brownfields	EPA	ADEQ	Municipalities
Superfund	EPA	ADEQ	Interest groups
Mining reclamation	US Department of the Interior	ADEQ	Interest groups
Water quality monitoring	EPA (oversight, studies), USGS (monitoring, studies), USACE (monitoring, studies)	ADEQ, ANRC, U of A Arkansas Water Resources Center (studies), AGFC (stream teams), Arkansas State Plant Board (groundwater monitoring)	Stream teams (monitoring), water utilities (monitoring)
Fish tissue sampling	None	ADEQ (program lead), ADH (consumption advisories), AGFC (sampling)	None
Stormwater management	EPA	ADEQ, U of A Cooperative Extension Service	Counties, municipalities
Spill prevention	EPA	ADEQ	None
Finished drinking water criteria	EPA	ADH	Water utilities, water districts
Source Water Protection	EPA	ADH, Arkansas Water Well Construction Commission	Water utilities (planning)
Consumer Information	EPA	ADH	Water utilities
Regulation of drinking water utilities	EPA	ADH, Arkansas Public Service Commission	Water utilities
Pesticide registration, labeling and classification	EPA	Arkansas State Plant Board	Pesticide distributors and users
Community Forestry	USDA Forest Service	Arkansas Forestry Commission, Arkansas Urban Forestry Council	Municipalities
Forest stewardship	USDA Forest Service, USDA Farm Services Agency, NRCS	Arkansas Forestry Commission, AGFC, ANRC, Arkansas Historic Preservation Program, U of A Cooperative Extension Service, Arkansas Natural Heritage Commission	Landowners
Forest Legacy	USDA Forest Service (funding), Land Trust Alliance	Arkansas Forestry Commission	Landowners

Table 6.21. Examples of interactions of federal, state, and local entities in water resources management within the WAWRPR (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
State parks	USACE, National Park Service (funding)	Arkansas Department of Parks and Tourism	Arkansas Master Naturalists
Stream teams	None	AGFC	Region I / Region II Arkansas Master Naturalists
Wildlife management areas, refuges	USFSW	AGFC	Holla Bend National WMA
Fishing and boating programs	USACE, USFWS	AGFC, Arkansas Department of Parks and Tourism	None
Pollution prevention program	EPA	ADEQ	None
Commercial navigation	USACE Little Rock District	Arkansas Waterways Commission	None

7.0 REFERENCES

5News Web Staff. 2013. *Scott County Flood Victim Dies from Medical Complications.* 5newsonline.com: 1.

Adams, S. Reid, Bradley S. Williams, Matt D. Schroeder, and Robert L. and Clark. 2007. *Abundance and Distribution of Fishes in Riparian Wetlands of the Arkansas River.* Conway: University of Central Arkansas,

Adamski, J.C., D.A. Freiwald, and J.V. Davis. *Environmental and Hydrologic Setting of the Ozark Plateaus Study Unit, AR, KS, MO, and OK.* USGS Water Resources Investigations 94-4022, USGS, 1995, 69.

ADEM. 2010.*All Hazard Mitigation Plan - State of Arkansas.* Little Rock, AR: Arkansas Department of Emergency Management.

ADEQ. 2004. *2004 Integrated Water Quality Monitoring and Assessment Report.* Little Rock, AR: Arkansas Department of Environmental Quality.

ADEQ. 2008 . *2008 Integrated Water Quality Monitoring and Assessment Report.* Water Division, Little Rock, AR: Arkansas Department of Environmental Quality, 350.

ADEQ. 2009. *Approved Arknasas 2008 Section 303(d) List.* Little Rock, AR: Arkansas Department of Environmental Quality, Water Division.

ADEQ. 2011. *Timeline of Historical Events of Arkansas Solid Waste Management, 1971 - 2011.* Little Rock: Arkansas Department of Environmental Quality.

ADEQ. 2012d. *2012 Integrated Water Quality Monitoring and Assessment Report.* Little Rock: Arkansas Department of Environmental Quality.

ADEQ. 2012a. *Arkansas Hazardous Waste Generators Facility Summary.* http://www.adeq.state.ar.us/hazwaste/rcra2/facil_sum.asp (accessed November 11, 2013).

ADEQ. 2012b. *Arkansas TMDLs.* http://www.adeq.state.ar.us/water/tmdls/default.asp (accessed November 8, 2013).

ADEQ. 2012c. *State of Arkansas Nutrient Criteria Development Plan.* Little Rock: Arkansas Department of Environmental Quality.

ADEQ. 2013a. *ADEQ Facility and Permit Summary.* http://www.adeq.state.ar.us/home/pdssql/pds.asp (accessed March 13, 2013).

ADEQ. 2013b. *NPDES Industrial Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/industrial/npdes_industrial_permit_tracking.asp (accessed November 11, 2013).

ADEQ. 2013c. *NPDES Construction Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/construction/npdes_constructionstormwater_permit_tracking.asp (accessed November 11, 2013).

ADEQ. 2013d. *NPDES MS4 Small Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/ms4/npdes_ms4_stormwater_permit_tracking.asp (accessed November 11, 2013).

ADEQ. 2013e. *Surface Water Quality Monitoring Station Data Search Page.* http://www.adeq.state.ar.us/techsvs/water_quality/water_quality_station.asp (accessed October 1, 2013).

ADEQ. 2013f. *ADEQ Water Quality Planning Branch.* http://www.adeq.state.ar.us/water/branch_planning/ (accessed January 28, 2014).

ADEQ. 2013g. "Star Starrett Facility." *Arkansas's Remedial Action Trust Fund.* http://www.adeq.state.ar.us/ftproot/Pub/hw/PriorityList/pdf/Star%20Starrett%20SPL%20Summary.pdf (accessed January 17, 2014).

ADEQ. 2013h. *Arkansas's Remedial Action Trust Fund.* http://www.adeq.state.ar.us/hazwaste/branch_tech/ratf.aspx (accessed November 11, 2013).

ADEQ. 2013i. *Final Permits.* http://www.adeq.state.ar.us/water/branch_permits/individual_permits/finalpermits/finalpermits.aspx#Display (accessed January 28, 2014).

ADH. n.d. *Drinking Water Information for Arkansans.* http://www.healthy.arkansas.gov/eng/autoupdates/pwslist0.htm (accessed March 20, 2013).

ADH. 2011. *Marine Sanitation.* Arkansas Department of Health. http://www.healthy.arkansas.gov/programsServices/environmentalHealth/MarineSanitation/Pages/MarineSanitation.aspx (accessed July 26, 2013).

ADH. 2012. *Arkansas Public Water System Compliance Summary.* Arkansas Department of Health, Environmental Health, Engineering, Reports and Forms. http://www.healthy.arkansas.gov/programsServices/environmentalHealth/Engineering/Documents/Reports/Compliance/ComplianceSummary.pdf (accessed July 30, 2013).

ADH, AGFC, ADEQ. 2011. *Fish Consumption Notice - Mercury in Fish.* Little Rock, AR: Department of Health.

ADPCE. 1990. *Arkansas Water Quality Inventory Report 1990.* Little Rock: Arkansas Department of Pollution Control and Ecology.

AGFC. 2009. *Wildlife Management Area Boundary (polygon), Arkansas*. Geocommons. http://geocommons.com/overlays/18197 (accessed April 25, 2013).

AHTD. 2001. *Mitigation Bank Instrument for the Hartman Bottoms Wetland Mitigation Bank Arkansas.* Little Rock: Arkansas State Highway and Transportation Department.

AHTD. 2006. *Public Land Boundaries Database*. Little Rock, AR: AHTD, 8 29,

Albin, D.R. *Water-resources Reconnaissance of the Ouachita Mountains, AR.* USGS Water Supply Paper 1809-J, USGS, 1965, 14.

Anderson, J.E. (ed.). 2006. *Arkansas Wildlife Action Plan.* Little Rock: Arkansas Game and Fish Commission.

ANRC. 2010. *Rules Governing the Arkansas Soil Nutrient and Poultry Litter Application and Management Program, Title 22.* Little Rock: Arkansas Natural Resources Commission.

ANRC. 2011a. *Water Law in Arkansas.* Little Rock: Arkansas Natural Resources Commission.

ANRC. 2011b. *2011-2016 Nonpoint Source Pollution Management Plan*. August http://arkansaswater.org/data/Full_NPSPlan_Document.pdf (accessed April 17, 2013).

APCEC. 2011. *Regulation No. 2, Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas.* Little Rock: Arkansas Pollution Control and Ecology Commission.

Arkansas Department of Parks and Tourism. 1991. *1990 Arkansas Travel and Tourism Report.* Little Rock, AR: Arkansas Department of Parks and Tourism.

Arkansas Department of Parks and Tourism. 2012. *2012 Annual Report*. Arkansas Tourism Official Site. http://www.arkansas.com/!userfiles/editor/docs/apt-annual-report-financials-2012.pdf (accessed June 2013).

Arkansas Geological Survey. n.d. *Physiographic Regions.* http://www.geology.ar.gov/education/physio_regions.htm (accessed March 2013).

Arkansas Multi-agency Wetlands Planning Team. 1995. *Arkansas Wetland Resource Information System, Arkansas State Wetland Strategy.* http://awrims.cast.uark.edu/home/ar-wetland-strategy.aspx (accessed March 2013).

ANHC. 2012. *River Designations*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2623 (accessed January 31, 2014).

ANHC. 2013. *Rare Species Search Engine: Find Arkansas Endangered Species.* http://www.naturalheritage.com/research-data/rarespecies-search.aspx (accessed July 2013).

Arkansas Multi-Agency Wetland Planning Team. 2001. *Clasification of Arkansas Wetlands.* http://www.mawpt.org/wetlands/classification/classes.asp (accessed September 19, 2013).

Arkansas River Compact Committee. 1970. *Arkansas River Basin Compact, Arkansas-Oklahoma, 1970.* Austin, TX: Office of Representaive, United States.

Arkansas Waterways Commission. 2013. *2011-2012 Biennial Report.* News - Biennial report. http://waterways.arkansas.gov/Documents/___BiennialReportFInal.pdf (accessed February 7, 2014).

ArkansasWater. *ArkansasWater.org.* 2012. www.arkansaswater.org (accessed March 22, 2013).

Association of Arkansas Counties. 2014. *http://www.arcounties.org/.* http://www.arcounties.org/ (accessed January 24, 2014).

ASWCC. 1981. *Arkansas State Water Plan, Lakes of Arkansas.* Little Rock: Arkansas Soil and Water Conservation Commission.

ASWCC. 1987. *Arkansas State Water Plan, Upper Ouachita Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

ASWCC. 1988. *Arkansas State Water Plan Eastern Arkansas Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

Audubon Arkansas. n.d. *Important Bird Areas in Arkansas.* http://ar.audubon.org/important-bird-areas-arkansas (accessed March 22, 2013)

Audubon Arkansas. n.d. *Audubon Arkansas IBA Site Descriptions.* http://ar.audubon.org/iba-site-descriptions (accessed April 2, 2013).

Bedinger, M.S., L.F. Emmett, and H.G. Jeffery. 1963. *Ground-water Potential of the Alluvium of the Arkansas River between Little Rock and Fort Smith, AR.* USGS Water Supply Paper 1669-L, USGS, 29.

Bell, James W. 2013. *Little Rock (Pulaski County)*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=970 (accessed March 25, 2013).

Boulden, Benjamin. 2012. *Fort Smith (Sebastian County)*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=988 (accessed March 25, 2013).

Branyan, Scott. 2012. *Floods.* The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=5148 (accessed March 25, 2013).

Buckner, Ed. 2011.*Climate and Weather*. Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=4579 (accessed March 15, 2013).

Center for Business and Economic Research. 2012. *Revisiting the Economic Impact of the Natural Gas Activitiy in the Fayetteville Shale: 2008-2012.* Fayetteville: University of Arkansas Sam M. Walton School of Business.

Central Arkansas Water. n.d.a. *Water Treatment*. http://www.carkw.com/water-source-info/water-treatment/ (accessed February 7, 2014).

Central Arkansas Water. n.d.b. *Watershed Management Plan.* http://www.carkw.com/water-source-info/watershed-management/watershed-management-plan/ (accessed February 7, 2014).

Clark, Patterson, and Laris Karklis. *USDA Upgrades Plant Hardiness Zone Map*. Washington Post. January 25, 2012. http://www.washingtonpost.com/wp-srv/special/local/planthardinesszones/index.html (accessed March 2013).

Cole, E.F., and E.E. Morris. 1986. *Water Resources of the Ouachita National Forest, AR.* USGS Water-Resources Investigations Report 86-4166, USGS, 1.

Conway Corporation. 2007. *James H Brewer Lake.* https://www.conwaycorp.com/About/History/BrewerLake.aspx (accessed October 8, 2013).

Cooperative Conservation America. n.d. *Cooperative Conservation Case Study, Arkansas Conservation Partnership.* http://www.cooperativeconservation.org/viewproject.asp?pid=103 (accessed July 29, 2013).

Cordova, R.M. 1963. *Reconnaissance of the Ground-water Resources of the Arkansas Valley Region.* USGS Water Supply Paper 1669-BB, USGS 33.

Dahl, T.E. 1990. *Wetlands - Losses in the United States, 1780's to 1980's.* Washington, DC: US Fish and Wildlife Service.

Department of Arkansas Heritage. 2013. *Discover Arkansas History, Regions - Arkansas River Valley.* http://www.arkansasheritage.com/discover/natural_environments/regions/rivervalley.aspx (accessed March 2013).

Ducks Unlimited. n.d. *Ducks Unlimited - Arkansas.* http://www.ducks.org/viewTag.aspx?tagID=533 (accessed 11 20, 2013).

Early, Ann M. 2011. *Pre-European Exploration (Prehistory - 1540).* Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=395 (accessed September 2013).

EPA. 2008. *Handbook for Developing Watershed TMDLs.* Washington, DC: US Environmental Protection Agency, Office of Wetlands, Oceans & Watersheds.

EPA. 2012a. *Landfills.* http://www.epa.gov/osw/nonhaz/municipal/landfill.htm (accessed June 3, 2013).

EPA. 2012b. *Large Quantity Generators.* http://www.epa.gov/osw/hazard/generation/lqg.htm (accessed July 9, 2013).

EPA. 2012c. *Small Quantity Generator.* http://www.epa.gov/osw/hazard/generation/sqg/index.htm (accessed July 9, 2013).

EPA. 2012d. *State Detail Analysis, The National Biennial RCRA Hazardous Waste Report (Based on 2011 Data).* Washington DC: US EPA.

EPA. 2012e. *Basic Information.* http://water.epa.gov/infrastructure/drinkingwater/pws/dwoperatorcert/basicinformation.cfm (accessed June 11, 2013).

EPA. 2013a. *Western Ecology Division.* www.epa.gov/wed/pages/ecoregions.htm (accessed June 2013).

EPA. 2013b. *Consumer Confidence Reports.* http://water.epa.gov/lawsregs/rulesregs/sdwa/ccr/index.cfm (accessed September 29, 2013).

EPA. 2013c. *Regulatory Topics.* http://www.epa.gov/lawsregs/topics/#water (accessed March 2013).

EPA. 2013d. *Compensatory Mitigation.* http://water.epa.gov/lawsregs/guidance/wetlands/wetlandsmitigation_index.cfm (accessed June 17, 2013).

EPA. 2013e. *EPA Information Related to the American Recovery and Reinvestment Act of 2009. EPA.* July 12, http://www.epa.gov/recovery/basic.html (accessed April 1, 2014).

EPA. n.d. *EPA Recovery Mapper*. http://epamap17.epa.gov/arra/# (accessed April 2014).

Faulkner County RSWMD. 2011. *Annual Plan Update.* Little Rock: ADEQ.

Federal Highway Administration. n.d. *FHA Water, Wetlands, and Wildlife.* http://www.environment.fhwa.dot.gov/ecosystems/eei/ar05.asp (accessed 11 18, 2013).

FEMA. 2013. *The National Flood Insurance Program Community Status Book.* http://www.fema.gov/national-flood-insurance-program/national-flood-insurance-program-community-status-book (accessed March 20, 2013).

Filipek, Steve, William E. Keith, and John Giese. 1987. *The Status of the Instream Flow Issue in Arkansas*. Proceedings Arkansas Academy of Science Vol. 41: 43-48.

Fortune. 2012. *Fortune 500, States.* CNNMoney. http://money.cnn.com/magazines/fortune/fortune500/2012/states/AR.html (accessed March 2013).

Foti, Thomas. 2008. *The Natural Divisions of Arkansas.* Little Rock: Arkansas Natural Heritage Commission.

Foti, Thomas. 2011a. *Arkansas Valley.* The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=441&type=Category&item=Six+Natural+Divisions&parent=Geography&grandparent=Land+and+Resources (accessed March 25, 2013).

Foti, Thomas. 2011b. *Geography and Geology.* http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Foti, Thomas. 2011c. *Ouachita Mountains*. The Encyclopedia of Arkansas History & Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=442 (accessed 9 2013).

Fry, J. et al. 2011. *Completion of the 2006 national land cover database for the conterminous United States.* PE&RS, Vol.77(9): 858-864.

Galloway, JM, BE Haggard, MT Meyers, and WR Green. 2005. *Occurence of Pharmaceuticals and Other Organic Wastewater Constituents in Selected Streams in Northern Arkansas, Scientific Investigations Report 2005-5140.* Reston, Va: USGS.

GCGW. 2008. *Arkansas Governor's Commission on Global Warning Final Report.* Little Rock: Arkansas Governor's Commission on Global Warming (GCGW).

Gleason, Mildred Diane. 2011. *Dardanelle (Yell County).* The Encyclopedia of Arkansas History and Culture.

http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=1020 (accessed March 25, 2013).

Goss, Kay C. 2012. *McClellan-Kerr Arkansas River Navigation System (MKARNS).* The Encyclopedia of Arkansas History & Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=2309 (accessed September 2013).

Halberg, H.N., C.T. Bryant, and M.S. Hines. 1968. *Water Resources of Grant and Hot Spring Counties, AR.* USGS Water Supply Paper 1857, USGS, 64.

Heartland Boating. 2013. *Heartland Boating June 2013*. Heartland Boating. http://www.heartlandboating.com/June-2013/14-Million-in-Grants-Support-Clean-Waters-and-Recreational-Boating/ (accessed November 13, 2013).

Holland, Terry. 2013. *Written Communication.*

Imes, J.L., and L.F. Emmett. 1994. *Geohydrology of the Ozark Plateaus Aquifer System in Parts of Missouri, Arkansas, Oklahoma, and Kansas.* USGS Professional Paper 1414-D, USGS, 127.

Interagency Wild and Scenic Rivers Council. *National Wild and Scenic Rivers Program Arkansas.* http://www.rivers.gov/arkansas.php (accessed October 2013).

Jackson, R. Scott, Daniel J. Stynes, Dennis B. Propst, and Bruce D. Carlson. 1996. *A Summary of the National and State Economic Effects of the 1994 U.S. Army Corps of Engineers Recreation Program.* Technical Report R-96-1, Washington: US Army Corps of Engineers.

James Fork Regional Water District. 2014. *About Us.* http://www.jamesforkwater.com/about-us (accessed February 7, 2014).

Key, Joseph Patrick. 2012. *European Exploration and Settlement, 1541 through 1802*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2916&type=Time+Period&item=European+Exploration+and+Settlement+%281541+-+1802%29&parent=&grandparent= (accessed March 25, 2013).

Kilpatrick, J.M., and A.H. Ludwig. 1990. *Ground-water Resources of the Arkanasas River Basin in Arkansas.* USGS Open-File Report 88-725, USGS, 45.

Koon, David. 2012. *Arkansas Times.* http://www.arktimes.com/arkansas/whirlpool-withdrawal-in-fort-smith-careers-shattered/Content?oid=2552554 (accessed October 22, 2013).

Kresse, T. M., J.A. Fazio, R.A. Miller, and S.W. and Kline. 2006. *The Arkansas River's Alluvial Aquifer in Central Arkansas: Geochemistry of the Aquifer at Dardanelle*. Proceedings of the Arkansas Water Resources Center Annual Conference. Fayetteville.

Kresse, T. M., and P. D. Hays. 2009. *Geochemistry, comparative analysis, and physical and chemical characteristics of the thermal waters east of Hot Springs National Park, AR 2006-2009.* USGS Scientific Investigations Report 2009-5263, USGS, 48.

Kresse, T. M., N. R. Warner, P. D. Hays, A. Down, A. Vengosh, and R. B. Jackson. 2012. *Shallow groundwater quality and geochemistry in the Fayetteville Shale gas-production area, north-central Arkansas.* US Geological Survey Scientific Investigations Report 2012-5273, USGS.

Kresse, T.M. et al. 2013. *In review: Aquifers of Arkansas: protection, management, and hydrologic and geochemical characteristics of Arkansas' groundwater resources.* Little Rock: USGS.

Lancaster, Guy. 2011a. *Fourche La Fave River.* The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=6247 (accessed March 28, 2013).

Lancaster, Guy. 2011b. *Petit Jean River*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=6252 (accessed March 28, 2013).

Manger, W.L. 1983. *The Geologic Provinces of Arkansas*. Arkansas Naturalist 1, no. 7: 1-6.

Manger, W.L., and J. Lloyd. 2008. *An Introduction to the Geology of Northwestern Arkansas.* Field Trip Guide, U Of A Dept of Geosciences, 55.

McFarland, John David. 2004. *Stratigraphic Summary of Arkansas.* Information Circular 36, Little Rock: Arkansas Geologic Commission.

National Agricultural Law Center. 2012. *United States Farm Bills.* http://www.nationalaglawcenter.org/farmbills/ (accessed June 11, 2013).

NatureServe. 2002. *Number of Extince Species in Each State.* http://www.natureserve.org/consIssues/ivoryBilled_table1.htm (accessed December 19, 2013).

Nelson, Rex. 2012. *Stephens, Inc*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryid=6985 (accessed June 5, 2013).

NOAA NCDC. 2013a. *Historical Palmer Drought Indices.* http://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers.php (accessed May 15, 2013).

NOAA NCDC. 2013b. *Climate at a Glance.* http://www.ncdc.noaa.gov/cag/time-series/global (accessed May 24, 2013).

NOAA. 2012. *NOAA's Drought Information Center, the Palmer Drought Severity Index.* http://www.drought.noaa.gov/palmer.html (accessed June 12, 2013).

NOAA NWS. 2013. *Little Rock, AR - Daily Climate Data.* http://www.srh.noaa.gov/lzk/?n=wxcntl3.htm (accessed December 19, 2013).

NRCS. n.d.a. *Arkansas, Major Land Resource Areas.* http://www.ar.nrcs.usda.gov/soils/mo16_mlra.html (accessed March 2013).

NRCS. n.d.b. *Seven Lakes Wetland Project.* http://www.nrcs.usda.gov/wps/portal/nrcs/detail/ar/home/?cid=nrcs142p2_035182 (accessed 11 21, 2013).

NRCS. 2012. *Arkansas Annual Report 2012*. NRCS Arkansas. http://www.ar.nrcs.usda.gov/news/annual_report_2012.html (accessed July 15, 2013).

NRCS Plant Materials Program. n.d. *AR Plant Materials Program.* http://www.nrcs.usda.gov/wps/portal/nrcs/main/plantmaterials/pmc/southeast/arpmc/ (accessed 11 13, 2013).

NRI Group. 2010. *Cadron Creek Mitigation Bank.* http://tnrig.com/Cadron_Creek_Mitigation_Bank.php (accessed 11 18, 2013).

Oklahoma Waterways Branch. 2012. *McClellan-Kerr Arkansas River Navigation System 2012 Inland Waterway Fact Sheet.* Waterways Advisory Board. http://www.okladot.state.ok.us/waterway/pdfs/fact_sheet_2012.pdf (accessed 10 01, 2013).

Oklahoma Water Resources Board. 2013. Title 785 Chapter 45 Oklahoma's Water Quality Standards. Oklahoma City: Oklahoma Water Resources Board.

Ouachita Ecoregional Assessment Team. 2003. *Ouachita Mountains Ecoregional Assessment.* Arkansas Wildlife Action Plan. http://www.wildlifearkansas.com/materials/updates/Appendix_3%5B1%5D.2_Ouachita_Ecoregional_Assessment.pdf (accessed January 31, 2014).

Petrimoulx, Drew. 2013. *Deal to Sell Water Rights Irks LR City Directors* . arkansasmatters.com.

PRISM Climate Group. 2004. Corvallis: Oregon State University.

Pugh, A.L., D.A. Westerman. 2014. *Mean Annual, Seasonal, and Monthly Precipitation and Runoff in Arkansas, 1951-2011.* US Geological Survey Scientific Investigations Report 2014-5006. Reston, VA: USGS.

Pulaski County RSWMD. 2011. *Regional Solid Waste Management Plan.* Little Rock: ADEQ.

Renken, R.A. 1998. *Groundwater Atlas of the United States: Segment 5, Arkansas, Louisiana, Mississippi*. US Geological Survey Hydrologic Atlas 730-F: 28.

Reynolds, Jerry. 2012. *Hydroelectricity*. Encyclopedia of Arkansas History & Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=5527 (accessed 09 2013).

Scott, H. Don, James A. Ferguson, Linda Hanson, Todd Fugitt, and Earl Smith. 1998. *Agricultural Water Management in the Mississippi Delta Region of Arkansas. Research Bulletin 959.* Fayetteville: University of Arkansas.

Sebastian County RSWMD. 2011. *Combined Regional Solid Waste Management Plan, Regional Needs Assessment, Annual Waste Tire Site Report, and Annual Recycling Program Report.* Little Rock: ADEQ.

Sloan, Kitty. 2011. Trail of Tears. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2294 (accessed March 25, 2013).

Smith, Bill. 2012. *Dardanelle Water Works*. Personal Communication.

Spurgeon, John. 2011. *Holla Bend National Wildlife Refuge*. The Arkansas Encyclopedia of History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2465 (accessed March 28, 2014)

State of Arkansas. 2009. *Recovery.Arkansas.Gov.* http://recovery.arkansas.gov//programs.php?do:home=1 (accessed 11 14, 2013).

State of Oklahoma. 1970. *Arkansas River Basin Compact.* The Oklahoma State Courts Network. http://www.oscn.net/applications/OCISWeb/DeliverDocument.asp?CiteID=97776 (accessed February 7, 2014).

Stewart-Abernathy, Leslie C. 2011a. *Cherokee*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Stewart-Abernathy, Leslie C. 2011b. *Steamboats*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=4466&type=Category&item=Water&parent=Transportation&grandparent= (accessed March 18, 2013).

Stone, C.G., and W.V. Bush. 1984. *General Geology and Mineral Resources of the Caddo River Watershed.* Information Circular 29, AR Geologic Commission, 32.

The City Wire. 2009. *Lake Fort Smith*. TheCityWire.com. http://www.thecitywire.com/node/4656#.Uo4s6Z3nbcs (accessed 11 21, 2013).

The Nature Conservancy. 2013. *Arkansas Mulberry River Preserve.* http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/arkansas/placesweprotect/mulberry-river-preserve.xml (accessed April 2, 2013).

The Nature Conservancy. 2006. *Multi-site Management Plan - Ecoregional Conservation for the Ouachita Ecoregion Arkansas and Oklahoma*. DENIX: DoD Environment, Safety, and Occupational Health Network and Information Exchange. http://www.denix.osd.mil/nr/upload/Multisite-Management-Plan-for-Ouachitas.pdf (accessed January 31, 2014).

Tradewind. n.d. *Find Lakes: Lake Shepherd Springs.* http://findlakes.com/lake_shepherd_springs_arkansas~ar00445.htm (accessed September 2013).

University of Arkansas at Little Rock Institute for Economic Advancement. 2002. *Index for Arkansas State and Counties Population and Social/Economic Characteristics by County 1990 Census of Population and Housing.* http://iea.ualr.edu/arkansas-census-data.html?id=174:index-for-arkansas-state-and-counties&catid=1 (accessed June 18, 2013).

University of Georgia - Center for Invasive Species and Ecosystem Health. 2013. *Invasive Plant Atlas of the United States.* www.invasiveplantatlas.org (accessed December 20, 2013).

US Census Bureau. n.d.a. *DP03 - Selected Economic Characteristics, 2007-2011 American Community Survey 5-year Estimates.* http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_11_5YR_DP03 (accessed March 18, 2013).

US Census Bureau. n.d.b. *American FactFinder*. DP-1 Profile of General Population and Housing Characteristics:2010. http://factfinder2.census.gov/faces/nav/jsf/pages/community_facts.xhtml#none (accessed March 25, 2013).

US Census Bureau. 1989. *1987 Census of Agriculture Volume 1 Geographic Area Series Part 4 Arkansas State and County Data.* Washington, DC: US Government Printing Office.

US Census Bureau. 1992. *1992 Economic Census Area Profiles - AR.* http://www.census.gov/epcd/www/92profiles/www/EC92AR.HTM.

US Census Bureau. 1993. *1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR), Arkansas.* Washington, DC: US Government Printing Office.

US Census Bureau. 2003. *Arkansas: 2000 Population and Housing Unit Counts.* Washington DC: US Census Bureau.

US Census Bureau. 2011a. *Urban Area Criteria for the 2010 Census*. Federal Register, 76(164): 5303-53043.

US Census Bureau. 2011b. *EC0700A1, All Sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007 Economic Census*. American FactFinder. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_00A1&prodType=table (accessed March 26, 2013).

US Census Bureau. 2012a. *Arkansas 2010: Population and Housing Unit Counts.* Washington, DC: US Department of Commerce.

US Census Bureau. 2012b. *Table 20. Large Metropolitan Statistical Areas - Population: 1990 to 2010.* Washington, DC: US Census Bureau.

US Census Bureau. 2014. *National Survey of Fishing, Hunting, & Wildlife-Associated Recreation (FHWAR).* http://www.census.gov/prod/www/fishing.html (accessed February 4, 2014).

US Congress. 1992. *Clean Vessel Act of 1992.* Digest of Federal Laws of Interest to the U.S. Fish and Wildlife Service. http://www.fws.gov/laws/lawsdigest/clenves.html (accessed July 12, 2013).

US Nuclear Regulatory Commission. 2013. *About NRC.* July http://www.nrc.gov/about-nrc.html (accessed October 31, 2013).

USACE. n.d. *US Army Corps of Engineers Little Rock District.* http://www.swl.usace.army.mil/Missions/Recreation/Lakes/ (accessed September 2013).

USACE. 2011. V*alue to the Nation Fast Facts. State Level Report - Arkansas.* http://www.corpsresults.us/recreation/fastfacts/stateReport.cfml?State=12 (accessed October 2013).

USACE. 2012. *www.swd.usage.army.mil.* http://www.swd.usace.army.mil/Portals/42/docs/civilworks/Fact%20Sheets/Little%20Rock/FY13%20Arkansas%20River%20Levees,%20AR.pdf (accessed October 09, 2013).

USACE. 2012. *Fiscal Year 2013 - Civil Works Budget for the US Army Corps of Engineers*. US Army Corps of Engineers. http://www.usace.army.mil/portals/2/docs/civilworks/press_book/budget2013.pdf (accessed January 10, 2014).

USACE. 2013. *Regulatory In-lieu Fee and Bank Information Tracking System (RIBITS).* https://rsgisias.crrel.usace.army.mil/ribits/f?p=107:158:2210333181022334::NO:RP:P27_BUTTON_KEY:1 (accessed November 18, 2013).

USACE Little Rock District. n.d. *Navigation.* http://www.swl.usace.army.mil/Missions/Navigation.aspx (accessed 09 2013).

USACE Little Rock District. 1988a. *Arkansas State Water Plan, Arkansas River Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

USACE Little Rock District. 2004. *Navigable Streams*.

USDA National Agricultural Statistics Service. 1992. *The Census of Agriculture*. 1992 Census Publications - Arkansas. http://www.agcensus.usda.gov/Publications/1992/Volume_1_Chapter_2_County_Tables/Arkansas/index.asp (accessed February 4, 2014).

USDA National Agricultural Statistics Service. 2007. *2007 Census of Agriculture State Profile, Arkansas.* Washington, DC: USDA National agricultural Statistics Service.

USDA National Agricultural Statistics Service. 2009. *2007 Census of Agriculture Arkansas State and County Data Volume 1 Geographic Area Series Part 4.* Washington, D.C.: USDA National Agricultural Statistics Service..

USFS. 2013. *Forest Inventory Data Online (FIDO).* http://apps.fs.fed.us/fia/fido/index.html (accessed September 13, 2013).

USFWS. n.d.a. *Holla Bend National Wildlife Refuge.* http://www.fws.gov/refuges/profiles/index.cfm?id=43590 (accessed January 31, 2014).

USFWS. n.d.b. *Arkansas' Federally Endangered, Threatened, and Candidate Species.* http://www.fws.gov/arkansas-es/docs/ESDay/Photographs%20of%20Endangered%20Species%20in%20Arkansas.pdf (accessed January 28, 204).

USFWS. 2007. *Best Management Practices for Fayetteville Shale Natural Gas Activities.* Conway: US Fish and Wildlife Service.

USFWS. 2013. *Endangered Species Act: Overview.* http://www.fws.gov/endangered/laws-policies/index.html (accessed March 13, 2013).

USGS. 2013a. *Surface-water monthly statistics for the nation.* http://waterdata.usgs.gov/nwis/monthly/?referred_module=sw (accessed June 19, 2013).

USGS. 2013b. *Friday Storms Caused Record Flooding on Fourche LaFave River in Scott and Yell Counties.* USGS Newsroom: 1.

USGS. 2013c. *USGS Water-Quality Data for Arkansas.* http://waterdata.usgs.gov/ar/nwis/qw (accessed October 1, 2013).

USGS. 2013d. *NAS - Non Aquatic Species.* http://nas.er.usgs.gov/default.aspx (accessed December 19, 2013).

Vance, David L. 2012. *Russellville (Pope County).* The Encyclopedia of Arkansas History & Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=963 (accessed October 22, 2013).

Warner, Nathaniel R., et al. 2013. *Geochemical and isotopic variations in shallow groundwater in areas of the Fayetteville shale development, north-central Arkansas.* Applied Geochemistry. http://dx.doi.org/10.1016/j.apgeochem.2013.04.013 (accessed May 31, 2013).

Weakley, A., E. Dinerstein, R. Noss, S. Robinson, J. Strittholt, and J. Adams. 2013. *Ozark Mountain forests.* http://worldwildlife.org/ecoregions/na0412 (accessed December 18, 2013).

West River Valley RSWMD. 2011. *West River Valley RWSMD Regional Solid Waste Management Plan.* Little Rock: ADEQ.

Wiest, Jason. 2011. D*oes the Future Hold Water For Arkansas?* inarkansas.com,

Winthrop Rockefeller Foundation. 2008. *Water Issues in Arkansas: A Companion Report to "Water Issues in Arkansas - An Unfinished Story" Summary Report.* Little Rock, AR: Winthrop Rockefeller Foundation.

Woods, Alan J et al. 2004. *Ecoregions of Arkansas (color poster with map, descriptive text, summary tables, and photographs).* Reston, VA: US Geological Survey.

APPENDIX A

2008 303(d) List of Impaired Waterbodies in the WAWRPR

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
3C – Arkansas River & tributaries: Lock & Dam 4 and 7*	96.3	96.3	Aquatic life	20.4	DO	20.4	Unknown
					Copper	20.4	Unknown
					Zinc	11.2	Unknown
			Drinking water	11.2	Sediment/ siltation	11.2	Unknown
					Beryllium	17.9	Unknown
			Primary contact recreation	20.4	Pathogens	20.4	Unknown
			Total	20.4			
3D – Arkansas River & tributaries: Lock & Dam 7 to Morillton*	179.3	168.2	Aquatic life	26.8	Copper	11.2	Agriculture
					Sediment/ siltation	15.6	Erosion
					Zinc	11.2	Agriculture
3E – Fourche LaFave River	211.5	201.3	Fish consumption	8.7	Mercury	8.7	Unknown
			Aquatic life	145.3	DO	126.7	Unknown
					Sediment/ siltation	20.2	Erosion
					pH	43.8	Unknown
			Total	154			
3F – Arkansas River*	283.2	164.3	Aquatic life	28	DO	2	Hydropower
					Ammonia	3	Municipal WWTP
					Copper	10	Municipal WWTP
					Nitrate	13	Municipal WWTP
					Zinc	3	unknown
					Sediment/ siltation	10	Unknown

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
			Agriculture & industrial water supply	9.4	TDS	9.4	Unknown
			Total	34.4			
3G – Petit Jean River & tributaries	198.5	153.5	Aquatic life	48.2	DO	28.9	Unknown
					Sediment/ siltation	19.3	Unknown
			Drinking water supply	21.6	Beryllium	21.6	Unknown
			Total	50.2			
3H – Arkansas River & tributaries: state line to river mile 210*	707.2	539.3	Aquatic life	24	Copper	14.9	Municipal WWTP
					pH	9.1	Unknown
			Agriculture & industrial water supply	12.4	TDS	12.4	Unknown
			Agriculture & industrial water supply, drinking water	11	Chloride	11	Unknown
			Primary contact recreation	47.8	Pathogens	47.8	Unknown
			Total	115.7			
3I – Poteau River	105.3	55.8	Aquatic life	14.8	DO	2	Unknown
					Copper	6.6	Industrial point source
					Total phosphorus	6.6	Municipal WWTP
					Sediment/ siltation	14.8	Erosion

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
					Zinc	8.6	Unknown, municipal WWTP
			Drinking water, agriculture & industrial water supply	6.6	Chloride	6.6	Municipal WWTP, industrial point source
					Sulfate		
					TDS		
			Total	21.4			
Total	1781.3	1378.7		394.1			

* A portion of this planning segment is in another water resources planning region. Values shown are for stream segments in the WAWRPR.

ftn Associates Ltd.
water resources / environmental consultants

Arkansas Waterplan
Essential For Life

ARKANSAS WATER PLAN UPDATE
TASK NO. 6 – SOUTH-CENTRAL ARKANSAS WATER RESOURCES PLANNING REGION

AUGUST 11, 2014

ARKANSAS WATER PLAN UPDATE
TASK NO. 6 – SOUTH-CENTRAL ARKANSAS
WATER RESOURCES PLANNING REGION

Prepared for

Arkansas Natural Resources Commission
101 East Capitol Avenue, Suite 350
Little Rock, AR 72201-3813

Prepared by

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, Arkansas 72211

FTN No. R03015-0003-001

August 11, 2014

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF APPENDICES

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

LIST OF ABBREVIATIONS AND ACRONYMS

ACS	American Community Survey
ADEQ	Arkansas Department of Environmental Quality
ADH	Arkansas Department of Health
ADPCE	Arkansas Department of Pollution Control & Ecology (now ADEQ)
AGFC	Arkansas Game and Fish Commission
AHF	anhydrous hydrogen fluoride
AHTD	Arkansas State Highway and Transportation Department
ANHC	Arkansas Natural Heritage Commission
ANRC	Arkansas Natural Resources Commission
APCEC	Arkansas Pollution Control and Ecology Commission
AP&L	Arkansas Power & Light
ASWCC	Arkansas Soil and Water Conservation Commission (now ANRC)
AWAG	Arkansas Watershed Advisory Group
AWP	Arkansas Water Plan
CAW	Central Arkansas Water
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
COPC	Contaminant of Potential Concern
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
CWA	Clean Water Act
DCE	dichloroethene
DDD	dichlorodiphenyldichloroethane
DDT	dichlorodiphenyltrichloroethane
DO	dissolved oxygen
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FEMA	Federal Emergency Management Agency
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
GCGW	Governor's Commission on Global Warming
gpm	gallons per minute
HUD	United States Department of Housing and Urban Development
LDNR	Louisiana Department of Natural Resources
MCL	maximum contaminant level
MEK	methyl ethyl ketone
mg/L	milligrams per liter
mgd	million gallons per day
MS4	municipal separate storm sewer system
n.d.	no date
NCDC	National Climatic Data Center

LIST OF ABBREVIATIONS AND ACRONYMS (CONTINUED)

NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NRCS	Natural Resources Conservation Service
NTU	Nephelometric turbidity unit
NWIS	National Water Information System
NWR	National Wildlife Refuge
PCBs	polychlorinated biphenyls
PCE	perchloroethylene
PCP	phencyclidine
PDSI	Palmer Drought Severity Index
RCRA	Resource Conservation and Recovery Act
RSWMD	Regional Solid Waste Management District
SCAWRPR	South-Central Arkansas Water Resources Planning Region
SDWA	Safe Drinking Water Act
SFHA	Special Flood Hazard Area
SGCN	Species of greatest conservation need
TCA	trichloroethane
TCE	trichloroethene
TDS	total dissolved solids
TMDL	total maximum daily load
TOC	total organic carbon
TSCA	Toxic Substances Control Act
TSS	total suspended solids
U of A	University of Arkansas
UCWCB	Union County Water Conservation Board
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
USFS	USDA Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VOC	volatile organic compound
WHIP	Wildlife Habitat Incentives Program
WMA	Wildlife Management Area
WRDA	Water Resources Development Act
WRPR	Water Resources Planning Region

1.0 INTRODUCTION

The Arkansas Natural Resources Commission (ANRC) is responsible for preparing and periodically updating a statewide water resources planning document. The previous update of the Arkansas Water Plan (AWP) was completed in 1990. In 2012, ANRC initiated an update of the 1990 AWP to be completed in 2014.

This document was prepared as part of the 2014 update of the AWP (Project Task 6). This document provides background information about the South-Central Arkansas Water Resources Planning Region (SCAWRPR) that will be used in the 2014 AWP update. The SCAWRPR is one of five state water resources planning regions being addressed in the 2014 AWP update. The information in this document will serve as background for updated discussion and analysis of state water supplies, water demand, and alternatives for meeting the water resources needs in the SCAWRPR. This background information includes a description of the history of the planning region, its physical characteristics, natural resources, water resources, demographics, and economy. Finally, the regulatory and institutional framework for water resources management in this planning region is outlined.

2.0 GEOGRAPHY AND HISTORY

This section provides a general description of the geography of the SCAWRPR, a brief history of the regional culture, and an overview of historical water resources management in the region.

2.1 Geography

The SCAWRPR encompasses approximately 12,000 square miles in central south Arkansas (Figure 2.1). This region is bounded on the south by Louisiana. The remainder of the boundary of the SCAWRPR roughly corresponds to the hydrologic boundary of the Ouachita River basin. All or part of 21 counties fall within the SCAWRPR. Table 2.1 lists these counties, the area of each county that is in the SCAWRPR, and the corresponding percentage of the county in the SCAWRPR. Major cities in the SCAWRPR include Benton, Hot Springs, Malvern, Arkadelphia, Camden, and El Dorado.

2.2 History

Water resources have influenced the history of this region, and the current condition of water resources in the region is a product of human activities throughout its history. The cultural history of the region is outlined below. The history of water resources development in the planning region is summarized separately.

2.2.1 Cultural

Native Americans settled the SCAWRPR prior to European exploration and settlement. The Caddo tribe was well established in this region when Europeans first explored the region. They lived and farmed in the valleys and river bottoms. The Caddo were a mound-building culture. They used novaculite found in the region to make arrowheads and for trade (Department of Arkansas Heritage 2013a, Department of Arkansas Heritage 2013b, Early 2012, Foti 2008). The Caddo also used and traded salt they made from natural brine seeps that occur in the area (Early 2010).

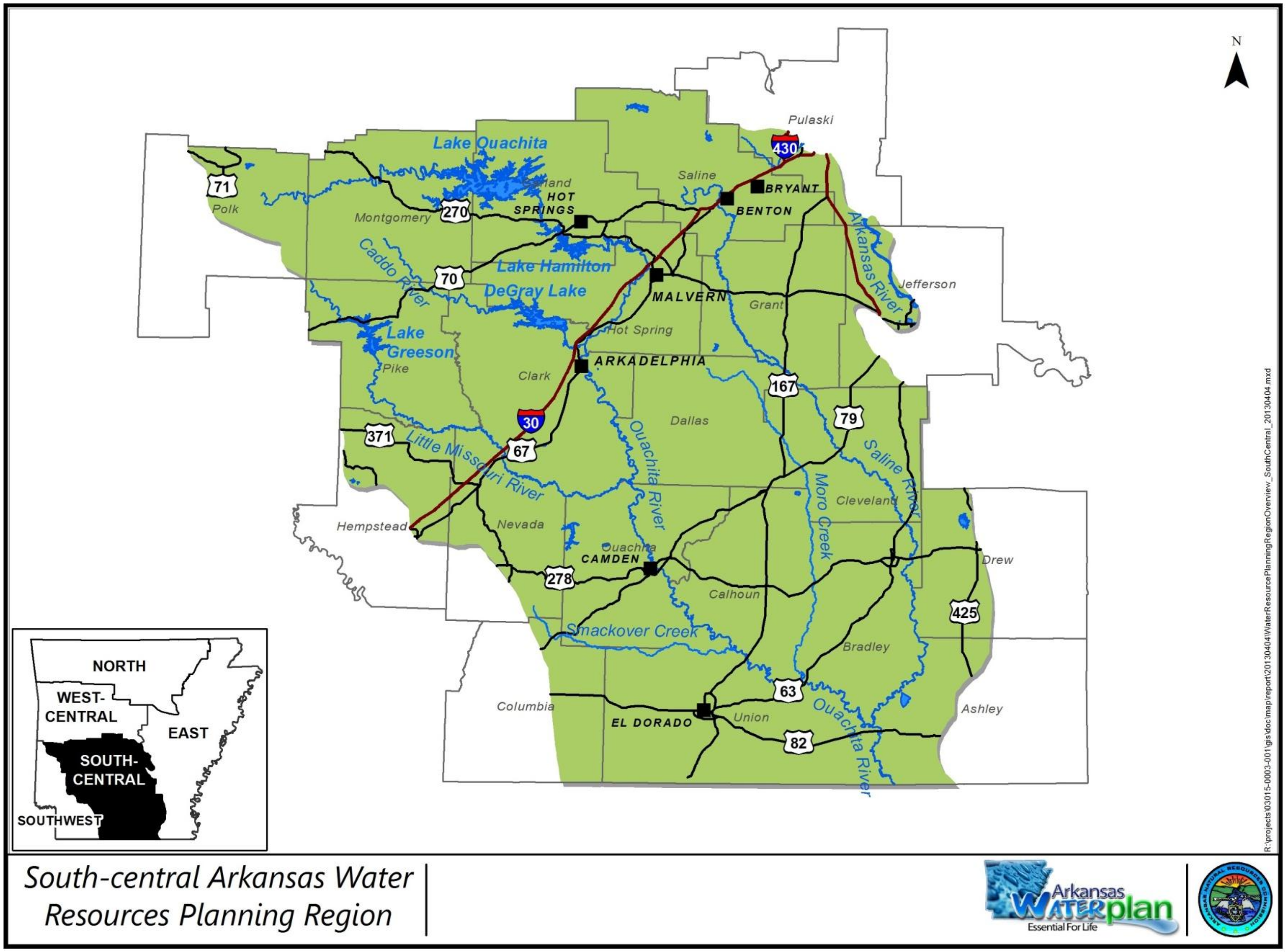

Figure 2.1. Map of the SCAWRPR.

Table 2.1. Counties in the SCAWRPR.

County	County Area in Planning Region (square miles)	Percentage of County Area in Planning Region
Ashley	317.5	33.8%
Bradley	652.4	100.0%
Calhoun	631.9	100.0%
Clark	882.2	100.0%
Cleveland	598.5	100.0%
Columbia	261.6	34.1%
Dallas	667.5	100.0%
Drew	314.2	37.6%
Garland	734.0	100.0%
Grant	632.5	100.0%
Hempstead	323.7	43.7%
Hot Spring	621.7	100.0%
Jefferson	247.9	27.1%
Montgomery	800.3	100.0%
Nevada	470.1	75.8%
Ouachita	739.2	100.0%
Pike	613.5	100.0%
Polk	319.7	37.1%
Pulaski	145.2	18.0%
Saline	729.9	100.0%
Union	1054.5	100.0%
Total	**11,758**	**--**

Hernando de Soto's Spanish expeditionary force were the first Europeans in the SCAWRPR, arriving in 1541. They passed through the region in 1541 on their way to southeastern Arkansas, where Hernando de Soto died in 1542. Under new leadership, the expedition then travelled to the Red River, passing through the region, and, finally, back to the Mississippi River, passing through the region once more (Key 2012).

Some 130 years later, French explorers, hunters, traders, and missionaries began exploring this region, establishing alliances with the Quapaw and Caddo Indians, and leaving behind French place-names. In 1682, French explorer La Salle claimed the region for France. In 1685, La Salle attempted to lead a group of colonists into the region from the Gulf Coast. La Salle and many of the colonists died, and other colonists were captured by the Spanish, but a few survivors did succeed in making their way to southern Arkansas, and eventually to the Arkansas River. In 1762, after the end of the French-Indian War, the SCAWRPR came under

Spanish control. Between the time of the La Salle expedition and the war, French hunters became established in the planning region, travelling along the Ouachita River and its tributaries, particularly the Saline River where natural salt licks attracted game. French hunters and traders remained in the area after the Spanish took over, and were joined by hunters and traders of other nationalities. In the 1780s, the Spanish attempted to establish a post on the Ouachita River near present-day Camden. They finally succeeded in establishing a post farther downstream, in what is now Louisiana. With the Louisiana Purchase in 1803, the territory that would become Arkansas became part of the United States (Key 2012).

At the time of the Louisiana Purchase, the Quapaw claimed the territory between the Arkansas and Red rivers, which included the SCAWRPR. In 1818, they signed a treaty where their lands were reduced to the area bounded by the Arkansas, Ouachita, and Saline Rivers. By 1825, the Quapaw were forced to move out of Arkansas to Louisiana so settlers could grow cotton.

In 1804, President Jefferson authorized exploration of the southwest portion of the Louisiana Purchase. This resulted in William Dunbar and George Hunter leading an expedition up the Ouachita River to Hot Springs.

The first significant settlement in the SCAWRPR occurred in the northern part of the region, along the Southwest Trail. Cotton plantations were established in the southern area of the planning region. By 1860, the planning region was one of the most heavily populated areas of the state due to the expansion of cotton production. At that time, Camden was one of the centers of political and commercial power in the state due to cotton agriculture. The first large-scale manufacturing operation in the state, a textile mill, was constructed in Pike County just before the Civil War (Bolton 2012).

A saltworks was established on the Saline River near Benton County around 1827 (Woodard 2012).

During the Civil War, there were a number of battles in the SCAWRPR. Several significant battles occurred in 1864 and 1865 when the Union army launched a large-scale military operation intended to move south from Little Rock to Shreveport, Louisiana. The Union army made it as far south as Camden and then was forced back to Little Rock. In 1862, Hot Springs served as the temporary state capital for several months.

After the Civil War, cotton plantations in the SCAWRPR were converted to tenant farms, or were operated using paid labor. However, cotton prices fell after the war, remaining low through the 1890s. As a result, many cotton operations were forced to shut down. In the 1930s, cotton production in the region declined, and soybean and rice production began to increase (Hawkins 2011).

In 1875, a railroad line was completed to Hot Springs to transport tourists, patients, and goods (Lancaster 2012a). In 1882, part of the Texas and St. Louis railroad line was constructed through Pine Bluff, Rison, Fordyce, and Camden. The primary purpose of this line was to transport cotton (Zbinden 2011).

The railroad also brought lumber entrepreneurs into the SCAWRPR. The first Arkansas lumber companies in the region were founded in the 1890s. By the early 1920s, nearly all the virgin timber in the state had been cut. Taking advantage of the relatively rapid regrowth rate of timber, local lumber companies began operating pine plantations in the region. The first paper mill in the region was opened in Camden in 1928 by International Paper. Other wood products-manufacturing operations established in the planning region included wood-based chemicals, food board, flake board, and plywood (Balogh 2013). By the end of the 1960s, local lumber companies had been taken over by national and international companies like International Paper and Georgia-Pacific (Balogh 2013, Moneyhon 2013).

Exploration for oil and gas began in the SCAWRPR in the early 20th century. Discovery of oil in 1920 set off an oil boom in south Arkansas in 1921. By 1922, 900 oil wells were in operation in the state. El Dorado became the center of the oil industry in Arkansas. Murphy Oil and Lion Oil companies were founded in the region in the early 1920s. The peak of the oil boom occurred in 1925. At that time, oil was being produced more rapidly than it could be transported to refineries. When production dropped in the late 1920s, several lawsuits were filed against Arkansas oil companies to require more responsible management of oil and gas resources. The Arkansas Oil and Gas Commission was established in 1939. Twelve major oil pools were discovered in the planning region between 1936 and 1947 (Bridges 2011).

2.2.2 Water Resources Development

A range of water resources development activities have occurred in this region throughout its history, as attitudes and policies have changed. Historically, human activities that have affected water resources in this planning region have included draining and clearing of wetlands, levee building, river transportation and navigation, development of surface water and ground water for water supply and hydropower, changes in cropping, wildlife habitat and wetland conservation, and development of the recreation industry in the region.

2.2.2.1 Navigation

During the territorial period, rivers were important means of transportation throughout Arkansas. The Ouachita River linked southern Arkansas to New Orleans. The first steamboat navigated the Ouachita River in 1819. Steamboat traffic on the Ouachita River was the primary mode of transportation in the region until around 1910. During high water, steamboats travelled as far upriver as Camden and Arkadelphia (Gore 2009). Steamboats also navigated the Saline River as far upstream as Bridges Bluff in Cleveland County. Fifty-four steamboats have been documented operating on the Saline River (Woodard 2012).

The Ouachita-Black Rivers Navigation Project was initiated in 1902. Construction of the six locks and dams was completed in 1924. The navigation project maintains naviation on the Ouachita River from Camden downstream to the Black River (USACE Vicksburg District 2013b). In Arkansas, the Ouachita River – Black River navigation project consists of two locks and dams constructed on cutoff canals. A 9-ft navigation channel is maintained in the Ouachita River to Camden by dredging and snagging. There are two public ports on the Ouachita River in Arkansas, at Crossett and Camden (Figure 2.2). Commercial navigation on the Ouachita River is feasible year-round in Arkansas.

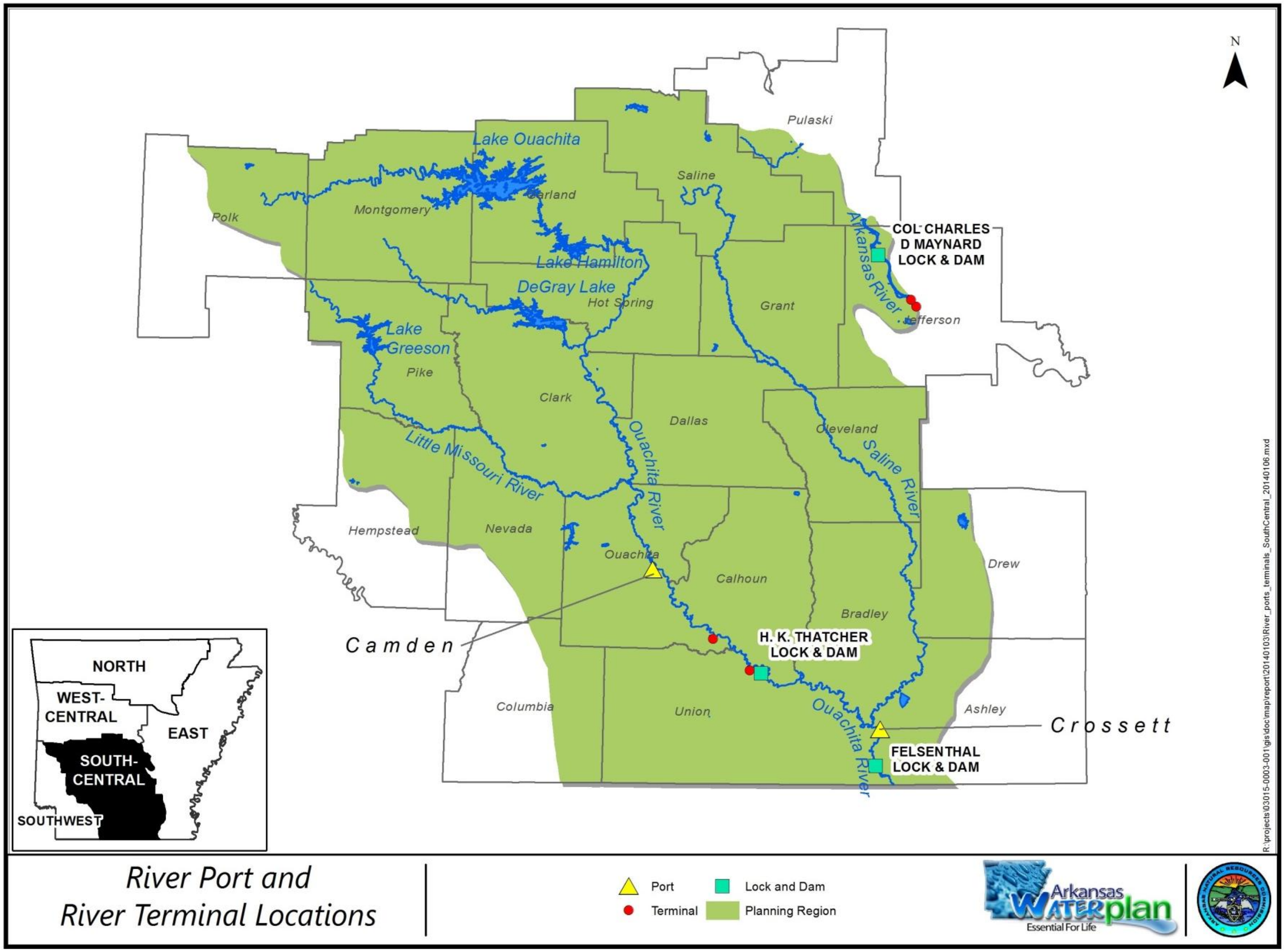

Figure 2.2. Facilities of the Ouachita-Black Rivers Navigation System within the SCAWRPR.

2.2.2.2 Flood Control

In 1870, the US Congress authorized a survey of the Ouachita River to investigate improving navigation and flood prevention (Lancaster 2012b). The Flood Control Act of 1937 proposed that every major stream in the Ouachita River watershed be dammed (Woodard 2012). The Flood Control Act of 1941 authorized construction of the Narrows Dam on the Little Missouri River for flood control. The dam was completed in 1950 (Lancaster 2011).

2.2.2.3 Hydropower

The first hydroelectric power facility in Arkansas was Remmel Dam, constructed on the Ouachita River in 1924. This facility was constructed by Arkansas Power & Light (AP&L). In 1931, AP&L finished construction of Carpenter Dam, a second hydroelectric power facility, upstream of Remmel Dam on the Ouachita River (Reynolds 2013).

Beginning in 1938, the US Army Corps of Engineers (USACE) began constructing hydropower dams in Arkansas (Reynolds 2013). Construction of Blakely Mountain Dam on the Ouachita River upstream of the AP&L reservoirs was initiated by USACE in 1946. This project was initially planned as a joint project by USACE and AP&L. The power plant was completed and began operation in 1955 (Lancaster 2012a). The DeGray Lake dam hydropower project on the Caddo River was authorized by the 1950 River and Harbors Act. Funds were appropriated for the project in 1961. Construction was initiated in 1964 and completed in 1966 (Lancaster 2012c).

2.2.2.4 Commercial Fishing

Commercial fishing played an important role in the SCAWRPR during settlement and early development. Historical records indicate that commercial fishing occurred on the Ouachita River during the 19th century, though takes were not as large as from other rivers in the state (Townsend 1902, US Commisison of Fish and Fisheries 1895). In recent history, there have not been significant amounts of fish taken commercially from the Ouachita River in Arkansas (Robison and Buchanan 1988). Both the Ouachita River and Saline River are mentioned in the current state commercial fishing regulations (AGFC 2013a).

In the 1890s, pearl fishing was fashionable on the Saline River (Woodard 2012).

2.2.2.5 Red River Compact

In 1955, the US Congress authorized Texas, Oklahoma, Arkansas, and Louisiana to begin negotiating a compact to resolve disputes over rights to water in the Red River and its tributaries, as well as preventing future disputes. In 1978, after 23 years of negotiations, representatives of Texas, Oklahoma, Arkansas, and Louisiana signed the Red River Compact (Lancaster 2011). The purpose of the compact is to provide for equitable apportionment of the waters of the Red River and its tributaries among the four states to ensure conservation and protection of this shared resource.

2.2.2.6 Health Spas

The thermal springs of Hot Springs in Garland County were first used by native Americans (Lancaster 2012d). After the Louisiana Purchase, President Jefferson commissioned an expedition led by William Dunbar and Dr. George Hunter to travel up the Ouachita River to the already famous hot springs in what would become Garland County. The expedition arrived at the springs in 1804 and conducted studies of the springs. They noted evidence of use of the springs by locals (Shugart 2013).

Over the period from 1807 through 1830, settlement around the springs and visitors to the springs increased. There was dispute among the locals and the state legislature about whether the hot springs and surrounding area should be developed as a private health spa, or as a public resource. In 1832, the US Congress set aside the area as a federal reservation, the first national park. The thermal springs were not significantly developed until the 1880s. At that time, the first hospital was built, as well as the bathhouses, establishing the area as a health spa resort (Shugart 2013).

The Parnell Springs in Bradley County were also developed into a health resort sometime prior to 1880. Between 1880 and the 1920s, the healing Parnell Springs were the center of a booming health resort. The resort closed during the Depression (Moseley 2011).

2.2.2.7 Bottled Water

A number of springs throughout the SCAWRPR have been developed through the bottled water industry. Table 2.2 lists the springs in the planning region where water is bottled for sale.

Mountain Valley Spring Water, the company that bottles water from the Hot Springs area, is probably the oldest bottled water company in the planning region. This company began operations in Garland County in the early 1870s (Speed 2007).

Table 2.2. Bottled spring water in the SCAWRPR (Arkansas Geological Survey 2012a).

Company	Springs	County	Start of Operations
Mountain Valley Spring Water	Diamond Spring	Garland	1871
Monticello Spring Water Company[a]	Unnamed	Montgomery	1923
Alexa Springs[b]	Unnamed	Montgomery	Unknown
Crystal Springs Bottled Water[c]	Wilderness Valley Spring	Polk	Unknown
Mountain Pure LLC[d]	Walker Spring	Montgomery	Unknown
CG Roxane, LLC[e]	Cox Spring	Montgomery	2007

Notes: a. http://www.monticellospringwater.com/
b. http://www.alexasprings.com
c. http://www.crystalh2o.com/products_office.html
d. http://www.mtnpurewater.com/home.htm
e. http://www.crystalgeyserasw.com/resources.html

2.2.2.8 Waterfowl and Aquatic Habitat Conservation

Just after the turn of the 20th century, preservation of migratory waterfowl became a national priority (Morrow n.d.). The Arkansas Game and Fish Commission (AGFC) began establishing wildlife management areas (WMAs) in the region in the 1960s (Table 2.3). The US Fish and Wildlife Service (USFWS) established a National Wildlife Refuge (NWR) in the area for protection of habitat migratory waterfowl in 1975. The Arkansas Natural Heritage Commission (ANHC) has established several state natural areas in the planning region to protect aquatic and wetland habitats.

After passage of the Flood Control Act of 1937, plans were developed for damming the Saline River for the purpose of flood control, hydropower, lake recreation, and water supply. However, this plan was met by opposition from local citizens and elected officials who wanted to preserve the river in its free-flowing state. Plans to dam the Saline River languished until the 1970s when it was officially rejected by Arkansas Governor David Pryor.

Table 2.3. History of WMAs in the SCAWRPR (AGFC 2011, USFWS 2013d, ANHC 2010).

Name	Type	Area (acres)	Counties	Year Established	Management	Purpose	Other
Beryl Anthony Lower Ouachita	WMA	7,500	Ashley, Union	1987	AGFC	Hunting, fishing, and other outdoor recreational activities	
Felsenthal	NWR	65,000	Ashley, Bradley, Union	1975	USFWS	Habitat for migratory waterfowl, hunting, fishing	World's largest green-tree reservoir
Big Timber	WMA		Clark	1988	AGFC	Hunting and outdoor recreation	
DeGray Lake	WMA		Clark, Hot Spring		USACE		
Electric Island	WMA		Garland		AGFC		
Winona	WMA	160,000	Garland, Perry, Saline	1968	US Department of Agriculture (USDA), Weyerhaeuser	Wildlife enhancement	
Caney Creek	WMA	85,000	Howard, Montgomery, Pike, Polk	1968	USDA Forest Service (USFS)	Wildlife enhancement	
Muddy Creek	WMA	150,000	Montgomery, Scott, Yell	1968	USFS, Weyerhaeuser	Wildlife enhancement	
Poison Springs	WMA	22,162	Nevada, Ouachita	1972	ANHC, AGFC, Arkansas Forestry Commission	Hunting and other outdoor activities	
Two Bayou Creek	WMA		Ouachita		AGFC	Hunting	
Lake Greeson	WMA	36,200	Howard, Pike	1981	Weyerhaeuser, USACE, private	Wildlife habitat, public hunting	
Longview Saline	Natural Area	2,215	Ashley	2011	ANHC	Protection of water quality and endangered mussels	

Table 2.3. History of WMAs in the SCAWRPR (continued).

Name	Type	Area (acres)	Counties	Year Established	Management	Purpose	Other
Moro Big Pine	Natural Area, WMA	120,000	Calhoun	2007	ANHC	Habitat protection	Best and largest remaining loblolly pine flatwoods in Arkansas
Moro Creek Bottoms	Natural Area	81.1	Cleveland	1987	ANHC	Habitat protection	
Mills Park	Natural Area	10.5	Saline	1990	City of Bryant	Ecosystem protection	
Lorance Creek	Natural Area	294.3	Pulaski, Saline	1990	ANHC	Ecosystem preservation	
Middle Fork Barrens	Natural Area	135.98	Saline	2004	ANHC	Ecosystem preservation	
Gap Creek	Natural Area	10.07	Montgomery	1981	ANHC	Preservation, water quality	
Big Fork Creek	Natural Area	13.58	Polk	1978	ANHC	Preservation of creek and spring ecosystems	
Arkansas Oak	Natural Area	200.27	Nevada	1980	ANHC, AFC	Preservation of creek bottom and seep ecosystems	
Logoly	Natural Area, State Park	200	Columbia	1979	ANHC, Arkansas State Parks	Education, preservation of spring and moist ravine ecosystems	
Kingsland Prairie	Natural Area	399.19	Cleveland	2009	ANHC	Seasonally-wet depression ecosystem preservation	

In 1968, the National Wild and Scenic Rivers System was created to preserve free-flowing rivers with outstanding recreational, cultural, and/or natural features. In 1979, the Arkansas Natural and Scenic Rivers System was created (ANHC 2012). The Saline River was designated as an Arkansas Natural and Scenic River by the Arkansas legislature in 1985 (Table 2.4) (Arkansas Code 15-23-313). In 1992 a portion of the Little Missouri River was added to the National Wild and Scenic Rivers System (Interagency Wild and Scenic Rivers Council n.d.).

Table 2.4. Natural/wild and scenic rivers in the SCAWRPR (ANHC 2012, Interagency Wild and Scenic Rivers Council n.d.).

River	System	Length (miles)	County	Year designated	Agency
Saline River	State	157	Ashley, Bradley, Cleveland, Drew, Grant	1985	ANHC
Little Missouri River	National	15.7	Montgomery, Polk	1992	USFS

3.0 PHYSICAL CHARACTERISTICS

This section summarizes the physical and biological characteristics of the SCAWRPR. This includes the physiography, geology, climate, and land use, as well as descriptions of the ecological, surface water, and groundwater resources within the planning region.

3.1 Physiography

Arkansas is typically divided into two major physiographic regions. These are the Interior Highlands of northern Arkansas, and the Gulf Coastal Plain of southern and eastern Arkansas. These regions are further divided into smaller physiographic provinces based on topography and geology. The "fall line" is where the two major physiographic regions in Arkansas meet.

The SCAWRPR is located primarily in the Gulf Coastal Plain physiographic region, with a part of the Interior Highlands included in the northern portion of the planning region. The physiographic subdivision of the Gulf Coastal Plain that occurs in the planning region is the West Gulf Coastal Plain province (Figure 3.1). The physiographic subdivision of the Interior Highlands that occurs in the planning region is the Ouachita Mountain province (Figure 3.1) (Fugitt, ANRC, personal communication, April 9, 2013).

3.1.1 West Gulf Coastal Plain Province

The West Gulf Coastal Plain physiographic province accounts for the majority of the area of the SCAWRPR (Figure 3.1). The West Gulf Coastal Plain is characterized as a south-sloping plain with gently rolling hills and broad, level to nearly level stream valleys. This area is only moderately dissected by streams. Elevations range from over 500 feet in the northern uplands to less than 50 feet (the lowest elevation in the state) along the Ouachita River at the Louisiana border (Woods et al. 2004).

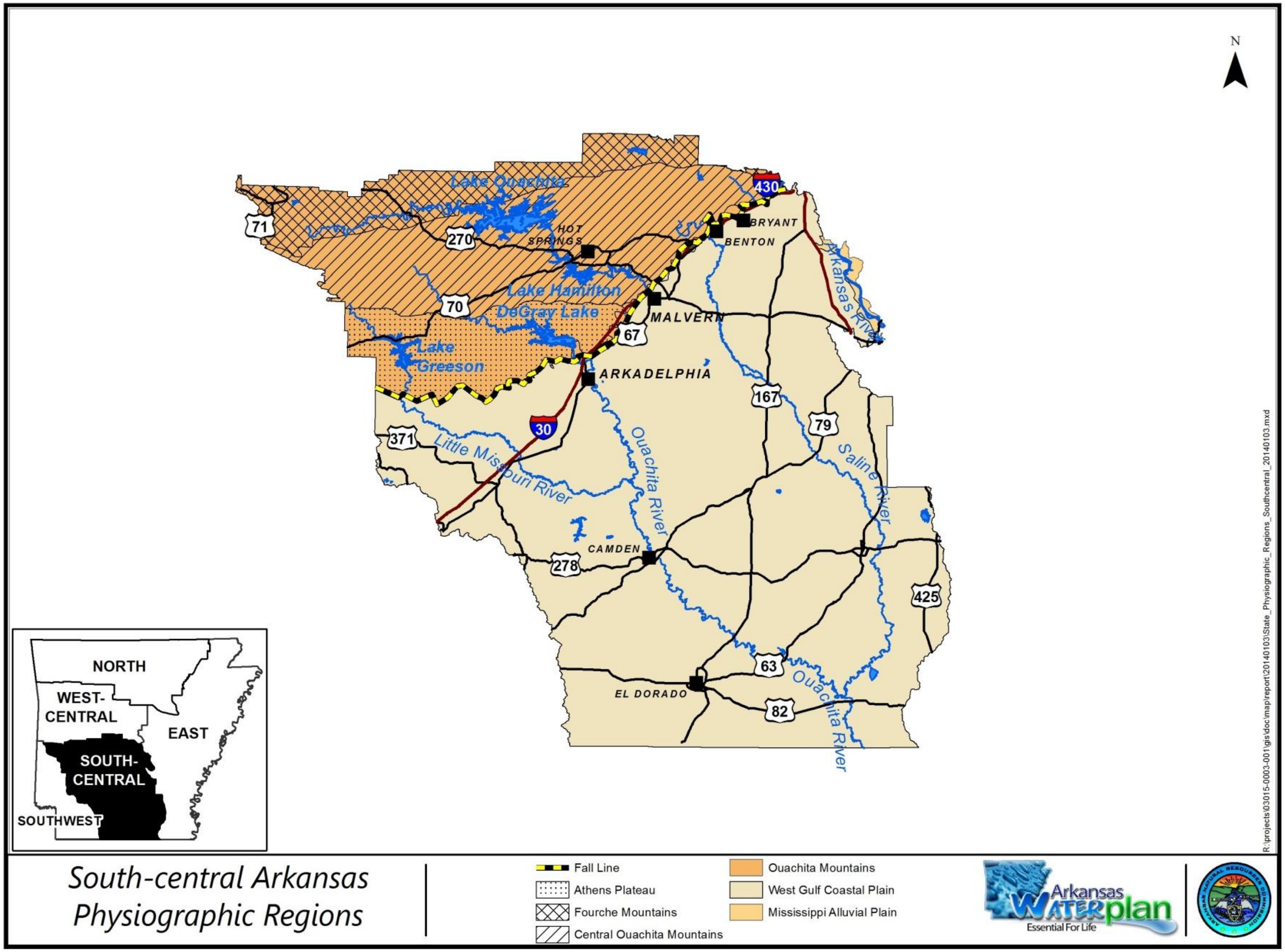

Figure 3.1. Physiographic subdivisions of the SCAWRPR.

3.1.2 Ouachita Mountain Province

The Ouachita Mountain Province includes the Arkansas River Valley, and the Fourche Mountains, Central Ouachita Mountains, and Athens Plateau. The Fourche Mountains, Central Ouachita Mountains, and Athens Plateau occur in the planning region (Figure 3.1). These physiographic regions are characterized by generally parallel ridges and valleys which have an east-west orientation. The different regions are distinguished largely by the spacing of the ridges. Elevations are lower in the eastern portion of the Ouachita Mountain Province and higher to the west (Foti 2011; Fugitt, ANRC, personal communication, April 9, 2013).

The Fourche Mountains are present along the northern boundary of the SCAWRPR (Figure 3.1). The Fourche Mountains include the highest ridges in the planning region, over 2,000 feet above sea level. These ridges are characteristically oriented east to west and are long, even crested, and steep-sloped (Arkansas Geological Survey 2012b). Valley floors are broad and often of considerable elevation, reaching 1,100 feet above sea level at the center around Mena.

The Central Ouachita Mountains are south of the Fourche Mountains, and are present along the northern boundary of the planning region east of Polk County (Figure 3.1). The ridges of the Central Ouachita Mountains are very close, separated by narrow valleys with steep gradients. These ridges are east-west oriented, long, even-crested, and steep-sloped. Some of the principal mountains in this area are the Caddo, Cossatot, Trap, Crystal, and Zigzag. Elevations of 2,000 feet are common, and local relief is between 300 and 900 feet.

The Athens Plateau is a very narrow belt extending along the southern edge of the Interior Highlands (Figure 3.1). Elevation is little above 500 feet and the topography has an undulating appearance. Occasional hills are remnants of an older surface. The low ridges of the Athens Plateau are generally oriented east to west.

3.2 Geologic Setting

Formations underlying the SCAWRPR range in stratigraphic order from the earliest deposited layers of the Cambrian Period to Quaternary alluvium. The only recognized Cambrian formation in Arkansas is the Collier Shale located in a valley in Montgomery County between the watersheds of the Ouachita and the Little Missouri Rivers. Figure 3.2 displays the surface geology of the planning region.

The varied geology of the SCAWRPR makes it rich in economically important minerals. Industrial minerals available in the Ouachita Mountain province include barite, clay, copper, crushed stone, iron, manganese, mercury, novaculite, quartz crystals, sand and gravel, soapstone, titanium, tripoli, wavelite, and vanadium. In the West Gulf Coastal Plain, bauxite/aluminum, bromine, chalk, clay, crushed stone, diamonds, gypsum, oil, sand and gravel are extracted (Mayfield 2001, USGS 2013a).

3.2.1 Geology of the West Gulf Coastal Plain Province

Geologic formations comprising the West Gulf Coastal Plain in Arkansas are contained within the Mississippi Embayment, which is a low-lying basin that is filled with Cretaceous age to recent sediments. The Mississippi Embayment is a structural trough (syncline) formed from downwarping and rifting related to the Ouachita orogeny. This activity resulted in a deep catch basin for sediment deposition. The axis of this syncline plunges southward, with the axis roughly parallel to the Mississippi River (Clark, Hart and Gurdak 2011). In the SCAWRPR, this is an area of low relief underlain by unconsolidated to semi-consolidated deposits of Cretaceous through Quaternary age sand and clay. Recent alluvial deposits are also associated with the major rivers in SCAWRPR such as the Saline and Ouachita.

Cycles of rising and falling sea levels from the Cretaceous through the Tertiary periods resulted in older deposits cropping out on the periphery of the embayment, in bands of varying widths roughly parallel to the fall line and dipping gently to the south and southeast. The Cretaceous-age deposits, consisting of sand, clay, gravel, marl, limestone, and chalk, represent shallow, marginal, and usually restricted marine environments. Most of the beds are coarse sand, clay, or gravel. The lowermost formation is the Trinity Group, which also contains gypsum. The Tokio and Ozan Formations represent the middle Cretaceous and contain some lignite; the upper Cretaceous is represented by the Brownstown marl, which is fossiliferous, calcareous clay, and the Nacatoch Sand. Petroleum reservoir rocks are widely distributed in Cretaceous and Jurassic sandstones and limestones underlying the planning region.

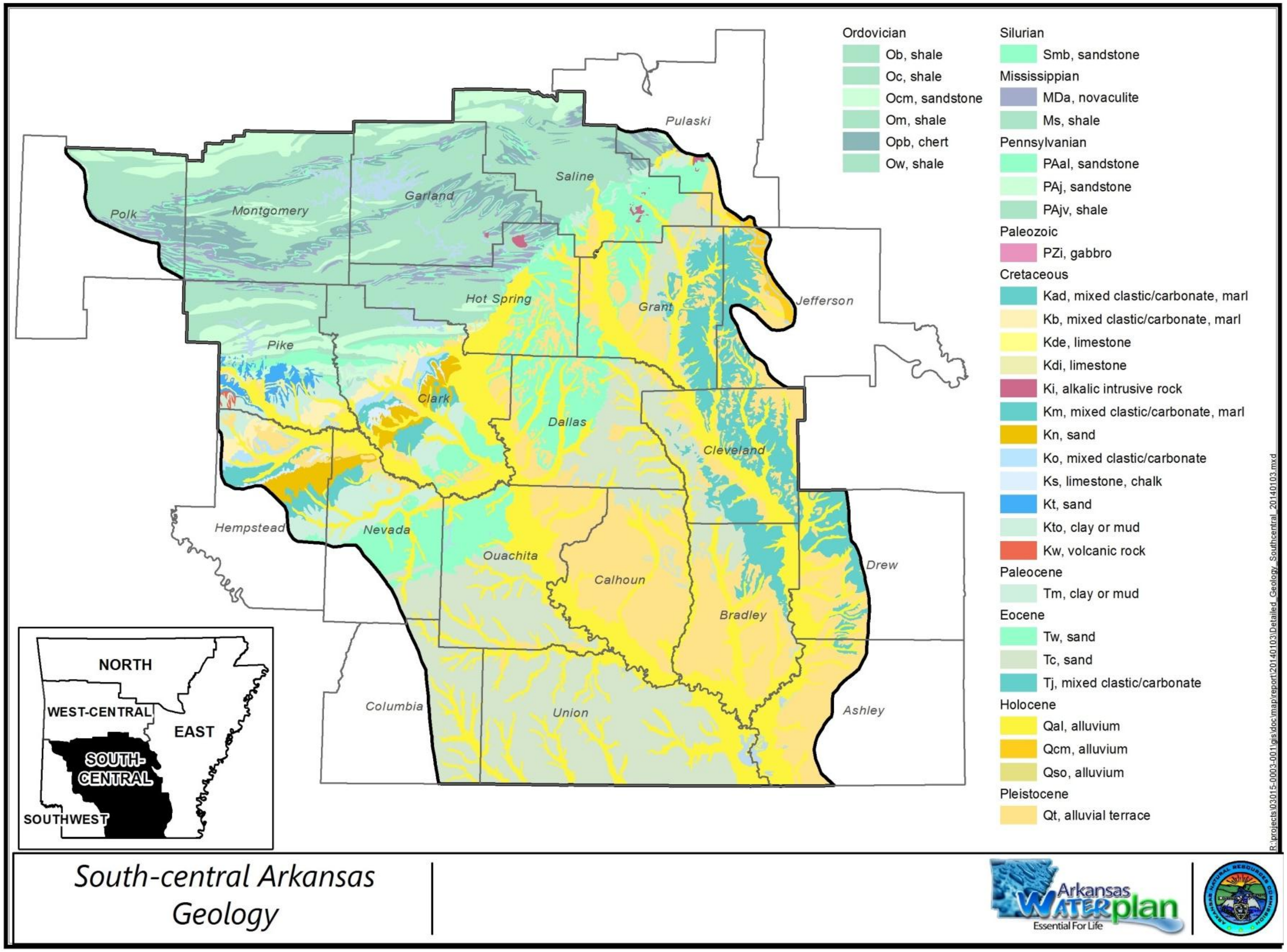

Figure 3.2. Surface geology of the SCAWRPR (Haley et al. 1993).

The Tertiary-age deposits, mostly sand, silt, and clay, represent marginal marine and alluvial deposits. Scattered deposits of lignite are found also, especially in the Wilcox Group. The Midway Group contains some semi-consolidated white limestone. The bauxite deposits of Pulaski and Saline counties occur near the surface in this area.

The hydrogeology of the West Gulf Coastal Plain can be described as layers of unconsolidated silt, sand, and gravel which function as aquifers, yielding large quantities of water to wells. These aquifers are separated by clays which store greater volumes of water but have relatively low hydraulic conductivity, and therefore do not yield adequate volumes of water to wells. The aquifers of the West Gulf Coastal Plain consist of strata with high volumes of sand which has a high hydraulic conductivity and; therefore, a high specific yield of water to wells. Groundwater resources of the SCAWRPR are described in detail in Section 3.8.

3.2.2 Geology of the Ouachita Mountain Province

Sedimentary Paleozoic-age rocks are exposed over the northern sections of the SCAWRPR, including Montgomery and Garland counties and portions of Polk, Pike, Clark, Hot Springs and Saline counties. This area is part of the Ouachita Mountain section of the Interior Highlands. The sedimentary rocks of the Ouachita Mountains consist of a thick sequence of shale, chert, sandstone, conglomerates, novaculite, and volcanic tuff deposited during the Paleozoic Era within an elongate, subsiding trough (Renken 1998). The Ouachita Mountains are true geosynclinal mountains formed from strata deposited in deep water settings and uplifted and deformed by the compressional events associated with continental collision. The general structure of the Ouachita Mountains is a broad uplift with complex folds and numerous complex faults (McFarland 2004). Sediments of the Ouachita Mountains are well-indurated and generally well-cemented as a result of deep burial, intense compression, and complex rock-forming history (Renken 1998).

In the Fourche Mountains and the Athens Plateau of the Ouachita Mountains, the Jackfork Sandstone is particularly important in the major mountain ridges. The Stanley Shale is the most widespread formation. Two prominent formations of the Central Ouachita Mountains are the Crystal Mountain sandstone, which is overlain by the Mazarn shale. Arkansas novaculite is exposed along the outer edge of the Central Ouachitas, sometimes referred to as the Novaculite Uplift. The novaculite is Devonian in age and is situated below the Hot Springs sandstone. It is a very hard, fine-grained silica-rich rock, which has been broken by the folding of the Ouachita Mountains.

Generally, the hydrogeology of the Interior Highlands can be described as an area of consolidated formations which yield relatively low volumes of water to wells. The low specific capacity in these wells is a direct result of the lithological nature of the strata itself. The consolidated formations typically are confined with most of the water yielded to wells coming through secondary porosity found in fractures and bedding plains. Typically, two of the most noted aquifers within the Ouachita Mountain province of the Interior Highlands are the Bigfork Chert and Arkansas Novaculite aquifers in the Central Ouachita Mountains. The Atoka Formation is significant as a source of shallow domestic wells in the Ouachita Mountains, but yields are typically small and therefore, limited for other purposes. Groundwater resources of the SCAWRPR are further described in Section 3.8.

With respect to surface water supplies, the topography of the Ouachita Mountain province is especially conducive to the development of reservoirs. Construction of dams in the narrow valleys produces reservoirs with large volumes of water storage. In general, if a quantity of water over 35 gallons per minute (gpm) is needed in the Ouachita Mountains, the potential user should develop surface water supplies. Surface water resources of the SCAWRPR are further described in Section 3.7.

3.3 Ecoregions

Ecoregions are areas within which ecosystems, and the type, quality, and quantity of environmental resources, are generally similar (EPA 2013d). The US Environmental Protection Agency (EPA) has defined eight ecoregions within the SCAWRPR (Figure 3.3). The high number of ecoregions in this relatively small area is a result of the variability in elevation, orientation, and geology present in this region. There are three Ouachita Mountain ecoregions within the SCAWRPR: Athens Plateau, Central Ouachita Mountains, and Fourche Mountains.

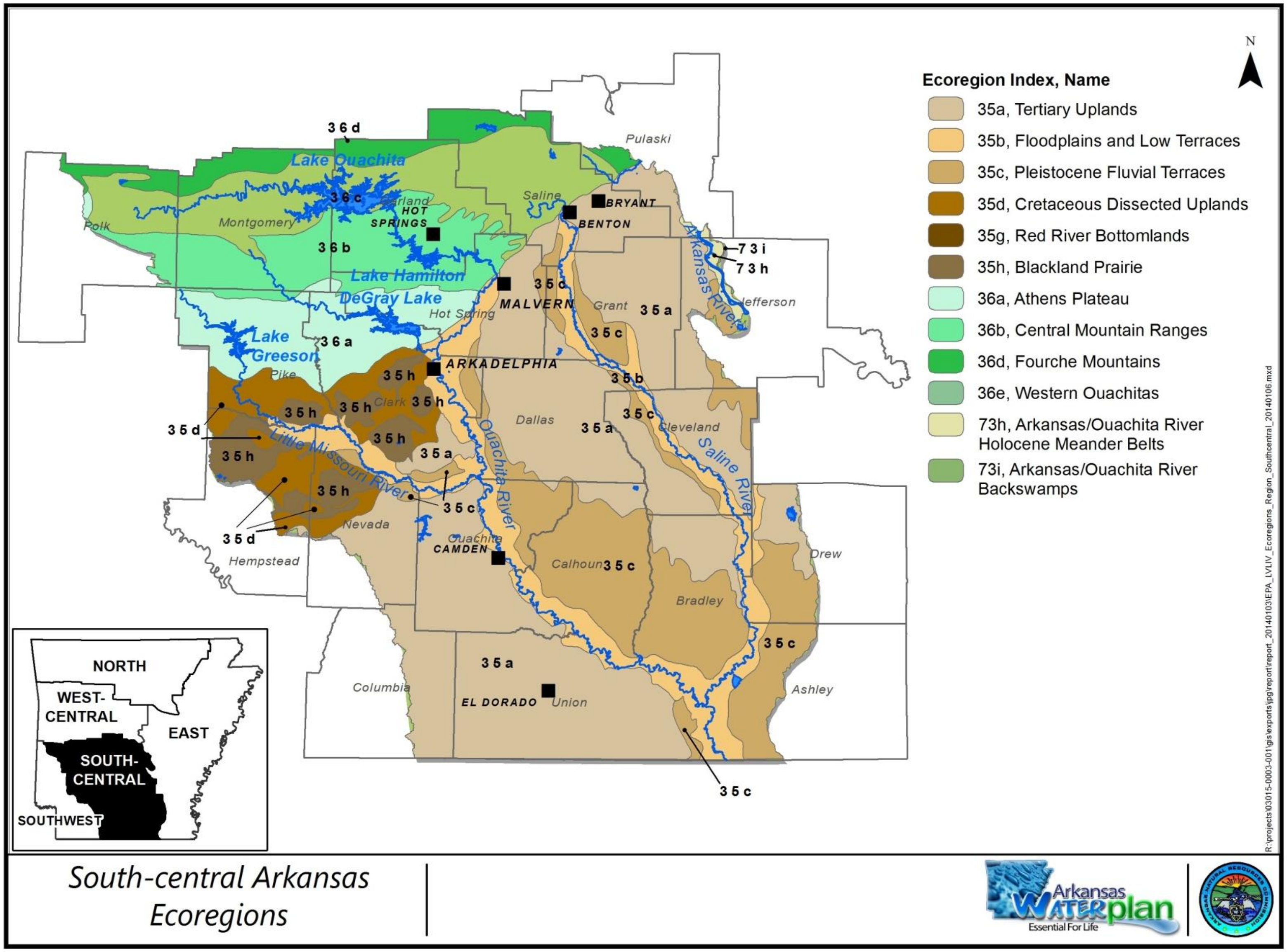

Figure 3.3. Ecoregions of the SCAWRPR (Woods et al. 2004).

There are five ecoregions within the West Gulf Coast Plain (classified as the South Central Plains Level III ecoregion): Blackland Prairie, Cretaceous Dissected Uplands, Floodplains and Low Terraces, Pleistocene Fluvial Terraces, and Tertiary Uplands. Characteristics of each of these ecoregions are summarized in Table 3.1.

Table 3.1. Characteristics of ecoregions within the SCAWRPR (Anderson 2006, Foti 2008, The Nature Conservancy 2013, Woods et al. 2004).

Level III Ecoregion	Level IV Ecoregion	Native Vegetation	Other
Ouachita Mountains	Athens Plateau	Oak-hickory-pine forest	
	Central Mountain Ranges	Oak-hickory-pine forest, novaculite glades, mixed pine and upland deciduous forest on uplands	Perennial springs and seeps are common
	Fourche Mountains	Mixed shortleaf pine and upland deciduous forest on south-facing slopes, sugar maple and magnolia on north-facing slopes, oak-hickory-pine forest in valleys, loblolly pine in wet lowland sites along rivers, stunted oak forest and other mountain vegetation on highest ridges, e.g., Rich Mountain	
South Central Plains	Blackland Prairie	Woodland, savannah, and prairie	21 globally imperiled plant communities, rare birds
	Cretaceous Dissected Uplands	Oak-hickory-pine forest, mixed pine and upland deciduous forest	
	Floodplains and Low Terraces	Southern floodplain forest and oak-hickory-pine forest	
	Pleistocene Fluvial Terraces	Pine flatwoods of loblolly pine and oak, hardwood wetlands, pine savannah, prairie	
	Tertiary Uplands	Oak-hickory-pine forest, mixed shortleaf pine-loblolly pine forest, upland deciduous forest, bottomland forest along rivers	

Streams in the Ouachita Mountains have high gradients, and substrates are made up of gravel, cobbles, boulders, or bedrock (ASWCC 1987b, Woods et al. 2004). Fish communities in these streams are dominated by sensitive species (Woods et al. 2004).

Streams are in the South Central Plains have low gradients. Water tends to be turbid or stained and substrates are sand, gravel, and silt. Fisheries are composed of diverse species but few sensitive species.

The Cretaceous chalks and marls that occur south of the Ouachita Mountains have a relatively low permeability and do not yield much water to streams. Therefore, streams in the Cretaceous Dissected Uplands and Black1and Prairie generally have lower sustained flows during low-flow periods than streams in the rest of the South Central Plain area, which usually exhibit sustained base flow conditions as a result of the higher permeability of soils in the area that favor the transmission of water (ASWCC 1987b).

3.4 Aquatic Biodiversity

The complexity of the drainages and geologic history that occurs in the SCAWRPR translates into high aquatic biodiversity. The fish species in the Ouachita Mountains have experienced multiple periods of division, isolation, and mixing. As a result, 24 families of fish are found in Ouachita Mountain rivers and streams. Small streams have the most diverse fish communities.

The SCAWRPR (i.e., Ouachita River drainage) has been identified as having the second-highest number of aquatic animal species of greatest conservation need in the state; 130 out of the 268 identified (Anderson 2006). Figure 3.4 provides a summary of the aquatic and semi-aquatic species of greatest conservation need found in the planning region. Of the over 180 aquatic and semi-aquatic plant species tracked by ANHC, over 110 occur in the SCAWRPR (ANHC 2013). Of the 42 Arkansas endemic species (found nowhere else in the world), 14 occur in the planning region (Figure 3.5) (Anderson 2006). Approximately 600 miles of streams in the planning region have been designated by the Arkansas Department of Environmental Quality (ADEQ) as Ecologically Sensitive Waterbodies because they provide habitat for endemic, threatened, or endangered species (Figure 3.6) (APCEC 2011). Additional information on threatened and endangered species in the planning region is provided in Section 5.3.7. The many reservoirs in the SCAWRPR provide important resting and feeding sites for migrating water fowl.

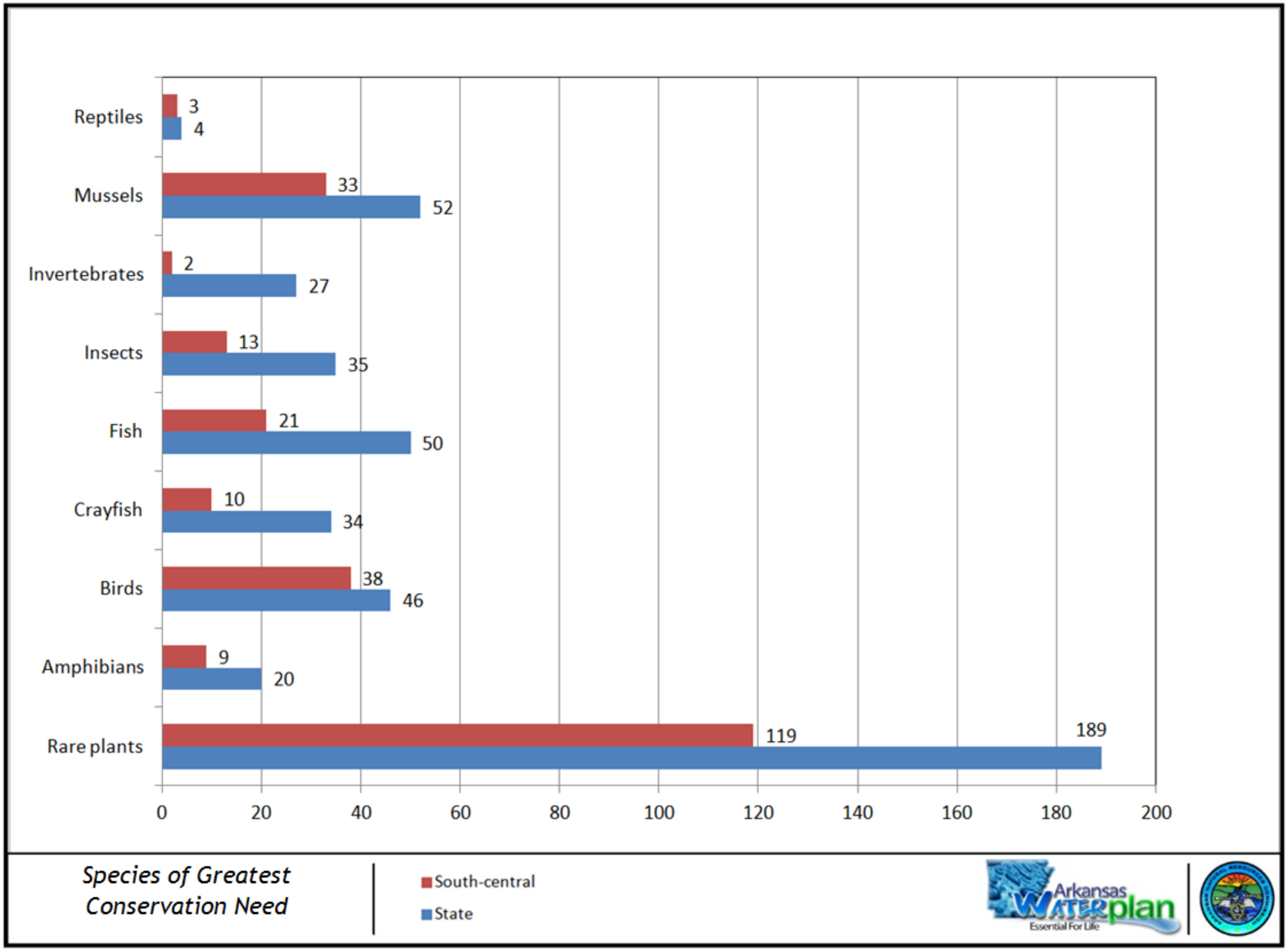

Figure 3.4. Species of greatest conservation need found in the SCAWRPR (Anderson 2006, ANHC 2013).

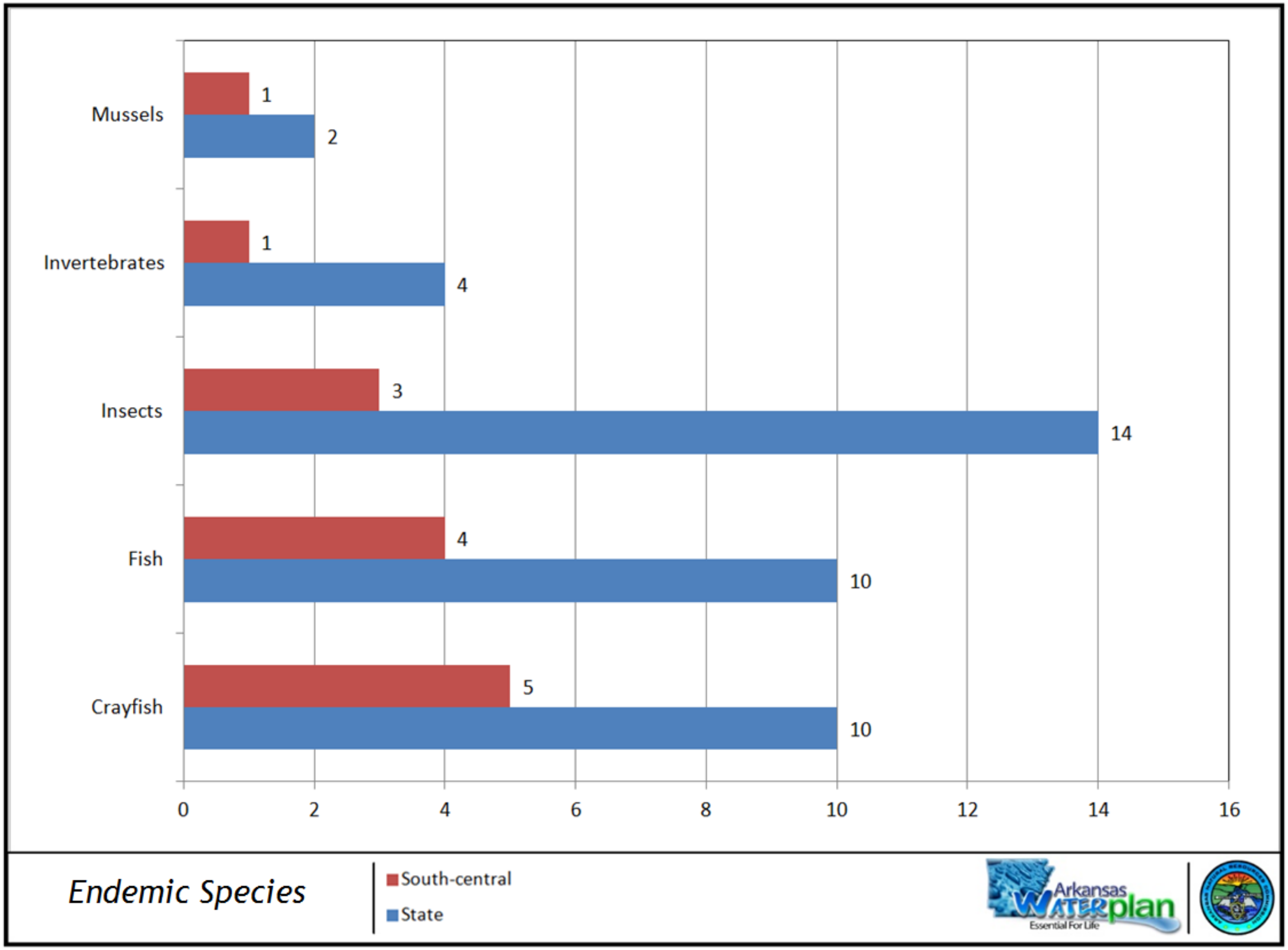

Figure 3.5. Endemic species of the SCAWRPR.

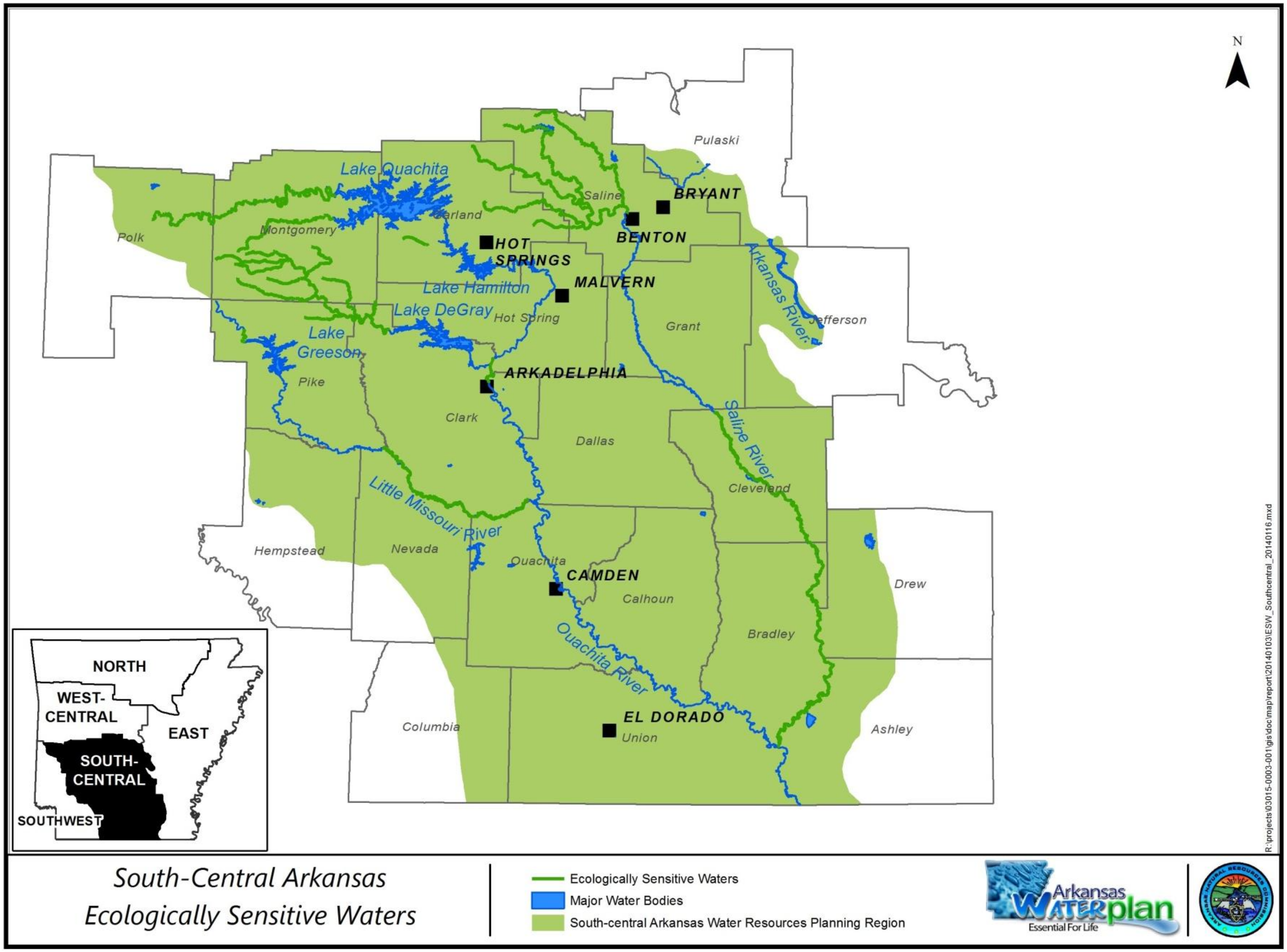

Figure 3.6. Ecologically Sensitive Waterbodies in the SCAWRPR (APCEC 2011).

3.5 Climate

The climate in the SCAWRPR is humid with warm summers. Temperature, precipitation, and evaporation data were obtained from the National Weather Service, National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC), and the PRISM Climate Group and reviewed. These data are available for each of the climate divisions in Arkansas (Figure 3.7). Data for climate division 8 were used to characterize the climate for the SCAWRPR. Summaries of these data are presented below, along with discussions of factors that influence climate in the SCAWRPR and long-term climate trends in the region.

3.5.1 Temperature

The average annual temperature in the SCAWRPR is approximately 63 ºF (NOAA NCDC 2013a). Average daytime maximum temperatures range from 92 ºF in August to 53 ºF in January (Figure 3.8). Average minimum nighttime air temperatures range from 70 ºF in July to 31 ºF in January. The average difference between the monthly normal minimum and maximum air temperatures is 23 ºF.

Variations in average annual maximum daily temperature temperatures across the planning region are shown on Figure 3.9. Temperatures are generally cooler in the higher elevations in the north. The growing season (frost-free days) in the planning region ranges from 190 to 233 days in the Ouachita Mountains to 200 to 245 days in the West Gulf Coastal Plain (Woods et al. 2004).

3.5.2 Precipitation

Mean annual precipitation in the SCAWRPR ranges from 66 inches in the north to 48 inches in the south (Woods et al. 2004). The high precipitation amounts in the Ouachita Mountains are due to the influence of their high elevations (Figure 3.10). When moist south winds from the Gulf of Mexico reach the Ouachita Mountains, the air is forced to rise, causing the air to cool so that the moisture condenses into clouds and rain that falls on the mountains (Foti 2011).

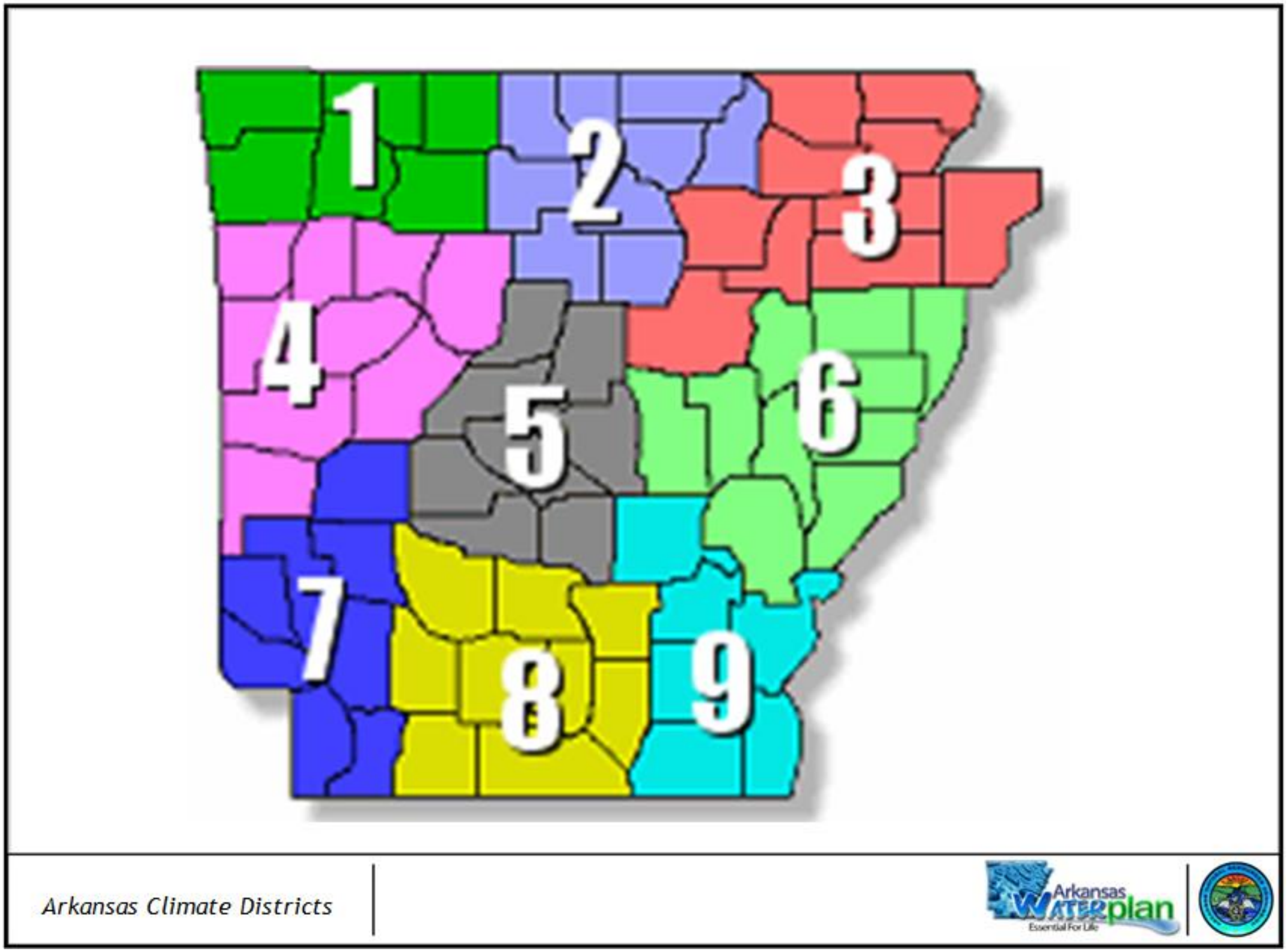

Figure 3.7. Climate divisions in Arkansas (National Weather Service 2013).

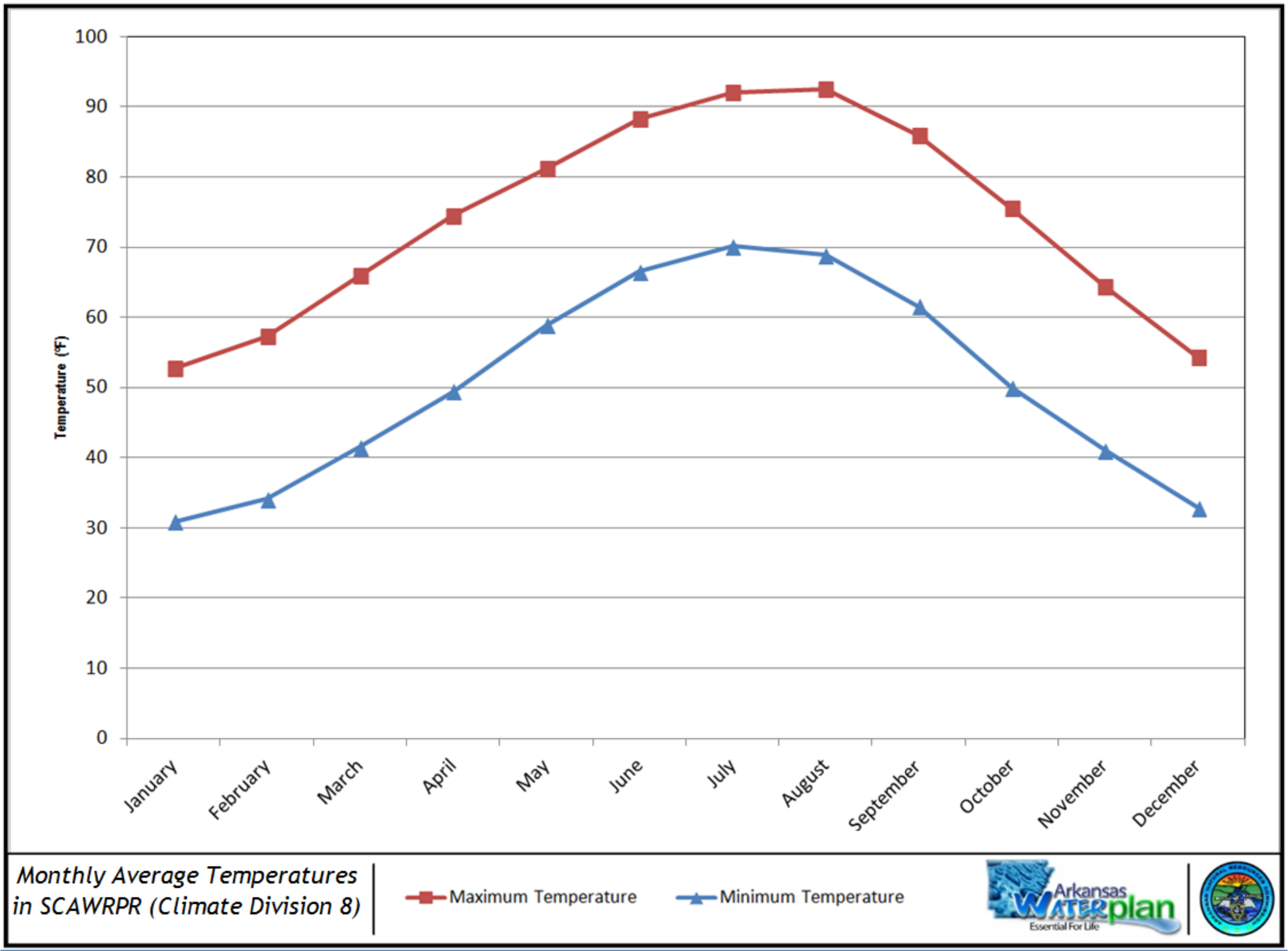

Figure 3.8. Monthly average minimum and maximum temperatures in the SCAWRPR, 1981-2010 (PRISM Climate Group 2004).

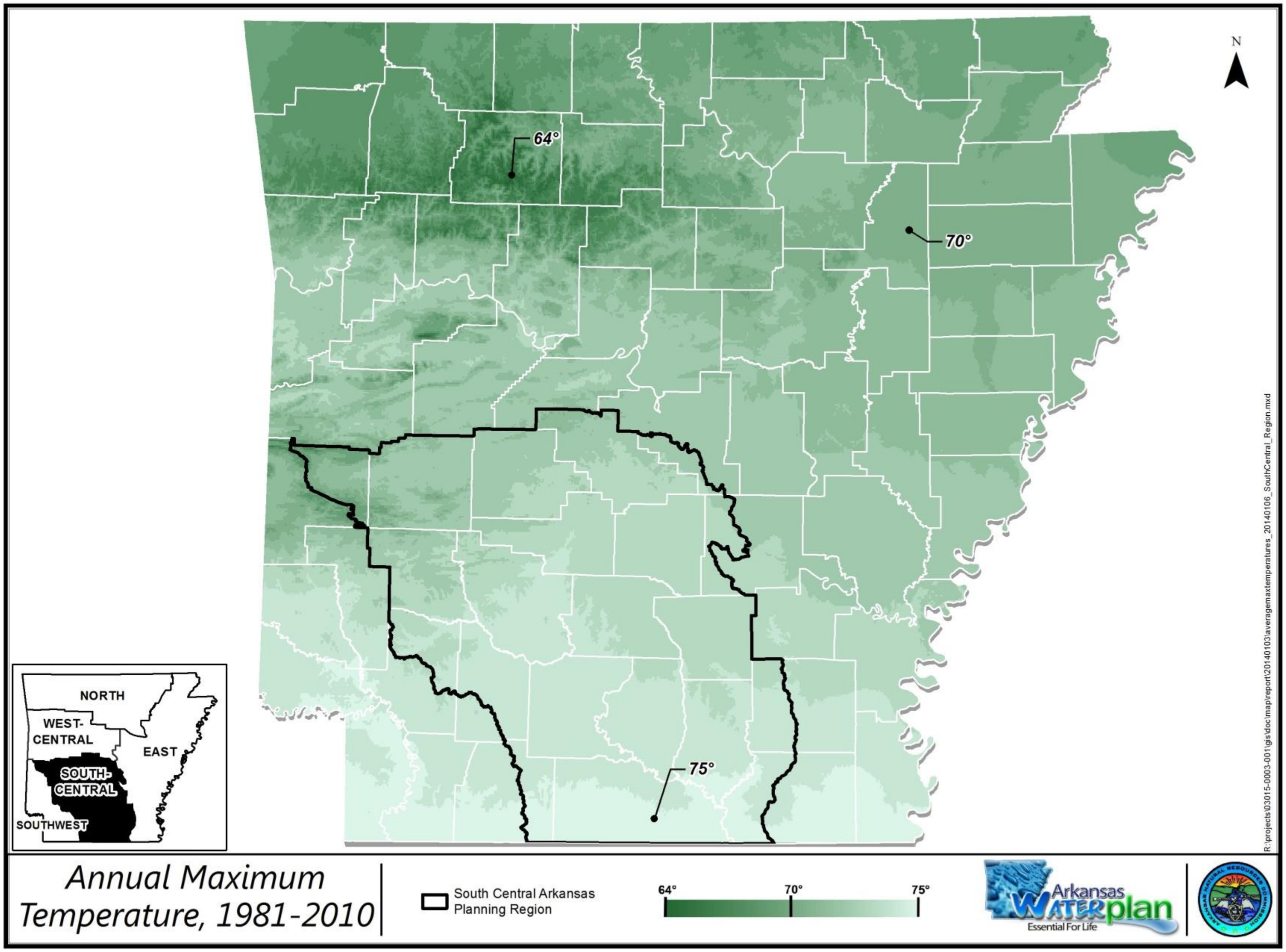

Figure 3.9. Map of average annual maximum daily temperature (^oF) in the SCAWRPR, 1981-2010 (PRISM Climate Group 2004).

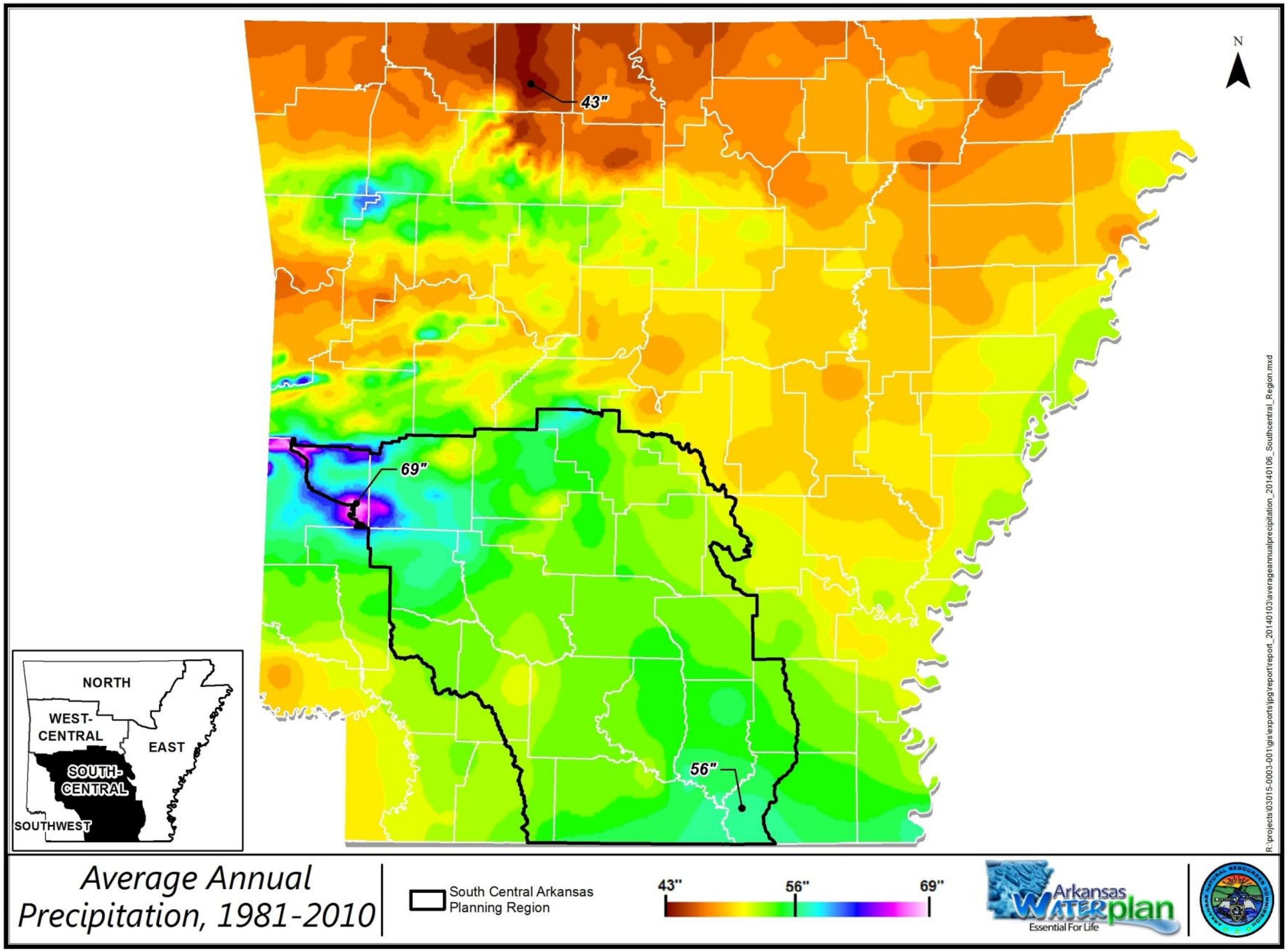

Figure 3.10. Map of average annual precipitation (inches) in the SCAWRPR, 1981-2010 (PRISM Climate Group 2004).

Mean monthly precipitation for the SCAWRPR for the period from 1981 through 2010 is shown on Figure 3.11. The months in late spring and late fall to early winter are generally the wettest. Average precipitation amounts are highest in May, and October through December. Precipitation is lowest in January and during the summer, July through September.

Summer precipitation primarily occurs during rainstorms, where locally high rainfall amounts can occur over a short period of time. During the fall, winter, and early spring, precipitation events are usually less intense and of longer duration. The majority of the precipitation in the SCAWRPR falls as rain; snow occurs here only occasionally, more frequently at the higher elevations in the Ouachita Mountains (Buckner 2011, NOAA NCDC n.d.).

3.5.3 Evaporation

Evaporation is the process by which water changes from liquid in soil to gaseous water vapor. When the conversion from liquid to water vapor occurs on leaves, the process is called transpiration. Evapotranspiration is the combination of these processes. The amount of evapotranspiration is controlled primarily by sunlight, but is influenced by humidity and wind (Scott et al. 1998).

Potential evapotranspiration is the maximum rate at which water in soil and on plants would change to water vapor, assuming there is no shortage of water to be changed. Actual evapotranspiration is usually less than the potential. Potential evapotranspiration is difficult to measure, but can be estimated from the meteorological measurement pan evaporation. Pan evaporation is the rate of evaporation of water from a specific style of open pan at a weather station. In humid regions like Arkansas, potential evapotranspiration is similar to pan evaporation. Based on data from eastern Arkansas, the ratio of potential evapotranspiration to pan evaporation is assumed to be 0.85. Evaporation exhibits less variation from year to year and place to place than precipitation (Scott et al. 1998). Figure 3.11 shows monthly average potential evapotranspiration estimated from pan evaporation measurements at Millwood Lake Dam in Hempstead County and Blakely Mountain Dam in Garland County for the period of 1995 through 2010 (the available period of record for these stations).

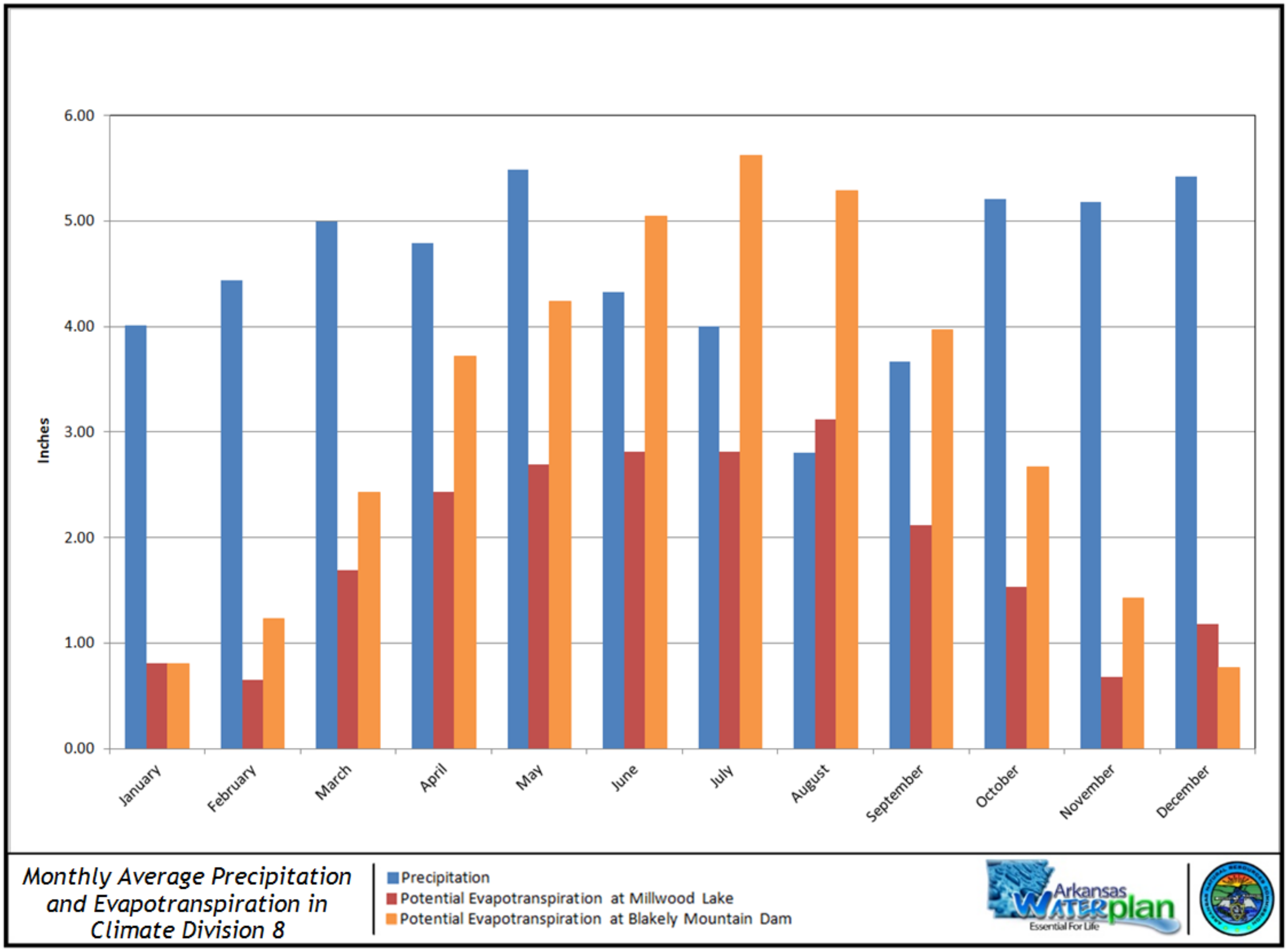

Figure 3.11. Monthly average precipitation in Climate Division 8, and potential evapotranspiration at selected sites associated with the SCAWRPR, 1981-2010 (NOAA NCDC 2013b, PRISM Climate Group 2004).

The estimated potential evapotranspiration at Millwood Lake exceeds the normal precipitation in only one month, August. The estimated potential evapotranspiration at Blakely Mountain Dam exceeds the average precipitation during the entire summer, June through September.

3.5.4 Drought

Although the SCAWRPR receives precipitation throughout the year, drought conditions occur in the region. One of the tools NOAA uses to determine when drought conditions exist is the Palmer Drought Indices. These indices are based on the differences of precipitation and temperatures from normal. The Palmer Drought Severity Index (PDSI) also takes into account the length of time that drought conditions last. PDSI values less than zero indicate drought conditions. An index of -2 indicates moderate drought, -3 indicates severe drought, and -4 indicates extreme drought (NOAA 2012). Figure 3.12 shows a time-series plot of PDSI values for climate division 8 in Arkansas (see Figure 3.7 for a map of Arkansas climate divisions). Periods with multiple consecutive years of drought have occurred in southwest Arkansas (Figure 3.12). This region is currently experiencing a period of drought that began in 2010 (NOAA NCDC 2013a).

3.5.5 Climate Variability

In 2007, the Governor's Commission on Global Warming (GCGW) was established to, among other tasks, evaluate the potential impacts of global warming on the state citizens, natural resources, and economy. The literature review conducted by the GCGW identified the following climate change effects anticipated for the state (GCGW 2008):

- Increased incidence of severe weather events,
- Increased incidence of flooding,
- Increased incidence of drought,
- Possible saltwater intrusion into aquifers resulting from sea level rise, and
- Changes in climatic zones.

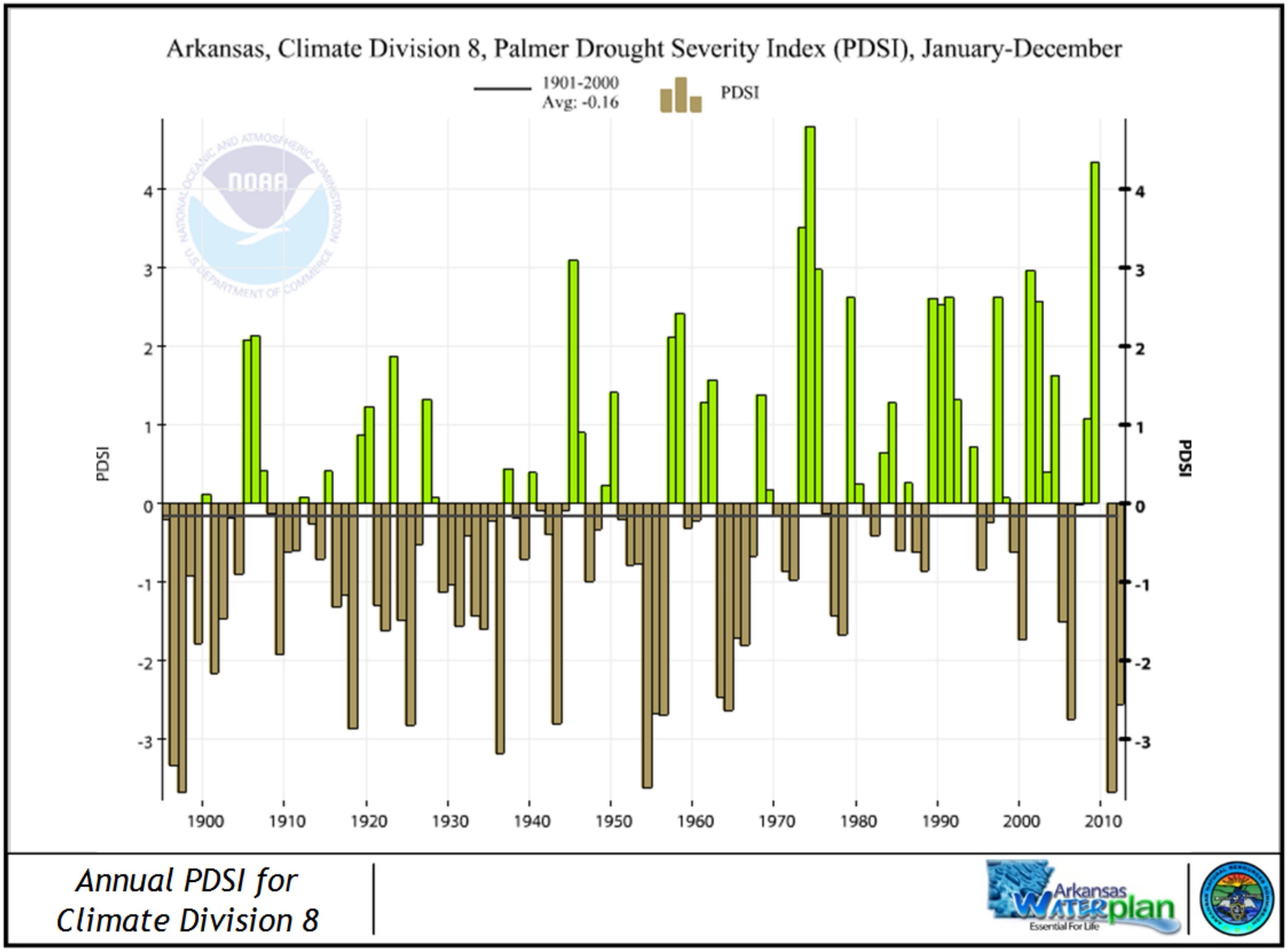

Figure 3.12. Annual PSDI for climate division 8 (SCAWRPR) (NOAA NCDC 2013c).

Plots of annual average temperature and total annual precipitation from 1895 to 2012 for the climate division 8 are shown on Figures 3.13 and 3.14, respectively. The temperature data appear to exhibit a cycle of change, where temperatures in the first half of the 20^{th} century were warmer than the second half, but appear to be warming again in the early 21^{st} century (Figure 3.13). The United States Department of Agriculture (USDA) develops a plant hardiness zone map that shows annual average minimum winter temperature. The 2012 update of the USDA map shows warmer minimum temperatures in the region as compared to the 1990 zone map. This relationship follows the cycle shown on Figure 3.13 (Clark and Karklis 2012). Precipitation totals for climate division 8 appear to exhibit a slight long-term increasing trend (Figure 3.14). A detailed analysis of long-term precipitation trends across the state is being prepared as part of the 2014 water plan update.

3.6 Land Use

Land use in the SCAWRPR is summarized on Figure 3.15 and mapped on Figure 3.16. Major land use categories are discussed in the sections below, including present day extent, and changes since the 1990 AWP.

3.6.1 Forest

The SCAWRPR is primarily forested (Figures 3.15 and 3.16). Table 3.2 lists the acreage of forest land per county in 2012 as reported by the USDA Forest Service (USFS). There are over 7.4 million acres of forest land in the counties of the SCAWRPR. Union county has the greatest acreage of forest. The majority of the forest land in the planning region (over 99%) is classified by the USDA Forest Service (USFS) as timberland, or commercial forest land, and the majority of timberland in the region is privately owned (USFS 2013). The timber industry is active in this region, particularly south of the Ouachita Mountains (Stroud 2011). A little over 1% of the forest in the SCAWRPR is national forest.

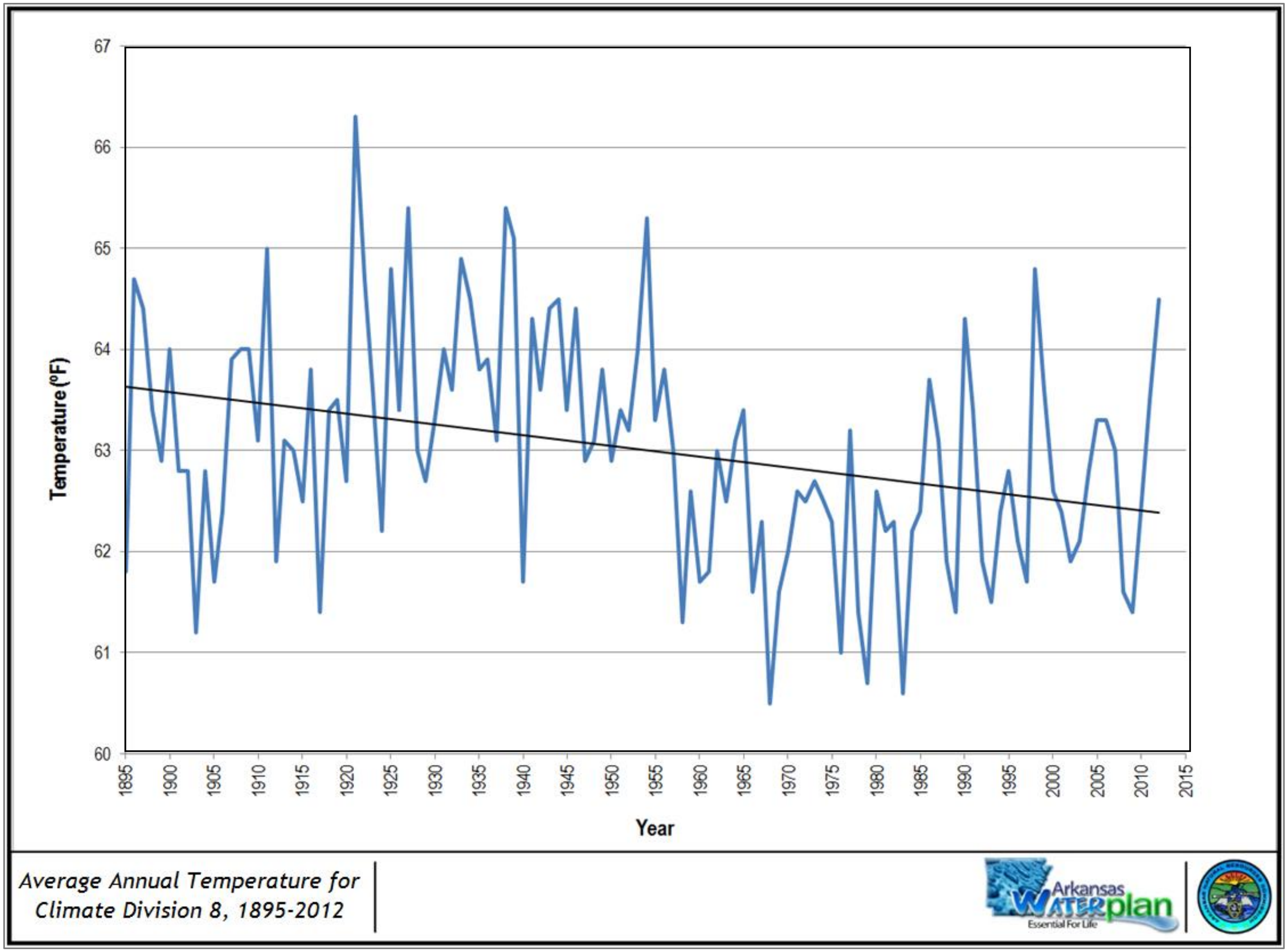

Figure 3.13. Average annual temperature for climate division 8 in the SCAWRPR (NOAA NCDC 2013c).

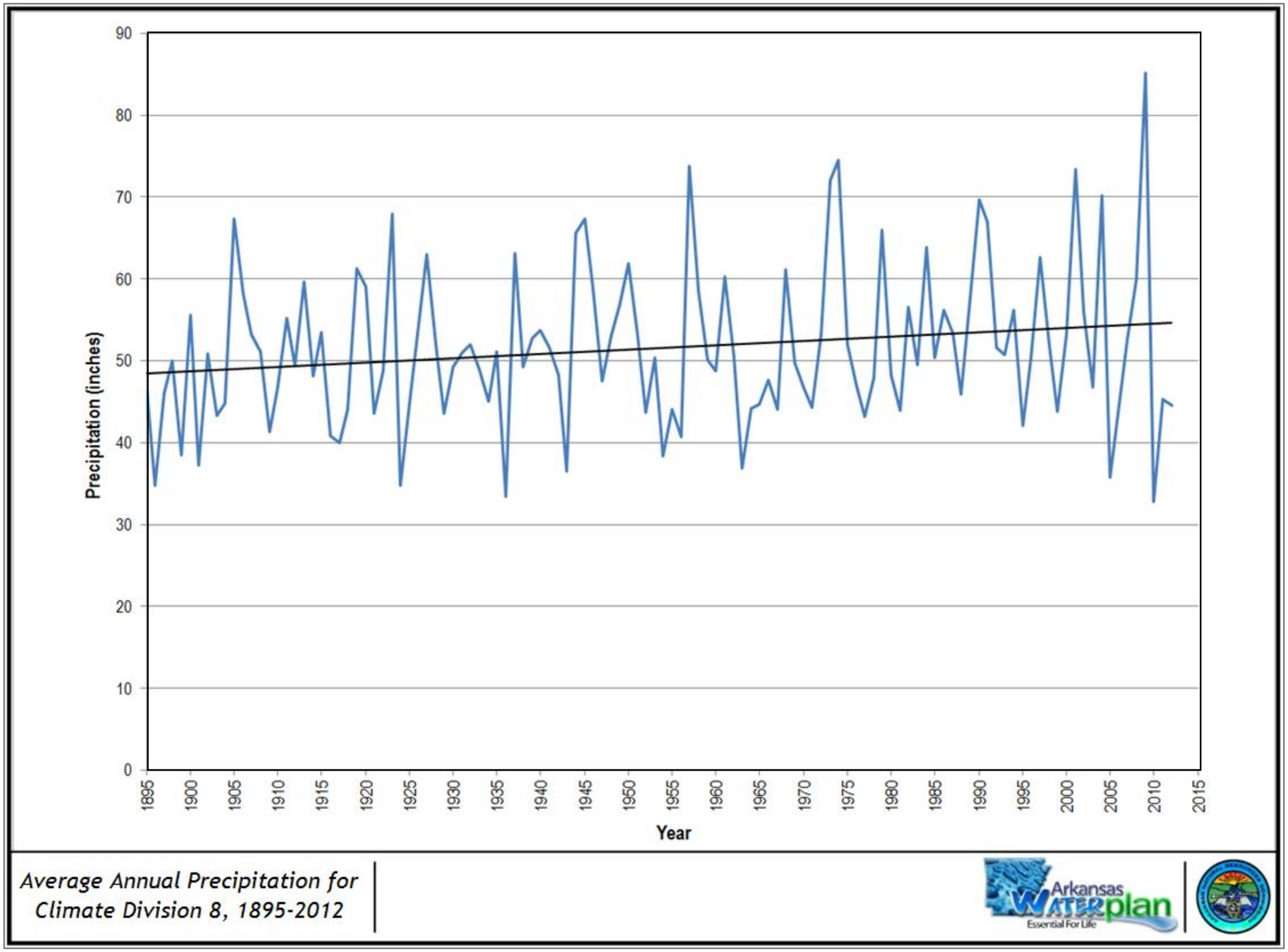

Figure 3.14. Annual total precipitation for climate division 8 in the SCAWRPR (NOAA NCDC 2013c).

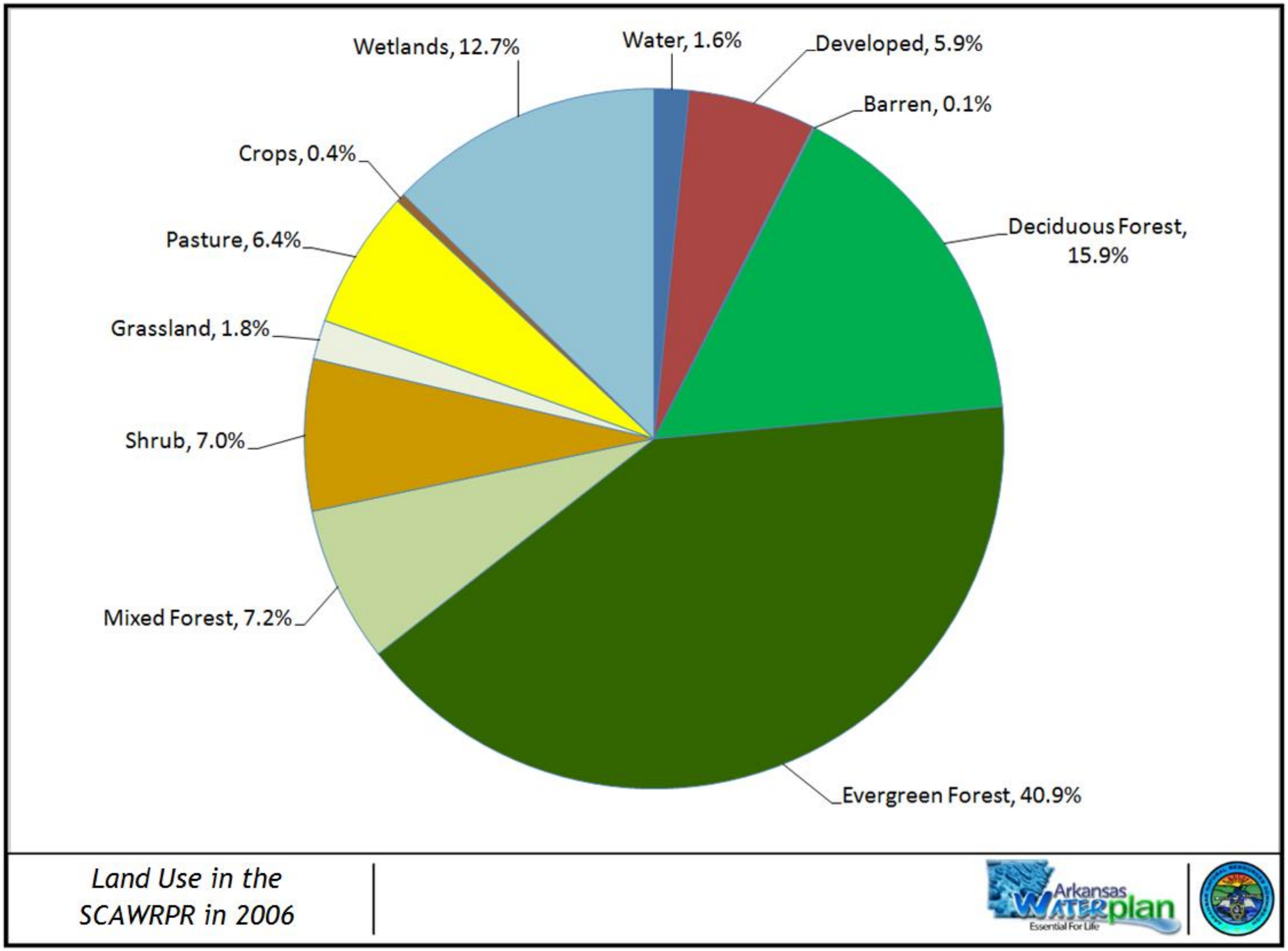

Figure 3.15. SCAWRPR land use, 2006 (Fry et al. 2011).

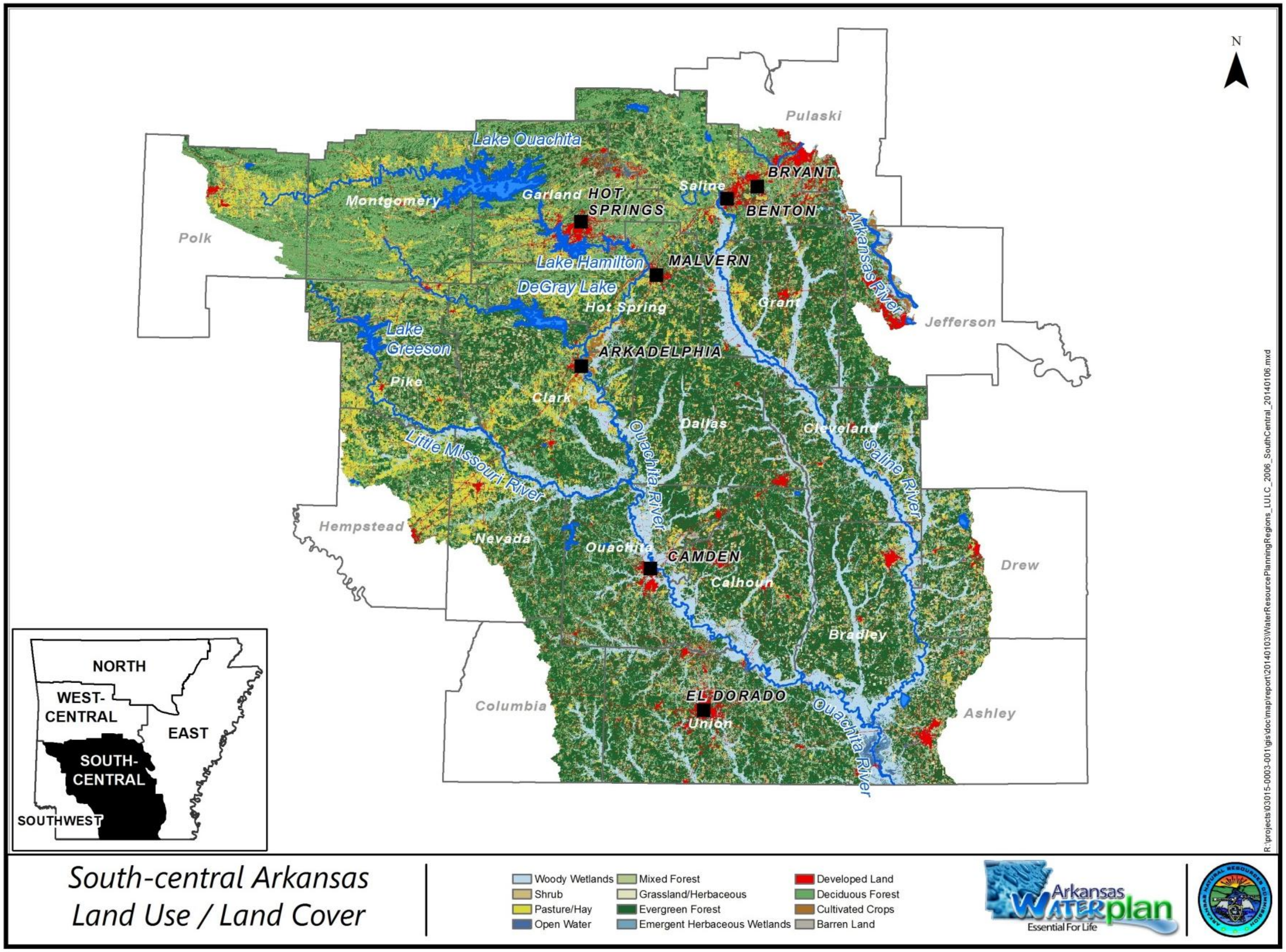

Figure 3.16. Map of 2006 land use in the SCAWRPR (Fry et al. 2011).

Table 3.2. Comparison of forest land in the SCAWRPR (ASWCC 1987a, b; USFS 2013).

County	1977 Forest Land (acres)	2012 Forest Land (acres)	Change
Ashley*	434,604	408,851	-
Bradley	376,975	356,084	-
Calhoun	365,126	352,330	-
Clark	443,074	454,473	+
Cleveland	342,966	320,258	-
Columbia*	400,835	438,645	+
Dallas	377,579	398,824	+
Drew*	394,532	407,198	+
Garland	300,604	381,524	+
Grant	361,827	398,304	+
Hempstead*	281,652	299,503	+
Hot Spring	297,305	254,138	-
Jefferson*	200,007	201,198	+
Montgomery	436,764	405,011	-
Nevada*	310,032	330,803	+
Ouachita	414,062	408,667	-
Pike	290,754	296,303	+
Polk*	453,808	431,058	-
Saline	359,913	315,350	-
Union	628,495	621,077	-
Total	**7,470,914**	**7,479,599**	**+**

Forest acreage for 1977 from the Resource Inventory Data System was reported by county in the 1990 AWP and is included in Table 3.2 (ASWCC 1987a, b). Because these data are from different sources, their comparability is uncertain. However, comparing these values suggest there has been no significant change in the amount of forest land in the counties of the SCAWRPR since the 1990 AWP.

3.6.2 Wetlands

Wetlands account for the second largest proportion of the land use in the SCAWRPR, 959,360 acres, or 12.7%. In the 1990 AWP basin reports, it was estimated that there were 567,200 acres of wetlands in the Ouachita River basin (ASWCC 1987 a, b). Because the data are from different sources, there comparability is uncertain. However, comparing these values suggests there may have been an increase in wetland area in the planning region. Wetlands in the planning region are discussed in greater detail in Section 3.7.3.

3.6.3 Agriculture

Agriculture accounts for less than 10% of the area in the SCAWRPR (Figure 3.15). Pasture and haylands account for the majority of this land use category (95%). In the 2007 Census of Agriculture, the total area of pasture in the counties within the planning region was 716,530 acres, with 694,412 acres of cropland (harvested and other) (USDA National Agricultural Statistics Service 2009). In the 1990 AWP, the acreage reported for pasture in the counties of the SCAWRPR was 1.1 million, with 475,304 acres of cropland (ASWCC 1987 a, b). Because these data are from different sources, their comparability is uncertain (see Table 3.3). Comparing pasture and cropland areas from the 1987 and 2007 Census of Agriculture (Table 3.3) indicates there has not been a significant change in the amount of cropland and a slight decline in pasture area.

The major crops reported for the counties of the planning region in the 2007 Census of Agriculture, in order of acreage, were forage, soybeans, cotton, and rice (USDA National Agricultural Statistics Service 2009). In the 1990 AWP, soybeans and rice were identified as the crops with the largest acreage in the Ouachita River Basin (ASWCC 1987a, b).

In the 2007 Census of Agriculture, 54% of the 694,412 acres of cropland in the counties of the planning region was irrigated (note that the amount of irrigated land was not reported for 3 of the 21 counties to protect farmers' privacy) (USDA National Agricultural Statistics Service 2009). The 1990 AWP reported that approximately 20% of the cropland in the Upper Ouachita River basin was irrigated (ASWCC 1987 b). Information on irrigated cropland was not provided for the lower Ouachita River basin in the 1990 AWP (ASWCC 1987a). In the 1987 Census of Agriculture, approximately 3% of the 696,039 acres of cropland in the planning region counties was irrigated (note that the amount of irrigated land was not reported for 13 of the 21 counties in 1987 to protect farmers' privacy) (US Census Bureau 1989). This indicates that there has been a large increase in the amount of irrigated cropland in the planning region since 1987 (over 90%).

Table 3.3. Comparison of agriculture land areas in the counties of the SCAWRPR (ASWCC 1987a, b; USDA National Agricultural Statistics Service 2009; US Census Bureau 1989).

County	Cropland (acres)			Pasture (acres)		
	1987 Census of Agriculture[a]	1990 AWP	2007 Census of Agriculture[a]	1987 Census of Agriculture[b]	1990 AWP	2007 Census of Agriculture[b]
Ashley*	126,152	142,450	116,294	22,035	15,191	15,374
Bradley	6,835	6,883	6,123	19,591	31,165	16,000
Calhoun	4,037	2,673	2,976	16,010	21,667	10,596
Clark	41,352	25,887	20,116	65,247	75,961	47,982
Cleveland	6,202	0	7,684	108,082	41,717	14,733
Columbia*	10,952	0	10,922	29,095	62,929	26,133
Dallas	3,851	9,477	3,540	15,251	35,160	7,845
Drew*	70,867	74,664	78,184	37,542	64,528	20,961
Garland	6,564	2,130	7,260	38,408	56,695	29,270
Grant	7,514	0	9,640	28,339	39,111	20,192
Hempstead*	52,718	34,023	47,922	136,608	146,832	137,992
Hot Spring	18,550	5,174	18,927	64,047	70,329	44,934
Jefferson*	246,360	132,646	253,727	18,189	21,168	24,667
Montgomery	13,027	0	17,941	71,929	68,871	50,037
Nevada*	18,743	14,717	17,868	64,619	66,841	36,152
Ouachita	10,955	9,937	7,072	29,522	37,214	16,753
Pike	15,043	7,943	17,525	57,243	75,306	58,209
Polk*	16,337	2,359	31,026	103,692	81,251	92,129
Saline	14,472	1,963	11,749	44,836	55,342	27,560
Union	5,508	2,378	7,916	23,579	27,123	19,011
Total	**696,039**	**475,304**	**694,412**	**993,864**	**1,094,401**	**716,530**

*Note: The acreage reported is for the entire county, but part of this county is in other planning regions.

a. Sum of “harvested cropland” and “other cropland” reported in census.

b. Sum of “pastureland, all types” and “cropland used only for pasture” reported in census.

3.6.4 Public Land

There are over 1.2 million acres of public land in the SCAWRPR, around 16% of the land in the planning region (Table 3.4). National forest and wildlife management areas (WMAs) account for the majority of this public land (Table 3.4). There are also national parks, state parks, natural areas, wilderness areas and a National Wildlife Refuge (NWR) in the planning region.

Table 3.4. Public lands in the SCAWRPR (AGFC 2009, AHTD 2006).

Land Use	Acreage	Percent of SCAWRPR Area	Count
City Park	3,369	< 1%	132
County Park	744	< 1%	34
Local Park	74	< 1%	6
National Forest	873,238	11.6%	37
National Park	5,419	< 1%	3
NWR	65,242	< 1%	1
Natural Area	1,996	< 1%	16
Park	33	< 1%	1
Public Use Area	2,789	< 1%	34
Recreation Area	16,424	< 1%	15
Research Area	15,019	< 1%	2
State Forest WMA	18,680	< 1%	2
State Park	5,982	< 1%	15
Wayside Park	15	< 1%	22
Wilderness Area	7,413	< 1%	3
WMA	204,964	2.7%	19
Total	**1,221,401**	**16.2%**	

3.7 Surface Water

There are approximately 9,700 miles of rivers and streams in the SCAWRPR, 38,000 acres of impounded water, and 959,000 acres of wetlands (ASWCC 1981, USGS 2009, Fry et al. 2011). The major river in the region is the Ouachita River. The largest impoundments in this region are Lake Ouachita, Lake Hamilton, and Lake Catherine. Surface water availability issues, both water quantity and water quality, are discussed in detail in Section 5.

3.7.1 Rivers and Streams

There are approximately 9,710 miles of rivers and streams in the SCAWRPR (USGS 2009). Principal streams in the Fourche Mountains and central Ouachita Mountains generally flow eastward, e.g., the upper Ouachita River. Streams in the Athens Plateau and West Gulf Coastal Plain generally flow southward. The major river in the region is the Ouachita River (see Figure 2.1), which begins in the Ouachita Mountains in western Polk County. The river flows east through Montgomery and Garland counties, where its flow is regulated by three lakes:

Lake Ouachita, Lake Hamilton, and Lake Catherine. In Hot Spring County, it turns southwest. The Caddo River joins the Ouachita River near Arkadelphia, and the river turns southeast just downstream. Another impoundment, Lake Jack Lee, is located near the confluence of the Saline River in Union County. The river flows generally south-southeast until leaving Arkansas, and eventually flows into the Black River in Louisiana (Gore 2009).

The main tributary of the Ouachita River is the Saline River. It is a free flowing river with no impoundments. It begins north of Benton and is formed by four forks; South Fork, Middle Fork, Alum Fork, and North Fork. The Saline River flows generally southward until its confluence with the Ouachita River in the Felsenthal NWR in Union County (Woodard 2012). The federal refuge is an area of wetlands, streams, lakes, and sloughs and is the world's largest green tree reservoir (USFWS 2013c, Unknown 2011).

The Caddo River is a tributary of the Ouachita River. It is a spring-fed stream that begins in Polk County. The Caddo River flows east-southeast through Montgomery and Clark counties, where it is impounded to form DeGray Lake. A little further east it flows into the Ouachita River (Westfall 2010).

Another tributary to the Ouachita River is the Little Missouri River. It begins in south Polk County and flows south-southeast through the Ouachita Mountains. One impoundment, Lake Greeson, is found on the river (Arkansas Department of Parks & Tourism 2013).

Smackover Creek is another tributary to the Ouachita River. Its headwaters are found in southern Nevada County, where the creek flows south-southeast. It then flows east along the Columbia-Ouachita County border and Union-Ouachita County border before meeting the Ouachita River at the point where Ouachita, Calhoun, and Union counties meet (USGS 2009).

Moro Creek is also a tributary to the Ouachita River. It begins in Dallas County and flows generally southward along the Dallas-Cleveland county border and Calhoun-Bradley county border. It flows into the Ouachita between the confluences of Smackover Creek and the Saline River (USGS 2009).

The historical average annual surface runoff in the SCAWRPR ranges from approximately 11 inches in the southwest area of the planning region to approximately 15 inches in the far northwest area of the planning region (Figure 3.17). Seasonal variation in surface runoff mirrors seasonal variation in precipitation (Pugh and Westerman 2014).

Mean monthly discharges at selected gaging stations are summarized on Figure 3.18. Locations of these gages are shown on Figure 3.19. Streamflow in the SCAWRPR is generally highest from December through May because of the large amount of precipitation during this period (Figure 3.11). Similarly, streamflow is generally lowest during June through November due to lower precipitation and increased water use and evapotranspiration that occur during the growing season (see Figure 3.11).

Long-term flow records in the SCAWRPR have recently been analyzed for trends. A 1992 USGS report found that no trend existed for 7-day annual low-flow series at a gage station on the Saline River with a 50-year period of record. An analysis of stations in undisturbed watersheds showed that there were no climatic trends for the period of record and therefore it could be inferred that any increasing or decreasing flow trends could be attributed to human influences (Ludwig 1992). An updated state-wide analysis of long-term trends in flow runoff is being conducted by USGS and USACE as part of the 2014 AWP update.

3.7.2 Lakes and Impoundments

In 1981 there were over 38,010 acres of lakes and impoundments in the planning region (Table 3.5).The majority of the impoundments in Arkansas at that time were irrigation and aquaculture ponds (ASWCC 1981). An updated state-wide inventory of impoundments is being prepared for the 2014 AWP update. ADEQ has identified 15 significant publicly owned lakes in the planning region. These are lakes that are at least 100 acres and have access designed to enhance public use (ADPCE 1990). A list of these significant publicly owned lakes is given in Table 3.6.

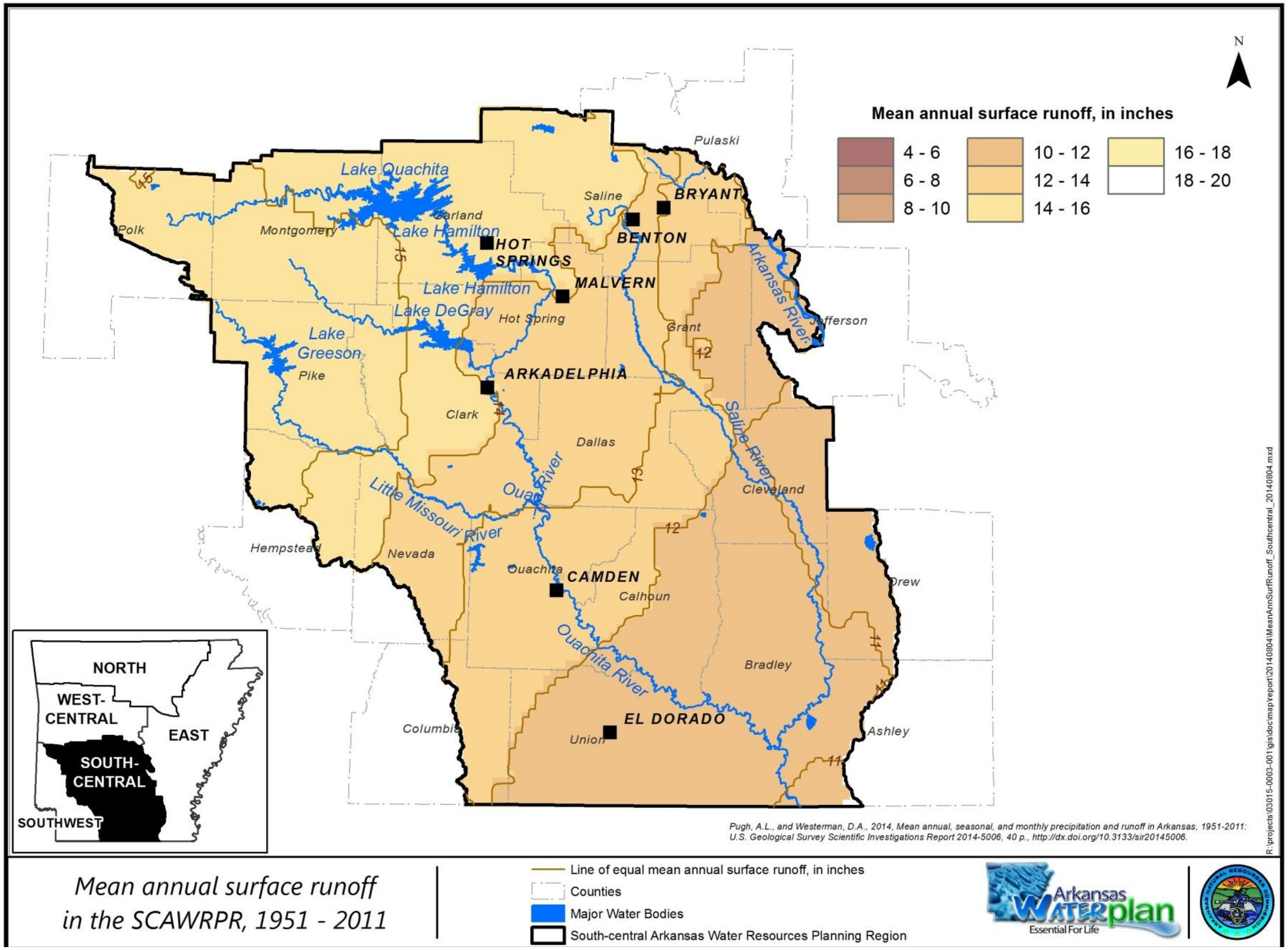

Figure 3.17. Average annual surface runoff in the SCAWRPR, 1951 to 2011 (Pugh and Westerman 2014).

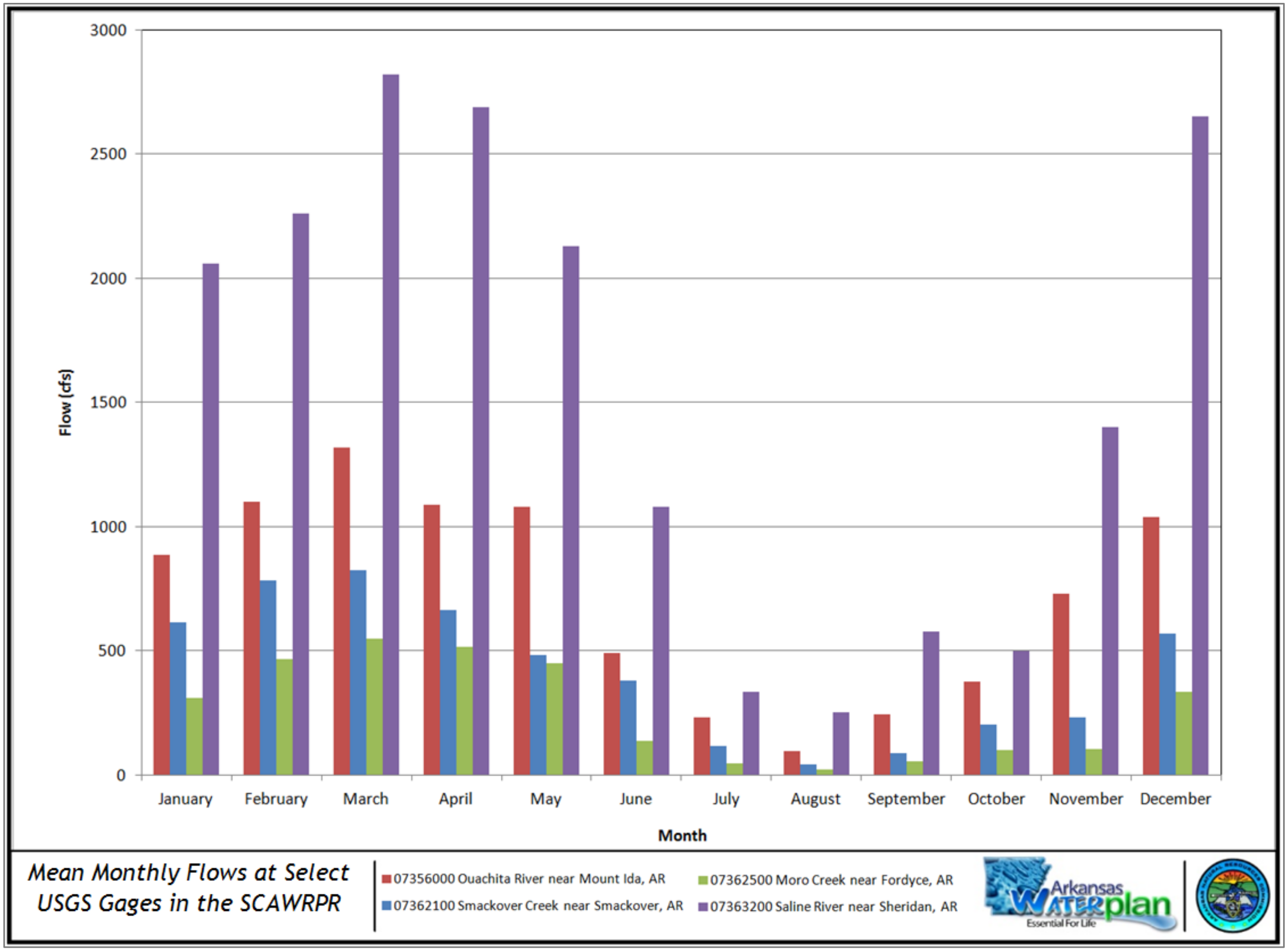

Figure 3.18. Mean monthly flows reported for USGS gaging stations on selected streams in the SCAWRPR (USGS 2014).

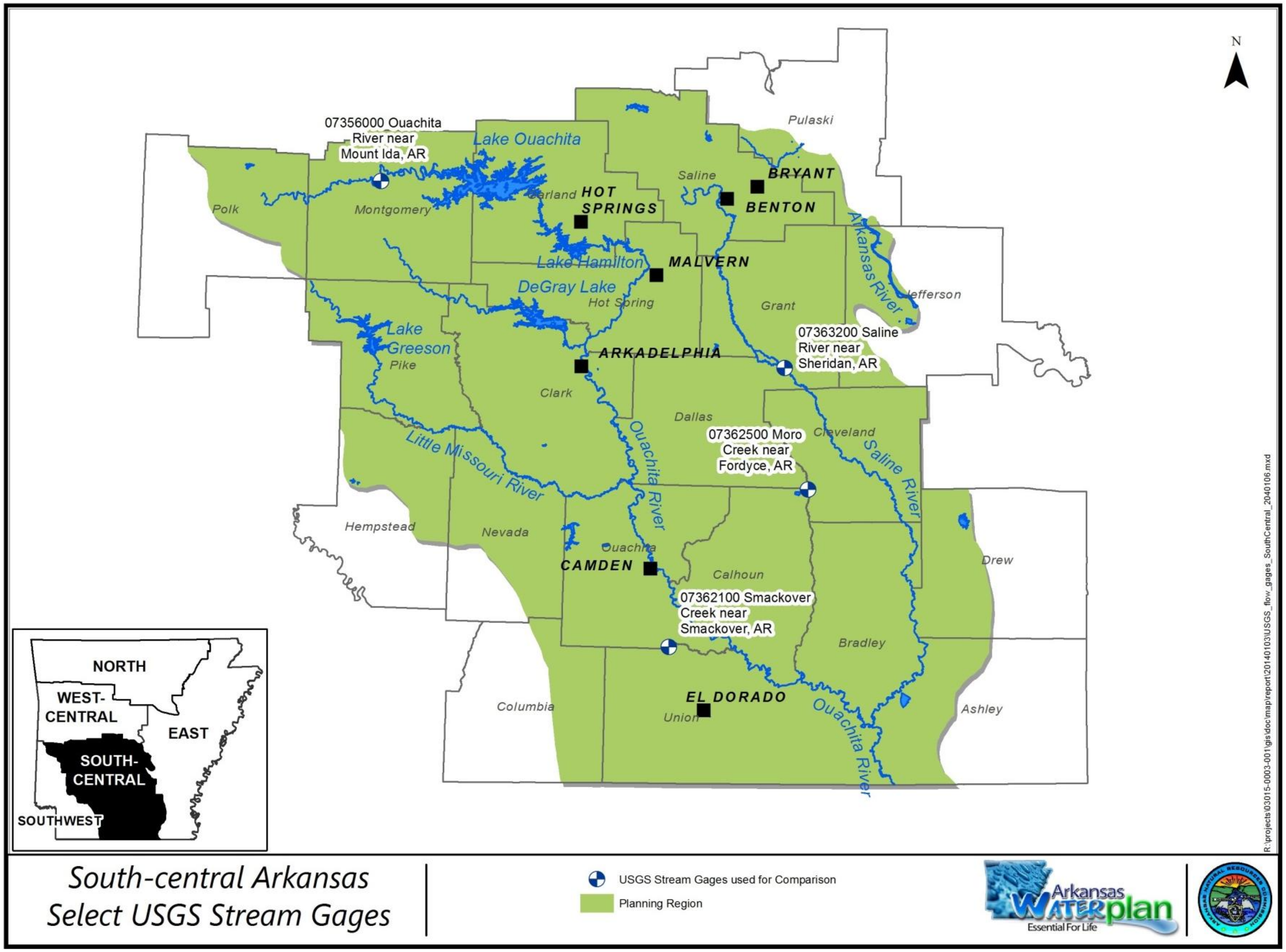

Figure 3.19. Locations of USGS gages graphed on Figure 3.18.

Table 3.5. Summary of lakes and impoundments in the SCAWRPR (ASWCC 1981).

County	Number of Lakes and Impoundments	Area (acres)	Capacity (acre-feet)
Ashley County*	478	3,200	12,410
Bradley County	1,170	1,332	6,225
Calhoun County	515	1,223	11,662
Clark County	1,318	997	4,494
Cleveland County	878	1,074	4,447
Columbia County *	1,283	1,566	6,763
Dallas County	645	418	2,293
Drew County *	1,307	741	1,766
Garland County	1,442	7,071	201,875
Grant County	1,251	2,138	5,037
Hempstead County *	2,665	2,441	6,002
Hot Spring County	953	2,477	37,107
Jefferson County *	371	495	5,364
Montgomery County	436	1,327	1,662
Nevada County *	1,523	808	4,367
Ouachita County	998	1,918	14,726
Pike County	1,060	452	1,518
Polk County *	1,910	1,439	7,386
Pulaski County *	735	1,128	8,284
Saline County	878	3,371	42,531
Union County	656	2,397	9,431
Owned by USACE	3	163,300	4,056,800
Owned by Arkansas Department of Parks & Recreation	1	3	17
Owned by AGFC	6	4,396	33,008
Total	**22,482**	**205,712**	**4,485,175**

*Part of this county is outside the SCAWRPR. The number of lakes, area, and capacity of lakes was altered so that any lake over 5 acres that was outside of the planning region was not included. An inventory of exact locations of smaller lakes was not available.

Table 3.6. Information for significant publicly owned lakes in the SCAWRPR (ADEQ 2012a).

Name	County	Surface Area (acres)	Average Depth (feet)	Capacity (acre-feet)	Purpose
Winona	Saline	1,240	30.0	43,000[a]	Water supply
Catherine	Hot Spring	1,940	18.0	34,920[b]	Hydropower
Greeson	Pike	7,200	39.0	279,700[c]	Hydropower
Hamilton	Garland	7,300	26.0	189,800[b]	Hydropower
DeGray	Clark	13,400	48.8	644,160[b]	Hydropower

Table 3.6. Information for significant publicly owned lakes in the SCAWRPR (continued).

Name	County	Surface Area (acres)	Average Depth (feet)	Capacity (acre-feet)	Purpose
Ouachita	Garland	40,100	51.0	2,151,000[(d)]	Hydropower
Tricounty	Calhoun	280	7.0	1,960[(b)]	Public fishing
Cox Creek	Grant	300	6.0	1,800[(b)]	Public fishing
Calion	Union	510	6.0	3,060[(b)]	Public fishing
Upper White Oak	Ouachita	630	8.0	6,300[(b)]	Public fishing
Lower White Oak	Ouachita	1,080	8.0	8,640[(b)]	Public fishing
Pine Bluff	Jefferson	500	6.0	3,000[(b)]	Public fishing
Georgia Pacific	Ashley	1,700	4.0	6,800[(b)]	Water supply
Felsenthal	Bradley	14,000	7.0	98,000[(b)]	Recreation

Notes:
a. From Central Arkansas Water n.d.
b. Capacity not reported; calculated as surface area (acres) times average depth (ft).
c. From http://www.lakegreeson.org/lake-greeson-narrows-dam.htm, accessed January 8, 2014.
d. From USACE Little Rock District 2009.

The largest lake entirely in the state of Arkansas is Lake Ouachita. It is the most upstream of the three lakes along the upper reach of the Ouachita River. It was formed after the completion of Blakely Mountain Dam on the Ouachita River in 1952 by USACE with funding from the Flood Control Act of 1944. A power plant was completed at the dam in 1955 (USACE n.d.[a]). The lake is maintained as Lake Ouachita State Park by the state of Arkansas, while the dam is maintained by USACE.

The next lake downstream of Lake Ouachita is Lake Hamilton. It was formed by the construction of Carpenter Dam. This dam was built by AP&L, an electric company that would eventually become Entergy. The dam was built in 1931 for the means of producing hydroelectric power. It has more potential for flooding than Lake Ouachita as it was not built for flood control (Lancaster 2012b).

Downstream of Lake Hamilton is Lake Catherine, which was formed in 1924 with the completion of Remmel Dam. This dam was also built by AP&L for the means of producing hydroelectric power. Lake Catherine State Park was created by the Civilian Conservation Corps in the 1930s and is one of the six original state parks (Smethers 2012).

The fourth impoundment on the Ouachita River is Lake Jack Lee. This lake is formed by the Felsenthal Lock and Dam, located a few miles south of the Saline River confluence. This area is also part of the Felsenthal NWR (USFWS 2013c, Unknown 2011).

DeGray Lake is an impoundment on the Caddo River. It was completed in 1972 and is managed by USACE. Hydroelectric power is produced at the dam. The lake was the first USACE lake built with pump-back capabilities. A lower lake below the main dam holds storage water that can be pumped back into the main lake if needed (USACE n.d.[b]). A resort state park is located on the banks of Lake DeGray in an area leased by the state of Arkansas from USACE (Arkansas Department of Parks and Tourism 2012b).

Lake Greeson is an impoundment found in the Little Missouri River. It was formed by the completion of Narrows Dam in 1950. The dam was built as a means of both flood control and hydroelectric power production and is maintained by USACE (Foshee 2013).

3.7.3 Wetlands

The SCAWRPR is located in the Coastal Plain Wetland Planning Region. All classes of wetlands are found in the region. These classes are depressions, flats, fringe, riverine, and slope wetlands (Klimas et al. 2005). Flats are found outside the direct vicinity of the rivers. The types of flat wetlands found in the Ouachita and Saline River valleys are hardwood, alkali wet prairie, pin/post oak, and wet tallgrass prairie. Riverine wetlands are found along the rivers and streams of the region. Those in the Ouachita and Saline river areas are mid-gradient riverine, low-gradient backwater, low-gradient overbank, and sand prairie. Sand prairie wetlands are extremely unique and only occur in the Ouachita River floodplain in the southern portion of the region. Depressions occur in low points that accumulate precipitation. Unconnected and floodplain depressions both occur in the SCAWRPR. Unconnected depressions are isolated from the river system. Floodplain depressions occur near the rivers and are flooded much more frequently than the unconnected depressions. Fringe wetlands occur near lakes. Reservoir fringe wetlands and connected lake margin wetlands both occur in the SCAWRPR. Reservoir fringes are wetlands that are manmade in order to provide water storage and water supply for their nearby manmade reservoir. Connected lake margin wetlands usually occur near oxbow lakes and frequently exchange flow, nutrients, and organisms with the lake. The last class of wetlands is slope wetlands. Bayheads and perennial seeps are both types of slope wetlands that occur in the SCAWRPR. Bayhead seeps are generally found in the southeast portion of the region while perennial seeps usually occur in the more northern area (Klimas et al. 2005).

A large wetland area in the SCAWRPR is in the Felsenthal NWR. It is home to the world's largest green tree reservoir, and is also considered an excellent winter waterfowl habitat (USFWS 2013c).

3.7.4 Surface Water Quality

Surface water quality in the SCAWRPR is generally good. Surface waters of the Ouachita Mountains overall have exceptional water quality, with low nutrient, biochemical, and turbidity concentrations in most streams. Surface water quality in the West Gulf Coastal Plain is good, with some perennial spring-fed streams as well as some intermittent creeks during summers. Water quality in the forested areas of the planning region is better than that of the pastures (Woods et al. 2004). Surface water quality issues within the SCAWRPR are discussed in detail in Section 5.

3.8 Groundwater

The largest and most productive of the state's major aquifers are in the Gulf Coastal Plain. The SCAWRPR is located primarily in the West Gulf Coastal Plain, which is underlain by aquifers consisting of various geologic units mainly of poorly consolidated formations that are blanketed with alluvium along the Ouachita and Saline rivers. The primary water use of these aquifers is for domestic, industrial, and public water supply.

3.8.1 Aquifers

There are 12 recognized aquifers in the SCAWRPR, which are listed in Table 3.7 and mapped on Figure 3.20. Many of these aquifers are designated as regional aquifers and encompass parts of several states, whereas a few of these aquifers are considered minor and are only important as local sources of water. For a detailed description of the geologic formations that comprise the aquifers in the SCAWRPR, refer to McFarland 2004. Kresse and others (2013) provide a comprehensive review of the aquifers of Arkansas to include the geologic setting, hydrologic characteristics, water levels, water use, and water quality. Much of the information presented in this section was taken or summarized from the Kresse and others (2013) report.

Table 3.7. Nomenclature, geologic age, and use for aquifers in the SCAWRPR.

<table>
<tr><th>Major Division</th><th>Province</th><th>Section</th><th>Formation or Group of Formations</th><th>Geologic Age</th><th>Hydrogeologic Unit Name</th><th>Aquifer Use*</th></tr>
<tr><td rowspan="11">Coastal Plain</td><td rowspan="11">Gulf Coastal Plain</td><td rowspan="8">Mississippi Alluvial Plain and West Gulf Coastal Plain</td><td>Coastal Plain Alluvium</td><td>Quaternary</td><td>Mississippi River Valley, Ouachita-Saline</td><td>IR, PS, IN</td></tr>
<tr><td>Jackson Group</td><td>Tertiary</td><td>Vicksburg-Jackson confining unit</td><td>D</td></tr>
<tr><td>Cockfield Formation</td><td>Tertiary</td><td>Cockfield aquifer</td><td>PS</td></tr>
<tr><td>Sparta Sand</td><td>Tertiary</td><td>Sparta aquifer</td><td>IR, PS, IN</td></tr>
<tr><td>Cane River Formation</td><td>Tertiary</td><td>Cane River aquifer</td><td>PS, D</td></tr>
<tr><td>Carrizo Sand</td><td>Tertiary</td><td>Carrizo aquifer</td><td>D</td></tr>
<tr><td>Wilcox Group</td><td>Tertiary</td><td>Wilcox aquifer</td><td>PS, IR, IN</td></tr>
<tr><td>Nacatoch Sand</td><td>Cretaceous</td><td>Nacatoch aquifer</td><td>PS</td></tr>
<tr><td rowspan="3">West Gulf Coastal Plain</td><td>Ozan Formation</td><td>Cretaceous</td><td>Ozan aquifer</td><td>D</td></tr>
<tr><td>Tokio Formation</td><td>Cretaceous</td><td>Tokio aquifer</td><td>PS, IN</td></tr>
<tr><td>Trinity Group</td><td>Cretaceous</td><td>Trinity aquifer</td><td>PS, IN</td></tr>
<tr><td>Interior Highlands</td><td>Ouachita Province</td><td>Ouachita Mountains</td><td>Johns Valley Shale
Jackfork Sandstone
Stanley Shale
Arkansas Novaculite
Missouri Mountain Shale
Blaylock Sandstone
Polk Creek Shale
Bigfork Chert
Womble Shale
Blakely Sandstone
Mazarn Shale
Crystal Mountain Sandstone
Collier Shale</td><td>Cambrian through Pennsylvanian</td><td>Ouachita Mountains aquifer</td><td>D</td></tr>
</table>

*Note: IR= irrigation, PS = public supply, IN = industrial, D = domestic. Listed in order of highest use by volume. Primary use in capital letters; secondary use in small caps.

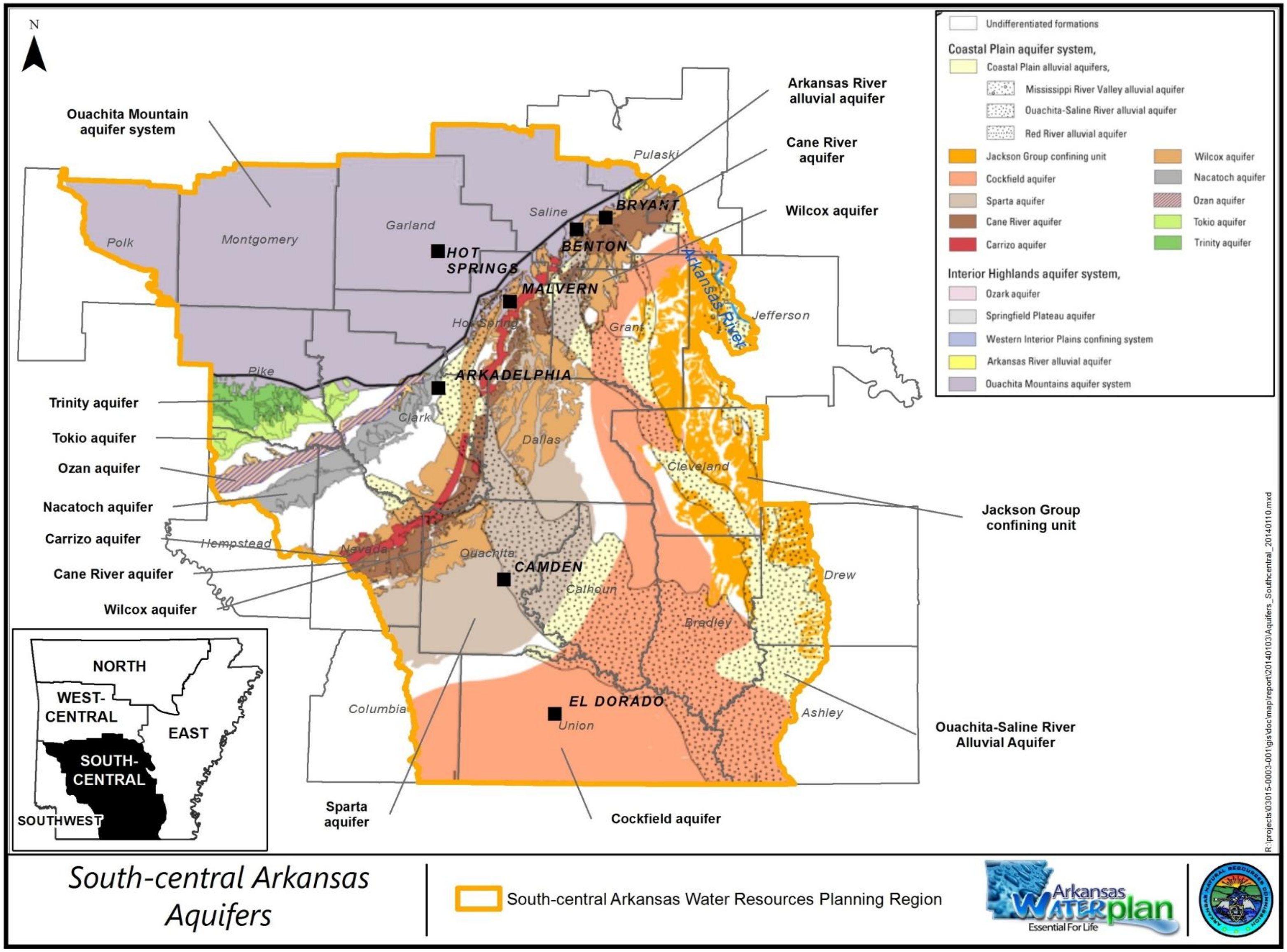

Figure 3.20. Aquifers of the SCAWRPR (Kresse et al., in review).

From youngest to oldest, the following formations serve as aquifers in the West Gulf Coastal Plain section of the SCAWRPR: alluvium associated with the Ouachita and Saline rivers, the Jackson Group, the Cockfield Formation, the Sparta Formation, the Cane River Formation, the Carrizo Sand, the Wilcox Formation, the Nacatoch Sand, the Ozan Formation, the Tokio Formation, the Trinity Group, and the Ouachita Mountains aquifer. All but the Jackson Group have been or are used as a significant source of water supply in the region. The Jackson Group is a regional confining unit that historically served as an important source of domestic supply. The Cretaceous Formations (Nacatoch Sand, Ozan Formation, Tokio Formation, and Trinity Group) are not designated as regional aquifers but are considered to be important local groundwater supplies (Kresse et al. 2013). Of these aquifers, the Sparta aquifer is the most important, yielding 82% of the groundwater used in the areas of the planning region where it occurs, during 2010.

The unconsolidated sand and gravel that comprise the Quaternary alluvial aquifers have intergranular porosity, and all contain water primarily under unconfined or water-table conditions. The hydraulic conductivity of the aquifers is variable, depending on the sorting of aquifer materials and the amount of silt and clay present, but generally it is high. The alluvial aquifers are susceptible to contamination because of their generally high hydraulic conductivity. Groundwater in the Ouachita-Saline alluvial aquifer flows along relatively short flow paths from recharge to discharge areas typical of local flow systems; however, the Mississippi River Valley alluvial aquifer has a regional flow system. Mississippi River Valley alluvial aquifer is an important aquifer in the Mississippi Alluvial Plain, but only a small portion of the alluvial aquifer occurs within the planning region (Drew and Ashley counties). The reader is referred to discussions of this major aquifer in the East Arkansas Water Resources Planning Region report.

The remaining West Gulf Coastal Plain aquifers consist of semi-consolidated and unconsolidated sand interbedded with silt, clay, and minor carbonate (limestone) rocks. Porosity is intergranular, and the hydraulic conductivity of the aquifers is moderate to high. The aquifers are in a thick wedge of sediments that dips and thickens toward the Arkansas-Louisiana border. Groundwater in topographically high recharge areas is unconfined, but it becomes confined as it moves downdip. Discharge may occur by upward leakage to shallower aquifers. These aquifers typically have lengthy regional flow paths, and because flow is sluggish near the ends of regional flow paths, the aquifers commonly contain unflushed saline water in their deeply buried, down dip parts. Where shallower aquifers have been heavily pumped, saltwater intrusion has locally contaminated groundwater. The northern one-third of the planning region lies within the Ouachita Mountains section of the Interior Highlands, where groundwater occurs in shallow, fractured, and discontinuous bedrock that results in lower porosity, storage, and yields than the laterally extensive, coarse-grained, and unconsolidated sediments of the West Gulf Coastal Plain.

3.8.1.1 Ouachita-Saline Alluvial Aquifer

Alluvial deposits constituting the Ouachita-Saline rivers alluvial aquifer are thin and restricted in areal extent. Locally, the alluvium of the Ouachita and Saline rivers provides readily available groundwater. The alluvium is comprised of silt and beds of fine to very fine sand, with some clay throughout. Locally the alluvium may contain coarse sand. The alluvium ranges from 0 to 40 feet in thickness in Grant and Hot Spring counties (Halberg, Bryant and Hines 1968). Groundwater is under water table conditions (unconfined), and, where the sand is coarse, the alluvium may be in hydraulic connection with the rivers. Halberg and others (1968) noted a maximum yield of 25 gpm.

In the area of Clark, Cleveland, and Dallas counties, the alluvium of the Ouachita River is comprised of silt, clay, sand, and gravel, reaching a maximum thickness of about 40 feet (Plebuch and Hines 1969). Plebuch and Hines (1969) report that two industrial wells south of Arkadelphia yield 240 gpm each, yet nearby wells were capable of yielding much lower quantities of water, indicating a wide variability of the properties of the aquifer in this area. The groundwater in this area is under water table conditions. In most locations, deposits from the Ouachita and Saline rivers incise older Pleistocene terrace deposits and no distinction is made between the groundwater from all of these combined alluvial deposits (Kresse et al. 2013).

3.8.1.2 The Jackson Group

The Jackson Group comprises an upper Tertiary-age sequence of largely unconsolidated clays with variable abundances of fossils, gypsum, marls, carbonate lenses, and lignite (Hosman and Weiss 1991, Veatch 1906); sand units are a minor but an important occurrence (Stephenson and Crider 1916). Because of the predominance of fine-grained sediments and overall low hydraulic conductivity, the Jackson Group is designated as a regional confining unit. However, groundwater in deposits of the Jackson Group served in the past as an important source of domestic and small farm water supply through the 1990s. As such, this group of deposits can be considered an aquifer, although a minor one in terms of poor yields and lack of economical supply for industrial, municipal, irrigation, and other important uses. The largest area of outcrop of the Jackson Group in Arkansas is located in the planning region south of the Arkansas River in Jefferson, Lincoln, Cleveland, Drew, and Bradley counties. Groundwater use from the Jackson Group was confined almost solely to this large area of exposed deposits. Yields to wells were reported to be very small (Plebuch and Hines 1969; Halberg, Bryant, and Hines 1968). Kresse and Fazio (2003) reported that most of the wells completed in the Jackson Group were dominantly less than 50 feet, with many less than 30 feet; only four wells were found to be deeper than 50 feet, ranging upward to 150 feet below land surface.

3.8.1.3 Cockfield Aquifer

The Cockfield Formation crops out extensively over south-central Arkansas (Figure 3.20). It is exposed over practically all of Union County and parts of Bradley, Cleveland, Dallas, Grant, and Saline counties (Hosman et al. 1968; Hosman 1982; Petersen, Broom and Bush 1985). The Cockfield Formation generally consists of silt, clay, and lignite in the upper portions and sand beds near the base, which form the more permeable portions of the Cockfield aquifer (Pugh 2010). There is considerable variability in unit thickness, ranging from 100 to 700 feet. Regional groundwater flow is to the southeast; however, sustained and intense pumping in some areas of southeastern Arkansas have led to the development of cones of depression and altered flow towards these pumping centers (Hosman et al. 1968, Petersen et al. 1985).

In the outcrop area and where overlain by Quaternary alluvium, the aquifer is unconfined. Where overlain by the Jackson Group, the aquifer is confined. In the confined part of the aquifer, the potentiometric surface can be near or above land surface (Ackerman 1987, Pugh 2010).

Recharge to the aquifer occurs as precipitation in the outcrop area and as seepage from overlying Quaternary alluvium in the subcrop area. Discharge from the aquifer occurs to streams in the outcrop area, to adjacent units, and wells. In and near the outcrop area, well depths are typically shallow (less than 200 feet) and yields are generally less than 30 gpm. Further away from the outcrop area, well depths can exceed 600 feet and yields range from 100 to 500 gpm (Kresse et al. 2013).

3.8.1.4 Sparta Aquifer

The Tertiary-age Sparta Sand is the thickest sand in the Mississippi embayment and its importance as an aquifer is recognized by the fact that it is second in use only to the Mississippi River Valley alluvial aquifer. The Sparta aquifer is present throughout the SCAWRPR. Kresse and others (2013) noted that the term "Sparta aquifer" is applied to a sequence of hydraulically connected sands that are often separated by silts and clays and is not an absolutely equivalent term with "Sparta Sand," the formal name for the geologic formation. This distinction is important because by Arkansas law, Critical Groundwater Area designation criteria for the Sparta aquifer are based on the top of the geologic formation rather than the top of the aquifer (ANRC 1996); this has been an important distinction in management of the Sparta aquifer. In areas where clays and silts in the Sparta Sand (the geologic formation) occur above productive sands, the top of the Sparta aquifer does not coincide with the top of the Sparta Sand. In this report, the term "Sparta Sand" always will refer to the geologic formation (comprising sands, silts, and clays), and the term "Sparta aquifer" will refer to the sequence of productive, hydraulically connected sands that constitute a part of the geologic formation.

The Sparta Sand consists of varying amounts of sand and occasionally gravel interspersed with layers of silt, clay, shale, and lignite. The lower half of the unit generally contains more sand and the upper part of the Sparta Sand generally contains more clay and shale (Hosman et al. 1968, Petersen et al. 1985). The occurrence, continuity, and thickness of the sand beds which constitute the aquifer are quite variable but in general appear to be hydraulically connected. Hydraulic properties in the Sparta aquifer vary widely, and groundwater appears to be more easily transmitted in the thickest sand intervals. Reported well yields range from hundreds to thousands of gallons per minute (Kresse et al. 2013).

The Sparta Sand outcrops in southern Arkansas, and the Sparta aquifer is unconfined at its western extent within the Mississippi Embayment. The Sparta aquifer becomes confined by the overlying Cook Mountain Formation and the underlying Cane River Formation (Kresse et al. 2013). The Sparta aquifer is recharged by direct infiltration in the outcrop, from rivers in the outcrop, and by leakage from overlying aquifers. Natural discharge occurs by leakage through the confining and discharge to rivers within the outcrop area. Natural groundwater flow is generally down dip toward the axis of the embayment and southward toward the Gulf of Mexico.

In the area of Union County, the Sparta Sand is divisible into three distinct hydrogeologic units: the upper 200 feet is composed of thin-bedded sands and clays referred to as the Greensand (upper Sparta aquifer); the middle 50 to 155 feet is composed of clay and silt and is referred to as the Middle Confining Unit; and the lower 300 feet of thick-bedded sands is referred to as the El Dorado Sand (lower Sparta aquifer). The Greensand is overlain by the Cook Mountain Formation and regionally dips southeastward. The Greensand is partially in contact with the Middle Confining Unit and the El Dorado Sand along faults. Differences in static water levels measured in sand beds within the Greensand aquifer indicate that some clay beds in the Greensand act as confining beds locally. In some areas of Union County, the Middle Confining Unit contains sand that makes the unit difficult to distinguish from the Greensand and El Dorado Sand. However, differences in potentiometric surfaces above and below this unit confirm that it effectively isolates the upper and lower sands of the Sparta aquifer in this area. In general, the El Dorado Sand is more productive and the local flow pattern within the El Dorado sand is heavily influence by groundwater withdrawals (Hosman et al. 1968, Broom et al. 1984, Leidy and Taylor 1992, Clark and Hart 2009). The El Dorado Sand overlies the Cane River Formation and regionally dips southeastward and is faulted against the Cane River Formation in some areas (Leidy and Taylor1992).

3.8.1.5 Cane River Aquifer

The Cane River Formation (hereinafter referred to as the Cane River aquifer when referring to the saturated part of the formation) is a sequence of marine clays and shale that includes minor amounts of marls, silts, and marine sand. Payne (1972) reported that the formation thickness ranged from 200 to 750 feet thick. The Cane River Formation overlies the Carrizo Sand and is overlain by the Sparta Sand. The Cane River Formation is considered an important aquifer within the planning region, where locally extensive, water-producing sands occur within the formation. Because the sand units are thin and discontinuous regionally as compared to thicker, regionally extensive sand units in adjacent formations, the clay-dominated lithology of the Cane River Formation in southern Arkansas was listed as part of a regional confining system, termed the lower Claiborne confining unit (Arthur and Taylor 1990; Clark and Hart 2009; Hart, Clark and Bolyard 2008; Hosman and Weiss 1991).

The Cane River aquifer is composed of poorly connected sand bodies 25 feet or more in thickness. Hydraulic properties in the Cane River aquifer vary widely, and groundwater appears to be more easily transmitted in the thickest sand intervals. Near the outcrop and subcrop areas in the planning region, the aquifer is under water-table conditions; however, the aquifer becomes confined by overlying and underlying beds downdip and is under artesian conditions (Petersen et al. 1985). Shallow wells in the outcrop area generally yield between 5 and 10 gpm (Hosman et al. 1968), but aquifer yields that vary between 50 and 920 gpm have been reported (Ludwig 1972, Plebuch and Hines 1969, Tait et al. 1953). Municipal wells in Dallas County each produced 50 gpm (Plebuch and Hines 1969). Although yields are variable, they are more than sufficient for smaller towns in the planning region. In Union County, the Cane River Formation is considered a confining unit with little capacity for transmission of fluids, with the exception of possible fluid transfer along fault zones (Broom et al. 1984).

The principal source of recharge to the aquifer is infiltration of precipitation through exposures in the outcrop areas (Hosman et al. 1968). Recharge may occur through younger sedimentary materials, where the Cane River Formation outcrop is covered. A minor amount of recharge takes place by upward movement from the underlying Carrizo Sand and the upper Wilcox aquifer. Water is lost from the aquifer from pumping wells and through natural discharge by upward leakage though confining units. A very minor component of natural discharge may occur as base flow into streams incised into the Cane River Formation (Hosman et al. 1968, Payne 1972).

Regional flow of water is generally south and southeast down dip toward the gulf coast and the Mississippi alluvial valley. Upward flow occurs through leaky confining units above the Cane River Formation. This occurs where the head of the Cane River Formation exceeds the head of the overlying Sparta Sand (Payne 1972, Petersen, Broom and Bush 1985).

3.8.1.6 Carrizo Aquifer

The saturated part of the Carrizo Sand comprises an aquifer of limited use only in and near the outcrop area within the planning region. The Carrizo Sand consists predominately of massive-bedded quartz sands with minor amounts of interbedded clays and silts and occasional lenses of lignite. The lithology is almost uniform, being composed of more than 80% sand in the majority of Arkansas. In Clark, Cleveland, and Dallas counties, the Carrizo Sand consists mainly of very fine to medium sand, although it does contain some clay and lignite (Plebuch and Hines 1969). The Carrizo Sand is discontinuous, notably in parts of Union, Ouachita, and Columbia counties, where thicknesses of 30 feet or less occur, and is highly variable in thickness. The thickness of the Carrizo Sand in Clark, Cleveland, and Dallas counties varies considerably over short distances, ranging from about 60 to 200 feet (Plebuch and Hines 1969).

Recharge to the Carrizo Sand in the planning region comes from rainfall on the outcrop, and discharge from the Carrizo Sand occurs by withdrawals from wells and by natural leakage through the overlying confining beds. Regional flow of water is generally down dip, toward the axes of the Mississippi embayment (Hosman et al. 1968; Payne 1975).

The Carrizo aquifer is not considered to be a major aquifer in Arkansas due to its erratic distribution, and therefore available hydrologic data are limited. There is an increase in permeability with increasing thickness of sand units in the Carrizo aquifer. Except in the outcrop area, water in the Carrizo Sand is under artesian conditions and the regional flow is down dip to the east and southeast (Payne 1975). In southern portions of the planning region, the groundwater flow in the Carrizo aquifer is confined by the Wilcox Group below and the Cane River Formation above (Hosman et al. 1968).

3.8.1.7 Wilcox Aquifer

The Wilcox Group is present throughout the Coastal Plain of Arkansas. Three aquifer units are used to represent the Wilcox Group: lower Claiborne-upper Wilcox aquifer [hereafter referred to as the upper Wilcox, or minor Wilcox aquifers after Hosman and others (1968), the middle Wilcox aquifer, and the lower Wilcox aquifer. The upper Wilcox Group predominates in the southern part of Arkansas and consists of complexly interbedded layers of clay, sandy clay, thin and discontinuous sand, and lignite (Joseph 1998), and the thin sands of this unit serve as aquifers (Hosman et al. 1968).

In southern Arkansas, the Wilcox Group overlies the Midway Group, crops out in a discontinuous band 1 to 3 miles wide (Joseph 1998), and commonly is overlain by terrace deposits and alluvium of Quaternary age. The Wilcox in the planning region becomes progressively thicker downdip from the outcrop, ranging in thickness from only a few feet at outcrop to about 750 feet in Bradley County (Albin 1964), and it dips toward the axis of the Mississippi Embayment at about 50 feet per mile in the south (Hosman et al. 1968). Zachary and others (1986) report that the Wilcox Group crops out in northern Nevada and Hempstead counties and underlies the Cane River Formation throughout Columbia and Union counties. In this area, the Wilcox group is composed dominantly of clay with thin erratic sand units and thin lignite beds in some areas. In the area of Columbia and Union counties, the Wilcox Group ranges from 350 to 550 feet in thickness.

Recharge to the Wilcox aquifer in the planning region is from precipitation in the outcrop areas, or from leakage through the confining clays (Hosman et al. 1968). The potentiometric surface of the Wilcox aquifer is below land surface (Hosman et al. 1968). Wells completed in the Wilcox aquifer in southeast Hot Spring County and southwestern Grant County yield 300 gpm (Halberg, Bryant and Hines 1968). The direction of groundwater flow is either down dip (southeast) or by pumping induced gradients. Pumping from minor Wilcox aquifers has caused declines in water levels in some areas.

3.8.1.8 Nacatoch Aquifer

The Nacatoch Sand is a Cretaceous-age formation of interbedded lithologies, predominated by generally unconsolidated sands with local lenses and beds of fossiliferous sandy limestone (Counts et al. 1955, Plebuch and Hines 1969). Formation thickness ranges from 150 to nearly 600 feet (Boswell et al. 1965; Zachary et al. 1986). The Nacatoch Sand outcrops along a belt 3 to 8 miles wide that extends from central Clark County southwestward to the west edge of Hempstead County. The Nacatoch Sand dips south and southeast into the subsurface at a rate of about 30 feet per mile (Boswell et al. 1965; Ludwig 1972, Veatch 1906). The Nacatoch Sand is faulted downdip in Hempstead, Nevada, Ouachita, Calhoun, and Bradley counties (Petersen, Broom and Bush 1985). The lower sand unit in the Nacatoch Sand is a petroleum-producing formation in the Smackover Field of southern Arkansas (Weeks 1938).

Most wells completed in the Nacatoch aquifer are relatively low-yield wells. Throughout southwestern Arkansas, Counts and others (1955) reported well yields from 1 to greater than 300 gpm. Flowing (artesian) wells in the lower stream valleys of Nevada County yield less than 5 gpm. Wells in Hempstead and Nevada counties can be expected to yield from 150 to 300 gpm (Counts et al. 1955, Ludwig 1972). The presence of artesian wells indicates that away from the outcrop the Nacatoch aquifer is under confined conditions.

The Nacatoch aquifer receives direct recharge from precipitation in the area of its outcrop. The regional direction of groundwater flow is to the southeast (Schrader and Blackstock 2010). The flow directions may be locally controlled by clay content and faulting (Boswell and Hosman 1964). Groundwater flow and flow direction have been altered by pumping at Hope, Arkansas, where water levels in the Nacatoch sand have declined (Ludwig 1972) and a cone of depression has developed. Vertical movement upward toward Tertiary aquifers was predicted to be slow or nonexistent (Zachary et al. 1986).

3.8.1.9 Ozan Aquifer

The Cretaceous-age Ozan Formation comprises an aquifer that is used solely in isolated parts of southwestern Arkansas. This aquifer is not listed in any regional reports, is one of the least-used aquifers, and contains some of the poorest-quality groundwater of any aquifer in the state. The Ozan Formation is a mixed limey, clayey, and primarily sand unit that ranges in thickness from 0 to about 200 feet thick. The Ozan Formation outcrop extends from northeastern Clark County, Arkansas, toward the southwest into Oklahoma. The outcrop ranges from 1 to 4 miles wide and through large areas is covered by terrace and alluvial deposits (Boswell et al. 1965). From central Union County eastward, the sand content and thickness of the Ozan Formation increases rapidly (Kresse et al. 2013).

Hydrologic data for the Ozan aquifer are limited because of the lack of importance as a regional water supply. Most wells completed in the Ozan aquifer are used as a domestic water supply (Boswell et al. 1965) of limited capacity and yielding highly mineralized water, and most of these wells are located in Clark County (Counts et al. 1955). Some of the wells in Clark County are flowing artesian wells (Plebuch and Hines 1969). A few wells are completed in the Ozan aquifer in Hempstead County, but the water is not suitable as a drinking water source (Counts et al. 1955). The Ozan aquifer dominantly receives recharge in the outcrop area.

3.8.1.10 Tokio Aquifer

The Tokio Formation of Cretaceous-age crops out in a narrow band from southeastern Sevier County (Southwest WRPR) through Howard, Hempstead, and Pike and western Clark counties and attains a maximum width of about 10 miles in Howard County (Schrader and Blackstock 2010). Most producing wells are located within the larger outcrop belt. Ludwig (1972) listed extensive variation in well depth, ranging from less than 30 feet to 1,200 feet below ground surface for parts of Hempstead County and Lafayette and Little River counties in the Southwest WRPR.

The Tokio Formation consists of discontinuous, interbedded gray clay and poorly sorted sands, lignite, scattered carbonaceous materials, and in some areas a prominent basal gravel (Boswell et al. 1965; Counts et al. 1955; Dollof et al. 1967; Petersen, Broom and Bush 1985; Plebuch and Hines 1969). In parts of Howard and Hempstead counties, the Tokio Formation comprises three distinct aquifers, including a basal sand that grades to gravel to the east and two upper sands (Boswell et al. 1965). Toward the east the clay layers separating the sands thin and the sands merge into a massive stand, which is prevalent over most of Hempstead, southern Pike, and northern Nevada counties. The formation dips at about 60 feet per mile to the southeast away from the outcrop and ranges in thickness from 50 to more than 300 feet (Boswell et al. 1965), obtaining its maximum thickness in Miller County in the Southwest WRPR (Dollof et al. 1967). A fault zone through the Tokio Formation occurs across Hempstead, Nevada, Ouachita, Calhoun, and Bradley counties (Petersen et al. 1985, plate 8).

The Tokio aquifer receives direct recharge at its outcrop and from the overlying alluvial deposits where it subcrops (Boswell et al. 1965). At its outcrop, the Tokio Formation weathers into a sandy soil, facilitating percolation of surface and rain water into the sand (Counts et al. 1955). Flow of groundwater in the Tokio aquifer is generally toward the south or southeast away from the outcrop area (Schrader 1998).

Most wells constructed in the Tokio Formation are low-yield wells, but some wells produce 150 to 300 gpm. Many wells are flowing artesian wells (found in southeastern Pike, northeastern Hempstead, and northwestern Nevada counties) and typically produce less than 20 gpm under natural flowing conditions. The Tokio Formation is the most important source of water from artesian wells in southwestern Arkansas. Wells in central Hempstead County yield up to 300 gpm. Wells flowing as much as 90 gpm occur in the bottom-land areas adjacent to streams (Counts et al. 1955). The prevalence of artesian wells indicates that away from the outcrop the Nacatoch is under confined conditions.

3.8.1.11 Trinity Aquifer

The Trinity aquifer crops out in an east-west trending band from western Sevier County through central Howard County in the Southwest WRPR to near the southeastern extent of Pike County in the SCAWRPR. The Trinity Group is a sequence of clastic rocks ranging from less than 100 feet in outcrop areas to more than 1,000 feet at downdip locations. The Trinity comprises six distinct units (Counts et al. 1955), with the Pike Gravel, the Ultima Thule Gravel Member of the Holly Creek Formation, and the Paluxy Sand (Boswell et al. 1965) comprising three aquifers within the Trinity Group. These formations achieve maximum thicknesses of 50 feet, 40 feet, and 900 feet, respectively. Wells that are screened in the Pike Gravel in southern Pike County were initially under flowing artesian conditions, but ceased to flow as potentiometric surfaces declined as a result of large withdrawals and over-pumping. Generally within Pike County, the Trinity Group is a calcareous clay with little potential to yield water. Aquifers in the Trinity Group receive recharge in the outcrop area and the direction of groundwater flow is southward (Boswell et al. 1965).

3.8.1.12 Ouachita Mountains Aquifer

A thick sequence of Paleozoic rock formations in the Ouachita Mountains serves as an important source of groundwater supply for domestic users, in addition to a limited number of small commercial- and community-supply systems. The shallow saturated section of the combined formations in the Ouachita Mountains is referred to as the Ouachita Mountains aquifer (Kresse et al. 2013). Formations comprising the aquifer are predominated by thick sequences of shale, siltstones, sandstones, and other quartz formations (i.e., chert, novaculite), with minor occurrences of carbonates and other rocks.

For this system, recharge occurs as precipitation that infiltrates the ground in upland areas and percolates to the water table. Groundwater flow paths are defined by small-scale topographic features where flow occurs from elevated areas to valley floors terminating in small stream systems. Groundwater storage in these aquifers is limited primarily to fractures and faults. Quartz formations such as the Bigfork Chert and Arkansas Novaculite are very brittle and prone to dense fracturing, and most researchers working in the Ouachita Mountains identified the Bigfork Chert as the most productive aquifer in the region (Albin 1965, Cole and Morris 1986, Halberg, Bryant and Hines 1968, Kresse and Hays 2009, Stone and Bush 1984).

Yields from wells completed in the Ouachita Mountains aquifer have a fairly large range depending on individual formations and lithology, but are typically low throughout the aquifer. Albin (1965) noted that most wells in the Ouachita Mountains aquifer yielded less than 10 gpm, and yields greater than 50 gpm were rare; however, one well completed in the Bigfork Chert was recorded as yielding 350 gpm (Kresse et al. 2013). In spite of the upper range for reported yields and other hydrologic characteristics for various formations constituting the Ouachita Mountains aquifer, caution was expressed by all authors for planning and management purposes that groundwater should not be considered as a source of supply for municipal growth and economic development unless the required quantity was small (Albin 1965; Halberg, Bryant and Hines 1968; Stone and Bush 1984).

Most wells in the Ouachita Mountains aquifer are less than 100 feet deep, but can range up to approximately 700 feet deep, with static water levels generally less than 20 feet below land surface, and flowing-artesian wells found throughout the region (Albin 1965, Kresse and Hays 2009). Pumping water levels may be as much as 150 feet below land surface in deeper wells. Seasonal water-level fluctuations in wells generally are less than 10 feet; however, larger fluctuations are common in abnormally wet or dry years because the groundwater reservoirs generally have small storage capacities and are recharged by rapid infiltration of local precipitation (Albin 1965).

3.8.2 Groundwater Quality

In general, groundwater quality in the SCAWRPR is considered good. Groundwater chemistry in the planning region is primarily calcium-bicarbonate. Water quality characteristics of the aquifers in the planning region are described below. Issues with groundwater quality (both natural and contamination) are discussed in detail in Section 5.

3.8.2.1 Ouachita-Saline Rivers Alluvial Aquifer

Kresse and others (2013) report on water quality within the alluvial deposits (including Pleistocene alluvial deposits) west of the divide between the Mississippi Alluvial Plain and the West Gulf Coastal Plain area as the Ouachita-Saline rivers alluvial aquifer without discriminating between these deposits. In general, groundwater quality of the Ouachita-Saline rivers alluvial aquifer is good when compared to EPA primary drinking water standards and levels of dissolved solids in the groundwater throughout most of this aquifer are low enough for the water to be suitable for most uses. Significantly lower concentrations of iron, arsenic and other trace metals were found in groundwater from the older Pleistocene-age terrace deposits compared to the younger, Holocene-age floodplain deposits. Flushing over time likely accounts for the differences in water quality for these deposits in Arkansas.

Numerous wells completed in the Ouachita-Saline rivers alluvial aquifer had nitrate concentrations greater than 10 milligrams per liter (mg/L), particularly in Calhoun and Bradley counties. Because most of the wells sampled in this area had well depths less than 30 feet, they possibly are shallow domestic wells, which are more vulnerable to surface sources of nitrate (for example, septic systems), and nitrate has not been reduced, which is typical for groundwater from the deeper parts of the aquifer (Kresse et al. 2013).

3.8.2.2 The Jackson Group

Most groundwater in the Jackson Group is a calcium- and sodium-sulfate water type (Kresse et al. 2013). Correlations of elevated sulfate concentrations to elevated iron concentrations and extremely low-pH groundwater strongly suggest that oxidation of pyrite in some regions of the aquifer contribute to this water type. Groundwater from the Jackson Group has some of the poorest water quality of any aquifer system in the state with naturally elevated chloride (greater than 800 mg/L), sulfate (greater than 3,000 mg/L), and total dissolved solids (TDS) (greater than 5,000 mg/L) concentrations. Nitrate concentrations revealed an inverse correlation with well depth, showing the increased vulnerability to surface sources of contamination (Kresse et al. 2013).

3.8.2.3 Cockfield Aquifer

The Cockfield aquifer contains groundwater that is typically of high quality and is used throughout southeastern Arkansas. The groundwater is typically a calcium-bicarbonate water type in the outcrop and subcrop areas and transitions to a sodium-bicarbonate type downgradient of these areas. Isolated areas of the aquifer contain elevated sulfate (primarily Jefferson and Drew counties) as a result of mixing with water of poor quality in underlying formations and elevated iron (Grant and Jefferson counties) concentrations that are possibly the result of infiltration of high iron-content groundwater from overlying formations (Kresse et al. 2013).

3.8.2.4 Sparta Aquifer

The quality of groundwater from the Sparta aquifer throughout the SCAWRPR is very good. The groundwater generally is a sodium-bicarbonate water type throughout most of the extent of the aquifer; however, a calcium-bicarbonate water type is found in the outcrop area for the Sparta Sand. Elevated iron and nitrate groundwater concentrations are found dominantly in the outcrop area of the Sparta Sand, with lower concentrations in the downgradient direction of flow. Generally, pH values, in addition to bicarbonate and dissolved solids concentrations, increase in the Sparta aquifer with increased residence time along the flow path moving downgradient from the outcrop area for the Sparta Sand; effects are attributed to increased dissolution of carbonates. Areas of high salinity are noted in isolated areas of the Sparta aquifer, predominantly as a result of inferred upwelling from high-salinity groundwater in underlying formations (Kresse et al. 2013).

3.8.2.5 Cane River Aquifer

Water quality from the Cane River aquifer is good with respect to federal drinking water standards. Groundwater from the Cane River aquifer generally is a calcium-bicarbonate water type in the outcrop area, but transitions at short distances from the outcrop area to a sodium-bicarbonate water type as a result of cation exchange processes. Nitrate concentrations were less than the maximum contaminant level of 10 mg/L as nitrogen for all samples. Salinity increases downdip of the outcrop area, and chloride concentrations can exceed the federal secondary drinking water regulation of 250 mg/L in some areas. Similar to other tertiary aquifers in the Coastal Plain, iron, nitrate, and sulfate are relatively higher in the outcrop areas (Kresse et al. 2013).

3.8.2.6 Carrizo Aquifer

Groundwater in the Carrizo aquifer is of overall good quality. The aquifer has a sodium-bicarbonate groundwater with low iron concentrations as compared to many other aquifers of the Coastal Plain. Nitrate concentrations from data compiled for this report were extremely low throughout the extent of the aquifer. Sulfate and chloride concentrations generally are low for areas near the outcrop, but increase appreciably at large distances from the outcrop area (Kresse et al. 2013).

3.8.2.7 Wilcox Aquifer

The Wilcox aquifer within the planning region is a viable groundwater supply only in the outcrop area; the water becomes brackish or saline within a short distance downdip of the outcrop and is unfit for most purposes (Ludwig 1972, Plebuch and Hines 1969; Terry et al. 1986). Plebuch and Hines (1969) describe groundwater from the Wilcox aquifer in Clark, Cleveland, and Dallas counties as a sodium-bicarbonate type, with water increasing in dissolved solids content and becoming a sodium-chloride type downdip. Broom and others (1984) noted that the Wilcox and Carrizo aquifers are indistinguishable in Union County, are hydraulically connected, and used solely for injection of brine. Hewitt and others (1949) noted abundant saltwater at depths of 1,000 feet in Ashley County. Ludwig (1972) described groundwater from the Wilcox aquifer as a soft to moderately hard, sodium-bicarbonate type for most of Hempstead, Lafayette, Miller, and Nevada counties. The southern extent of fresh water coincided with a fault system extending through central Miller, Lafayette, and Nevada counties, and groundwater south of the fault zone contained more than 1,000 mg/L dissolved solids based on electric logs (Ludwig 1972). Halberg and others (1968) reported that groundwater from the Wilcox aquifer in Hot Spring and Grant counties was a soft, sodium-bicarbonate type, although iron concentrations could be high and that groundwater from shallow wells was slightly acidic. Hosman and others (1968) noted that water type varied with dissolved-solids content: where dissolved-solids concentrations were low, water was either a calcium-magnesium-bicarbonate or sodium-bicarbonate type; increases in dissolved solids up to 400 mg/L were attributed to predominantly sodium and bicarbonate; and above 400 mg/L, the increase was attributed to sodium, bicarbonate, and chloride (Kresse et al. 2013).

3.8.2.8 Nacatoch Aquifer

Groundwater from the Nacatoch aquifer is most important in the southwestern part of the state, although it is also an available and good-quality source of water in the extreme northeastern part of the state. In the southwestern extent, fresh water mainly is obtained from areas in or near to the area of outcrop, especially for the eastern (Clark County) and western parts (Little River and Miller counties) of the outcrop area, and salinity increases in a downgradient direction from the outcrop area to a point where the groundwater is not suitable for most uses. Gradients of increasing chloride concentration are sharpest in the western and eastern parts of the outcrop, with a larger area of fresh water downgradient of the outcrop area in the central part of the aquifer (Hempstead and Nevada counties). Concentrations of sulfate, iron, and nitrate generally are very low throughout the extent of the Nacatoch aquifer, where water-quality data were available from producing wells (Kresse et al. 2013).

3.8.2.9 Ozan Aquifer

Groundwater from the Ozan aquifer represents some of the least used and poorer quality water of any aquifer in the state. Several historical reports mentioned that aquifer was used as a domestic source because in many areas no other water source was available. High chloride concentrations can occur in groundwater within the outcrop area of the Ozan aquifer, which is atypical of most Cretaceous and Tertiary aquifers of the Coastal Plain. Chloride concentrations exceeding the federal secondary drinking water regulation 250 mg/L (EPA 2009) occur mainly in central Clark County. The highest median sulfate concentrations of any aquifer in the state are found in the Ozan aquifer. Sulfate concentrations can exceed 500 mg/L (the federal secondary drinking water standard is 250 mg/L) (Kresse et al. 2013).

3.8.2.10 Tokio Aquifer

Good quality water is obtained from the Tokio aquifer throughout much of its outcrop area. Sharp increases in salinity are noted in the extreme southwestern (Sevier County) and northeastern (Clark County) parts of the aquifer, limiting use at distances greater than approximately 5 miles down dip of the outcrop area. Sulfate concentrations approach 400 mg/L and chloride concentrations are greater than 1,200 mg/L near the western and eastern extent of the outcrop area. These concentrations exceed the federal secondary drinking water standards of 250 mg/L chloride and 250 mg/L sulfate. In the central part of the aquifer, salinity increases are more gradual (with concentrations in the aquifer at less than 300 mg/L as far as 20 miles from the outcrop area), affording a larger area of low-salinity, high-quality water for multiple uses. In the southwestern part of the aquifer, sulfate is the dominant anion in the aquifer.

Dedolimitization is a likely process that may account the high-sulfate, low-bicarbonate groundwater in this area of the aquifer; however, this theory requires further analysis to achieve greater confidence (Kresse et al. 2013).

3.8.2.11 Trinity Aquifer

Similar to other Cretaceous aquifers in southwestern Arkansas, use of the Trinity is limited to the outcrop areas. Wells for which water-quality data were available were located only in Sevier and Howard counties (in the Southwest WRPR). Generally, water quality from the Trinity aquifer is good, although chloride and sulfate can be somewhat elevated in certain parts of the aquifer, although concentrations were less than the 250 mg/L secondary drinking water standard. All chloride concentrations, except one, were less than 15 mg/L at distances as great as 15 miles from the outcrop area, demonstrating the low overall salinity in the aquifer (Kresse et al. 2013).

3.8.2.12 Ouachita Mountains Aquifer

Groundwater quality in the Ouachita Mountains aquifer is good with respect to federal primary drinking water standards. Problems in regard to taste, staining, and other aesthetic properties are related to elevated levels of iron, which is a common complaint among domestic users. Water quality and type generally are defined by the two major rock types in the Ouachita Mountains: quartz rocks (sandstone, chert, and novaculite) and shale. Groundwater from quartz formations tend to have low pH values, low dissolved solids concentrations, and are very soft water of a mixed water type representative of precipitation concentrated by evapotranspiration processes. Groundwater from shale rock in the system is characterized by strongly calcium- to sodium-bicarbonate water type, with varying constituent concentrations defined by residence time along the flow path. Sulfate and chloride concentrations tend to be elevated in some areas for groundwater from shale formations. No spatial relation was noted, however, for the distribution of iron concentrations, and high and low concentrations occurred in shale and quartz formations. Iron is abundant in numerous mineral forms in sedimentary rocks throughout

Arkansas, and elevated iron in the Ouachita Mountain aquifer were attributed to microbially mediated processes (Kresse et al. 2013).

3.9 Groundwater-Surface Water Connections

Surface water in the area of outcrop is a potential recharge source for aquifers within the planning region (Hosman, Long et al. 1968). In general, surface waters receive discharge from aquifers in the planning region depending upon river-aquifer head relations (Kresse et al. 2013).

4.0 SOCIO-ECONOMIC CHARACTERISTICS

The socio-economic characteristics of the SCAWRPR include demographics, income, employment, and industries. This section describes these characteristics and presents changes in these regional characteristics since the 1990 AWP update. In addition, the wastes generated by the communities and industries in the SCAWRPR are characterized. These wastes must be properly managed to protect water quality in the SCAWRPR.

4.1 Demographics

Demographic information from the 2010 US census for the counties within the SCAWRPR is presented below. Demographic data presented include population totals, the percentages of people living in urban and rural areas, above or below selected ages, and of different races. Information from the 2010 census is compared to information from the 1990 census, to identify population changes that have occurred since the 1990 AWP update. Although the 1990 AWP update reported population data from the 1980 census, the 1990 census data better represents conditions at the time of the previous update. Population changes affect the need and demand for water resources, not just for drinking water, but also for recreation, food supply, irrigation, and aesthetics. Population demographics also affect the potential tax base to pay for water infrastructure upgrades, expansion, and repairs.

4.1.1 2010 Population

Population data from the 2010 census for the counties within the SCAWRPR are summarized in Table 4.1 and mapped on Figure 4.1. The population of the SCAWRPR in 2010 was just under one million. Pulaski and Saline counties had the highest 2010 populations. Calhoun County had the lowest 2010 population.

Table 4.1. 2010 county populations in the SCAWRPR (Census State Data Center 2013, US Census Bureau 2012a).

County	Total Population			Percent Urban Population		
	1990	2010	Change 1990 to 2010(%)	1990	2010	Change in Urban Population 1990 to 2010
Ashley*	24,319	21,853	-10.1%	45.9%	48.3%	+2.5
Bradley	11,793	11,508	-2.4%	54.7%	50.4%	-4.3
Calhoun	5,826	5,368	-7.9%	0%	0%	0
Clark	21,437	22,995	+7.3%	46.7%	45.6%	-1.1
Cleveland	7,781	8,689	+11.7%	0%	0%	0
Columbia*	25,691	24,552	-4.4%	43.4%	42.5%	-0.9
Dallas	9,614	8,116	-15.6%	49.2%	47.4%	-1.8
Drew*	17,369	18,509	+6.6%	46.7%	51.4%	+4.7
Garland	73,397	96,024	+30.8%	58.2%	63.1%	+4.9
Grant	13,948	17,853	+28.0%	22.2%	25.0%	+2.8
Hempstead*	21,621	22,609	+4.6%	44.6%	44.2%	-0.3
Hot Spring	26,115	32,923	+26.1%	35.5%	34.0%	-1.5
Jefferson*	85,487	77,435	-9.4%	72.5%	69.1%	-3.4
Montgomery	7,841	9,487	+21.0%	0%	0%	0
Nevada*	10,101	8,997	-10.9%	36.4%	30.8%	-5.5
Ouachita	30,574	26,120	-14.6%	47.0%	43.6%	-3.4
Pike	10,086	11,291	+11.9%	0%	0%	0
Polk*	17,347	20,662	+19.1%	31.6%	26.6%	-4.9
Pulaski*	349,660	382,748	+9.5%	87.9%	87.7%	-0.2
Saline	64,183	107,118	+66.9%	48.6%	63.8%	+15.3
Union	46,719	41,639	-10.9%	49.5%	45.5%	-4.0
Total	**880,909**	**976,496**	**+10.9%**	**64.0%**	**64.8%**	**+0.9**

*Part of this county is in another planning region

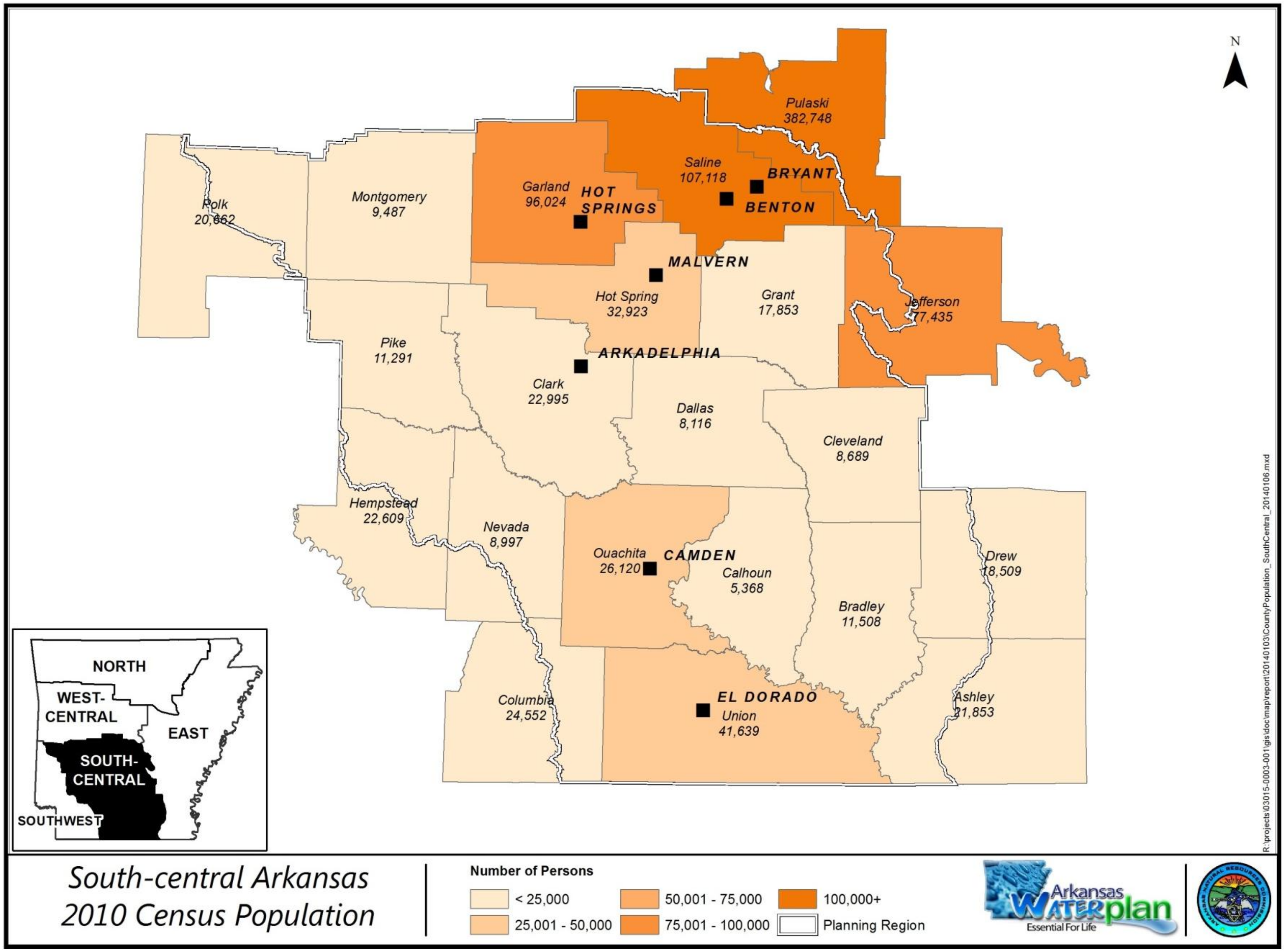

Figure 4.1. County populations from 2010 census (US Census Bureau 2012a).

Part of one Large Metropolitan Statistical Area is located within the SCAWRPR: Little Rock-North Little Rock-Conway (Figure 4.2) (US Census Bureau 2012b). Large Metropolitan Statistical Areas are geographic regions, defined by the US Office of Management and Budget, where an area of high population density has close economic ties. There are four Urbanized Areas identified in the 2010 census that are located in the SCAWRPR: Hot Springs, Little Rock, Pine Bluff, and Texarkana (Figure 4.2). These are areas with population of at least 50,000 people at a density of 1,000 to 500 people per square mile (US Census Bureau 2011a). In addition, 11 areas within the planning region were identified as Urban Clusters in the 2010 census (Figure 4.2). Urban clusters are areas with population densities of 500 to 1,000 people per square mile, which contain a total of 25,000 to 50,000 people (US Census Bureau 2011a, 2012a). The majority of the population in the SCAWRPR (65%) lives in urban areas (Table 4.1). The percentage of the county population living in rural areas varies from 87% in Pulaski County, to 0% in Calhoun, Cleveland, Montgomery, and Pike counties (Table 4.1) (US Census Bureau 2012a).

Demographic data on race for the counties within the SCAWRPR are summarized in Table 4.2. The racial make-up of the population is primarily white non-Hispanic (66%), black non-Hispanic (27%), and Hispanic (4%). Other races each account for 1% or less of the population. Demographic data on age, sex, and education level for the counties within the SCAWRPR are summarized in Table 4.3. The majority of the population in this region is between the ages of 18 and 65, 29% of adults are high school graduates, and 19% have college degrees.

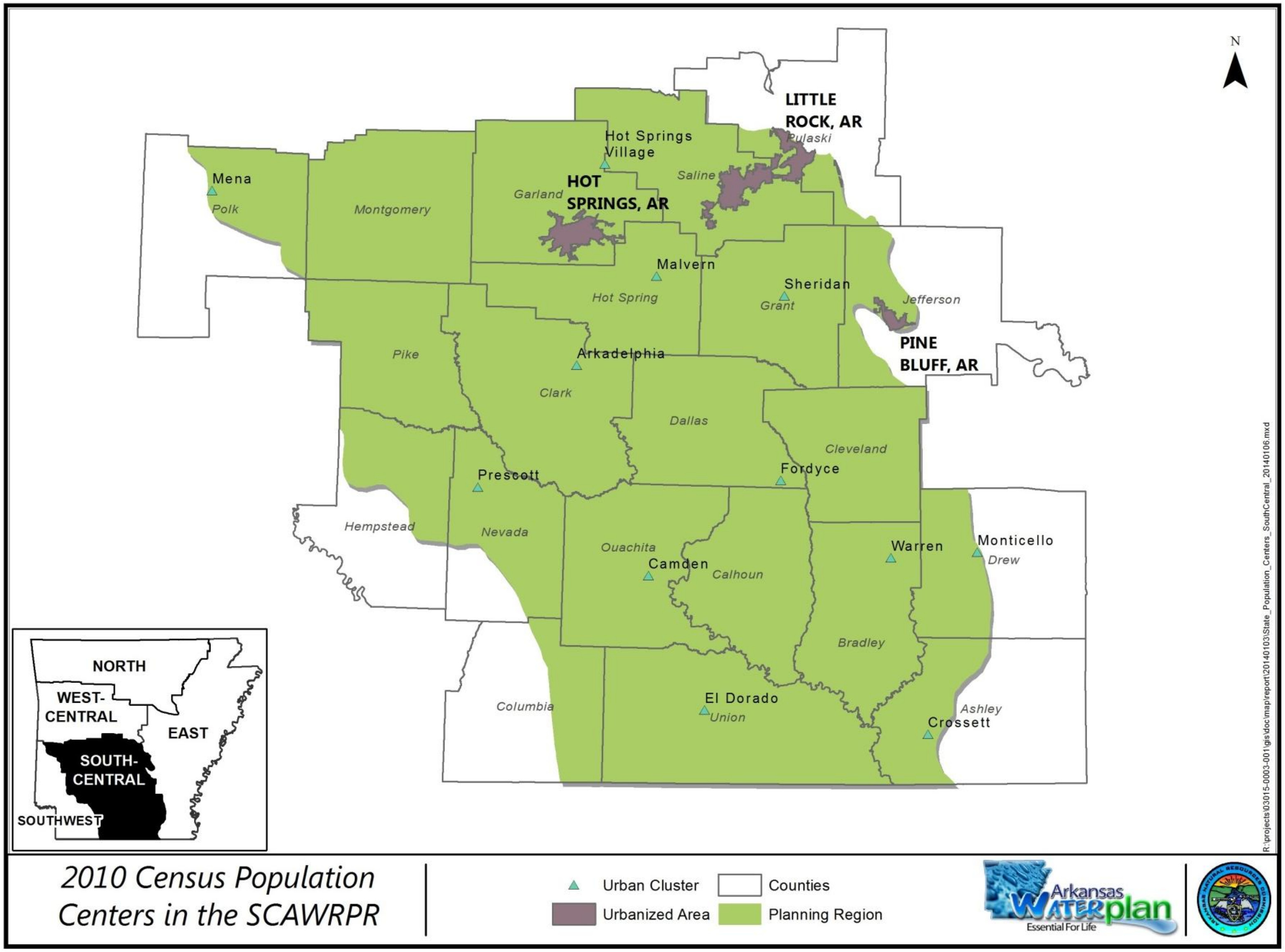

Figure 4.2. 2010 population centers located in the SCAWRPR (US Census Bureau 2012b).

Table 4.2. Demographic summary for counties in the SCAWRPR (US Census Bureau n.d.[b]).

County	White, Non-Hispanic	Black	Hispanic	Asian	American Indian	Pacific Islander	Other Single Race	Multiple Race
Ashley*	14,942	5,654	1,011	40	7	0	0	312
Bradley	6,748	3,287	1,417	0	58	0	0	70
Calhoun	3,978	1,287	66	0	0	0	0	86
Clark	16,222	5,533	912	160	43	0	0	196
Cleveland	7,398	1,120	142	0	0	0	0	78
Columbia*	14,617	9,066	518	185	50	5	4	162
Dallas	4,446	3,559	178	0	4	0	13	0
Drew*	12,553	5,163	442	129	11	0	0	201
Garland	80,601	7,915	4,514	782	519	18	175	1,390
Grant	16,677	410	371	31	17	0	14	247
Hempstead*	12,842	6,802	2,627	7	0	0	6	374
Hot Spring	27,647	3,363	894	84	101	0	0	708
Jefferson*	32,600	42,329	1,236	648	79	30	5	766
Montgomery	8,815	21	334	0	151	0	0	171
Nevada*	5,873	2,859	218	0	26	0	1	101
Ouachita	14,697	10,414	423	51	51	0	0	501
Pike	9,950	398	693	16	128	0	0	103
Polk*	18,489	36	1,130	28	357	8	10	466
Pulaski*	212,602	131,509	20,636	7,320	1,011	99	578	6,226
Saline	93,817	4,740	3,726	967	583	19	151	1,030
Union	25,964	13,751	1,393	262	104	0	0	405
Total	**641,478**	**259,216**	**42,881**	**10,710**	**3,300**	**179**	**957**	**13,593**
Percentage	**66.0%**	**26.7%**	**4.4%**	**1.1%**	**<1 %**	**<1 %**	**<1 %**	**1.4%**

*Part of this county is in another planning region

Table 4.3. Additional demographic characteristics of counties in the SCAWRPR (US Census Bureau n.d.[b]).

County	Total female population	Total population under 18 years	Total population 65 years and over	High school graduates	College graduates[a]
Ashley[b]	11,366	5,412	3,503	6,573	1,947
Bradley	6,036	2,747	2,068	3,346	938
Calhoun	2,576	1,165	910	1,794	470
Clark	12,010	4,553	3,374	5,025	2,471
Cleveland	4,407	2,197	1,373	2,742	1,139
Columbia[b]	12,860	5,612	3,949	5,676	3,275
Dallas	4,176	2,015	1,459	2,617	844

Table 4.3. Additional demographic characteristics of counties in the SCAWRPR (continued).

County	Total female population	Total population under 18 years	Total population 65 years and over	High school graduates	College graduates[a]
Drew[b]	9,538	4,383	2,664	4,349	2,250
Garland	49,301	20,150	19,955	22,173	14,255
Grant	8,968	4,296	2,570	5,160	1,780
Hempstead[b]	11,538	5,952	3,340	5,623	2,223
Hot Spring	16,150	7,703	5,083	8,900	3,919
Jefferson[b]	39,469	18,667	10,136	19,182	8,433
Montgomery	4,806	2,000	2,078	2,839	1,013
Nevada[b]	4,656	2,233	1,598	2,346	881
Ouachita	13,791	6,150	4,431	7,289	2,832
Pike	5,629	2,822	1,907	2,943	917
Polk[b]	10,453	4,895	4,049	5,460	1,978
Pulaski[b]	197,558	91,817	45,169	69368	66,161
Saline	52,943	25,514	15,692	25,846	16,345
Union	21,642	10,161	6,556	10,173	5,568
Total	**499,873**	**230,444**	**141,864**	**219,424**	**139,639**
Percentage	**51.4%**	**23.6%**	**14.6%**	**29.4%**[c]	**18.7%**[c]

Notes:

a. Includes associate degrees and bachelor degrees.

b. Part of this county is in another planning region.

c. Percentage based on population 18 years of age or older.

4.1.2 Changes from 1990

The population of the SCAWRPR increased by almost 11% between the 1990 and 2010 census (Table 4.1). In 1990, Pulaski and Jefferson counties had the greatest total populations in the region. Nine of the 21 counties within the SCAWRPR experienced population declines between 1990 and 2010 (Figure 4.3). Declines ranged from -2.4% in Bradley County to -15.6% in Dallas County. The remaining counties in the SCAWRPR experienced population increase between 1990 and 2010, ranging from 4.6% in Hempstead County to 67% in Saline County (Table 4.1). In Saline County, the Bauxite-Benton-Bryant area experienced the greatest population increase between 1990 and 2010 (US Census Bureau 2012b).

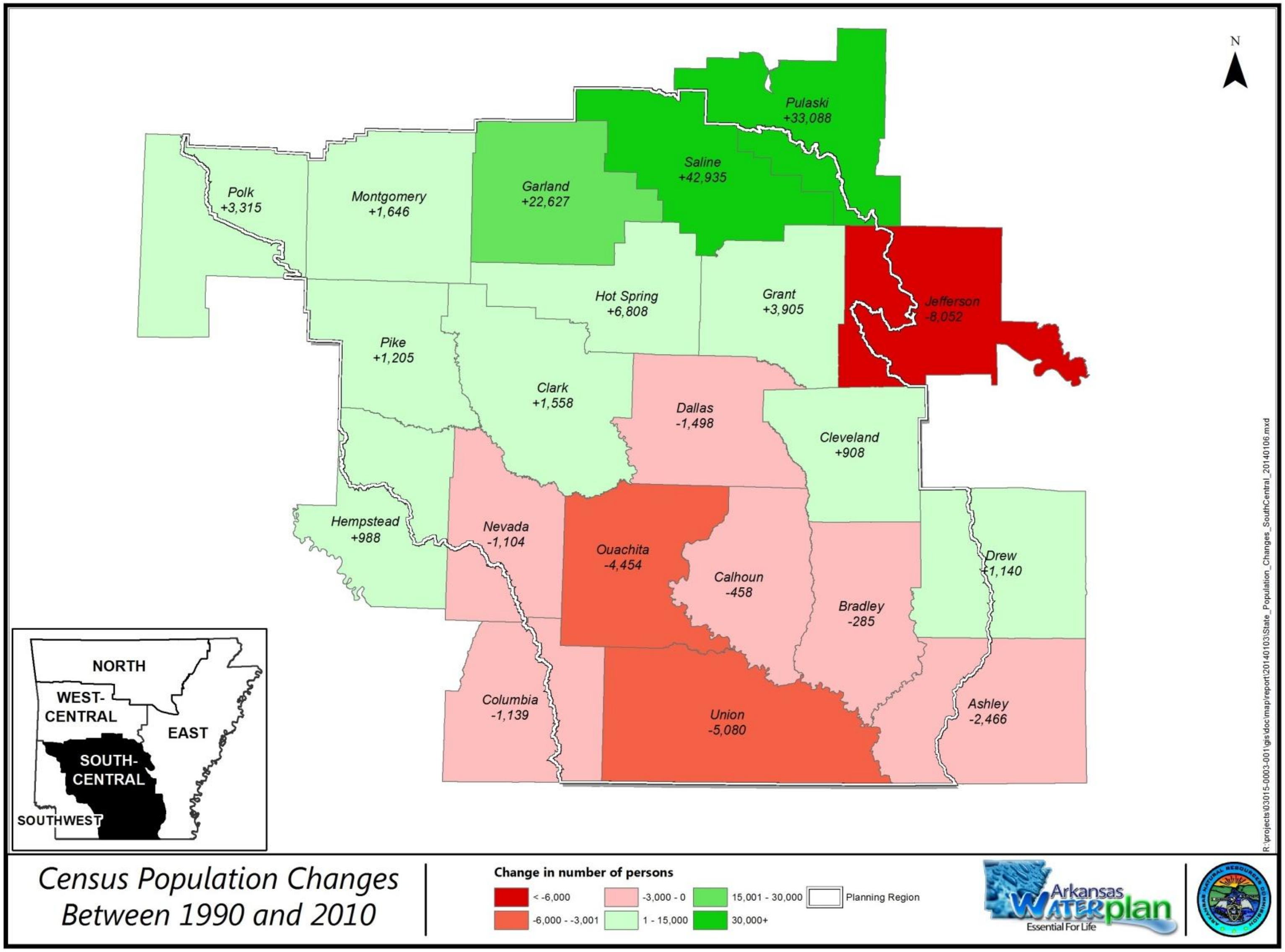

Figure 4.3. Population change between 1990 and 2010 in counties of the SCAWRPR (Census State Data Center 2013, US Census Bureau 2012a).

4.2 Income and Employment

Income and employment data are available by county from the US Census Bureau. Recent data are presented below to characterize employment and income levels within the SCAWRPR. Data from 1990 are also presented for comparison, to provide insight into changes that have occurred in the region since the 1990 AWP update.

4.2.1 Current Income and Employment Levels

Median household incomes reported by the US Census Bureau in the 2007 – 2011 Community Survey for counties in the SCAWRPR are shown in Table 4.4. The average median income in the region is $36,590, less than the state-wide median household income of $40,149 (US Census Bureau n.d.[a]). Three of the counties within the SCAWRPR are in the top five in terms of highest median household incomes in the state, including Saline County, which has the highest median household income in the state, $52,982.

The 2007-2011 Community Survey shows that counties in the SCAWRPR have some of the lowest percentages of families and population with income below poverty level. The average percentage of families with income below poverty level in these counties is 15.3%, but county values range from 6.4% in Saline County to 29.4% in Dallas County. The percentage of families with income below poverty level for Arkansas as a whole is 13.8%. The average percentage of county population with income below poverty level is 19.8%, with values ranging from 8.7% in Grant County to 34.7% in Dallas County. The percentage of Arkansas population with income below poverty level is 18.4% (US Census Bureau n.d.[a]). The average of the unemployment rates for all of the counties in the SCAWRPR is higher than the overall state unemployment rate of 8.4%. However, unemployment rates in these counties range from 3.1% in Polk County to 17.1% in Dallas County, and in 10 of the 21 counties the unemployment rate is lower than the state rate.

Table 4.4. Income and employment characteristics for counties in the SCAWRPR (Census State Data Center 2013, US Census Bureau n.d.[a]).

County	Median Household Income		Families with Income Below Poverty Level		Population Below Poverty Level		Unemployment	
	1990	2007 - 2011	1990	2007 – 2011	1990	2007 – 2011	1990	2007 – 2011
Ashley*	$20,609	$35,657	17.4%	16.1%	20.9%	17.9%	5.9%	9.7%
Bradley	$17,259	$32,337	20.4%	19.6%	24.9%	25.4%	9.0%	6.8%
Calhoun	$21,198	$30,625	13.5%	7.6%	15.6%	9.8%	11.1%	6.2%
Clark	$18,068	$32,998	18.3%	16.0%	23.9%	23.0%	6.1%	9.8%
Cleveland	$19,703	$34,292	14.7%	14.0%	19.0%	17.8%	6.7%	9.3%
Columbia*	$18,470	$36,163	19.1%	17.9%	24.4%	24.8%	8.0%	5.6%
Dallas	$17,651	$26,909	17.2%	29.4%	22.3%	34.7%	6.7%	17.1%
Drew*	$18,906	$32,038	20.2%	19.3%	24.2%	25.0%	8.7%	11.8%
Garland	$20,260	$38,210	13.1%	14.3%	18.0%	18.5%	5.4%	8.8%
Grant	$24,278	$50,927	12.9%	5.4%	14.9%	8.7%	5.5%	7.4%
Hempstead*	$16,986	$34,885	18.4%	17.8%	22.7%	22.5%	7.6%	5.3%
Hot Spring	$19,355	$38,188	15.7%	10.0%	18.6%	13.4%	8.7%	11.2%
Jefferson*	$21,322	$37,682	19.3%	17.3%	23.9%	22.9%	8.9%	14.1%
Montgomery	$16,503	$34,934	17.3%	13.9%	23.8%	20.2%	4.2%	7.0%
Nevada*	$18,919	$38,006	15.9%	18.5%	20.3%	23.1%	6.3%	8.4%
Ouachita	$21,056	$33,008	15.0%	16.6%	21.2%	20.8%	8.2%	13.4%
Pike	$19,240	$32,457	14.5%	15.2%	17.9%	19.4%	5.3%	10.2%
Polk*	$17,789	$32,395	14.7%	14.8%	18.5%	20.2%	5.5%	3.1%
Pulaski*	$26,883	$45,897	10.5%	12.5%	14.1%	16.7%	5.4%	8.1%
Saline	$28,262	$52,982	6.9%	6.4%	9.3%	9.1%	5.1%	6.2%
Union	$21,041	$37,794	17.7%	19.1%	22.0%	22.0%	7.0%	8.7%
Average	$20,179	$36,590	15.8%	15.3%	20.0%	19.8%	6.9%	9.0%

*Part of this county is in another planning region

4.2.2 Changes in Income and Employment from 1990

Information on income and employment from the 1990 census for the counties in the SCAWRPR is included in Table 4.4. This information indicates that the some of the income characteristics of this region have changed over the past two decades. The average median income in the SCAWRPR in 1990 was less than the state-wide median income of $21,147. Median incomes have increased since 1990, and there have been slight reductions in percentages of families and population with incomes below the poverty level. However, the unemployment rate is higher than in 1990.

4.3 Economic Drivers

Timber, tourism, agriculture, and resource extraction are important economic drivers in the SCAWRPR (Association of Arkansas Counties 2013). Transportation of goods on the Ouachita River downstream of Camden also contributes to the regional economy. The US Census Bureau conducts an economic census every 5 years. This includes information on the value of sales, and the number of people employed by the industrial sector by county. Information from the 1992 and 2007 economic census, as well as the 1990 and 2010 census, are presented below.

4.3.1 Current Regional Economic Drivers

The value of sales and receipts reported for the counties within the SCAWRPR in the 2007 economic census is summarized on Figure 4.4. Agriculture and forestry are not economic sectors reported in the economic census. However, agriculture and forestry contribute value to manufacturing, real estate, wholesale trade, and transportation and warehousing economic sectors (U of A Divison of Agriculture 2012). Manufacturing accounts for the largest proportion of the value of sales and receipts, closely followed by wholesale trade, with retail trade and services not far behind.

The number of people employed in the SCAWRPR by economic sectors, as reported in the American Community Survey 2007-2011 and the 2007 Economic Census, are summarized on Figure 4.5. The economic sectors for which employment is reported in these two sources are slightly different. However, both sources indicate that health care and education, retail trade, and manufacturing provide the majority of employment in the SAWRPR. Agriculture and forestry generate jobs in every economic sector, particularly manufacturing, health care, retail trade, and transportation and warehousing (included in administration on Figure 4.5) (U of A Divison of Agriculture 2012).

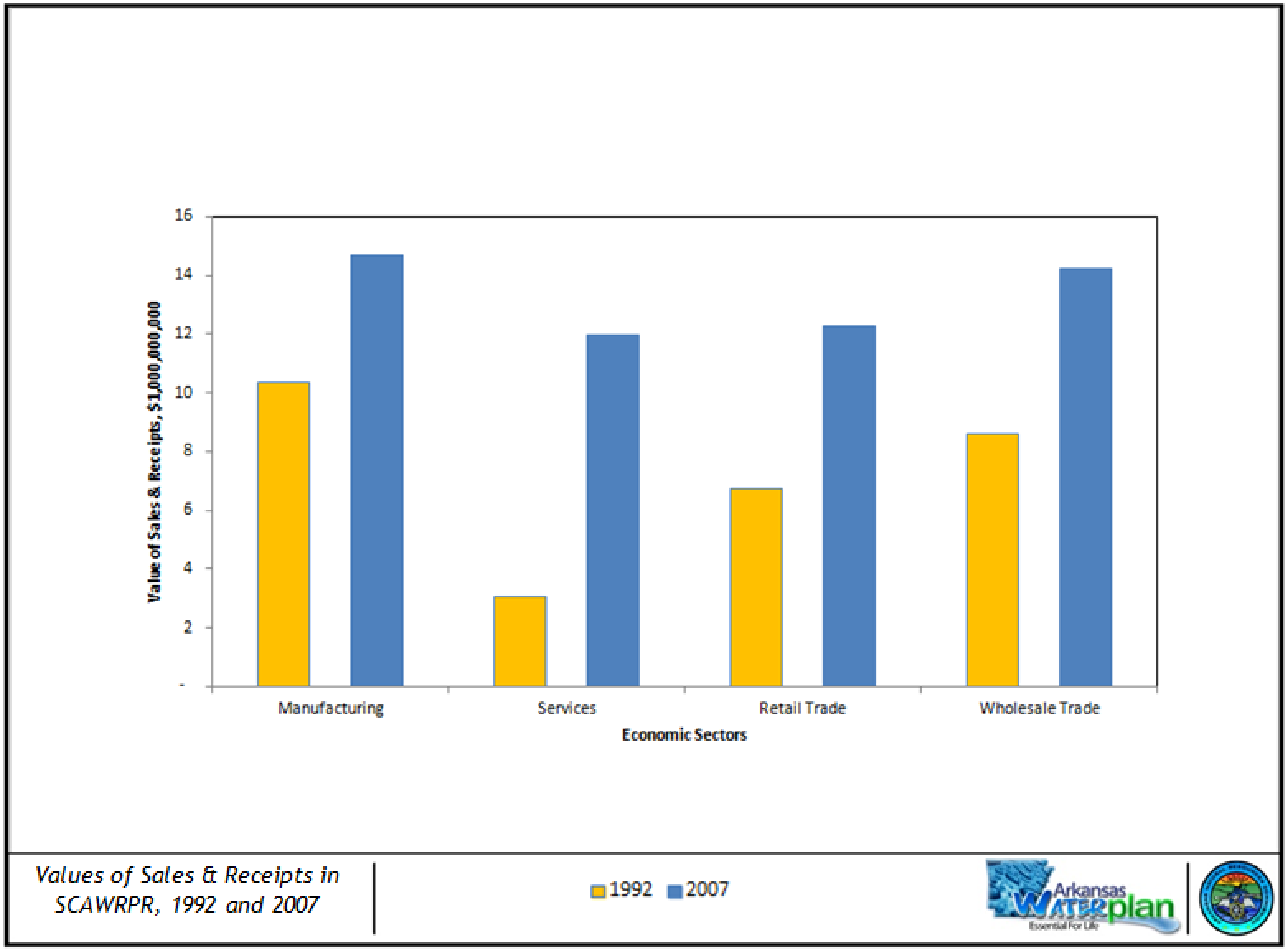

Figure 4.4. Value of sales and receipts in counties of the SCAWRPR (US Census Bureau 1993, 2011).

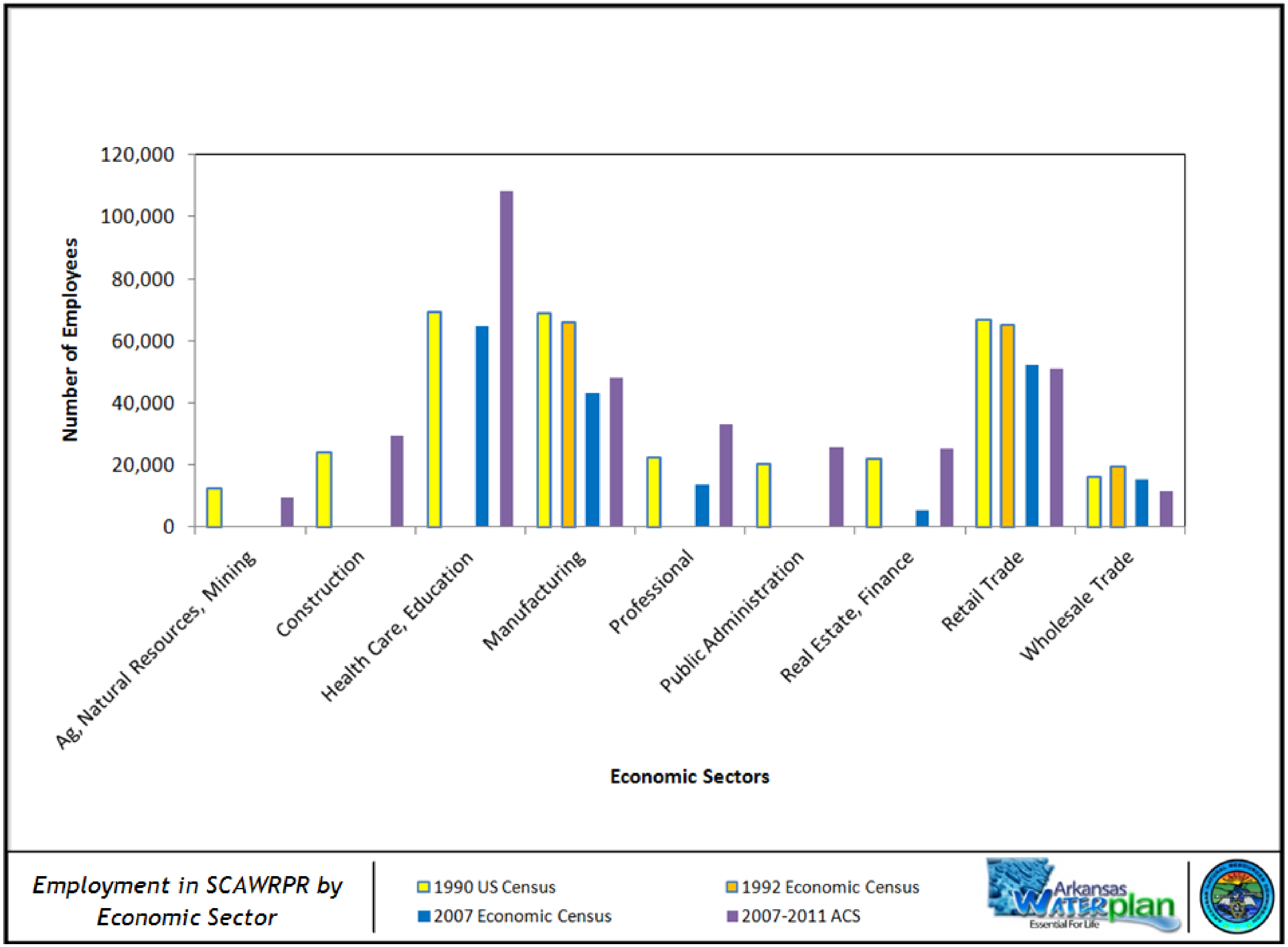

Figure 4.5. Employment in counties of the SCAWRPR by economic sector (Census State Data Center 2013, US Census Bureau n.d.[b], US Census Bureau 2011).

4.3.1.1 Timber

Forestry is the leading employer in south Arkansas, which includes the SCAWRPR. Forestry contributes to a number of economic sectors including manufacturing, health and social service, retail trade, wholesale trade, real estate, and transportation and warehousing (U of A Divison of Agriculture 2012).

Arkansas is the fourth-largest producer of saw logs in the South (U of A Divison of Agriculture 2012). Of the state softwood (i.e., pine) roundwood timber product output, 68% is produced in the counties of the SCAWRPR (Table 4.5). The majority of the timber processing capacity of the state is also located in this planning region (Brandeis et al. 2011). The total revenue from forestry reported for 2007 in the counties of the SCAWRPR was over $5.0 million (Table 4.5).

Table 4.5. Timber industry metrics for the counties within the SCAWRPR.

County	2009 Roundwood Timber Product Output (thousand cubic feet) [a]		Value of Forest Product Sales (thousand dollars)	
	Softwood	Hardwood	1987[b]	2007[c]
Ashley[d]	21,593	8,810	$96	$295
Bradley	28,334	3,558	$122	$126
Calhoun	12,882	2,537	$18	–[e]
Clark	13,266	10,843	$295	$838
Cleveland	16,777	3,236	$376	$352
Columbia[d]	6,108	3,397	$137	$319
Dallas	19,849	3,892	$153	$153
Drew[d]	132	1,904	–[e]	$379
Garland	8,344	590	$171	$62
Grant	13,518	2,212	$238	$32
Hempstead[d]	6,276	2,383	$878	$642
Hot Spring	9,388	1,860	$346	$355
Jefferson[d]	4,876	1,567	–[e]	$100
Montgomery	2,429	1,806	$187	$145
Nevada[d]	9,554	2,004	$512	$361
Ouachita	8,775	5,077	$156	$313
Pike	21,125	3,012	$402	–[e]

Table 4.5. Timber Industry metrics for the counties within the SCAWRPR (continued).

County	2009 Roundwood Timber Product Output (thousand cubic feet) [a]		Value of Forest Product Sales (thousand dollars)	
	Softwood	Hardwood	1987[b]	2007[c]
Polk[d]	11,185	2,170	$203	$268
Pulaski[d]	1,931	855	$86	$23
Saline	8,211	1,322	$60	$179
Union	22,923	5,489	$219	$120
Total	**247,476**	**68,524**	**$4,655**	**$5,062**

Notes:
a. Brandeis et al. 2011.
b. US Census Bureau 1989.
c. USDA National Agricultural Statistics Service 2009.
d. Part of this county is in another planning region.
e. Data withheld to protect privacy.

Water use in the timber industry is primarily during processing. Timberlands are not generally irrigated. Timberlands can impact water quality through erosion of forest roads, stream crossings, and harvested areas; and runoff of chemicals used in timber management.

4.3.1.2 Tourism

Tourism is the second largest industry in Arkansas. Tourism, including water-based recreation, is a significant contributor to the economy of the SCAWRPR. According to the 2012 Annual Report Summary from the Arkansas Department of Parks and Tourism, tourism in the counties of the planning region generated over $3 billion dollars in revenue and taxes. The Hot Springs area in Garland County contributes significantly to the tourism economy of the planning region (Table 4.6).

Recreation on lakes in the SCAWRPR, including the USACE reservoirs and the Ouachita River navigation system, contribute to the economy of the region. USACE has estimated economic impacts of recreation at the reservoirs located in the planning region. Overall, the USACE reservoirs in the planning region generate over 1,000 jobs, and over $1 billion in revenue, wages, and taxes (Table 4.7). There are at least six other public lakes in the planning region for swimming, fishing, and boating.

Table 4.6. Tourism revenues for the counties of the SCAWRPR (Arkansas Department of Parks and Tourism 2012a).

County	Visitors		Travel Expenditures		Payroll		Employment		Tax Revenue	
	1990	2012	1990	2012	1990	2012	1990	2012	1990	2012
Ashley*	77,060	121,243	$10,797,773	$27,910,389	$1,954,397	$5,322,679	225	322	$637,068	$2,270,411
Bradley	18,289	35,776	$2,610,480	$9,630,143	$472,497	$1,482,995	54	78	$154,019	$883,240
Calhoun	4,604	7,072	$556,552	$2,732,776	$100,736	$291,027	12	11	$32,837	$263,420
Clark	247,983	209,930	$33,948,243	$48,118,665	$6,144,632	$9,359,532	706	536	$2,002,946	$3,814,780
Cleveland	6,308	10,228	$846,511	$3,457,373	$153,218	$433,329	18	27	$49,944	$298,111
Columbia*	86,583	99,512	$12,062,964	$23,830,162	$2,183,396	$4,236,833	251	275	$711,351	$1,932,859
Dallas	23,760	48,890	$3,443,388	$11,516,911	$623,253	$1,633,769	72	97	$203,160	$1,001,091
Drew*	70,154	95,329	$10,159,056	$22,235,266	$1,838,789	$4,236,627	211	282	$599,385	$1,770,561
Garland	1,691,749	2,476,332	$239,245,485	$601,682,105	$43,303,433	$107,176,941	4,977	6,911	$14,115,484	$47,240,510
Grant	11,760	21,433	$1,511,339	$5,126,670	$273,552	$642,145	31	47	$89,169	$421,203
Hempstead*	152,629	197,347	$20,644,723	$47,579,879	$3,736,695	$8,936,209	430	518	$1,218,039	$4,051,871
Hot Spring	51,785	14,585	$7,126,421	$3,282,714	$1,289,882	$404,822	148	21	$120,459	$274,263
Jefferson*	357,784	442,069	$49,703,500	$110,788,911	$8,996,334	$20,900,407	1,034	1,308	$2,932,507	$8,416,041
Montgomery	83,859	95,644	$11,342,494	$25,763,286	$2,052,991	$4,139,224	236	240	$669,207	$2,361,240
Nevada*	36,629	57,386	$5,109,778	$20,652,272	$924,870	$3,706,355	106	154	$301,477	$1,200,779
Ouachita	149,342	114,857	$21,786,680	$24,993,279	$3,943,389	$4,568,327	453	292	$1,285,414	$1,985,510
Pike	54,006	62,018	$7,565,143	$14,808,135	$1,369,291	$2,651,871	157	178	$446,344	$1,221,991
Polk*	80,967	82,515	$11,252,278	$20,362,835	$2,036,662	$3,713,437	234	232	$663,884	$1,674,082
Pulaski*	2,889,431	5,653,505	$488,766,742	$1,612,013,724	$88,466,780	$335,126,264	10,169	12,972	$28,837,238	$90,739,999
Saline	91,623	213,803	$13,735,657	$50,387,070	$2,486,154	$9,418,933	286	597	$810,404	$3,988,427
Union	228,030	394,914	$31,752,668	$104,064,813	$5,747,233	$11,799,530	661	850	$1,873,407	$6,785,781
Total	6,414,335	10,456,400	$983,967,875	$2,790,939,390	$178,098,184	$540,183,268	20,471	25,948	$57,753,743	$182,598,182

*Part of this county is included in another planning region.

Table 4.7. Economic benefits from USACE reservoirs in the SCAWRPR in 2010 (USACE 2011).

Reservoir	Total Sales	Jobs	Payroll	Value Added*
DeGray	$19,227,014	309	$7,411,709	$11,761,953
Greeson	$9,039,560	173	$3,345,358	$5,289,211
Ouachita	$27,015,112	433	$10,558,006	$16,692,389
Felsenthal Pool	$5,064,129	78	$1,772,866	$2,784,299
Calion Pool	$888,244	15	$307,255	$486,108
Total	**$61,234,059**	**1,008**	**$23,395,194**	**$37,013,960**

*Includes wages, salaries, payroll benefits, profits, rents, and indirect business taxes.

Hunting, fishing, and wildlife watching associated with the lakes, rivers, and wetlands of the planning region, contribute to the economy of the SCAWRPR. In 2011, Arkansas ranked seventh in the nation in hunting-related sales, and more mallard ducks were harvested in Arkansas than any other state (AGFC 2013b). The wetlands, rice, and bean fields along the Ouachita River make it a major flyway for ducks and geese (Gore 2009). Economic contributions from wildlife recreation in Arkansas are summarized in Table 4.8. Regional data are not available.

Table 4.8. Economic contributions from wildlife recreation in Arkansas.

Activity	Total Expenditures (million dollars)		2011 Retail Sales (million dollars)[c]	2011 State/Local Tax Revenue (million dollars)	2011 Federal Tax Revenue (million dollars)
	1991[a]	2011[b]			
All Hunting	$85.0	$1,018.8	$877.4	$99.2	$99.5
Waterfowl Hunting	NR	$288.0	$236.7	$29.1	$23.9
Sport Fishing	$216.9	$495.6	$508.0	$49.4	$49.8
Wildlife Watching	NR	$216.1	NR	NR	NR

Notes:
a. USFWS, US Census Bureau 1993.
b. USFWS, US Census Bureau 2013.
c. AGFC 2013b.
NR=Not Reported

Streams in the SCAWRPR are also important to the tourism and recreation economy of the planning region. ADEQ has designated Lake DeGray, Lake Ouachita, and 634 miles of streams in the planning region as Extraordinary Resource Waterbodies for “scenic beauty, aesthetics, …broad scope recreation potential, and intangible social values” (Figure 4.6) (APCEC 2011). Over 213 miles of streams in the planning region are designated as Natural and Scenic Waterways (Figure 4.6). The Little Missouri River is a designated National Wild and Scenic River, and the Saline River is a designated Arkansas Natural and Scenic River.

4.3.1.3 Agriculture

Agriculture is also a major economic driver in the SCAWRPR. This includes cattle production, poultry and egg production, swine, some row crop agriculture (including vegetables and melons), and some tree fruit and berries.

Arkansas is second in the nation broiler production, which are produced in the SCAWRPR. Livestock sales accounted for the majority (80%) of the 2007 revenues from sale of agricultural products in the counties in the planning region. The total value for sale of livestock produced in these counties during 2007 was over $1 million (Table 4.9). In most counties, the value of poultry sales was greater than the value of cattle sales (USDA National Agricultural Statistics Service 2009).

The total value for sale of crops produced in the counties of the SCAWRPR during 2007 was over $260 million (Table 4.9). Bradley County in the planning region is the state tomato-raising capital (Association of Arkansas Counties 2013).

4.3.1.4 Resource Extraction

A number of economically important minerals occur in the SCAWRPR, making resource extraction another important economic driver in the planning region. Bromine, natural gas and petroleum are the top three minerals produced in Arkansas (Table 4.10). Bromine is produced in Columbia and Union counties (Hill 2010). In these counties, this industry in a major employer and influence on the economy (Cottingham 2012). Oil is produced in Ashley, Bradley, Calhoun, Columbia, Hempstead, Nevada, Ouachita, and Union counties in the planning region.

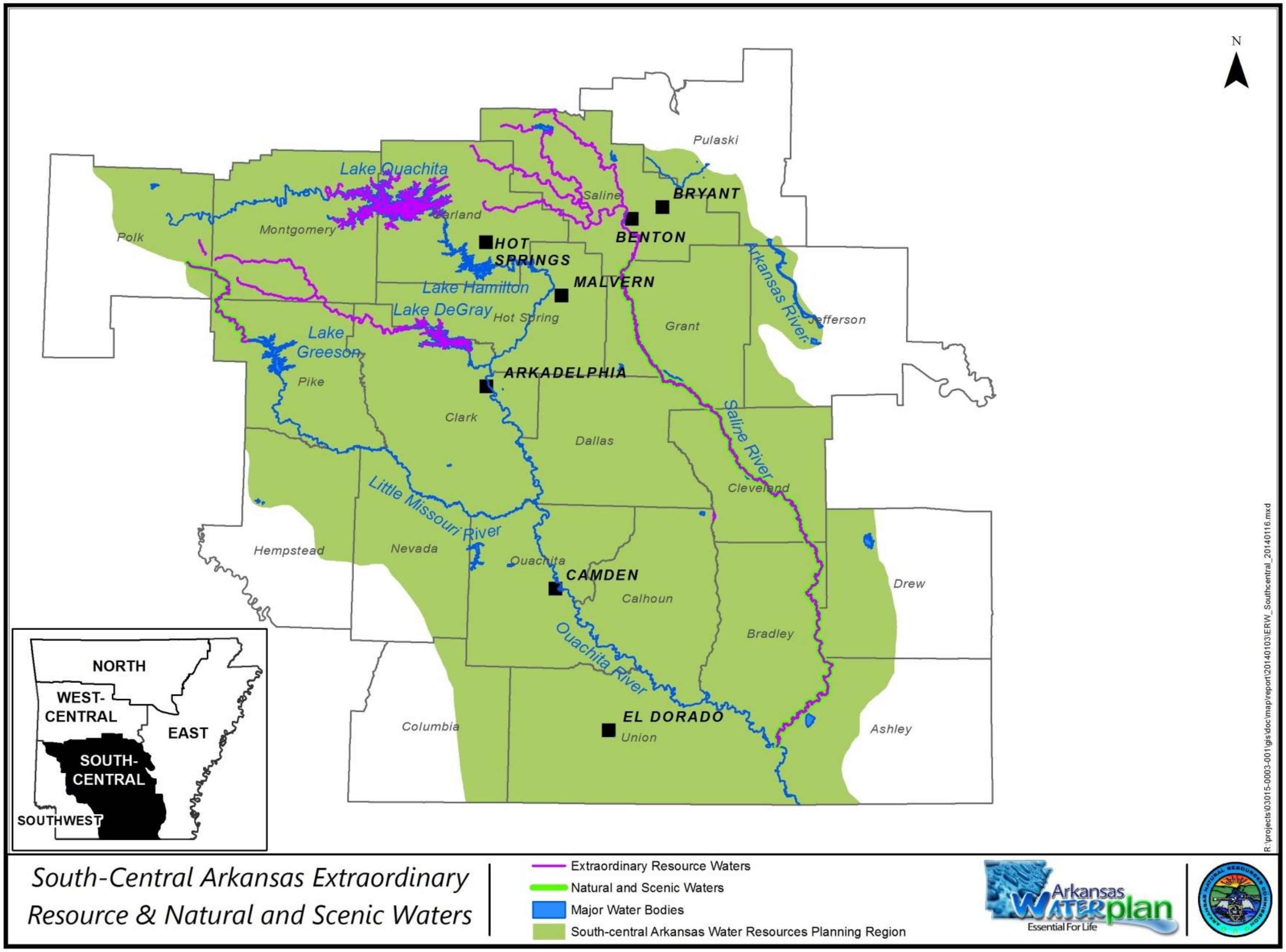

Figure 4.6. Designated Extraordinary Resource Waters and Natural and Scenic Waterways in the SCAWRPR (APCEC 2011).

Table 4.9. Value of agricultural sales (dollars) in counties of the SCAWRPR (US Census Bureau 1989, USDA National Agricultural Statistics Service 2009).

County	Value of Crop Sales		Value of Livestock, Poultry, & Products Sales	
	1987	2007	1987	2007
Ashley*	30,127	55,231	2,386	9,482
Bradley	2,781	3,526	6,783	26,329
Calhoun	99	D	959	D
Clark	3,094	2,258	5,940	14,620
Cleveland	289	363	26,110	147,698
Columbia*	1,994	9,772	17,789	35,369
Dallas	156	D	836	D
Drew*	12,739	35,925	2,685	21,413
Garland	755	2,379	11,115	9,863
Grant	319	955	4,182	18,249
Hempstead*	2,543	5,000	105,071	162,118
Hot Spring	871	1,496	6,628	14,675
Jefferson*	53,245	117,532	3,614	182,252
Montgomery	187	1,127	26,862	18,401
Nevada*	839	1,266	25,883	47,122
Ouachita	404	1,514	7,610	47,224
Pike	596	750	30,519	15,154
Polk*	228	1,687	63,589	92,148
Pulaski*	10,862	18,618	4,694	133,842
Saline	1,012	2,822	2,644	8,797
Union	309	921	31,018	2,772
Total	**123,449**	**263,142**	**386,917**	**1,080,749**
Partial counties excluded		**18,111**		

Notes: * Part of this county is in another planning region., D = Data withheld to protect privacy.

Table 4.10. Oil and gas production in counties of the SCAWRPR in 2012 (Arkansas Geological Survey 2013).

County	Oil Production (barrels)	Gas Production (million cubic feet)	Bromine Brine (barrels)
Ashley*	8,161	0	0
Bradley	20,283	0	0
Calhoun	11,055	0	0
Columbia*	36,079	0	128,086,440
Hempstead*	2,484	0	0
Nevada*	246,943	734	0
Ouachita	415,727	5,537	0
Union	2,701,418	83,539	137,240,212
Total	**3,442,150**	**89,810**	**265,326,632**

*Part of this county is in another planning region.

Oil companies are one of the leading employers in the planning region (Bridges 2011). Other nonfuel minerals produced in the planning region include crushed stone, sand and gravel, diamonds and other gemstones, metals, and abrasives (USGS 2013a). Lignite is mined in Ashley and Bradley counties (Arkansas Geological Survey 2012a). Mineral extraction and processing in the planning region do not generally require large quantities of water. They do tend to have the potential to impact water quality, however (see Section 5.3.2).

In 2009, the value of nonfuel mineral production in Arkansas was $636 million (USGS 2013a). The market value of crude oil produced in Arkansas in 2008 was $413 million (U of A Sam Walton College of Business 2009).

Spring water is another natural resource of the SCAWRPR that contributes to the regional economy. There are six companies that bottle spring water in the planning region, in Garland, Montgomery, and Polk counties (see Table 2.2).

4.3.1.5 Waterborne Commodity Transport

Waterborne transportation of commodities directly and indirectly contributes to the economic growth of the state, and the SCAWRPR, through economic value, employment, and earnings (Nachtmann 2002). A recent study determined that the total economic impact of river transportation of commodities on the Arkansas economy is $811 million annually (Arkansas Waterways Commission 2013). The Ouachita River in the SCAWRPR is used to transport commodities into and out of the region, and the state. There are two public ports located on the Ouachita River within the planning region (Figure 2.2).

Transportation of commodities reported at the Felsenthal and H.K. Thatcher locks in the SCAWRPR are listed in Table 4.11. In 2010, over 60 thousand short tons of goods and materials passed through the Felsenthal lock and dam near the Louisiana border. The majority of these materials consisted of chemicals and petroleum products. Information on the value of these shipments was not located.

Table 4.11. Commodities (in tons) transported through the Ouachita River locks in the SCAWRPR during 2012 (USACE Institute for Water Resources n.d.).

Commodity Category	Felsenthal Lock and Dam	H.K. Thatcher Lock and Dam
Petroleum and Petroleum Products	28,100	27,700
Chemicals and Related Products	26,300	0
Waste Material	5,800	0
Manufactured Equipment and Machinery	0	200

4.3.2 Comparison to 1990 Regional Economy

Figure 4.4 shows the value of sales and receipts reported in the 1992 economic census. Note that the 1992 economic census reported values by county only for the manufacturing, services, retail trade, and wholesale trade sectors. The 2007 value for services shown on Figure 4.4 is a summation of values for economic sectors that were reportedly included in the 1992 value for services (US Census Bureau 2011b). It appears that all of the sectors have experienced expansion.

Employment data from the 1990 census and 1992 economic census are included on Figure 4.5. The industrial categories used to report employment are slightly different for the two sources and the different time periods shown on Figure 4.5. While these differences make direct comparisons uncertain, using the information from different sources during similar time periods allows us to have greater confidence when identifying changes over time. There appears to have been a decline in employment in the manufacturing and retail trade sectors. It also appears that there may have been an increase in the number of people employed in the health and education economic sectors since 1990.

4.3.2.1 Timber

Table 4.5 includes information on value of forestry products from the 1987 Census of Agriculture. Overall, the value of forestry product sales in 1987 was slightly lower than in 2007. Several counties in the planning region had lower forest product sales in 2007 than in 1987.

As today, in the 1990s, forestry was an important economic driver in the state, contributing over $4 billion annually to the state economy (Gray 1993). Lumber and wood products companies dominated the manufacturing sector of the state economy during this period (Advameg, Inc. 2010). Timber production and timber product output in Arkansas expanded between 1987 and 2005. Between 2005 and 2009, timber product output declined to a level below what it was in 1987 (Brandeis et al. 2011, May 1990). However, in comparing the value of forest product sales in 1987 and 2007, it appears that 2007 production was greater in several of the counties in the planning region (Table 4.5).

4.3.2.2 Agriculture

Table 4.9 includes information on the value of crops and livestock from the 1987 Census of Agriculture, which were lower than in 2007. The area of cropland in the counties of the planning region has increased by 40% since 1987, suggesting expansion of crop agriculture in the planning region. Comparison of inventories from the 1987 and 2007 census of agriculture indicates that there have been moderate increases in the numbers of livestock and poultry in the region (Table 4.12).

4.3.2.3 Tourism

Overall, the economic contribution of tourism in the SCAWRPR was greater in 2012 than in 1990 (Table 4.6). Declines in visitors and employment occurred in Clark, Hot Spring, and Ouachita counties. Only in Hot Spring County did this translate into lower expenditures and payroll. The 2012 numbers were higher than 1990 for the rest of the counties. Tax revenues from tourism were higher in 2012 than in 1990 in all counties. The economic contribution of hunting and fishing in the state has increased since 1990 (Table 4.7).

4.3.2.4 Resource Extraction

Oil and natural gas production in south Arkansas was greater in 1990 than in 2012. Brine production in south Arkansas was slightly less in 1990 than in 2012. There have been 15 oil/gas/brine reservoirs discovered and developed in the planning region since 1990, and 24 that have been abandoned (Arkansas Geological Survey 2013).

Table 4.12. Livestock inventories in the counties of the SCAWRPR (US Census Bureau 1989, USDA National Agricultural Statistics Service 2009).

County	Cattle and Calves		Swine		Poultry			
					1987		2007	
	1987	2007	1987	2007	Layers	Broilers	Layers	Broilers
Ashley*	4,360	3,818	745	163	778	28	824	D
Bradley	4,648	4,209	678	29	56,694	577661	317,755	1,239,320
Calhoun	3,650	1,631	5	22	D	0	D	0
Clark	14,959	12,853	967	D	D	D	225,450	350,090
Cleveland	8,148	5,607	1,072	41	175,774	2818298	360,353	7,619,780
Columbia*	13,634	11,828	593	56	(b)	1391077	190,191	2,241,500
Dallas	3,396	2,334	461	131	154	D	66	0
Drew*	8,091	8,200	1,411	117	219	D	165,503	738,400
Garland	8,466	6,170	289	1,091	D	D	122,786	53
Grant	8,256	19,051	D	53	D	206,264	637	726,610
Hempstead*	38,737	62,759	3,452	4,870	3,925,295	5,573,081	231,135	8,806,490
Hot Spring	15,042	15,346	823	86	D	D	411,164	D
Jefferson*	4,498	3,152	628	272	D	323,435	D	1,382,360
Montgomery	16,356	17,442	11,814	12,030	466,048	2,020,853	490,020	1,401,800
Nevada*	20,654	17,042	531	D	495,769	1,829,236	276,210	2,305,218
Ouachita	5,404	9,229	1,608	104	34,653	567,006	D	1,031,509
Pike	17,303	42,852	10,156	26,738	433,054	3,127,264	664,375	2,025,030
Polk*	29,707	45,060	14,067	17,133	457,840	5,276,442	302,159	6,225,614
Pulaski*	11,102	8,080	1,092	204	652	150	855	428,000
Saline	9,696	7,292	1,091	60	1,081	D	906	0
Union	6,521	7,198	275	64	238,283	1,889,300	42,534	4,349,469
Total	**252,628**	**311,153**	**51,758**	**63,264**	**6,286,294**	**25,600,095**	**3,802,923**	**40,871,243**

Notes: *Part of this county is in another planning region. D = Data withheld to protect privacy.

4.4 Waste Generation and Disposal

Industries and communities in the SCAWRPR produce wastes that must be properly managed to protect water quality, which contributes to water availability for the water users of the SCAWRPR. ADEQ is the state agency responsible for regulating solid waste, hazardous waste, and wastewater. These three waste streams are managed through separate permitting programs overseen by EPA. Waste management in the SCAWRPR is quantified below, along with changes in waste management that have occurred since the 1990 AWP update.

4.4.1 Solid Waste

All or part of six Regional Solid Waste Management Districts (RSWMDs) are within the SCAWRPR (Figure 4.7). Information on solid waste generation and disposal for each of these districts for 2010 is summarized in Table 4.13. For the most part, the RSWMDs report that their solid waste disposal facilities and collection services are sufficient to meet demand. However, illegal dumping that occurs in the districts could pose local threats to water quality.

Table 4.13. 2010 solid waste generation and disposal information for RSWMDs in the SCAWRPR.

RSWMD Name	Number of Counties in RSWMD	Counties in Planning Region	Number Of Landfills In Planning Region	Solid Waste Generated In-District (tons)	Solid Waste Disposed In-District (tons)	Number Illegal Dump Sites Identified[g]
Upper Southwest[a]	9	2 + 2 partial	2 Class IV	128,824	139,332	8
Southwest[b]	6	4 + 1 partial	1 Class I, 3 Class IV	94,673	67,418	2
Southwest Central[c]	3	3	2 Class IV	194,360	91,398	2
Saline[d]	1	1	1 Class I, 1 Class IV	83,999	83,999	2
Pulaski[e]	1	Partial	2 Class I, 1 Class IV, 1 combined	901,037	910,037	0
Southeast Arkansas[f]	10	3 + 3 partial	1 Class I, 1 Class IV	350,000[h]	340,000[i]	12

Notes:
a. Terracon 2013.
b. Southwest Arkansas Planning and Development District 2013.
c. West Central Arkansas Planning & Development District, Inc. 2011.
d. Grappe 2011.
e. Pulaski County Regional Solid Waste Management District 2011.
f. Southeast Arkansas Regional Solid Waste Management District 2011.
g. ADEQ 2013b.
h. Estimated annual projection.
i. 8,634 tons reportedly hauled out of district annually.

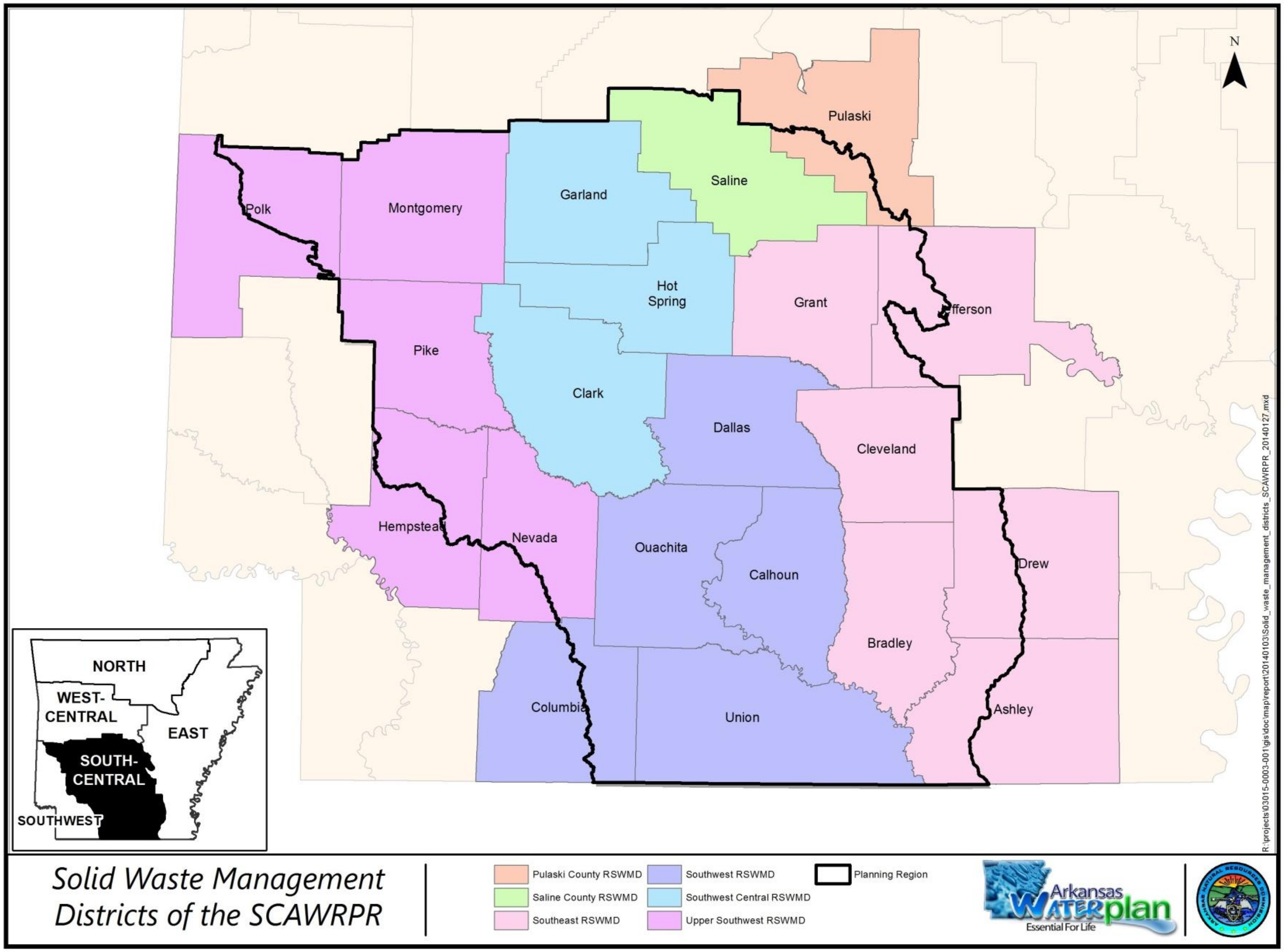

Figure 4.7. RSWMDs of the SCAWRPR (ADEQ 2011b).

There have been significant changes in the solid waste arena since 1990, driven by the need to protect water quality. In 1991, federal regulations changed, requiring improvements in the way landfills were constructed in order to protect groundwater quality. In addition, the new regulations required monitoring of groundwater quality around landfills (EPA 2012a, ADEQ 2011a). At the same time, state regulations set up programs to fund cleanup of groundwater contamination from landfills, and for collection and recycling of batteries and waste oil, both of which pose risks to surface and groundwater quality when disposed of improperly. Around 1995, the Arkansas General Assembly established a policy to eliminate illegal dumping, another threat to surface and groundwater quality. State legislation to implement this policy was passed in 1997. In 2005, state legislation was passed that resulted in the development and implementation of a comprehensive mercury minimization program for the state. Mercury is a surface water quality issue throughout the state (ADEQ 2011a). State programs initiated since 1990 for the collection and recycling of electronics, and collection of household hazardous wastes also protect water quality.

4.4.2 Hazardous Waste

There are 204 permitted hazardous waste generators in the counties within the SCAWRPR (Table 4.14). Eighty-one of these facilities are classified as large quantity generators, meaning they generate at least 1,000 kilograms of hazardous waste per month (EPA 2012b). One hundred twenty-three of the facilities are classified as small quantity generators, meaning they generate between 100 and 1,000 kilograms of hazardous waste per month (EPA 2012c). There are also nine hazardous waste treatment/storage/disposal facilities in the region; four in Camden, three in El Dorado, and two in Benton (ADEQ n.d.).

Table 4.14. Permitted hazardous waste generators in counties within the SCAWRPR (ADEQ 2014b).

County	Large Quantity	Small Quantity
Ashley*	3	2
Bradley	1	0
Calhoun	3	1
Clark	5	3
Cleveland	1	1
Columbia*	6	6
Dallas	0	0
Drew*	2	2
Garland	3	8
Grant	1	2
Hempstead*	0	3
Hot Spring	0	5
Jefferson*	5	10
Montgomery	0	1
Nevada*	2	0
Ouachita	8	8
Pike	0	0
Polk*	3	5
Pulaski*	24	56
Saline	3	6
Union	11	4
Total	**81**	**123**

*Part of this county is in another planning region.

Hazardous waste generation data are compiled annually, but this program was not implemented in Arkansas until after 1990. Information from 1990 on the number of hazardous waste generators is also not readily available. Therefore, a comparison with 1990 conditions is not made in this document.

4.4.3 Wastewater and Stormwater

As of January 2014, there are 2,650 point sources permitted to discharge wastewater and stormwater in the SCAWRPR (Table 4.15). These discharges are permitted by ADEQ through the federal National Pollutant Discharge Elimination System (NPDES) program. Industrial, municipal, and domestic wastewater discharges are permitted through NPDES as well as discharges of stormwater and runoff associated with industrial sites, municipalities (MS4s), and temporary construction sites. See Section 6 for more details on wastewater regulations and permitting in Arkansas.

Table 4.15. NPDES-permitted discharges in the SCAWRPR (ADEQ 2014a, ADEQ 2014e, ADEQ 2014c, ADEQ 2014d).

County	NPDES Industrial	NPDES Municipal	NPDES Domestic	NPDES Large MS4	NPDES Small MS4	NPDES Construction Stormwater[(a)]	NPDES Industrial Stormwater	NPDES Other[(b)]	Total
Ashley[(c)]	5	6	1	0	0	3	13	5	33
Bradley	6	3	1	0	0	27	13	0	50
Calhoun	9	5	1	0	0	14	5	1	35
Clark	15	5	15	0	0	50	18	3	106
Cleveland	2	2	1	0	0	23	5	3	36
Columbia[(c)]	20	5	3	0	0	4	18	5	55
Dallas	10	3	1	0	0	20	17	1	52
Drew[(c)]	6	2	1	0	0	2	12	1	24
Garland	37	6	19	0	2	210	80	4	358
Grant	12	2	3	0	0	37	23	3	80
Hempstead[(c)]	16	6	4	0	0	10	27	4	67
Hot Spring	18	3	11	0	0	61	52	6	151
Jefferson[(c)]	26	7	6	0	4	23	60	11	137
Montgomery	5	2	7	0	0	12	7	4	37
Nevada[(c)]	4	2	5	0	0	2	3	2	18
Ouachita	17	4	5	0	0	29	34	3	92
Pike	9	3	4	0	0	15	13	2	46
Polk[(c)]	8	3	3	0	0	3	14	2	33
Pulaski[(c)]	123	16	69	1	8	151	212	25	605
Saline	14	7	31	0	5	293	54	8	412
Union	33	11	19	0	0	80	73	7	223
Total	**395**	**103**	**210**	**1**	**19**	**1,069**	**753**	**100**	**2,650**

Notes:

a. Construction stormwater permits are temporary.

b. Includes filter backwash, process water, cooling water, and other discharges.

c. Part of this county is in another planning region.

Over 100 surface waterbodies in the planning region receive discharges from NPDES-permitted entities. A number of these waterbodies receive discharges from more than one NPDES-permitted point source (ADEQ 2012a).

ADEQ also issues water discharge permits through state regulatory programs. In January 2014, 647 state water permits are active in the counties within the SCAWRPR (Table 4.16). The majority of these permits (over 400) are for brine operations, the majority of which are in Union County. The counties with the largest numbers of facilities with state water permits are Union, Columbia, and Ouachita.

Table 4.16. State water permits (ADEQ 2014a).

County	Industrial	Municipal	Domestic	Brine (includes commercial)	Reserve Pits-B17 Rule	Underground Injection	Total
Ashley*	0	0	0	1	0	0	1
Bradley	0	0	0	4	0	0	4
Calhoun	0	0	0	5	0	0	5
Clark	3	1	0	0	0	0	4
Cleveland	0	0	0	0	0	0	0
Columbia*	8	0	0	56	49	2	115
Dallas	0	0	0	0	0	0	0
Drew*	0	0	0	0	0	0	0
Garland	4	1	0	0	0	0	5
Grant	1	2	0	0	0	0	3
Hempstead*	3	1	0	1	1	0	6
Hot Spring	5	1	0	0	0	0	6
Jefferson*	7	0	0	0	0	0	7
Montgomery	3	0	0	0	0	0	3
Nevada*	0	0	0	22	2	0	24
Ouachita	2	1	0	102	35	0	140
Pike	3	0	0	0	0	0	3
Polk*	3	1	0	0	0	0	4
Pulaski*	14	2	0	0	0	0	16
Saline	8	0	0	0	0	0	8
Union	12	0	1	218	58	4	293
Total	**76**	**10**	**1**	**409**	**145**	**6**	**647**

*Part of this county is in another planning region.

Table 4.17 compares the number of NPDES permits for municipal, domestic, and industrial wastewater reported for the SCAWRPR in the 1990 state-wide water quality assessment with the current numbers for the same categories of NPDES permits. Overall, the number of permitted wastewater discharges in the SCAWRPR has increased by over 300% since the 1990 AWP update. The majority of this increase is in the number of industrial and domestic permits. Note that the state-wide water quality assessment reports do not include permits for municipal, industrial, or construction stormwater runoff. The first industrial and construction stormwater runoff NPDES permits were issued by ADEQ in 1992 (ADEQ 2014c, ADEQ

2014d). ADEQ did not issue permits for stormwater runoff from small municipalities until 2004 (ADEQ 2014e).

Table 4.17. Numbers of NPDES wastewater permits reported for the SCAWRPR in 1990 and 2014 (ADPCE 1990, ADEQ 2014a).

Permit Type	1990	2014	Change
Industrial	42	395	+253
Municipal	60	103	+43
Domestic	68	210	+142
Cooling Water	4	2	-2
Filter Backwash	2	32	+30
Process Water	1	12	+11
Agricultural	0	0	0
Other	8	13	+5
Toxic	2	0	-2
Total	**187**	**767**	**+580**

5.0 WATER RESOURCES ISSUES

Water resources issues in the SCAWRPR include concerns about the amount of water that is available, how the water is used, and the chemical and biological quality of water resources. In addition, there are concerns in the region about how water is managed in terms of flood control, water supply infrastructure, and wastewater treatment infrastructure. These issues are discussed and, to some extent, quantified below. Changes in regional water resources issues since the 1990 AWP update are also discussed.

5.1 Flooding

Parts of the SCAWRPR have been known to experience recurring flood problems. The Ouachita River has historically had issues with flooding, leading to studies performed by the US government in the 1870s. Several significant flood events occurred on the river, notably the floods in May 1923 and March 1945. With the Flood Control Act of 1944, funding became available that would lead to the construction of Blakely Mountain Dam, forming Lake Ouachita and helping to decreasing flooding issues on the river (Branyan 2013, lakeouachita.org 2013).

Significant flood events have occurred in more recent years in the planning region. Heavy rainfall in May 1990 caused severe flooding in and around Hot Springs, Arkansas. The Ouachita River and several tributaries between Blakely Mountain Dam and Malvern, Arkansas, experienced flooding that led to significant property damage and one fatality. Both Lake Hamilton and Lake Catherine experienced flood stages near the 100-year event level. Several gage stations along the Ouachita River and its tributaries showed peak discharges that exceeded the 100-year event (Southard 1992).

A second significant flood event occurred on June 11, 2010, along the Little Missouri River. A flash flood occurred in the early morning due to a high-intensity rainstorm, with more than 5.3 inches of rain falling in 6 hours, causing an average flood depth of 7 feet to occur in the floodplain. USGS has estimated this storm to have a recurrence interval of less than 1% (100-year event). The flood killed 20 people and caused severe property damage (Holmes and Wagner 2011).

Columbia County, which is partially in the SCAWRPR, was listed as one of the six counties in Arkansas with the most federal disaster declarations. Eighty percent of these declarations were with regard to flooding (Branyan 2013).

5.2 Water Supply

Population growth, as well as expansion of water-intensive industries in this region, such as irrigated agriculture and aquaculture, has resulted in concern over whether there is sufficient water available to supply current and future demands in the SCAWRPR.

5.2.1 Groundwater

There are 12 recognized aquifers within the planning region, however, only some of these are considered sustaining aquifers. Other aquifers can supply only limited domestic use. There is concern about water level declines in several of the aquifers in the planning region. This is a somewhat localized issue as water use and groundwater recharge rates for these aquifers vary throughout the planning region.

5.2.1.1 Groundwater Level Monitoring

ANRC sponsors monitoring of water levels of the Sparta aquifer in Ashley, Bradley, Calhoun, Columbia, Dallas, Drew, Ouachita, and Union counties (Figure 5.1). This water-level monitoring program is a cooperative effort between ANRC, USGS, the USDA Natural Resources Conservation Service (NRCS), and local water-resources agencies. Each spring, water level measurements are collected from approximately 80 wells in the Sparta-Memphis aquifer within the planning region (ANRC 2012b). Results of the monitoring program are published in the annual Arkansas Groundwater Protection and Management Report on the ANRC website.

USGS also conducts water-level monitoring independently as part of the National Water Information System (NWIS). Since 2007, USGS has operated continuous groundwater-level recorders at 15 real-time stations in the planning region (Figure 5.1). These data provide a valuable dataset for improved understanding of water resources of the state. USGS also collects water level data for seven aquifers from 21 additional wells in the planning region (USGS 2014).

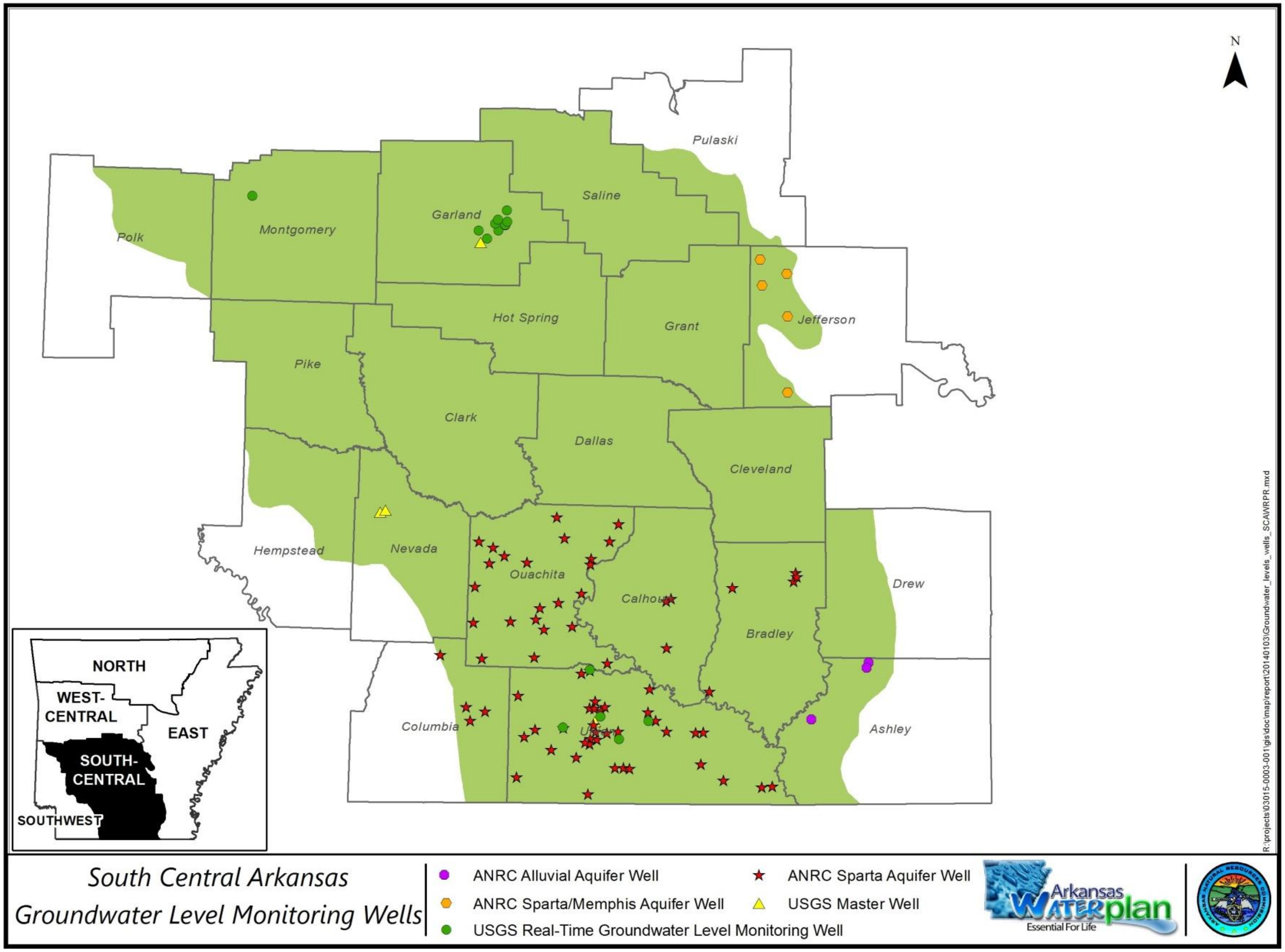

Figure 5.1. Groundwater level monitoring sites in the SCAWRPR.

Data from these programs may be retrieved at the NWIS website. USGS also works with its partners to prepare water level reports for aquifers associated with the SCAWRPR (USGS n.d.).

5.2.1.2 Ouachita-Saline Alluvial Aquifer

Locally, the alluvium of the Ouachita and Saline rivers provides readily available groundwater. Although the aquifer is thin in the area of Clark, Cleveland, and Dallas counties, (Plebuch and Hines 1969) this aquifer has been a historical source of water for these counties and other counties within the planning region. In 2010, Union County reported a use of 0.05 million gallons per day (mgd) and Grant County reported usage of 3.39 mgd from this aquifer, used largely for irrigation (Kresse et al. 2013).

5.2.1.3 The Jackson Group

Groundwater use from the Jackson Group was confined almost solely to a large area of exposed deposits south of the Arkansas River along the eastern border of the planning region. Because of the extensive clay content of sediments constituting the Jackson Group, yields were low and sufficient for only domestic and livestock supply in the past. Plebuch and Hines (1969) reported that the aquifer yielded small amounts for domestic use only. Halberg et al. (1968) similarly reported low yields throughout much of the extent of the Jackson Group and stated that where larger supplies were needed, wells would have to be drilled into the underlying Cockfield or Sparta Formations. Kresse and Fazio (2002) reported that, prior to 1960, a minimum of 90 wells in Drew and Lincoln counties and 6 wells in Jefferson County were using groundwater from the Jackson Group as a source for farm and domestic supply. Municipal water-supply sources have replaced use of groundwater from the Jackson Group, and remaining operational wells located in 1999 and 2000 by Kresse and Fazio (2002) were used solely for watering gardens and other ancillary purposes.

5.2.1.4 Cockfield Aquifer

The Cockfield aquifer is an important groundwater resource throughout eastern and southern Arkansas. Public supply accounted for 17% of water pumped from the Cockfield aquifer in 2010, and the aquifer ranks as the sixth-highest used aquifer for public supply in Arkansas (Kresse et al. 2013). Domestic use of the Cockfield aquifer is important in the planning region, but in some areas yields are high enough to support municipal and industrial supply. From 2000 to 2010, Ashley County was the largest user of the Cockfield aquifer for both public and industrial supply. Use of the Cockfield aquifer here increased from less than 4 mgd to approximately 10 mgd between 1990 and 2010 (Kresse et al. 2013).

As a result of sustained and intense pumping of the Cockfield aquifer in the planning region, water level declines have led to cones of depression in western Drew County, southwestern Calhoun County, and southeastern Lincoln County, but no regionally extensive declines in water levels have been observed in the Cockfield aquifer (Kresse et al. 2013). With growing population and water demands over time, some municipalities (e.g., Kingsland, El Dorado) in the planning region have switched their primary water supply from the Cockfield aquifer to the Sparta aquifer (Kresse et al. 2013).

5.2.1.5 Sparta Aquifer

The Sparta aquifer is an extremely important aquifer in Arkansas, generally providing water of excellent quality, with wells often yielding hundreds to thousands of gallons per minute. The Sparta aquifer provided approximately 197 mgd in 2010 with 700 wells reported in use (Kresse et al. 2013). Within the SCAWRPR, the Sparta aquifer is the best source for industrial use (primarily for oil and gas processing and development, chemical industry, and the lumber and paper industries) and public supply. Most counties within the planning region used the Sparta aquifer as a source of water supply in 2010, but the principal areas for groundwater withdrawal from the Sparta aquifer are in Union County and Jefferson County. Jefferson County, especially the Pine Bluff area within the SCAWRPR has been the largest user of the Sparta aquifer in the state.

The Sparta aquifer ranks first in groundwater used for public supply in Arkansas, with municipalities withdrawing 57.4 mgd from the Sparta aquifer in 2010 (Kresse et al. 2013). The Sparta aquifer has been the sole public supply source for El Dorado since the later 1940s (Baker et al. 1948). The Sparta aquifer has many municipal users in other areas within the planning region, including Carthage, Fordyce (both in Dallas County), and Rison (Cleveland County) (Plebuch and Hines 1969). Albin (1964) reported that the Sparta aquifer at Camden (Ouachita County) was nearing maximum sustainable yield in the mid-1960s, but Camden now gets their water from the Ouachita River. Use of the Sparta aquifer in Union County in 2010 was 7.59 mgd. Industrial water use of the Sparta aquifer by Union County was 3.98 mgd in 2010, or 52% of the total use. Use of the Sparta aquifer in Jefferson County in 2010 was 45.5 mgd. Industrial water use from the Sparta aquifer in Jefferson County was 31.79 mgd in 2010, or 69.9% of the total use (Kresse et al. 2013).

Water-level declines in the Sparta aquifer are a major concern for users in Arkansas and have been noted throughout the Sparta aquifer in Arkansas. Severe water-level declines were noted in southern and east-central Arkansas since development of the Sparta aquifer for primarily municipal and industrial uses in these areas. The reader is referred to Kresse and others (2013) for a discussion of the historical use of the Sparta and a general overview of changing water levels over time and development of cones of depression throughout the extent of the Sparta aquifer in Arkansas. Within the planning region, significant water level declines have been observed around Pine Bluff (Jefferson County) and El Dorado (Union County), with lesser declines observed in northern Cleveland County, northeastern Bradley County, eastern Calhoun County, northern Ashley County, and in Camden (Ouachita County). Minor cones of depression have developed in these latter areas since publication of the 1990 AWP.

5.2.1.6 Cane River Aquifer

Although present in many areas of southern Arkansas, water quality concerns have restricted use of the Cane River aquifer to primarily southwest Arkansas. Historically, the Cane River aquifer was a source of domestic supply and public supply for Sparkman (Dallas County) (Plebuch and Hines 1969). In the mid-2000s, Sparkman switched from the Cane River aquifer to the Ouachita River. Wells capable of producing smaller yields were present in Union County, north of El Dorado (Baker et al. 1948, Tait et al. 1953). Ouachita County had a reported use of 0.08 mgd in 2010 (Kresse et al. 2013).

Although hydrologic characteristics were deemed the most favorable for future development in south-central Arkansas (Hosman et al. 1968), abundant groundwater from overlying formations supply water needs within the planning region. Ludwig (1973) indicated that water levels in the aquifer have not been affected by pumping.

5.2.1.7 Carrizo Aquifer

The Carrizo aquifer serves only as a minor aquifer in Arkansas, mainly used for domestic supply within 5 to 10 miles of its outcrop (Albin 1964, Terry et al. 1986). Hosman et al. (1968) noted that in south-central Arkansas, where the hydrology of the Carrizo Sand was most favorable for future development, the unit was untapped. Older reports state that the aquifer was not commonly utilized, due perhaps to limited information available on the aquifer's extent and water availability and/or high iron contents (Halberg et al. 1968, Plebuch and Hines 1969). Most withdrawals from the Carrizo aquifer were domestic users. Published water use data for the Carrizo aquifer only is available from 1965 to 1980. In 1980, a total of 0.31 mgd was withdrawn from the Carrizo aquifer in Hempstead, Hot Spring, Nevada, and Ouachita counties (Kresse et al. 2013). No use has been reported for this aquifer within the planning region since 1980.

5.2.1.8 Wilcox Aquifer

In southern and southwestern Arkansas, which includes the planning region, total water use from the Wilcox aquifer is less than that in northeastern Arkansas. However, the Wilcox aquifer is very important in the planning region for domestic supply near its outcrop area. Many residences have wells completed in the Wilcox aquifer and depend on it for drinking water; schools and small businesses are also reported to use water from the Wilcox aquifer in this area (Counts et al. 1955, Onellion and Criner 1955, Albin 1964, Halberg and Stephens 1966, Plebuch and Hines 1969, Ludwig 1972, Terry et al. 1986). Domestic use has declined in recent years as more residents convert to municipal water supplies; however, small amounts still are assumed to be withdrawn for domestic supply by users in Nevada County. Rosston (Nevada County), the only town in the planning region using the Wilcox aquifer for public supply, installed a well in

1928, pumped 0.03 mgd from 1945 to 1965, and as of 2010, pumped 0.06 mgd (Kresse et al. 2013).

In the planning region, two cones of depression were noted in the 2006 Wilcox aquifer surface, in Nevada County near Rosston and southeastern Clark County (Schrader 2007a). The cone of depression in Nevada County is centered near a single well. From 2003 to 2009, water levels in this well dropped 17.7 feet, which was the largest decline in the southern area of the Wilcox aquifer (Pugh 2010). Previous work in the 1970s had reported the lowest water levels of the Wilcox aquifer in the south part of the state near the Rosston public supply well (Ludwig 1972); however, the lowest levels of the Wilcox aquifer were recorded in 2009 at the depression in southeastern Clark County (Pugh 2010).

5.2.1.9 Nacatoch Aquifer

Use of the Nacatoch aquifer is found in areas near its outcrop within the planning region. Poor water quality has restricted the aquifer's use farther away from its outcrop in southwestern Arkansas (Terry et al. 1986). Primary use of the aquifer has been public and industrial supply. Hempstead County has generally had the most use of the Nacatoch aquifer. Other counties within the planning region that have historically used the aquifer as a water supply include Clark, Ouachita, Nevada, and Hot Spring Counties. Users pumped the most water in 1980 (6.46 mgd). Water-use rates for the Nacatoch aquifer has decreased since 1980 to a reported level of 1.66 mgd in 2010 with wells located in Clark, Hempstead, Ouachita, and Nevada counties (Kresse et al. 2013).

Prescott (Nevada County) formerly had two wells in the Nacatoch aquifer, tapped in 1925 and 1948 (Hale et al. 1947, Counts et al. 1955), but now solely draws from the Little Missouri River. Other smaller communities in the area including Gurdon (Clark County) and Emmet (Nevada County) tap the Nacatoch aquifer for public supply.

Industrial use of water from the Nacatoch aquifer occurs in Clark and Hempstead counties. Lumber-processing facilities currently depend on Nacatoch aquifer wells in Clark County. Ice companies and Arkansas Louisiana Gas were also recorded users of the Nacatoch aquifer in Clark County. The current (2010) largest single use of the aquifer is for cooling water at a power plant in Hempstead County.

In the planning region, recent water-level contours have shown that water levels gradually decrease from the aquifer's outcrop north to south (Schrader and Blackstock 2010). In Prescott, water levels declined greater than 30 feet from the mid-1950s to the mid-1970s, but dramatic rises (up to approximately 70 feet) were recorded later in this well from 1985 to 1990, when the drinking water supply of Prescott was switched from groundwater to the Little Missouri River (Schrader and Blackstock 2010). Groundwater levels in the Nacatoch have been stable in this area since the early 1990s. In 2011, cones of depression were noted in southern Clark and north-central Hempstead counties (Kresse et al. 2013).

5.2.1.10 Ozan Aquifer

Wells completed in the Ozan aquifer are found mainly in Clark County where other water sources are not available. Primary use of this aquifer has been for domestic supply; however, use has been restricted due to high chloride concentrations (Counts et al. 1955, Boswell et al. 1965). Pleubuch and Hines (1969) estimated that 0.13 mgd was withdrawn in Clark County from the Ozan aquifer in 1965. Published water use data for the Ozan aquifer only is available from 1965 to 1980, and no use has been reported for this aquifer after this period.

5.2.1.11 Tokio Aquifer

The Tokio aquifer dominantly was used as a source of domestic water supply. Counts and others (1955) recorded 143 domestic wells into the Tokio aquifer in six counties in the SCAWRPR: Pike, Nevada, Clark, Hempstead (and Howard and Sevier in the Southwest AWRPR). Many of these wells originally were flowing artesian wells, and an estimated 66% of water was lost from the total 3 mgd that was withdrawn (Boswell et al. 1965). Use for domestic supply and livestock wells continued into the late 1960s and early 1970s in Clark County (Plebuch and Hines 1969, Ludwig 1972). Also, domestic wells are in use in Hempstead County.

Several towns in the planning region have used the Tokio aquifer for municipal supply. Several smaller communities in the area including Okolona (Clark County) and Blevins

(Hempstead County) tap the Tokio aquifer for public supply. Prescott (Nevada County) formerly had one well in the Tokio aquifer, completed in 1912 (Counts et al. 1955), but now solely draws from the Little Missouri River.

The Tokio aquifer has seen a small amount of industrial use in the past, including withdrawals for Arkansas Louisiana Gas Company near Prescott (Counts et al. 1955), but currently the aquifer is not used for industrial purposes within the planning region (Kresse et al. 2013).

Long-term ANRC and USGS cooperative monitoring has documented water-level changes in the Tokio aquifer (Schrader 1998, 1999, 2007b; Schrader and Scheiderer 2004; Schrader and Blackstock 2010; Schrader and Rodgers 2013). No appreciable changes in water levels were noted at the map scale between the 1996, 1999, and 2001 investigations (Schrader and Scheiderer 2004). Many reports cite the possibility of a cone of depression forming 5 miles northwest of Hope; however, not enough water-level data have been available in the southern part of the study area to confirm this situation (Schrader and Blackstock 2010). However, water levels in a well near the possible depression northwest of Hope (Hempstead County) have fallen with increasing use. A large drop was documented for this well between 1990 and 2000, when water use increased 215%, from 1.10 mgd to 3.46 mgd in Hempstead County. Water levels additionally appear to have slowly declined at Prescott.

5.2.1.12 Trinity Aquifer

The Trinity aquifer is present in Pike County in the SCAWRPR. The Trinity aquifer has been used for domestic and public water supply, including the public supply well at Murfreesboro (Pike County). However, published water use data for the Trinity aquifer only is available from 1965 to 1980, and no use has been reported for this aquifer after this period.

5.2.1.13 Ouachita Mountains Aquifer

Although Albin (1965) noted that wells in the Ouachita Mountains yielding greater than 10 gpm were considered “large-yield wells,” some wells commonly can yield between 10 and 50 gpm—yields more than sufficient for many community supply systems. A review of community supply wells from the Arkansas Department of Health resulted in 72 wells used by various entities including camps and other recreational areas, conference centers, rest areas, stores, and even sources of public supply. Five separate communities used wells completed in the Atoka, Bigfork Chert, Stanley Shale, and Arkansas Novaculite Formations for purpose of public supply, demonstrating that many formations constituting the Ouachita Mountains aquifer are capable of supplying volumes sufficient for small community supply sources of water (Kresse et al. 2013).

5.2.1.14 Critical Groundwater Areas

The 1990 AWP update advocated sustainable, conjunctive use of groundwater and surface water resources in this region to meet water resources needs. A number of voluntary programs have been initiated to try to reduce the rate of groundwater depletion in areas where groundwater level declines are the greatest.

Portions of southwest Pulaski County and western Jefferson County lie within both the SCAWRPR and the Grand Prairie Critical Groundwater Area (Figure 5.2). Concerns about potential water-level declines from an increasing number of wells and increasing demands on the Sparta aquifer for agricultural use in additional to declines observed in the Mississippi River Valley alluvial aquifer led ANRC to designate the Grand Prairie as a Critical Groundwater Area in 1998 (ANRC 2010). Two surface-water diversion projects are planned for the Grand Prairie area to provide irrigation water and decrease dependence on the Mississippi River Valley alluvial and Sparta aquifers (Kresse et al. 2013).

Historically, the Sparta aquifer in south Arkansas provided abundant water of high quality; however, demand for water, particularly in Union County (and Columbia County in the Southwest WRPR), resulted in withdrawals that significantly exceeded recharge and water levels that were declining at rates greater than 1 foot per year through the 1980s and 1990s. Regional cones of depression centered on El Dorado and Monroe, Louisiana, coalesced by 1990. As water levels began to drop below the top of the formation, water users and managers alike began to question the ability of the aquifer to supply water of high quality for the long term and began to evaluate management approaches to protect the aquifer.

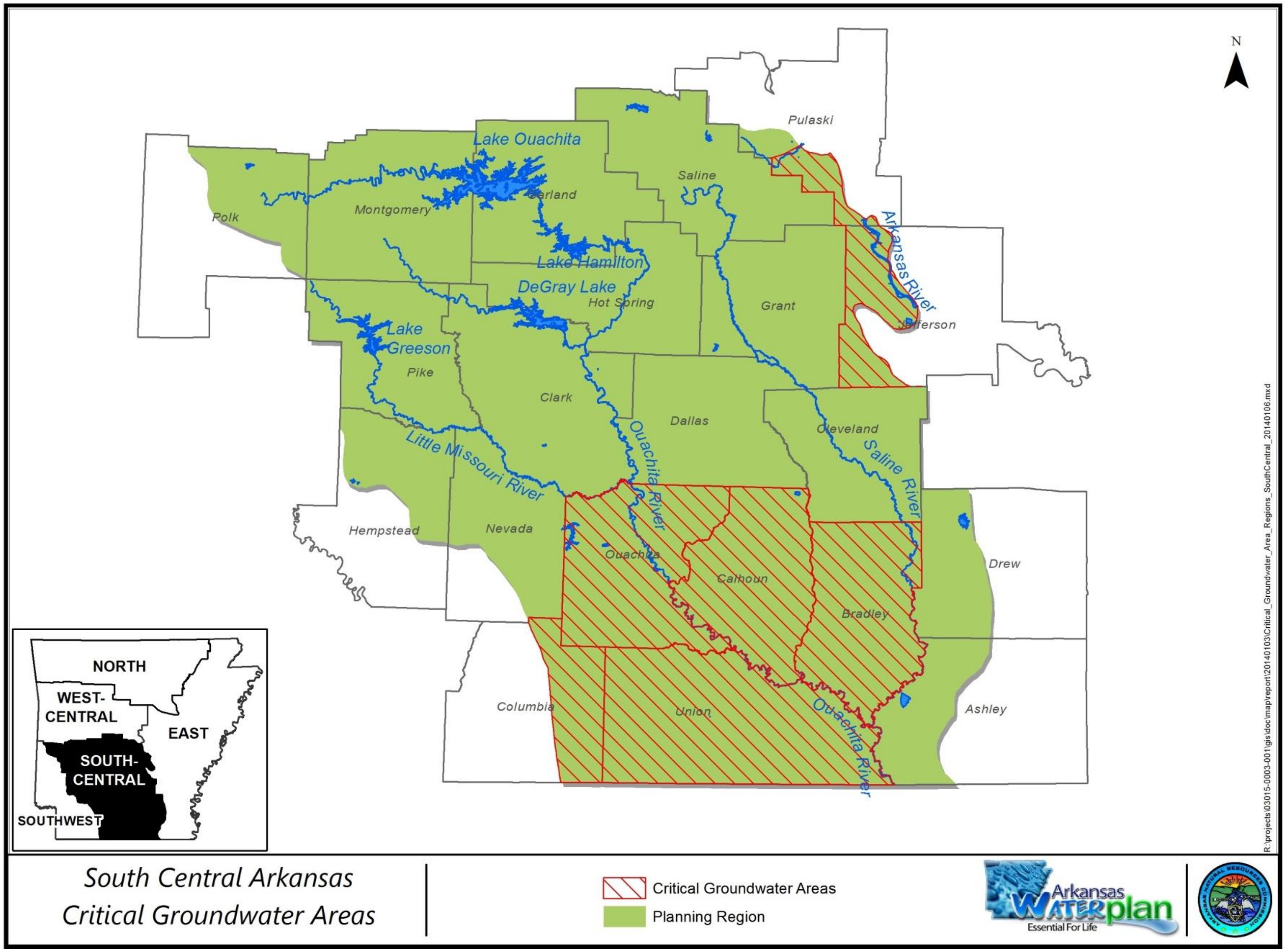

Figure 5.2. Critical groundwater areas within the SCAWRPR.

Water levels in Union County had been declining at rates greater than 1 foot per year for over a decade (Hays, Lovelace and and Reed 1998), and saltwater intrusion caused by intensive pumping increased near the cone of depression in Union County (Broom, Kraemer and and Bush 1984). Simulated results from Hays and others (1998) indicated that if pumping rates from the 1990s continued to 2027, water levels would approach or fall below the top of the Sparta aquifer at the major pumping centers in Arkansas and Louisiana. In 1996, the Sparta aquifer was declared a Critical Groundwater Area by ANRC in five counties: Ouachita, Calhoun, Bradley, Columbia, and Union (Figure 5.2). This action allowed counties within the designated area to establish local conservation boards with management, regulatory, and taxing authority to plan, guide, and implement management strategies targeting the achievement sustainable use of the aquifer.

The Union County Water Conservation Board (UCWCB) was formed and approved by ANRC in 1999. In an effort to conserve the aquifer, UCWCB instituted several water conservation measures, including (1) public education about water conservation practices, (2) industrial water reuse and sharing, and (3) reuse of reclaimed treated wastewater at local golf courses. Also, a temporary $0.01 sales tax was adopted in 2002 by the citizens of Union County for to help pay for a pumping facility on the Ouachita River to develop an alternative water source and supply surface water to local industry. This funding, in combination with a grant from EPA, were used to construct a pumping station and pipeline from the Ouachita River to major industrial groundwater users in the El Dorado area. The river intake, pumping facility, and 5 miles of 48-inch pipeline were completed in 2004. The facility is capable of producing 65 mgd. Also, funding allowed for the installation of eight real-time water-level monitors (Scheiderer and and Freiwald 2006). In recent developments, the Louisiana Department of Natural Resources (LDNR) has offered to share Sparta aquifer recovery monitoring responsibilities through September 2015 (personal communication between UCWCB, LDNR, and USGS Louisiana, August 7-8, 2013). More information can be found on the UCWCB website (http://www.ucwcb.org/).

From 2005 to 2010, use in Union County declined over 50% due to conservation efforts, and the efforts undertaken to reduce groundwater use led to rising water levels and a smaller cone of depression (Kresse et al. 2013). Groundwater models have been developed and are used to help manage water needs in the planning region with the goal of achieving and maintaining sustainable use of the Sparta aquifer.

5.2.2 Surface Water

Lakes and rivers in the SCAWRPR are important sources for water supply to cities, industry, and water utilities. Concerns about groundwater in the planning region have increased the demand for surface water as industry and water utilities switch from groundwater to surface water to supply their needs (e.g., the Union County Water Conservation Board described in Section 5.2.1.2). Surface water sources in the SCAWRPR are listed below (ADH n.d.):

- Caddo River,
- DeGray Lake,
- Ouachita River,
- Irons Fork Lake,
- Lake Columbia,
- Lake Lago,
- Middle Fork Saline River,
- Lake Nichols,
- Lake Ouachita,
- Lake Winona/Lake Maumelle,
- Lake Hamilton,
- Ricks Lake,
- Dillon Lake,
- Sanderson Lake,
- Little Missouri River,
- Little River, and
- Saline River.

Though the Little River is not located in this planning region, it is a source of water to utilities in the region, and is therefore listed.

Hot Springs Waterworks currently treats water from lakes Hamilton, Sanderson, Ricks, and Dillon. The city has two treatment plants: Lakeside Plant and Ouachita Plant. The Lakeside Plant treats water from lakes Ricks and Dillon, while the Ouachita Plant treats water from lakes Hamilton and Sanderson. Future plans for the city are to abandon the Lakeside Plant and build another with a new water source. A 2013 study found that choices for the acceptable new source would be either Lake DeGray or Lake Ouachita. Projected demands show an approximate 1% per year increase in need. Therefore, a suggested increase of 15 mgd from the new plant would allow for demands to be met and reassessed in the year 2030 (Crist Engineers, Inc. 2013). In October 2013, a deal between Hot Springs and Central Arkansas Water (CAW) was brokered, with CAW selling a portion of its future water rights to Lake DeGray to the City of Hot Springs. This deal has caused issue with some users of CAW water, who feel that the future water rights should have been saved (Petrimoulx 2013).

Some problems have arisen in the SCAWRPR due to surface water use. For example, the 2005-2009 NPS [Nonpoint Source] Management Program Update stated that water withdrawals along the Middle Fork of the Saline River have led to degradation of aquatic resources (ADEQ 2005). This was not mentioned in the 2011-2016 update, however. In 1995 there was an effort to make the Upper Saline River part of the Arkansas Natural and Scenic Rivers System, which would have disallowed its use as a water source. This effort was unsuccessful due to the fact that Saline County communities, including Benton, were suffering from a chronic water shortage at the time (Williams 1995). A 2002 study performed by a water study task force at the University of Arkansas at Little Rock stated that most sources in Saline County were sufficient for the next 5 to 20 years, but that further needs should be researched (Brenton et al. 2002).

Reallocation of storage from Ouachita Lake was considered to meet projected water supply needs for the communities of the Mid-Arkansas Water Alliance during the period from 2004 through 2009 (USACE Little Rock District 2009). Several communities in the planning region in Garland, Pulaski, and Saline counties are members of this alliance (Central Arkansas Water 2010).

5.3 Water Quality Issues

Federal law requires states to assess the water quality of the waters of the state (both surface water and groundwater) and prepare a comprehensive report documenting the water quality, which is to be submitted to EPA every 2 years. ADEQ is the agency in Arkansas responsible for enforcing the water quality standards and preparing the comprehensive report for submittal to EPA. This section discusses surface water and groundwater quality issues that have been identified in the SCAWRPR. These issues include non-attainment of surface water quality standards, non-attainment of drinking water standards and water quality guidelines in groundwater, fish consumption advisories, nonpoint source pollution of surface water and groundwater, and contaminants of emerging concern.

5.3.1 Water Quality Monitoring

To assess water quality, it is necessary to collect water quality data through monitoring programs. Monitoring of water quality in the SCAWRPR occurs under a range of programs, including routine ambient, special project, and research-oriented monitoring. Multiple agencies are responsible for the various water quality monitoring programs, and numerous entities assist with monitoring activities. Surface water and groundwater monitoring programs in the planning region are outlined below.

5.3.1.1 Surface Water

ADEQ monitors water quality of surface waters through several programs. The ambient water quality monitoring network includes 30 sites on rivers and streams in the SCAWRPR that are sampled monthly for chemical analysis. The roving water quality monitoring network includes 16 stream sites in the planning region. Roving monitoring sites are divided into four regional groups. The groups of roving sites are sampled for chemical and bacterial analysis on a rotating basis, bimonthly over a 2-year period. Each roving site group is monitored every 6 years (ADEQ 2008, ADEQ 2012a, ADEQ 2013c). ADEQ surface water quality monitoring stations are shown on Figure 5.3.

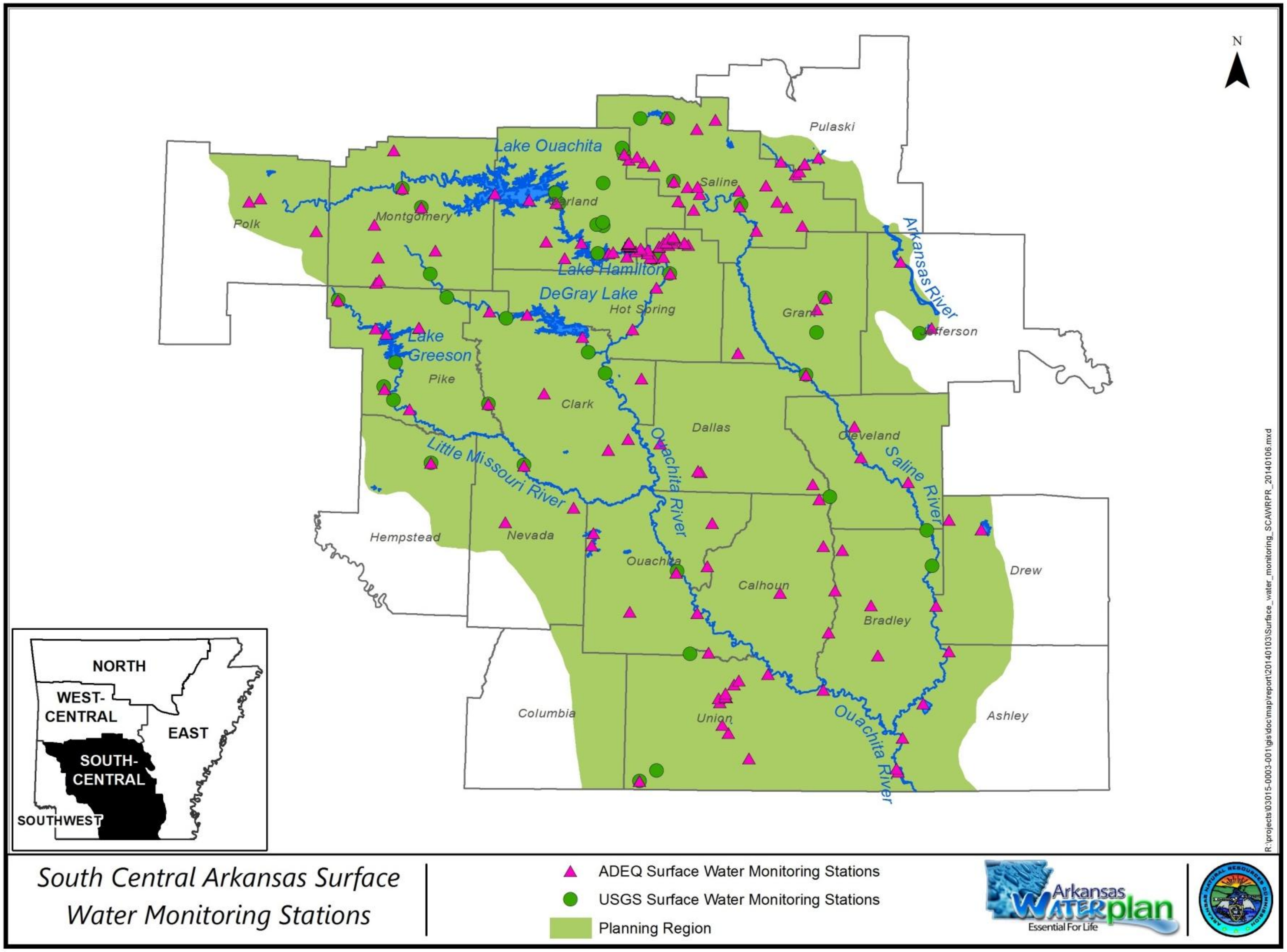

Figure 5.3. Surface water quality monitoring sites in the SCAWRPR.

Bacterial analysis is also performed on samples from the ambient water quality monitoring network within the active region of the roving water quality monitoring network. In addition, ADEQ conducts water quality monitoring during “intensive surveys.” These surveys can involve water sampling for chemical and bacterial analysis, as well as biological sampling to evaluate water quality. Intensive surveys are conducted for a variety of purposes, including determination of total maximum daily loads (TMDLs), and to augment water quality information from the routine water quality monitoring networks for more accurate assessment of designated use support. ADEQ also routinely monitors water quality in 18 significant publicly owned lakes within the planning region (ADEQ 2008, ADEQ 2012a, ADEQ 2013c).

Through its nonpoint source (NPS) management program, ANRC oversees water quality monitoring programs in 10 NPS priority watersheds. Two of these watersheds, Lower Ouachita Smackover and Upper Saline, are located in the SCAWRPR. These programs involve universities, contractors, and nonprofit organizations. Parameters monitored by these programs typically include nutrients and sediment, turbidity, and/or total suspended solids (TSS).

The monitoring and reporting requirements for surface water used for human consumption are authorized by both federal and state regulations. A summary of these requirements can be found in Chapter 5 of *Arkansas Public Water System Compliance Summary*, “Microbial Disinfection By-Products Rules” (ADH 2012). There are over 70 public water supply systems in the SCAWRPR that use surface water (ADH n.d.). Depending on the treatment methods used and the number of customers served by the public water supply utilizing surface water, the monitoring requirements for the raw surface water, or source water, will vary and may include turbidity, *Escherichia coli* (*E. coli*), cryptosporidium, total organic carbon (TOC), and alkalinity.

USGS also routinely monitors surface water quality data in the SCAWRPR. Data from USGS monitoring stations (Figure 5.3) may also be used in the biennial assessment. There are five active USGS water quality monitoring stations in the SCAWRPR. Samples are collected at these stations monthly, bi-weekly, or quarterly. There are five continuous USGS water quality monitoring stations in the SCAWRPR and 190 locations that have at least one sampling occurrence. Of these locations, 18 are in lakes and the remainder are in streams (USGS 2014).

5.3.1.2 Groundwater

In the SCAWRPR, groundwater quality monitoring is performed on many levels ranging from ambient to research-oriented and mandated monitoring. Multiple agencies are responsible for the various groundwater monitoring programs, and numerous entities assist with monitoring activities. Divisions of ADEQ administer mandated groundwater monitoring programs at various sites that are regulated by state and federal programs. The purpose of this monitoring is to evaluate potential and actual impacts to groundwater resulting from human activities and natural phenomenon (ADEQ 2012a). For example there are three Superfund sites located within the planning region where groundwater monitoring is currently performed. Within the planning region are three active properties in the state's Brownfields program that are currently being evaluated; six sites that are on the state Priority List that are monitored; one active site in the Elective Cleanup program; one Class I solid waste landfill; and a number of hazardous constituent sites and leaking underground storage tank sites that are being evaluated or monitored through other regulatory mechanisms. These sites may have contaminated groundwater with numerous organic chemicals exceeding safe drinking water standards, but the aerial extent of the plume may be limited with no offsite migration and no known groundwater users at risk.

ADEQ developed the Arkansas Ambient Ground Water Monitoring Program in 1986, which currently consists of 11 monitoring areas and approximately 250 wells and springs throughout the state (Kresse et al. 2013). ADEQ's Athens Plateau, Ouachita, El Dorado, and Pine Bluff areas are in whole or partially located within the planning region (Figure 5.4). Samples are collected from wells (Ouachita Mountains aquifer and Cretaceous aquifers) in the Athens Plateau (Pike and Howard counties) to develop baseline conditions and monitor potential impacts of the agricultural industry on groundwater. The El Dorado (Union County) area monitoring is performed in the Cockfield and Upper (Greensand) and Lower (El Dorado) Sparta aquifer to monitor the effects of this highly industrialized area (i.e., oil and gas production; bromine extraction, production and refining; light manufacturing; and food processing) on groundwater quality. The Ouachita (Ouachita County) area near Camden is monitored because it is the recharge area for the Sparta and Cockfield aquifers.

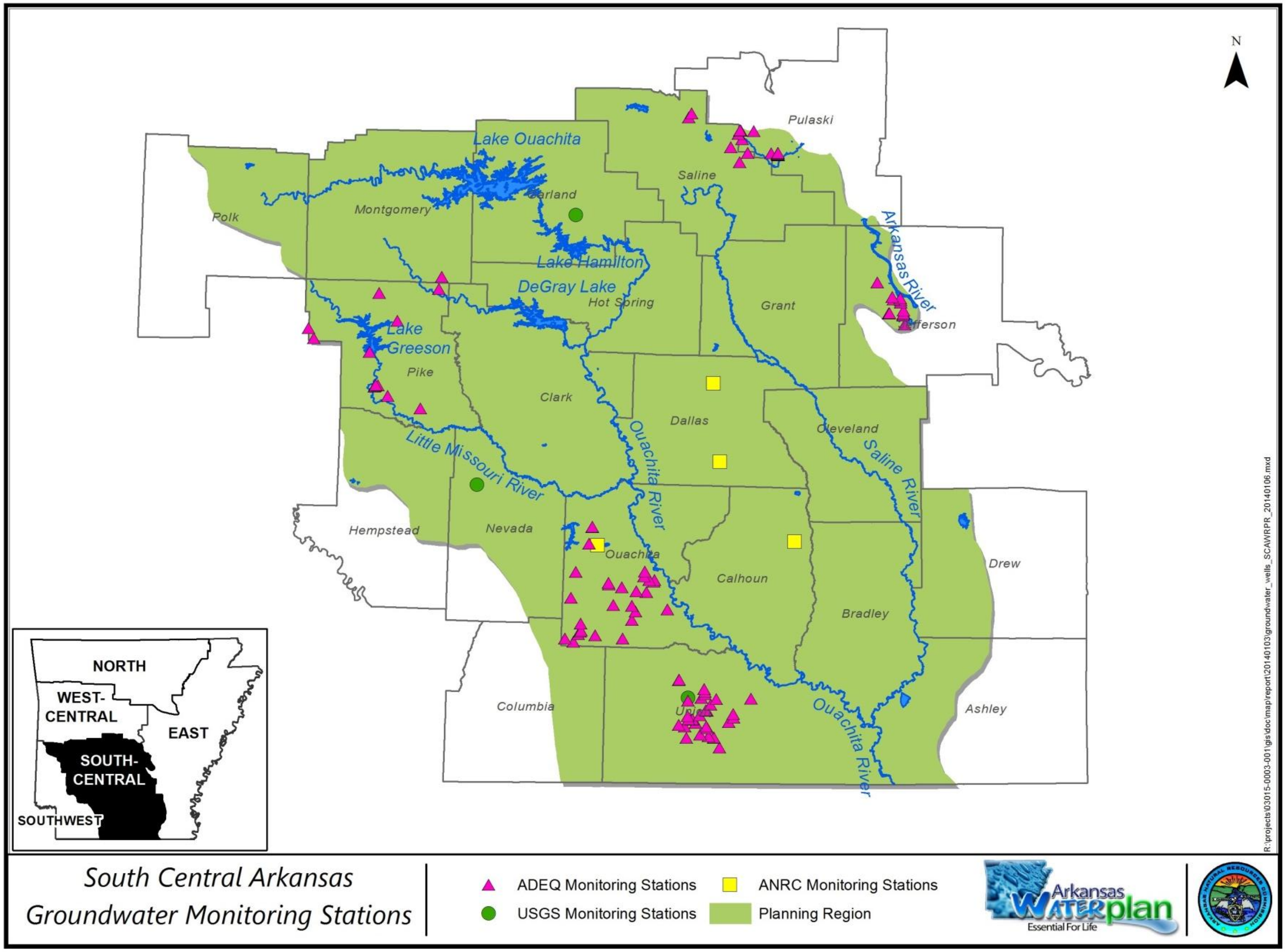

Figure 5.4. Routine groundwater quality monitoring sites in the SCAWRPR.

The Pine Bluff area straddles the SCAWRPR and East Arkansas WRPR, and is monitored because the alluvial aquifer and Cockfield and Sparta aquifers are the only sources of water to the Pine Bluff community. Data are presented in various ADEQ publications available on their website and in the EPA STORET database (ADEQ 2008).

The University of Arkansas (U of A) has conducted a significant amount of groundwater research that has resulted in scientific data and information necessary to understand, manage, and protect water resources within the state (Kresse et al. 2013). Hard-copy or digital reports, theses, dissertations, and journal articles are available at U of A's Mullins Library, Arkansas Water Resources Center technical library, or through various online sources.

The Arkansas Department of Health (ADH) is the primary agency for the federal Safe Drinking Water Act (SDWA) and is responsible for monitoring public water-supply wells. ADH maintains a statewide database that consists of 1,300 wells (Kresse et al. 2013). Every 3 years, these wells are sampled for inorganic, organic (including pesticides, herbicides, synthetic organic compounds, and volatile organic compounds), and radiochemical contaminants. The Total Coliform Rule of the SDWA requires sampling on monthly basis, where the number of samples required is dependent upon the population size. Nitrate monitoring is performed on a yearly basis unless a sample greater than or equal to 50% of the maximum contaminant level (MCL) is detected and prompts the need for increased frequency. Additionally, the Disinfection Byproduct Rule of the SDWA requires monitoring of trihalomethanes and haloacetic acids (byproducts of chlorine and other disinfectants used to treat drinking water) on a quarterly or annual basis. While all of the programs above collect samples from treated drinking water, ADH also collects samples from untreated water sources (surface and groundwater) that include bacteria, particulates, algae, organics, pathogens, total organic carbon on a weekly or monthly basis as required by the SDWA (ADEQ 2008).

Several routine ambient groundwater quality monitoring programs exist that involve cooperative efforts among USGS, ANRC, and ADEQ. Figure 5.4 shows the locations where ambient groundwater monitoring is performed in the SCAWRPR. Groundwater-quality monitoring activities are primarily funded by EPA grants under Section 106 and Section 319 of the Clean Water Act (CWA).

USGS has 24 master groundwater monitoring sites scattered throughout the state, with four of these sites located in the planning region (Figure 5.4). Samples are collected at these sites on a 5-year rotational basis for a variety of constituents to include nutrients, metals, organics, radioactivity, and selected primary and secondary drinking water standards (Kresse et al. 2013). In addition, USGS samples many other wells and springs for purposes of water quality and quantity investigations or as part of other monitoring programs, such as the National Water Information System. Data from these investigations and monitoring programs are presented in reports or available for download online at the Arkansas Water Science Center (http://ar.water.usgs.gov/) or similar USGS websites (ADEQ 2008; Kresse et al. 2013).

ANRC collects groundwater data statewide in areas where water-level declines or water-quality degradation have been historically observed (Kresse et al. 2013). In the SCAWRPR, ANRC performs groundwater monitoring at locations within the Sparta aquifer (four sites). These wells were installed as part of the Section 319 Core Program Monitoring Enhancement Wells program to establish long-term water quality trends and assist with the development of water quality standards. Samples are collected for the analysis of major water quality parameters and metals (Jay Johnston, ANRC, personal communication, 2013). When samples are collected, data are published in the annual Arkansas Groundwater Protection and Management Report available on the ANRC website (ANRC 2012b).

5.3.2 Non-Attainment of Surface Water Quality Standards

In 2008, approximately 1,920 miles of the 2,084 miles of streams within the SCAWRPR were assessed. Of the miles assessed, about 754 miles did not meet numeric water quality criteria or did not support all of their designated uses. Metals were the primary causes of impaired water quality in the majority of the stream miles assessed (Table 5.1) (ADEQ 2008). Mercury and beryllium were the sources of impairment for lakes in the SCAWRPR (Table 5.1). Figures 5.5 through 5.9 show locations of impaired waterbodies in the SCAWRPR. Resource extraction and industrial point sources are the most frequently identified sources of pollutants causing water quality impairments in the SCAWRPR, including metals, minerals, sediment, and low pH

(ADEQ 2009). A detailed listing of water quality impairments in the planning region identified in the 2008 303(d) list is included as Appendix A.

Table 5.1. Summary of impaired waters in the SCAWRPR (ADEQ 2008, ADEQ 2009).

Pollutant	Miles of Impaired Stream	Acres of Impaired Lakes
Sediment/Siltation	236.5	0
Low dissolved oxygen	53.9	0
Chloride	32.5	0
TDS	214.0	0
Pathogens	22.5	0
Zinc	449.1	0
Sulfate	135.2	0
Nitrate	85	0
Mercury	319.6	16,845+
Beryllium	158.0	53,300
Lead	188.6	0
pH	79.7	0
Copper	269.5	0
Cadmium	47.3	0
Ammonia	8.5	0
Unknown	0	300

It should be noted that while a waterbody may be impaired due to sediment, there is no numeric water quality standard for sediment/siltation. Arkansas has a numeric water quality standard for turbidity but not TSS; thus turbidity is the chemical parameter that is assessed to determine if a sediment impairment exists. There is currently no other method that is consistently used by EPA or ADEQ to measure sediment or siltation in water.

TMDL reports have been prepared for a number of waterbodies in the SCAWRPR addressing water quality issues such as turbidity, mercury contamination, low dissolved oxygen (DO), high TDS, high metal concentrations, and high mineral concentrations (Table 5.2).

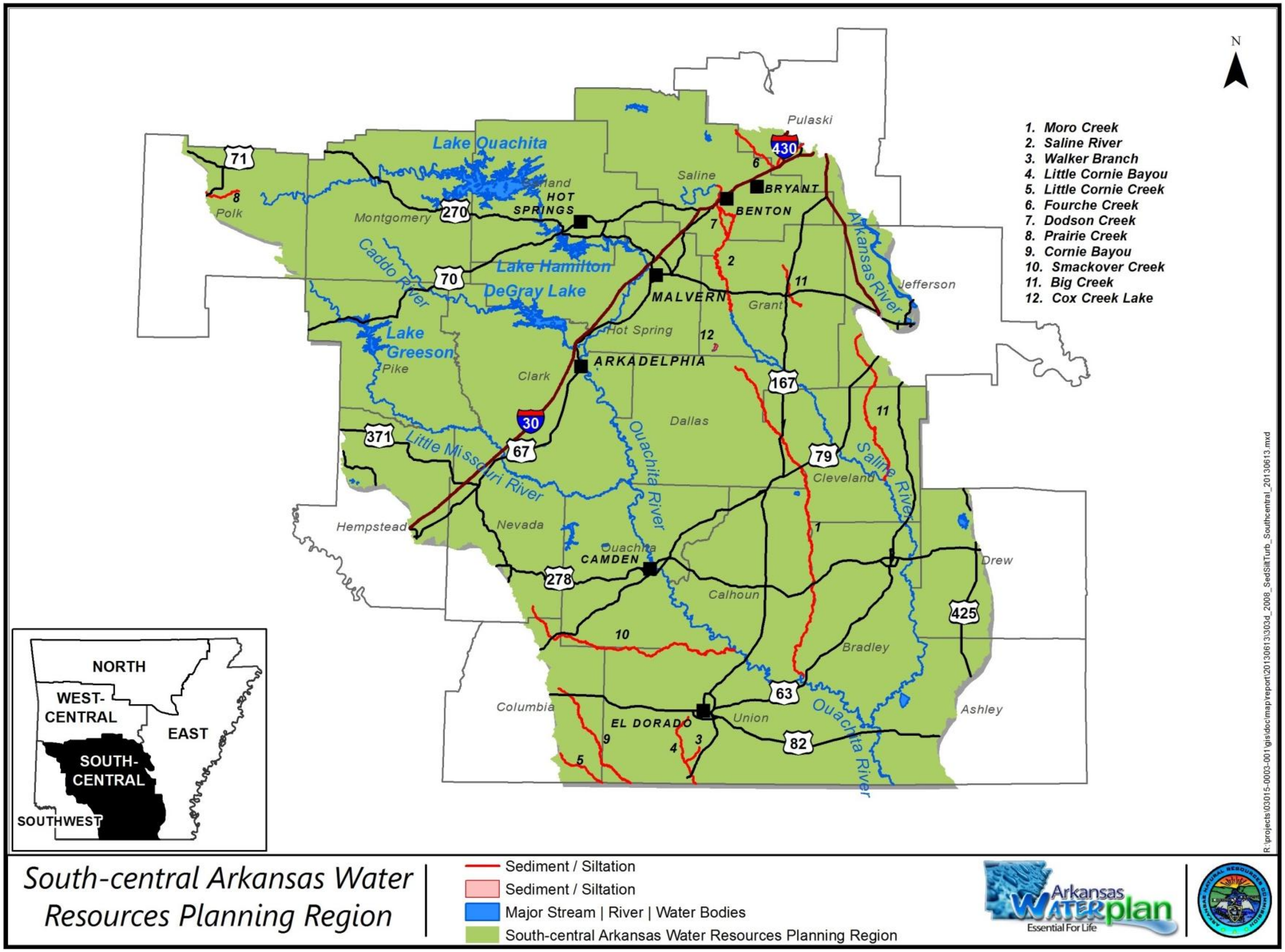

Figure 5.5. Waterbodies in the SCAWRPR with sediment/siltation listed as a cause of water quality impairment (ADEQ 2008, 2009).

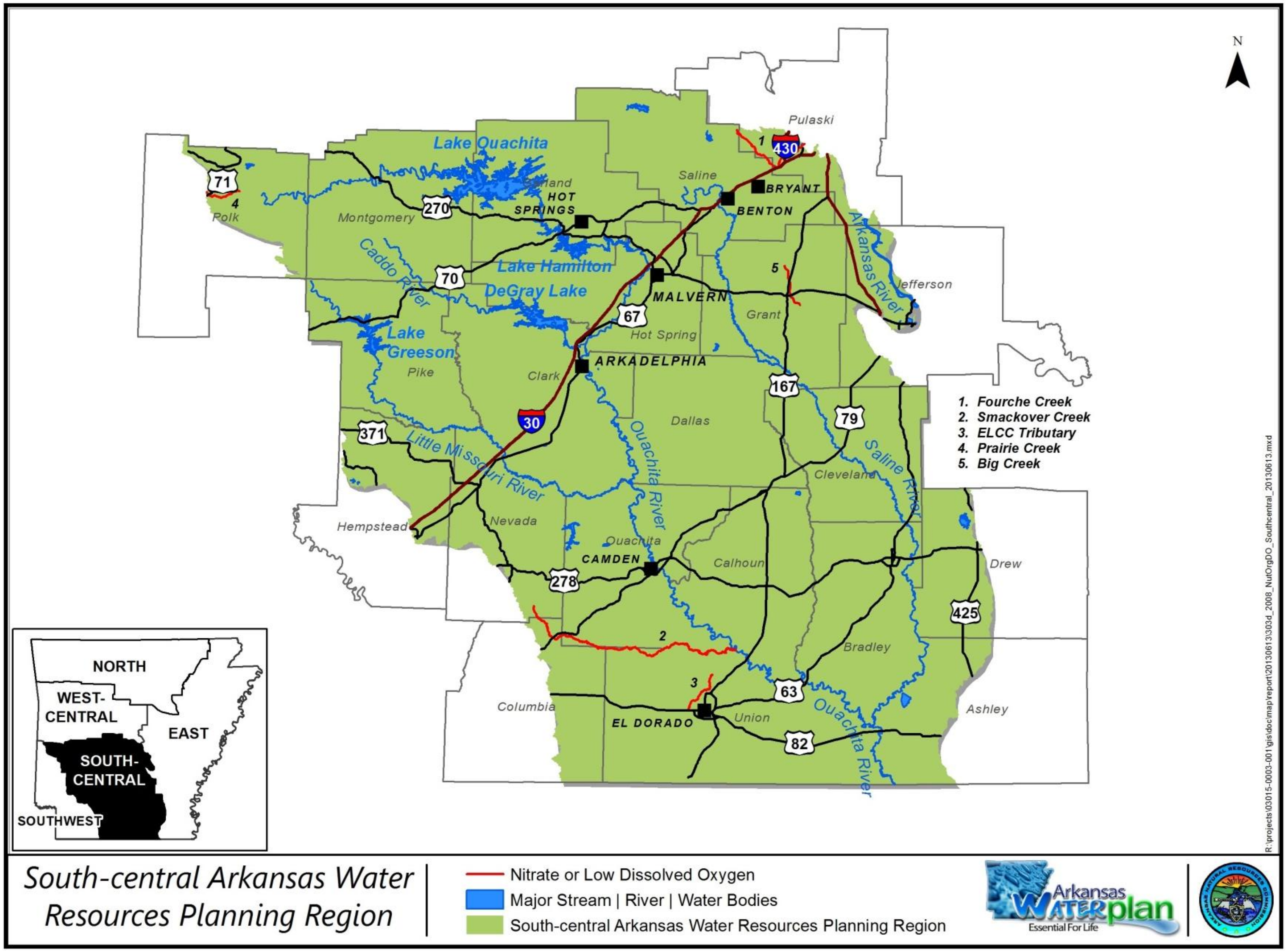

Figure 5.6. Waterbodies in the SCAWRPR with nutrients/organic enrichment/low DO listed as a cause of water quality impairment (ADEQ 2008, 2009).

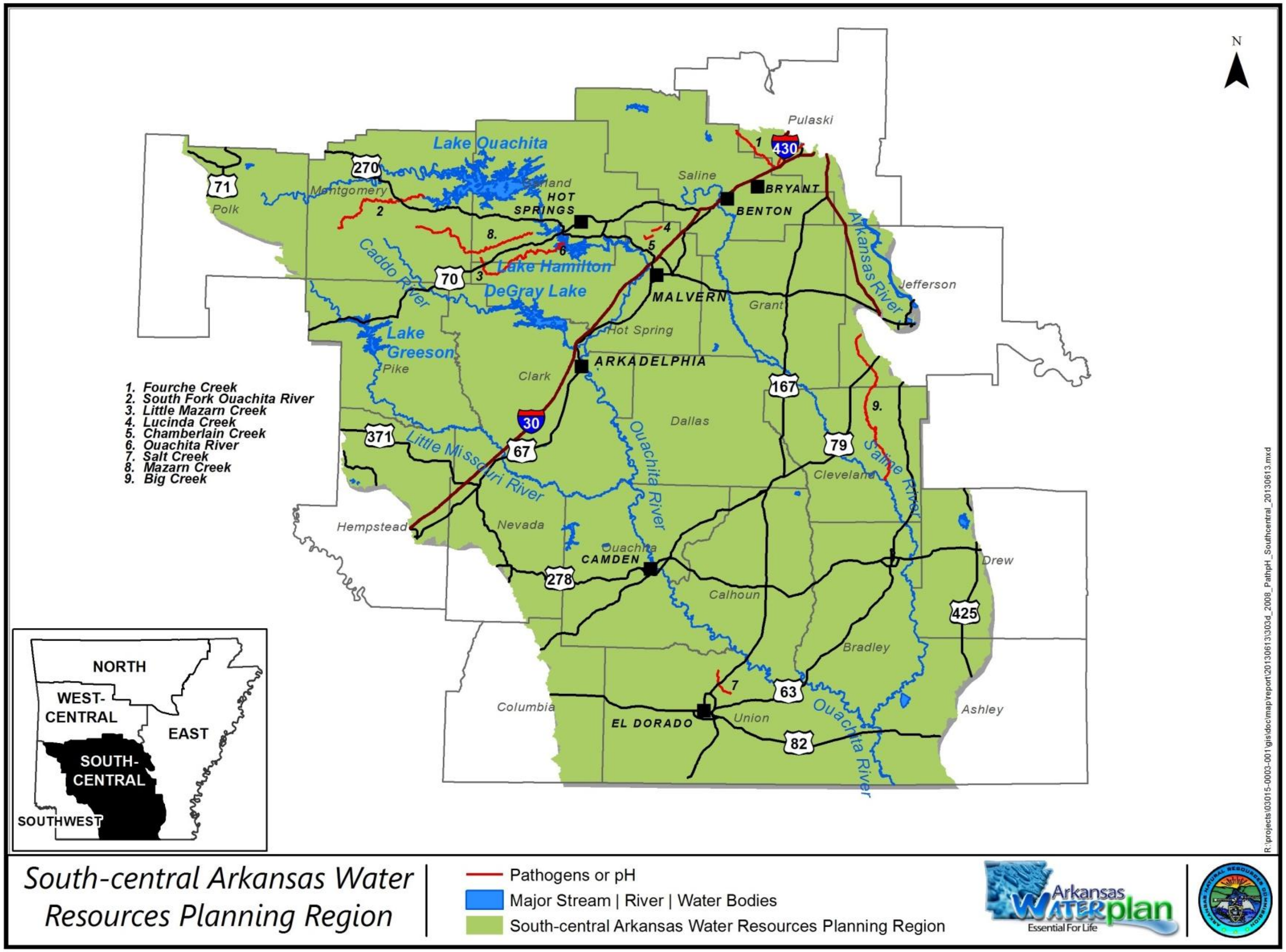

Figure 5.7. Waterbodies in the SCAWRPR with pathogens and/or low pH listed as a cause of water quality impairment(ADEQ 2008, 2009).

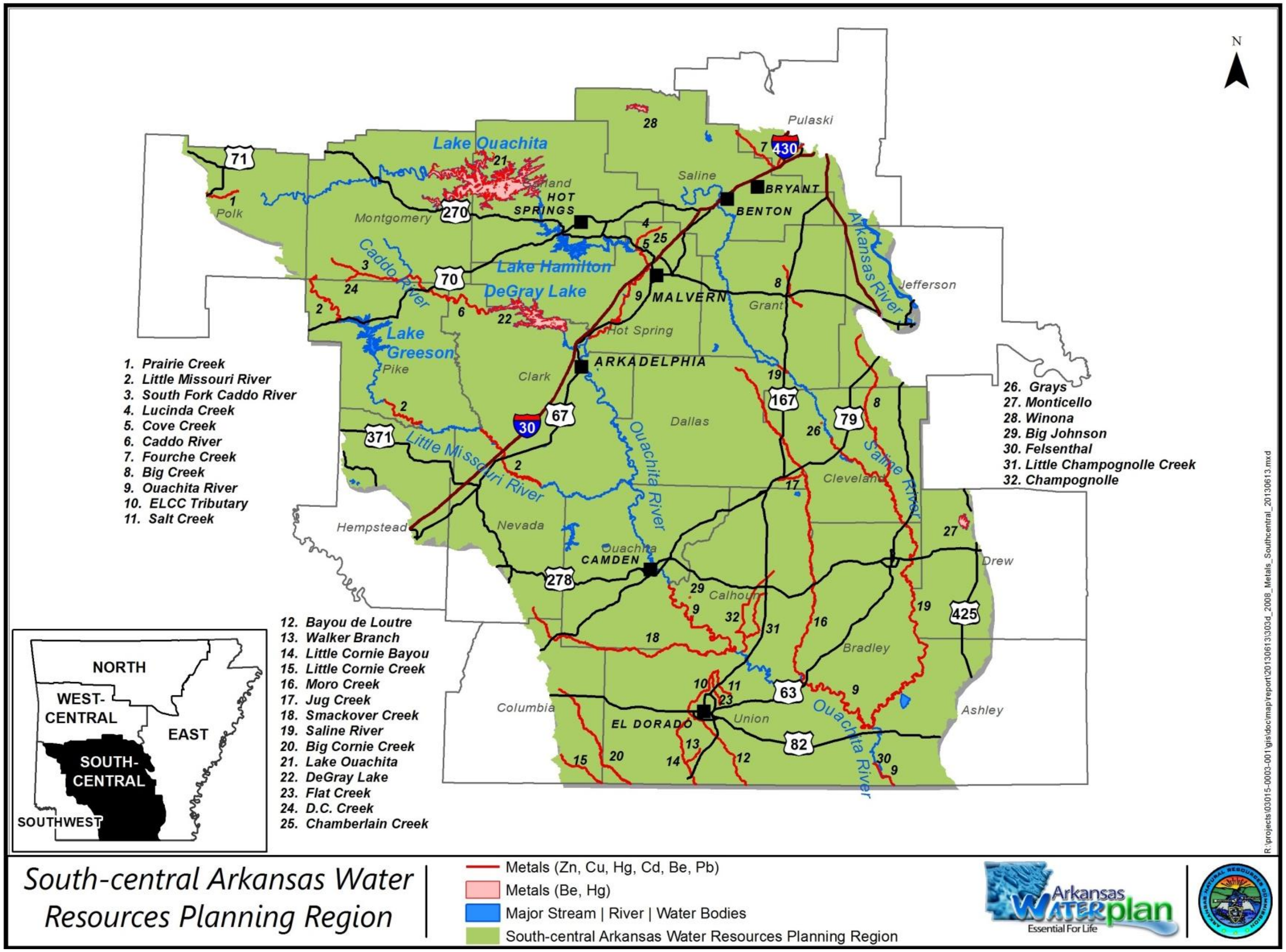

Figure 5.8. Waterbodies in the SCAWRPR with metals listed as a cause of water quality impairment (ADEQ 2008, 2009).

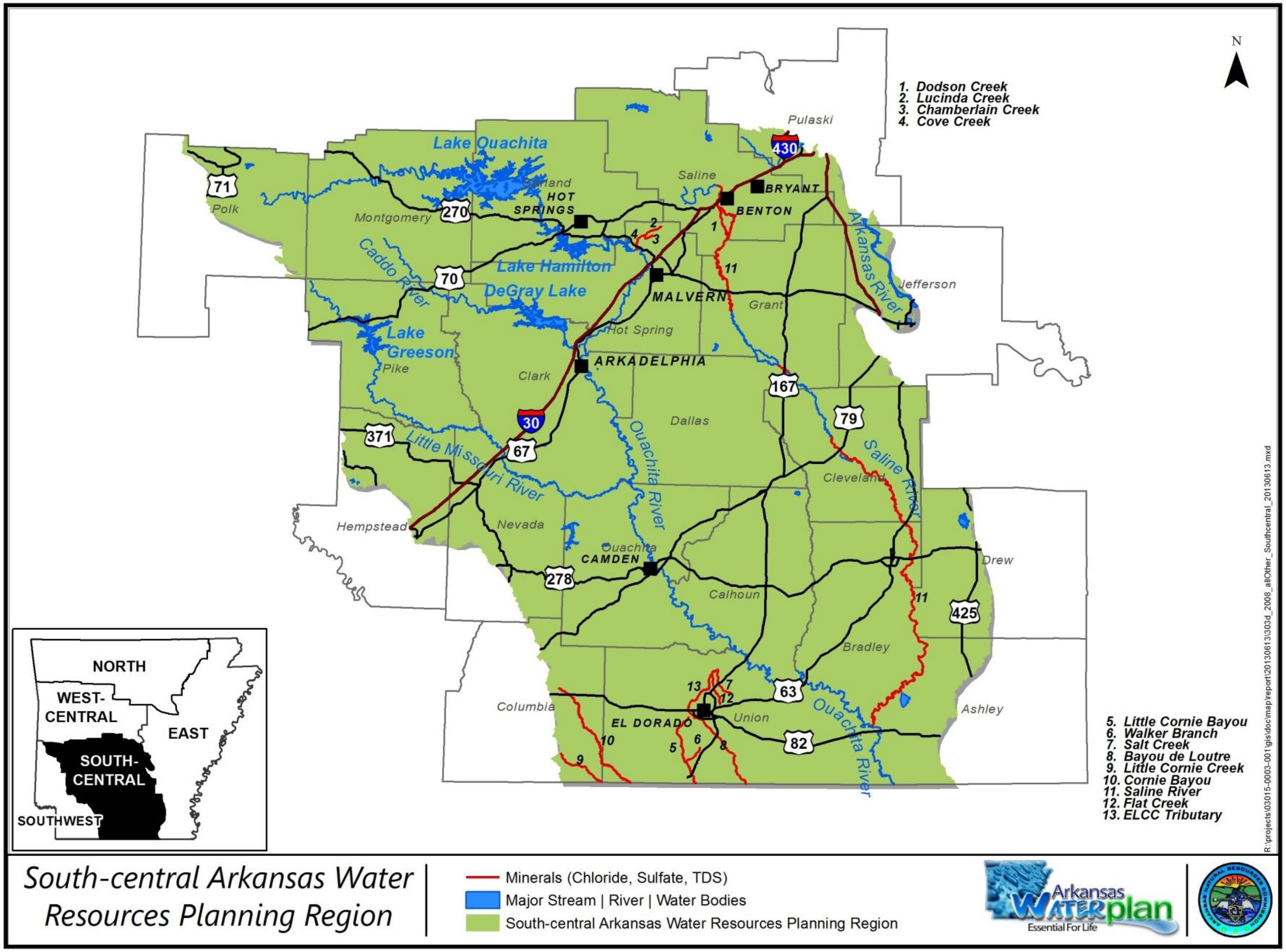

Figure 5.9. Waterbodies in the SCAWRPR with minerals listed as a cause of water quality impairment (ADEQ 2008, 2009).

Table 5.2. TMDLs for waterbodies in the SCAWRPR (ADEQ 2012b).

Waterbody	Impaired Uses	Pollutants	Completed
Big Creek	Aquatic Life	Turbidity	03/27/2008
Big Creek near Sheridan	Aquatic Life	DO	01/16/2007
Big Creek near Sheridan	Aquatic Life	Lead, Turbidity	03/21/2008
Grays Lake	Fish Consumption	Mercury	11/20/2003
Lake Monticello	Fish Consumption	Mercury	11/20/2003
Lake Sylvia	Fish Consumption	Mercury	09/17/2002
Lake Winona	Fish Consumption	Mercury	09/17/2002
Saline River		TDS	01/08/2011
Big Johnson Lake	Fish Consumption	Mercury	11/20/2003
Champagnolle Creek	Fish Consumption	Mercury	05/30/2002
ELCC Tributary	Aquatic Life, Water Supply	Chloride, Sulfate, TDS, Ammonia	10/03/2002
Felsenthal National Wildlife Refuge	Fish Consumption	Mercury	05/30/2002
Flat Creek	Aquatic Life, Water Supply	Chloride, Sulfate, TDS	10/08/2003
Little Champagnolle	Fish Consumption	Mercury	05/30/2002
Moro Creek	Fish Consumption	Mercury	05/30/2002
Moro Creek	Aquatic Life	Turbidity	03/27/2008
Ouachita River	Fish Consumption	Mercury	05/30/2002
Ouachita River Oxbow Lakes below Camden	Fish Consumption	Mercury	05/30/2002
Saline River	Fish Consumption	Mercury	05/30/2002
Salt Creek	Aquatic Life, Water Supply	Chloride, TDS	10/08/2003
Caddo River	Aquatic Life	Copper, Zinc	03/21/2008
Prairie Creek	Aquatic Life	Turbidity	03/27/2008
South Fork Caddo River	Aquatic Life	Copper, Zinc	03/21/2008

5.3.3 Non-Attainment of Drinking Water Quality Standards and Water Quality Guidelines by Groundwater

No groundwater quality standards have been set by state agencies in Arkansas; although there are state regulations to protect groundwater quality (see Section 6). However, groundwater used as a drinking water source is required to meet state and federal drinking water quality standards. Other groundwater users, such as farmers and industries, have developed guidelines that they use to determine if groundwater quality is suitable for their uses. Where shallower aquifers have been heavily pumped, saltwater intrusion has locally contaminated groundwater.

5.3.3.1 Ouachita-Saline Rivers Alluvial Aquifer

Kresse and others (2013) report on water quality within the alluvial deposits (including Pleistocene alluvial deposits) west of the divide between the Mississippi Alluvial Plain and the West Gulf Coastal Plain area as the Ouachita-Saline rivers alluvial aquifer without discriminating between these deposits. In general, groundwater quality of the Ouachita-Saline rivers alluvial aquifer is good when compared to EPA primary drinking water standards. However, numerous wells completed in the Ouachita-Saline rivers alluvial aquifer had nitrate concentrations greater than 10 mg/L, particularly in Calhoun and Bradley counties. Because most of the wells sampled in this area had well depths less than 30 feet, they possibly are shallow domestic wells, which are more vulnerable to surface sources of nitrate (for example, septic systems), and the nitrate has not been reduced, as happens in groundwater from the deeper parts of the aquifer (Kresse et al. 2013).

5.3.3.2 The Jackson Group

Groundwater from the Jackson Group has some of the poorest water quality of any aquifer system in the state with naturally elevated chloride (greater than 800 mg/L), sulfate (greater than 3,000 mg/L) and TDS concentrations (greater than 5,000 mg/L). Nitrate concentrations revealed an inverse correlation with well depth, indicating vulnerability to surface sources of nitrate contamination (Kresse et al. 2013).

5.3.3.3 Cockfield Aquifer

The Cockfield aquifer contains groundwater that is typically of high quality and is used throughout southeastern Arkansas. However, isolated areas of the aquifer contain elevated sulfate (primarily Jefferson and Drew counties) as a result of mixing with water of poor quality in underlying formations, and elevated iron concentrations (Grant and Jefferson counties) that are possibly the result of infiltration of high-iron content groundwater from overlying formations (Kresse et al. 2013).

5.3.3.4 Sparta Aquifer

The quality of groundwater from the Sparta aquifer throughout the SCAWRPR is very good. Elevated iron and nitrate groundwater concentrations are found dominantly in the outcrop area of the Sparta Sand, with lower concentrations in the downgradient direction of flow. Areas of high salinity are noted in isolated areas of the Sparta aquifer, predominantly as a result of inferred upwelling from high-salinity groundwater in underlying formations (Kresse et al. 2013).

5.3.3.5 Cane River Aquifer

Water quality from the Cane River aquifer is good with respect to federal drinking water standards. Salinity increases downdip of the outcrop area, and chloride concentrations can exceed the federal secondary drinking water regulation of 250 mg/L in some areas (Kresse et al. 2013).

5.3.3.6 Wilcox Aquifer

The Wilcox aquifer within the planning region is a viable groundwater supply only in the outcrop area; the water becomes brackish or saline within a short distance downdip of the outcrop and is unfit for most purposes (Ludwig 1972, Plebuch and Hines 1969, Terry et al. 1986). Plebuch and Hines (1969) describe groundwater from the Wilcox aquifer in Clark, Cleveland, and Dallas counties as a sodium-bicarbonate type, with water increasing in dissolved-solids content and becoming a sodium-chloride type downdip. Broom and others (1984) noted that the Wilcox and Carrizo aquifers are indistinguishable in Union County, are hydraulically connected, and used solely for injection of brine. Hewitt and others (1949) noted abundant saltwater at depths of 1,000 feet in Ashley County. Ludwig (1972) described groundwater from the Wilcox aquifer as a soft to moderately hard, sodium-bicarbonate type for most of Hempstead, Lafayette, Miller, and Nevada counties. The southern extent of fresh water coincided with a fault system extending through central Miller, Lafayette, and Nevada counties, and groundwater south of the fault zone contained more than 1,000 mg/L dissolved solids based on electric logs (Ludwig 1972). Halberg and others (1968) reported that groundwater from the Wilcox aquifer in Hot Spring and Grant counties was a soft, sodium-bicarbonate type, although iron concentrations could be high and that groundwater from shallow wells was slightly acidic. Hosman and others

(1968) noted that water type varied with dissolved-solids content: where dissolved-solids concentrations were low, water was either a calcium-magnesium-bicarbonate or sodium-bicarbonate type; increases in dissolved solids up to 400 mg/L were attributed to predominantly sodium and bicarbonate; and above 400 mg/L, the increase was attributed to sodium, bicarbonate, and chloride (Kresse et al. 2013).

5.3.3.7 Nacatoch Aquifer

Groundwater from the Nacatoch aquifer is most important in the southwestern part of the state, although it is also an available and good-quality source of water in the extreme northeastern part of the state. In the southwestern extent, fresh water mainly is obtained from areas in or near to the area of outcrop, especially for the eastern (Clark County) and western parts (Little River and Miller counties) of the outcrop area, and salinity increases in a downgradient direction from the outcrop area to a point where the groundwater is not suitable for most uses. Gradients of increasing chloride concentration are sharpest in the western and eastern parts of the outcrop, with a larger area of fresh water downgradient of the outcrop area in the central part of the aquifer (Hempstead County and Nevada counties). Concentrations of sulfate, iron, and nitrate generally are very low throughout the extent of the Nacatoch aquifer, where water quality data were available from producing wells (Kresse et al. 2013).

5.3.3.8 Ozan Aquifer

Groundwater from the Ozan aquifer represents some of the least used and poorer quality water of any aquifer in the state. Several historical reports mentioned that aquifer was used as a domestic source because in many areas no other water source was available. High chloride concentrations can occur in groundwater within the outcrop area of the Ozan aquifer, which is atypical of most Cretaceous and Tertiary aquifers of the Coastal Plain. Chloride concentrations exceeding the federal secondary drinking water regulation 250 mg/L (EPA 2009) occur mainly in central Clark County. The highest median sulfate concentrations of any aquifer in the state are found in the Ozan aquifer. Sulfate concentrations can exceed 500 mg/L (the federal secondary drinking water regulation is 250 mg/L)(Kresse et al. 2013).

5.3.3.9 Tokio Aquifer

Good quality water is obtained from the Tokio aquifer throughout much of its outcrop area. Sharp increases in salinity are noted in the extreme southwestern (Sevier County) and northeastern (Clark County) parts of the aquifer, limiting use at distances greater than approximately 5 miles downdip of the outcrop area. Sulfate concentrations approach 400 mg/L and chloride concentrations are greater than 1,200 mg/L near the western and eastern extent of the outcrop area. These concentrations exceed the federal secondary drinking water standard of 250 mg/L. In the central part of the aquifer, salinity increases are more gradual (with concentrations in the aquifer at less than 300 mg/L as far as 20 miles from the outcrop area), affording a larger area of low-salinity, high-quality water for multiple uses. In the southwestern part of the aquifer, sulfate is the dominant anion in the aquifer. Dedolimitization is a likely process that may account the high-sulfate, low-bicarbonate groundwater in this area of the aquifer; however, this theory requires further analysis to achieve greater confidence (Kresse et al. 2013).

5.3.3.10 Trinity Aquifer

Similar to other Cretaceous aquifers in southwestern Arkansas, use of the Trinity is limited to the outcrop areas. Wells for which water-quality data were available were located only in Sevier and Howard counties (in the Southwest Arkansas WRPR). Generally, water quality from the Trinity aquifer is good. Chloride and sulfate can be somewhat elevated in certain parts of the aquifer, although concentrations were less than the 250 mg/L secondary drinking water standard. All chloride concentrations, except one, were less than 15 mg/L at distances as great as 15 miles from the outcrop area, demonstrating the low overall salinity in the aquifer (Kresse et al. 2013).

5.3.3.11 Ouachita Mountains Aquifer

Groundwater quality in the Ouachita Mountains aquifer is good with respect to federal primary drinking water standards. Problems in regard to taste, staining, and other aesthetic properties are related to elevated levels of iron, which is a common complaint among domestic users. Sulfate and chloride concentrations tend to be elevated in some areas for groundwater from shale formations. No spatial relation was noted, however, for the distribution of iron concentrations, and high and low concentrations occurred in shale and quartz formations. Iron is abundant in numerous mineral forms in sedimentary rocks throughout Arkansas, and elevated iron in the Ouachita Mountain aquifer were attributed to microbially mediated processes (Kresse et al. 2013).

5.3.4 Fish Consumption Advisories

There are active fish consumption advisories due to mercury for several waterbodies in the SCAWRPR. Details of these advisories are given in Table 5.3. The locations of these waterbodies are shown on Figure 5.10.

Table 5.3. Fish consumption advisories in the SCAWRPR (ADH, AGFC, & ADEQ 2011, ADEQ 2012a).

Waterbody	Affected Length or Area	Pollutant of Concern	Restrictions for High-Risk Groups*	Restrictions for General Public
Felsenthal NWR – Saline River to Stillions Bridge	14,000 acres	Mercury	Should not eat largemouth bass (13 inches or longer, flathead or blue catfish, pickerel, gar, bowfin, or drum.	Should not eat flathead catfish, gar, bowfin, drum, pickerel, or largemouth bass (16 inches or longer). No more than two meals per month of blue catfish and largemouth bass (13-16 inches).
Ouachita River from Camden to north border of Felsenthal NWR to include all oxbow lakes, backwater, and overflow lakes and barrow ditches	25 miles	Mercury	Should not eat largemouth bass, flathead catfish, pickerel, gar or bowfin.	Should not eat largemouth bass, flathead catfish, pickerel, gar or bowfin.

Table 5.3. Fish consumption advisories in the SCAWRPR (continued).

Waterbody	Affected Length or Area	Pollutant of Concern	Restrictions for High-Risk Groups*	Restrictions for General Public
Saline River from highway 79 in Cleveland County to Stillions Bridge	89.4 miles	Mercury	Should not eat blue catfish, flathead catfish, gar, bowfin, drum, pickerel, or largemouth bass (13 inches or longer) or redhorse (20 inches or longer).	Should not eat blue catfish, flathead catfish, gar, bowfin, drum, pickerel, or largemouth bass (16 inches or longer) or redhorse (20 inches or longer). No more than two meals per month of largemouth bass (13-16 inches).
Lake Columbia	2,950 acres	Mercury	Should not eat pickerel, flathead catfish, gar, bownfin, or largemouth bass (16 inches or longer).	Should not eat flathead catfish, gar, pickerel, or bowfin. No more than two meals a month of largemouth bass (16 inches or longer).
Grays Lake	36 acres	Mercury	Should not eat flathead catfish (26 inches or longer), largemouth bass (13 inches or longer), gar, bowfin, or pickerel.	Should not eat largemouth bass over 16 inches in length. No more than two meals per month of gar, bowfin, pickerel, flathead catfish (26 inches or longer) or largemouth bass (13-16 inches in length).
Moro Bay Creek from Highway 160 to Ouachita River	54.4 miles	Mercury	Should not eat any fish from this creek.	Should not eat largemouth bass, catfish, crappie, gar, pickerel, or bowfin. No more than two meals per month of bream, drum, buffalo, redhorse, and suckers.
Champagnolle Creek from Highway 4 to Ouachita River	20 miles	Mercury	Should not eat flathead catfish, gar, bowfin, drum, pickerel, or largemouth bass (13 inches or longer).	Eat no more than two meals per month of flathead catfish, gar, pickerel, bowfin, or largemouth bass (13 inches or longer).
Lake Winona	1,240 acres	Mercury	Should not eat black bass (16 inches or longer).	Eat no more than two meals per month of black bass (16 inches or longer).
Lake Monticello	1,520 acres	Mercury	Should not eat flathead catfish, blue catfish, or largemouth bass (12 inches or longer).	Should not eat flathead catfish or blue catfish (over 15 inches). No more than two meals per month of largemouth bass (16 inches or less). Should not eat largemouth bass (over 16 inches).

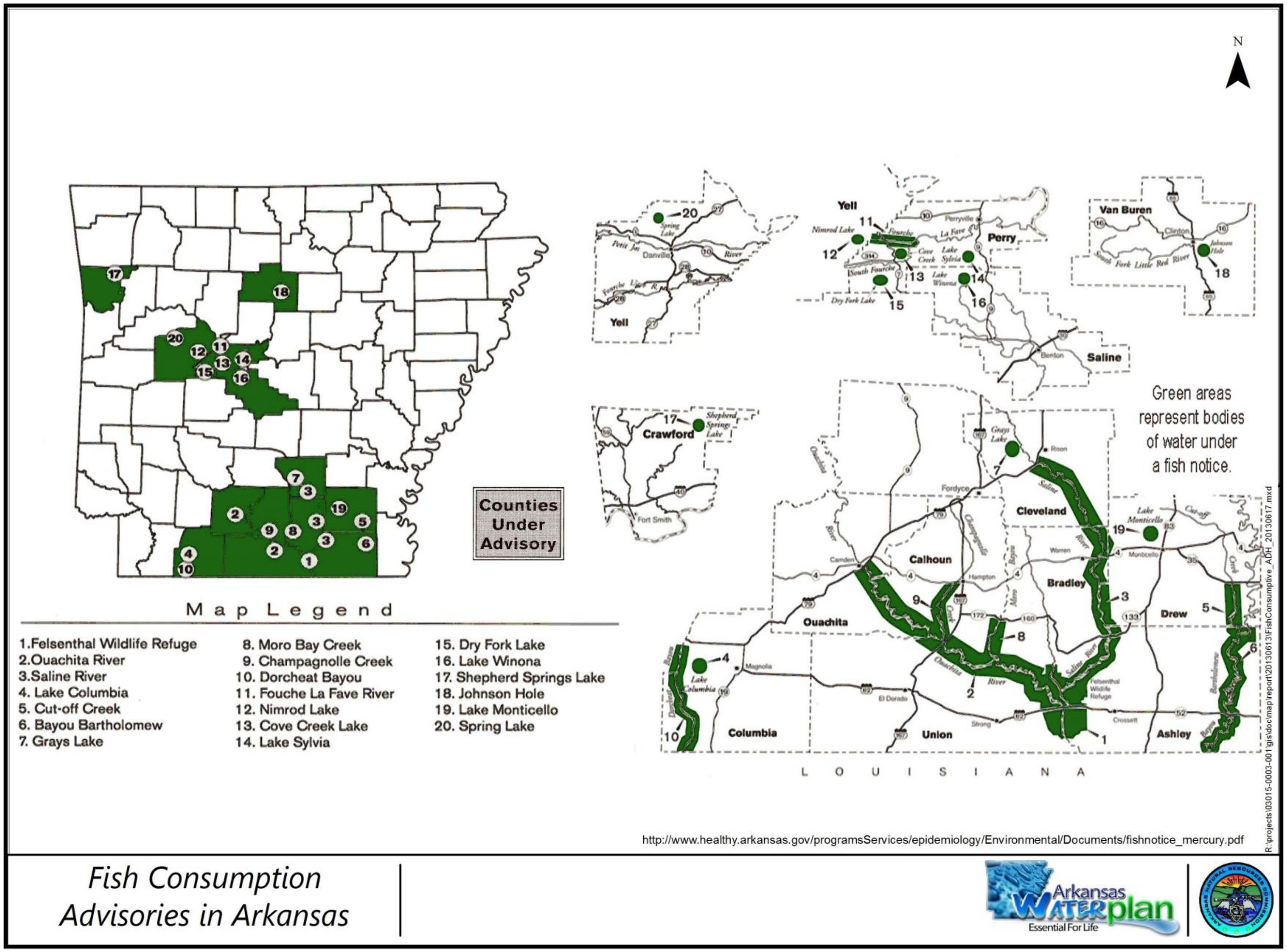

Figure 5.10. Waterbodies in the SCAWRPR for which fish consumption advisories have been issued (ADH, AGFC, & ADEQ 2011).

5.3.5 Nonpoint Source Pollution

Nonpoint source pollution was identified as a water resources issue in the 1990 AWP (ASWCC 1990). Nonpoint source pollution still contributes significantly to surface water and groundwater quality issues in Arkansas; it is the most frequently cited source of pollutants causing non-attainment of surface water quality standards (ADEQ 2012a).

In the 2011 – 2016 NPS Pollution Management Plan, two watersheds within the SCAWRPR have been identified as priority watersheds for nonpoint source pollution issues; Upper Saline River and Lower Ouachita – Smackover (Figure 5.11). This program primarily addresses nutrients and sediment in runoff. In these priority watersheds, the targeted source of nutrients is animal agriculture. The targeted sources of sediment are animal agriculture and timber production (ANRC 2012a).

There are two hazardous waste sites in the SCAWRPR that have been included on the National Priority List (i.e., Superfund sites). These sites are located in Ouachita and Union counties. Table 5.4 summarizes the information about these sites. At these sites, hazardous wastes contaminated the groundwater.

Table 5.4. Superfund sites in the SCAWRPR (EPA 2012d).

Site Name	EPA ID	Site Location	Pollutants of Concern	Remediation Status
Ouachita-Nevada Wood Treaters	ARD042755231	Ouachita County	Phencyclidine (PCP), arsenic	Ongoing
Popile, Inc.	ARD008052508	Union County	PCP, creosote	Ongoing

There are also several sites in the planning region that have been identified as a state priority for hazardous waste cleanup. Both surface water and groundwater contamination are issues at these sites (ADEQ 2013a). Information about these sites is summarized in Table 5.5.

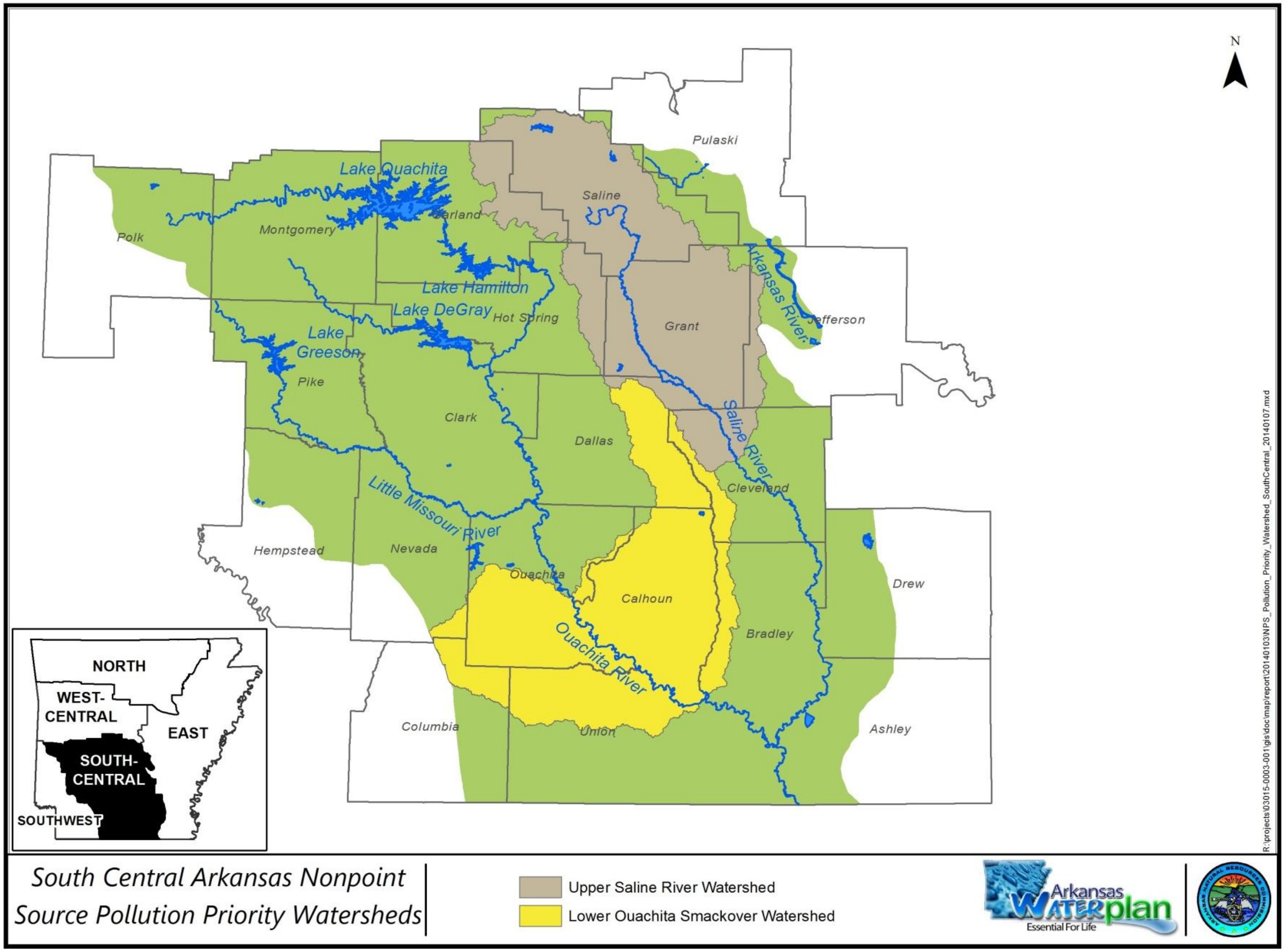

Figure 5.11. Priority NPS watersheds in the SCAWRPR (ANRC 2012a).

Table 5.5. State priority hazardous waste sites in the SCAWRPR with water quality issues (ADEQ 2013a).

Site Name	EPA ID	County	Pollutants of Concern	Contaminated Water Resources	Remediation Complete
BEI Defense Systems, Inc.	ARD980583470	Calhoun	Benzene, other volatile organic compounds (VOCs)	Groundwater	Ongoing
General Dynamics	ARD990661050	Ouachita	Trichloroethene (TCE), trichloroethane (TCA), 1,2-dichloroethene (1,2-DCE), trichloromethane	Groundwater	Ongoing
Griffing Railway Repair	ARD981055494	Union	Paint, wastewater treatment sludge, hazardous cleaners	Groundwater	Ongoing
Norphlet Chemical, Inc. Facility	ARD008049207	Union	Anhydrous hydrogen fluoride (AHF), AHF mixtures, several contaminants of potential concern (COPCs)	Massey Creek, groundwater	Ongoing
Utility Services, Inc.	AR0000100859	Jefferson	Polychlorinated biphenyls (PCBs), PCP, perchloroethylene (PCE)	Groundwater	Ongoing
Value Line Company (701 S. 3rd St.)	AR0000000331	Clark	Several hazardous materials, including acetone, alcohols, methyl ethyl ketone (MEK), and many others	Groundwater	Ongoing
Amity Lacquer, Paint, and Chemical Company	ARD983286337	Clark	MEK, acetone, lead	Groundwater	June 2013
Benton Salvage	ARD980812846	Saline	Lead, PCBs	Willow Creek, groundwater	June 2010
Minton Property	ARR000011106	Saline	Dichlorodiphenyldichloroethane (DDD), dichlorodiphenyltricholoroethane (DDT)	Private pond, groundwater	August 2012
Valspar Corporation	ARD059634659	Pulaski	Acetone, benzene, MEK, 1,2-DCE, several others	Groundwater	June 2010
Value Line Company (1205 N. 10th St.)	AR0000000331	Clark	General hazardous waste	Groundwater	August 2012
Walgreens Store #03425	ARR000011106	Garland	PCE, PCBs	Groundwater	August 2012
Garland County Industrial Park Landfill	ARD980748594	Garland	PCBs, metal-laded leachate	Lake Catherine (potential)	January 2009
Mid-South Reclamation Industries	N/A	Union	Toxic metals, cyanide	Surface waters	January 2009

5.3.6 Contaminants of Emerging Concern

There is growing interest, nationally and in Arkansas, in the occurrence of a group of chemicals called contaminants of emerging concern, which include pharmaceuticals, personal care products (e.g., soap and shampoo), natural and synthetic hormones, surfactants, pesticides, fire retardants, and plasticizers primarily in surface waters, but also starting to be measured in groundwater across the nation. The risks to human health and the environment from the majority of these chemicals are unknown, which is why they are referred to as “contaminants of emerging concern.” Contaminants of emerging concern have been detected in surface waters in Arkansas (Galloway et al. 2005). Detection, however, does not indicate there is an effect.

5.4 Water Infrastructure

Communities throughout the state struggle to maintain drinking water and wastewater infrastructure, including treatment plants and distribution lines. A few communities in the SCAWRPR are experiencing growth that is requiring expansion of water supply and wastewater capacity (see Section 5.2.2). In other areas within the planning region, maintaining aging infrastructure with limited financial resources is more likely an issue.

Of particular concern is the recent increased focus on nutrients in wastewater discharges. Historically, permitted point source discharges in Arkansas were not limited with regard to the amount of nutrients that can be in the wastewater they discharge. Current regulations require that all point source discharges in watersheds of waterbodies included on the Arkansas list of impaired waters due to phosphorus, be limited in the amount of phosphorus that can be present in their discharge (Arkansas Pollution Control and Ecology Commission [APCEC] Regulation No. 2, §2.509). While there are no phosphorus-impaired waterbodies in the SCAWRPR (Table 5.1), several municipalities in the planning region have wastewater treatment plants that are currently required to monitor total phosphorus and nitrate levels in their wastewater discharge (ADEQ 2014a). Substantial upgrades to existing wastewater facilities may be required to meet discharge nutrient limits.

There have been issues with two of the dams in the SCAWRPR. During routine inspection of Blakely Mountain Dam in 2005, it was determined that an element of the structure intended to aid normal seepage under the dam had been incorrectly installed. There has been no indication that this has affected the safety of Blakely Mountain Dam. A system was installed in 2009 to monitor the seepage (Worley 2013). Damage to the water control structure of Lower White Oak Lake was identified in 2012. The lake was drained in September 2012 and repairs initiated. The repairs were completed in February 2013 and the lake refilled (McNeill 2013).

5.5 Loss of Aquatic Biological Diversity

In a 2002 report, NatureServe ranked Arkansas 13th in the nation for the level of reportedly extinct species (NatureServe 2002). In 2005, 369 animal species of greatest conservation need (SGCN) were identified for Arkansas by a team of specialists (Anderson 2006). These species of greatest conservation need include 130 species associated with aquatic and semi-aquatic habitats that occur in the SCAWRPR (see Figure 3.4). Figures 5.12 through 5.15 show the numbers of aquatic species of greatest conservation need present in watersheds within the SCAWRPR. The greater the number of aquatic species of greatest conservation need present in a watershed, the more important it is to protect and restore water resources and their aquatic habitats in the watershed. The condition of aquatic habitats depend on characteristics such as water levels, flow volumes, and seasonal variability in both. High numbers of species of greatest conservation need are present in the Ouachita River and its tributaries, notably the Little Missouri and Saline rivers (Figure 5.15).

In addition to the animals of greatest conservation need, the Arkansas Natural Heritage Commission has identified 119 species of rare aquatic and semi-aquatic plants that occur in the SCAWRPR. Ten aquatic and semi-aquatic species present in the planning region are on the federal list of threatened and endangered species (Table 5.6). Five semi-aquatic plant species present in the planning region are on the state threatened and endangered plant species list (Table 5.7). Many of the species of concern, particularly species of mussels, fish, and plants, are affected by water quality, water levels, flow rates, and/or seasonal changes in water levels or flow.

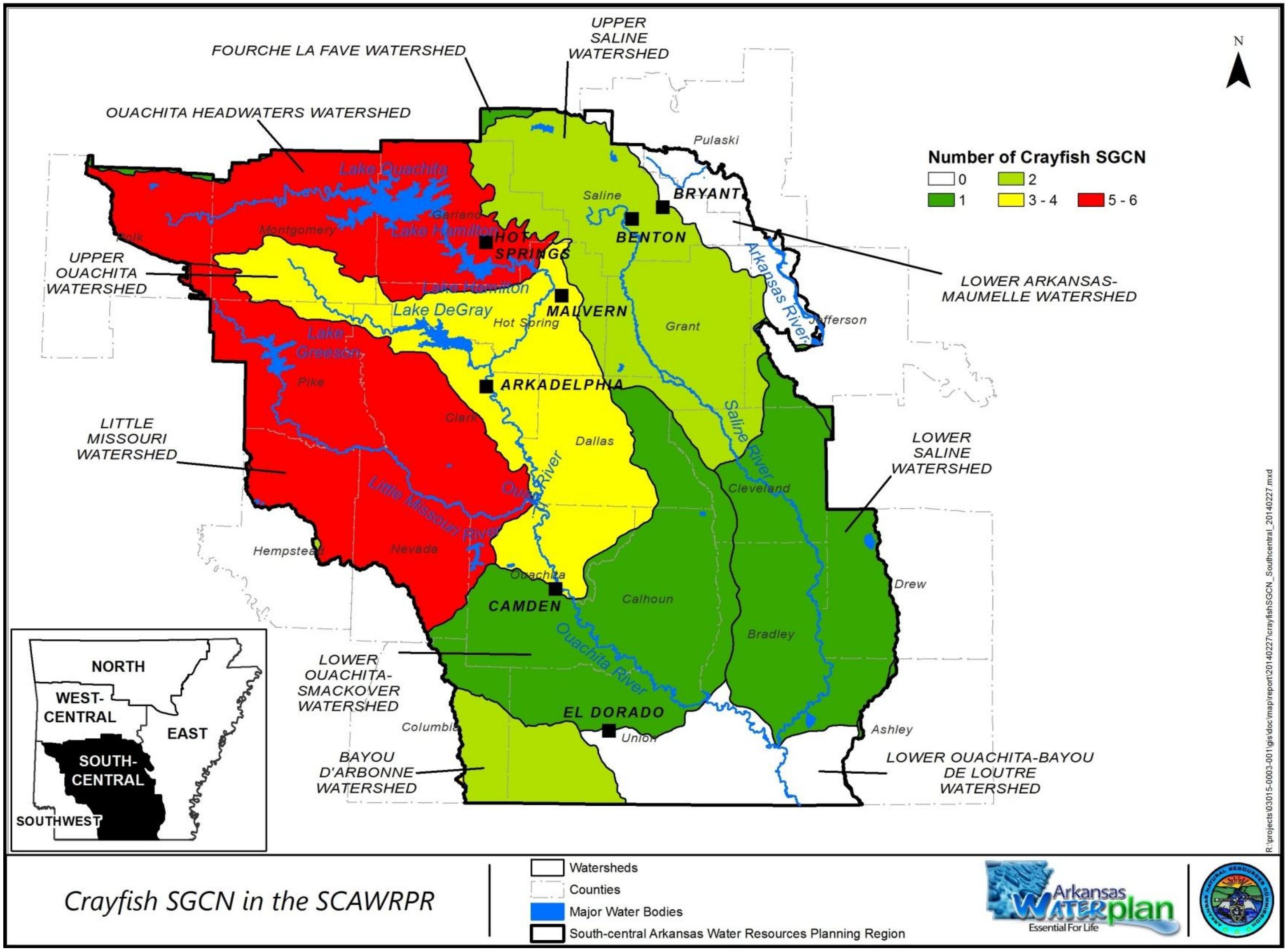

Figure 5.12. Numbers of crayfish SGCN in watersheds of the SCAWRPR.

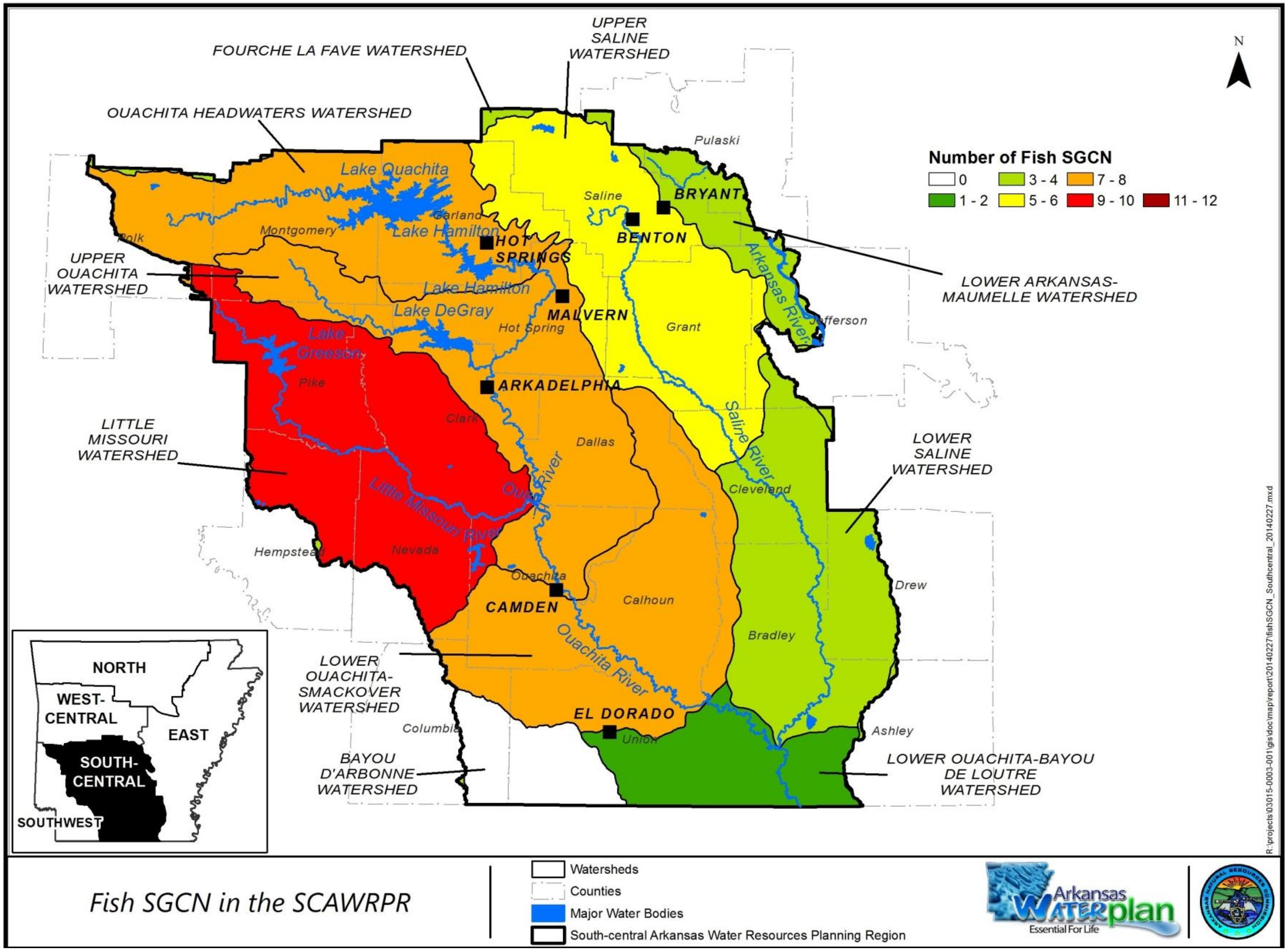

Figure 5.13. Numbers of fish SGCN in watersheds of the SCAWRPR.

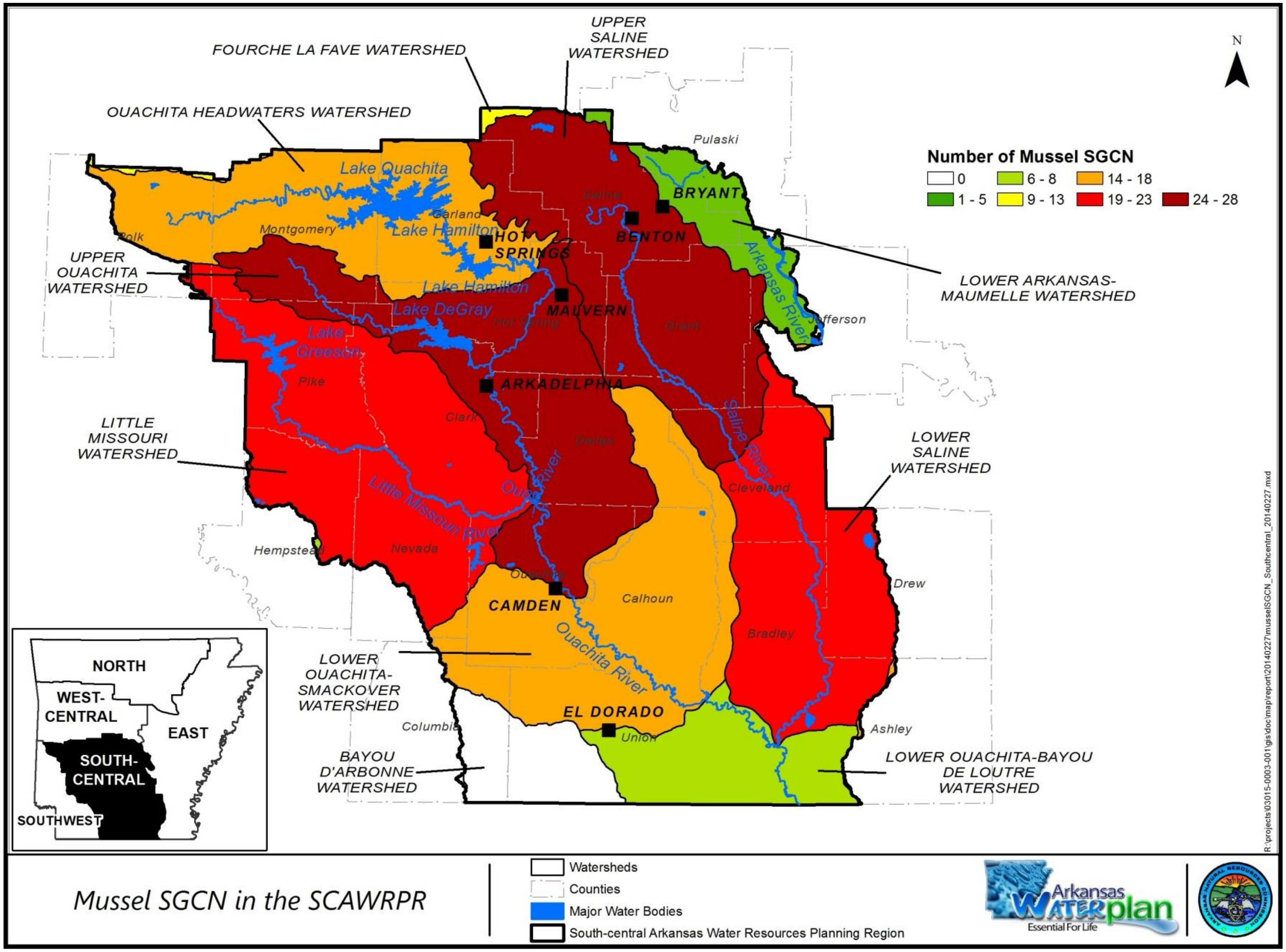

Figure 5.14. Numbers of mussel SGCN in the watersheds of the SCAWRPR.

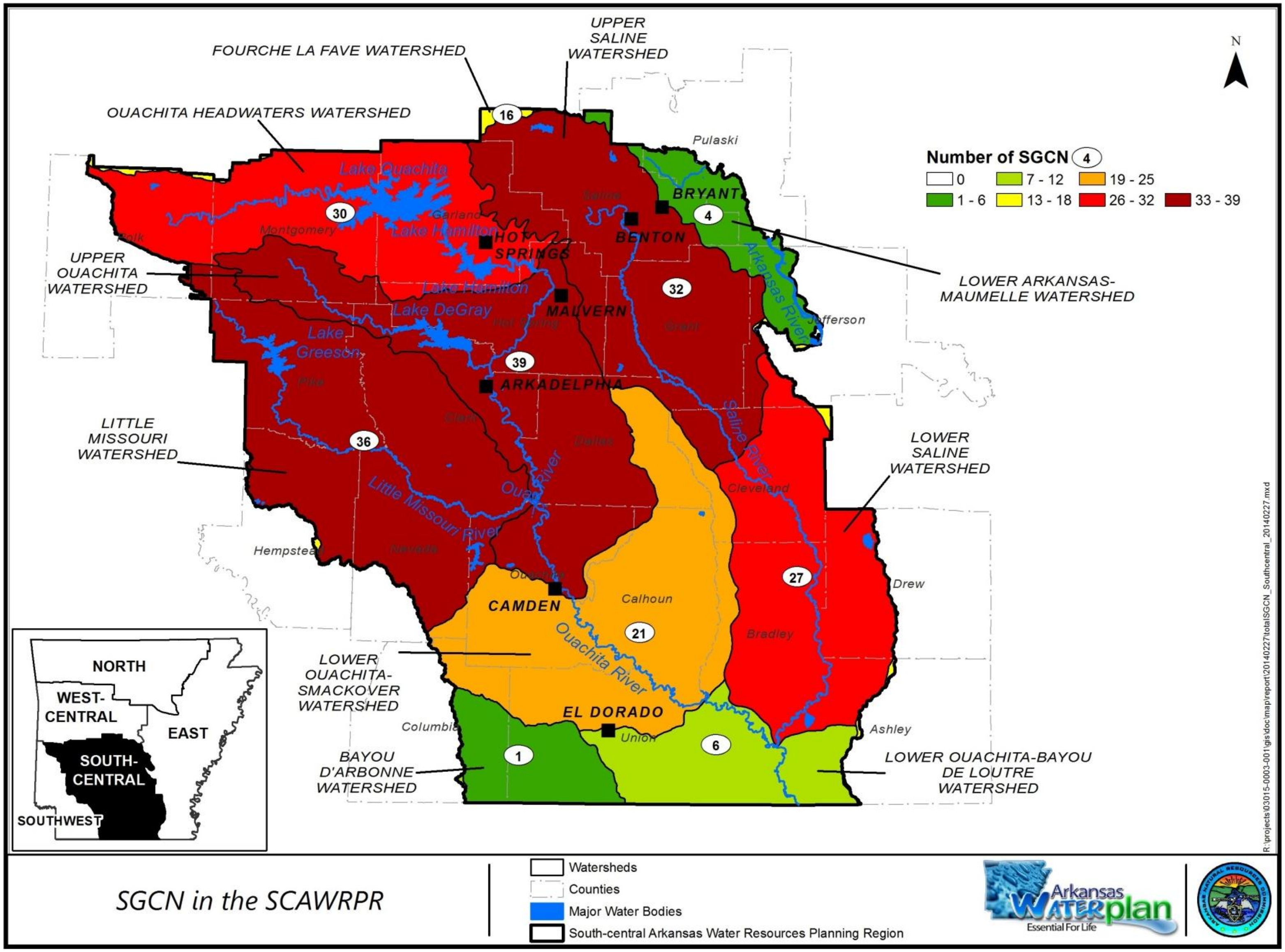

Figure 5.15. Total numbers of crayfish, fish, and mussel SGCN in the watersheds of the SCAWRPR.

Table 5.6. Federally listed threatened and endangered species occurring in aquatic and semi-aquatic habitats in the SCAWRPR (ANHC 2013, AGFC 2013c).

Common Name	Species Name	Status	SCAWRPR Habitat
Pondberry	*Lindera melissifolia*	Endangered	Ashley County
Lousiana pearlshell	*Margaritifera*	Threatened	Columbia County
Leopard darter	*Percina panterina*	Threatened	Hempstead County – southern Ouachita Mountains
Harperella	*Ptilimnium nodosum*	Endangered	Garland, Montgomery, and Polk counties
Scaleshell	*Leptodea leptodon*	Endangered	Several counties in the SCAWRPR
Ouachita rock pocketbook	*Arkansia wheeleri*	Endangered; declining	Formerly occurred in Ouachita River near Arkadelphia
Pink mucket	*Lampsilis abrupta*	Endangered; stable	Ouachita River system
Winged mapleleaf	*Quadrula fragosa*	Endangered; stable	Several counties in the SCAWRPR
Spectaclecase	*Cumberlandia monodonta*	Proposed endangered	Several counties in the SCAWRPR
Rabbitsfoot	*Quadrula cylindrica*	Proposed endangered/ proposed critical habitat	Several counties in the SCAWRPR
Arkansas fatmucket	*Lampsilis powellii*	Threatened; declining	Saline, Caddo, and upper Ouachita rivers
Interior Least Tern	*Sterna antillarum athalassos*	Endangered	Hempstead, Jefferson, and Pulaski counties

Table 5.7. State-listed threatened and endangered plant species occurring in aquatic and semi-aquatic habitats in the SCAWRPR (ANHC 2013).

Common Name	Species Name	Status	SCAWRPR Counties
Winterberry	*Ilex verticillata*	Threatened	Ashley, Hot Spring, Saline
Swamp thistle	*Cirsium muticum*	Threatened	Garland, Montgomery
Slender rose-gentian	*Sabatia campanulata*	Endangered	Calhoun, Hot Spring, Pulaski, Saline
Pondberry	*Lindera melissifolia*	Endangered	Ashley
Texas sunnybell	*Schoenolirion wrightii*	Threatened	Ashley, Bradley, Calhoun, Cleveland, Drew
Sedge	*Carex opaca*	Endangered	Saline
White-top sedge	*Rhynchospora colorata*	Endangered	Bradley, Pulaski
Few-flower beaksedge	*Rhynchospora rariflora*	Threatened	Bradley, Calhoun, Saline
Whorled nut-rush	*Scleria verticillata*	Threatened	Clark, Saline
Small-head pipewort	*Eriocaulon koernickianum*	Endangered	Calhoun, Montgomery, Pulaski, Saline
Loesel's twayplade	*Liparis loeselii*	Threatened	Garland
Southern tubercled orchid	*Platanthera flava*	Threatened	Ashley, Columbia, Montgomery, Pulaski, Union
Purple fringeless orchid	*Platanthera peramoena*	Threatened	Pulaski, Saline
Rose pogonia	*Pogonia ophioglossoides*	Threatened	Calhoun, Jefferson, Saline
Baldwin's yellow-eyed grass	*Xyris baldwiniana*	Threatened	Calhoun

In some cases, the presence of non-native aquatic species is believed to affect aquatic biodiversity. There are 26 non-native aquatic animal species known to occur in the SCAWRPR (Table 5.8). The majority of the non-native fish species present in the region are sportfish species that have been introduced purposely and are regularly stocked. The impact of many of these species on native species is unknown. Some species, such as carp, are suspected to affect native species as a result of modifying aquatic habitats, e.g., removing vegetative cover and increasing turbidity. Other species, such as non-native sportfish and exotic clams, are suspected to affect native species by competing with them for food and/or habitat (USGS 2013b). There are also 10 species of invasive aquatic plants known to occur in the planning region Table 5.8.

5.6 Operation and Maintenance of the Ouachita-Black Rivers Navigation System

Reduced federal funding is resulting in reductions in operation and maintenance of the federal navigation system on the Ouachita River in Arkansas. In 2012, USACE reduced the hours of operation of the Felsenthal and H.K. Thatcher locks on the Ouachita River from 24 to 16 hours a day. Monitoring of river traffic by the Ouachita River Valley Association indicates that the reduction in hours of operation of the locks is having an economic impact as a result of increased shipping times, and a 50% to 60% reduction in lockage of recreational boats. Reduced federal funding has also resulted in reduced dredging and snagging to maintain the navigation channel and a backlog of lock and dam maintenance projects. The navigation channel between Camden and Crossett has not been dredged in over 3 years. Lack of maintenance also impacts commercial and recreational use of the navigation system (Ouachita River Valley Association 2013).

Table 5.8. Non-native aquatic animal and plant species known to occur in the SCAWRPR.

Common Name	Scientific Name	Origin	Locations	Dates Identified	Method of Introduction	Impact
Freshwater jellyfish	*Craspedacusta sowerbyi*	China	Lake Greeson	1999	Accidental	Unclear
Waterflea	*Daphnia* lumholtzi	Asia	DeGray Lake, Wildcat Lake, Lake Georgia Pacific	1995	Accidental	Competition with natives
Inland silverside	*Menidia* beryllina	Mississippi River, Red River	Lake Greeson, Lake Hamilton, Ouachita River – Moro Bay	1988, 1987	Stocking	Competition with natives
Rock bass	*Ambloplites rupestris*	Northern US, east of Mississippi River	Caddo River, Ouachita River, Ten-mile Creek, Saline River, Little Missouri River	1955, 1962, 1970, 1973, 1976, 1997	Stocking	May compete with natives
Redbreast sunfish	*Lepomis* auritus	Atlantic drainage	Ouachita River	2000	Stocking	Competition & hybridization with natives
Red-bellied pacu	*Piaractus* brachypomus	South America	Hot Springs vicinity	2005	Aquarium release	Unknown
Oscar	*Astronotus* ocellatus	South America	Hot Springs vicinity	2005	Aquarium release	Potential competition with and predation of natives
Threadfin shad	*Dorosoma* petenense	Other basins in Arkansas	Lake Ouachita, Lake Hamilton, Lake Catherine	1988	Stocked	Competition with and predation on natives
Goldfish	*Carassius* auratus	Asia	DeGray Lake, Lake Hamilton, Saline River	1988	Accidental	Unknown
Grass carp	*Ctenopharyngodon idella*	Eastern Asia	White Oak Lake, Little Missouri drainage, Ouachita River, Lake Hamilton, Saline River, Lake Catherine, Lake Ouachita, Moro Creek	1988	Stocking	Habitat modification
Common carp	*Cyprinus* carpio	Eurasia	Throughout the region	1980, 1985, 1988, 1991, 1998, 2003	Stocking	Habitat modification
Silver carp	*Hypophthalmichthys molitrix*	Asia	Saline River, Ouachita River	1988, 1981	Accidental	Competition with natives
Bighead carp	*Hypophthalmichthys nobilis*	China	Saline River	1988	Accidental	Unknown
Fathead minnow	*Pimephales* promelas	US	DeGray Lake, Lake Catherine, Lake Ouachita, Lake Hamilton, Saline River	1988, 1980	Accidental	Unknown
Northern pike	*Esox lucius*	Northern US	DeGray Lake	1988	Stocked	Predation of natives

Table 5.8. Non-native aquatic animal and plant species known to occur in the SCAWRPR (continued).

Common Name	Scientific Name	Origin	Locations	Dates Identified	Method of Introduction	Impact
Muskellunge	*Esox* masquinongy	Northern and eastern US	DeGray Lake	1988	Stocked	Predation of natives
White catfish	*Ameiurus* catus	Atlantic drainage	Champagnolle Creek	1988	Stocked	Competition with natives
Brown bullhead	*Ameiurus* nebulosus	Northern US, Atlantic drainage	Lake Greeson, Lake Hamilton, White Oak Lake,L'Aigle Creek, Moro Creek, Ouachita River headwaters	1988	Stocked	Competition with natives
Blue catfish	*Ictalurus furcatus*	Mississippi River basin, Gulf coast drainage	Lake Ouachita, Lake Greeson, Ouachita River, DeGray Lake, Lake Catherine, Lake Hamilton, White Oak Lake, Bragg Lake	1988, 1997	Stocked	None
Wiper	*Morone chrysops x M. saxatilis*	None, artificial hybrid	DeGray Lake, Lake Greeson	1975, 1992	Stocked	Hybridize with native bass
Striped bass	*Morone* saxatilis	Atlantic & Gulf drainages	Lake Greeson, Ouachita River, Lake Ouachita, Lake Catherine, Lake Hamilton, Little Missouri	1957, 1967, 1976, 1980, 1984, 1988, 1992, 1997	Stocked	Can impact populations of small fishes
Sauger	*Sander* canadensis	Arkansas River basin	Lake Jack Lee	1980	Stocked	None known
Rainbow trout	*Oncorhynchus mykiss*	Pacific drainage	Little Missouri River, Lake Greeson, Ouachita River, Lake Catherine, Lake Ouachita, Lake Hamilton	1976, 1988, 1992, 1997	Stocked	Unknown
Brown trout	*Salmo trutta*	Europe, Africa, Asia	Little Missouri River	1988	Stocked	Competition with and predation of natives
Nutria	*Myocastor* coypus	South America	Throughout region	1978	Accidental	Over-grazing of wetlands
Asian clam	*Corbicula* fluminea	Asia	Ouachita River, Caddo River, Champagnole Creek	1968, 1969, 1976, 1981, 2004	Accidental	Competition with natives, biofouling
Alligator weed	*Alternanthera philoxeroides*	South America	Pike, Ouachita, Bradley, Ashley, Drew, Jefferson, Pulaski	2006, 1988	Accidental	Habitat modification
Brazillian waterweed	*Egeria densa*	South America	Hot Spring, Saline, Pulaski	1988	Accidental	Competition with natives, habitat modification

Table 5.8. Non-native aquatic animal and plant species known to occur in the SCAWRPR (continued).

Common Name	Scientific Name	Origin	Locations	Dates Identified	Method of Introduction	Impact
Water hyacinth	*Eichhornia crassipes*	South America	Clark, Jefferson, Pulaski, Hot Spring	1999, 2006	Accidental	Habitat modification
Hydrilla	*Hydrilla verticillata*	Asia	Clark, Garland, Hot Spring, Montgomery, Ouachita, Pulaski, Ashley	2005, 2010	Accidental	Competition with natives
Yellow iris	*Iris pseudacorus*	Asia, Africa, Europe	Bradley, Dallas, Drew, Jefferson, Pulaski	1988, 1997	Accidental	
European water clover	*Marsilea quadrifolia*	Europe, Asia	Pulaski	2010		
Parrotfeather	*Myriophyllum aquaticum*	South America	Ashley, Bradley, Calhoun, Garland, Jefferson, Montgomery, Polk, Saline, Union	1988, 1970	Introduced	Competition with natives
Eurasian water milfoil	*Myriophyllum spicatum*	Europe, Asia, Africa	Pulaski	2010	Accidental	Habitat modification, displacement of natives
Watercress	*Nasturtium officinale*	Europe, Africa, Asia	Garland, Montgomery, Polk	1988		
Water fern	*Salvinia minima*	Mexico, South America	Garland, Hot Spring, Jefferson, Montgomery, Pulaski	2010		
Narrow-leaved cattail	*Typha angustifolia*	Eurasia	Garland	1988		Habitat modification, displacement of natives*

*USDA Forest Service 2006.

6.0 INSTITUTIONAL AND REGULATORY SETTING

This section provides a description of the regulatory and institutional framework for water resources management in SCAWRPR. It includes general descriptions of federal and state laws, regulations, and programs that deal with water resources management in the region, as well as a listing of federal, state, and local governmental and nonprofit institutions that are involved in water resources management in the region. In addition, the interrelationships between regulations and institutions at the federal, state, and local levels in the SCAWRPR are illustrated.

6.1 Legal Framework

The legal framework for management and use of water resources in Arkansas is based on court case law, laws enacted by the Arkansas General Assembly, and rules and regulations enacted by state agencies. Federal laws and regulations also influence the regulation of water resources in the state (ANRC 2011). The discussion below identifies and summarizes the laws and regulations and associated programs that guide water management in SCAWRPR, and summarizes changes that have occurred in this legal framework since the 1990 AWP update.

6.1.1 Federal Laws and Regulatory Programs

Federal policy recognizes that states have primary authority for regulation of water usage within their borders. Therefore, the federal laws, regulations, and associated programs that influence water resources management in the SCAWRPR primarily relate to water quality. Federal legislation and programs also deal with other aspects of management of water resources in the region such as conservation and protection of waterbodies, flood control, and navigation.

6.1.1.1 Water Quality

The current federal laws and programs that guide management of water quality in the SCAWRPR are summarized in Table 6.1. The CWA of 1972 (most recently amended in 2002) and the SDWA of 1974 (most recently amended in 1996) are two important pieces of federal water quality legislation that authorize a number of federal water quality programs.

Table 6.1. Federal laws and regulatory programs that address SCAWRPR water quality.

Federal Law	Federal Water Quality Regulatory Programs	Responsible Federal Agency
CWA	Ambient nutrient water quality standards	EPA
	Biosolids regulations	
	Impaired waters	
	Nonpoint source pollution management	
	NPDES point source permitting	
	NPDES stormwater permitting	
	NPDES pesticide application permitting	
	NPDES confined animal feeding operations permitting	
	State ambient water quality standards	
	State biennial water quality assessment	
	TMDLs	
	Dredge and fill permitting	USACE
SDWA	Source water protection	EPA
	Underground injection wells	
Underground storage tank regulations	Underground storage tank program	EPA
Resource Conservation and Recovery Act (RCRA)	Hazardous waste management	EPA
	Solid waste management	
	Subtitle D	
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	Hazardous waste site clean up	EPA
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	Endangered species protection program	EPA
	Labeling requirements	
	Registration	
Surface Mining Control and Reclamation Act	Mine reclamation	US Department of the Interior (USDI)
	Surface mining control	
Toxic Substances Control Act (TSCA)	PCB Program	EPA
Soil and Water Resources Conservation Act	Conservation Effects Assessment Program	USDA
Arkansas Wilderness Act	National forests	USFS
National Forest Management Act		
Weeks Act		
Oil Pollution Act	Oil spill response planning	EPA
Pollution Prevention Act	Pollution prevention planning	EPA
National Environmental Policy Act (NEPA)	Environmental impact analysis of federal projects, with mitigation	EPA, Council on Environmental Quality

Note: Highlighted laws and programs were promulgated after the 1990 AWP update.

Legislation related to forest conservation, such as the Cooperative Forestry Assistance Act, is included here because forests can protect and improve water quality. EPA is responsible for administering themajority of these laws and programs; however, EPA has delegated some of this authority to state agencies such as ADEQ and ADH.

The CWA of 1972 established the NPDES program, which regulates point source discharges through a permit program. The NPDES program is managed by EPA, but ADEQ has been delegated authority to issue NPDES permits. NPDES permits are based on a combination of technology-based and water quality based standards. Technology-based standards are developed by EPA for certain categories based on the performance of pollution control technologies available to the industry without regard for the receiving waterbody. Water quality-based standards are developed after consideration of the designated uses of the receiving waterbody and the water quality criteria necessary to protect those uses. In 1987, Congress amended the CWA to include nonpoint sources of pollution such as stormwater runoff from industries, construction sites, and municipalities. NPDES permits for the SCAWRPR are summarized in Section 4.4.3. The 1987 amendments also addressed management of biosolids (sewage sludge). The CWA also requires permits for dredge and fill activities in wetlands, lakes, streams, rivers, and other waters of the US. These permits are issued by USACE.

The TMDL program was established by the CWA in 1972; however, TMDLs were rarely developed for waterbodies until the 1990s, after environmental groups began suing EPA over the lack of TMDLs being performed (EPA 2008). The CWA requires that a TMDL study be conducted for waterbodies identified as having impaired water quality. The TMDL study is conducted to determine the maximum amount of a pollutant that a waterbody can receive and still meet ambient water quality standards. This maximum load is split between point sources and nonpoint sources. These loads are then compared to the estimated existing point source and nonpoint source loads to determine the amount of reduction required for the waterbody to meet its water quality standards.

The first TMDLs for waterbodies in the SCAWRPR were completed in 2001. Prior to this, beginning in the 1980s, ADEQ routinely performed wasteload allocation studies as part of the NPDES permitting process to determine the amount of a pollutant that could be discharged to a waterbody. Since 2001, 17 TMDLs have been completed for waterbodies in the SCAWRPR (see Section 5).

In 1998, EPA initiated a program to develop ambient water quality criteria for nutrients, i.e., nitrogen and phosphorus. At the time, nutrients were identified as a leading cause of water quality issues across the nation, including such high profile events as the hypoxic zone in the Gulf of Mexico and algal blooms along the national seacoast. In 2001, EPA published recommended criteria development plans (EPA 2013c).

The drinking water source water protection program was initiated as a result of the 1996 amendment to the SWDA. The purpose of this program is to prevent the need for increased treatment of drinking water (resulting in increased treatment costs and costs to customers) due to water quality degradation, by protecting the quality of the drinking water source. In the majority of cases, the cost of protecting drinking water sources from pollution is far lower than the cost of upgrading water treatment to remove increased pollution. There are approximately 335 public water utilities in the SCAWRPR that are subject to SDWA regulations (ADH n.d.).

Subtitle D of the 1991 amendment of the Resource Conservation and Recovery Act (RCRA) introduced specifications for how landfills were to be constructed and managed to protect water quality. This led to sweeping changes in solid waste management across the country and in Arkansas (ADEQ 2011a).

6.1.1.2 Water Resources Management

The federal regulations and programs that address non-water quality aspects of water resources management are summarized in Table 6.2. These include regulations and programs that address flood control, river navigation, wetlands tracking, or water-based recreation. Programs related to drinking water infrastructure are also included in Table 6.2 and discussed below. Some of the legislation and programs that address water quality also address other aspects of water resources management. For example, preservation of forest lands protects water quality and hydrology. As a result, there is some duplication in Tables 6.1 and 6.2. Federally appropriated water, such as the water required to maintain navigation on the McClellan-Kerr Arkansas River Navigation System, is not available for other uses. Federal water appropriations preempt other beneficial water uses, such as irrigation.

Table 6.2. Federal laws and regulatory programs that address aspects of SCAWRPR water resources other than water quality

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
CWA	Wetland and stream mitigation	USACE	Physical protection of waterbodies, including wetlands
SDWA	Consumer confidence reports	EPA	Protects/improves public water supply
	Finished water criteria	EPA	Protects human health
	Operator certification	EPA	Informs the public
Endangered Species Act	Freshwater species protection	USFWS	Mechanism for physical protection of waterbodies that are habitats for endangered species
	Waterfowl protection		
Soil and Water Resources Conservation Act	Census of Agriculture	USDA	Irrigation and agriculture
	Conservation Effects Assessment Program	USDA	Water resources protection/improvement
	Natural Resources Inventory	USDA	Characterize water resources
NEPA	Environmental Impact Statements and Mitigation	EPA, Council on Environmental Quality	Water resources protection/mitigation
Flood Control Act/Water Resources Development Act (WRDA)	Dam safety	USACE	Water storage, water supply, flood reduction, flow management, restoration of physical aquatic habitat
	Flood control reservoirs		
	Levees		
	Navigation systems		
Arkansas Wilderness Act	National forests	USFS	Well managed forestlands improve and protect water resources
National Forest Management Act			
Weeks Act			
Rivers and Harbors Act	Navigation	USACE	Federal navigation systems in Arkansas
	Section 10	USACE	Protects waterbodies, including wetlands
Migratory Bird Hunting and Conservation Stamp Act	Small wetland acquisition program	USFWS	Protects wetlands
Emergency Wetlands Resources Act	National Wetlands Inventory	USFWS	Track wetland resources
Dam Safety and Security Act	National Dam Safety Program	Federal Emergency Management Agency (FEMA)	Protection of lives and property
National Parks Acts	National Parks	USDI National Park Service	Protection of water resources associated with national parks

Table 6.2. Federal law and regulatory programs that address aspects of SCAWRPR water resources other than water quality (continued).

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Migratory Bird Conservation Act	Acquisition of lands for wildlife refuges	Migratory Bird Conservation Commission	Preservation of water resources for bird habitat
National Wildlife Refuge System Improvement Act	National Wildlife Refuges	USFWS	Preservation of water resources for habitat
National Flood Insurance Act	National Flood Insurance Program	FEMA	Insurance against flood losses
	Floodplain management	FEMA	Reduction of flood damage
	Flood hazard mapping	FEMA	Identification of flood hazard areas
None	Climate monitoring	NOAA	Tracking precipitation and evaporation – water availability
	Climate prediction	NOAA	Future water availability
	Drought status	NOAA	Enactment of water shortage specific management
Wild and Scenic Rivers Act	National Wild and Scenic Rivers	USFS	Preservation of unregulated rivers and streams for recreation

Note: Highlighted programs were initiated after the 1990 AWP update.

An important federal program for mitigating impacts to wetlands and streams is part of the dredge and fill permitting program of the CWA (Section 404), overseen by USACE. This mitigation program was initiated in 1990, when EPA and USACE signed a memorandum of agreement establishing a process for determining the need for mitigation of impacts to wetlands, streams, and other water resources under the CWA Dredge and Fill Permitting program. This program provides a means for dredge and fill permit applicants to compensate for unavoidable destruction of aquatic habitat by either restoring or creating similar habitat either on site or at another location (EPA 2013a). There is one site within the SCAWRPR that has been designated as a mitigation banks for CWA dredge and fill permitting; on the upper Saline River (USACE 2013). The program is a mechanism for implementing the federal policy of no-net-loss of wetlands (EPA 2013a). Revised regulations governing this mitigation program were issued in 2008.

The Endangered Species Act provides for protection and recovery of imperiled terrestrial, freshwater, and marine plant and animal species (except pest insects) (USFWS 2013b). The SCAWRPR contains aquatic and semi-aquatic habitat important for a number of endangered species (see Table 5.6).

The 1996 amendments to the SDWA directed EPA and the states to develop requirements for certification of water treatment system operators (EPA 2012e). These amendments also initiated a program that required public water suppliers that operate community water systems to provide annual reports to drinking water utility customers on the quality of their drinking water (EPA 2013b).

Under the National Flood Insurance Act, flood hazard maps have been completed for the entire SCAWRPR, and most of the mapping has been, or is in the process of being, modernized, within the last 8 years, with the exception of Polk, Montgomery, Grant, Pike, Nevada, Calhoun, and Bradley counties (Figure 6.1). Flood hazard maps for these counties are more than 25 years old. Modernized flood hazard maps typically include updated Special Flood Hazard Areas (SFHAs), and are created in a digital countywide format. For the communities participating in the National Flood Insurance Program (NFIP), the flood hazard maps identify the regulatory SFHA whereby the community floodplain administrator applies the locally adopted and enforced floodplain management ordinance. Participation in the NFIP is voluntary; however non-participation results in federal flood insurance not being available to residents and limits post-disaster financial assistance. All of the counties included in the SCAWRPR are participating in the program, as well as a large percentage of the communities.

Surface waters in the SCAWRPR that are under some degree of federal management include the Ouachita River at Lake Ouachita and in the Ouachita National Forest, the Caddo River at Lake DeGray, and the Little Missouri River at Lake Greeson. The Felsenthal NWR is a federally controlled area at the confluence of the Saline River and the Ouachita River. This area includes Lake Jack Lee, which is formed on the Ouachita River by Felsenthal Lock and Dam. Federal water requirements preempt other beneficial water uses, such as irrigation.

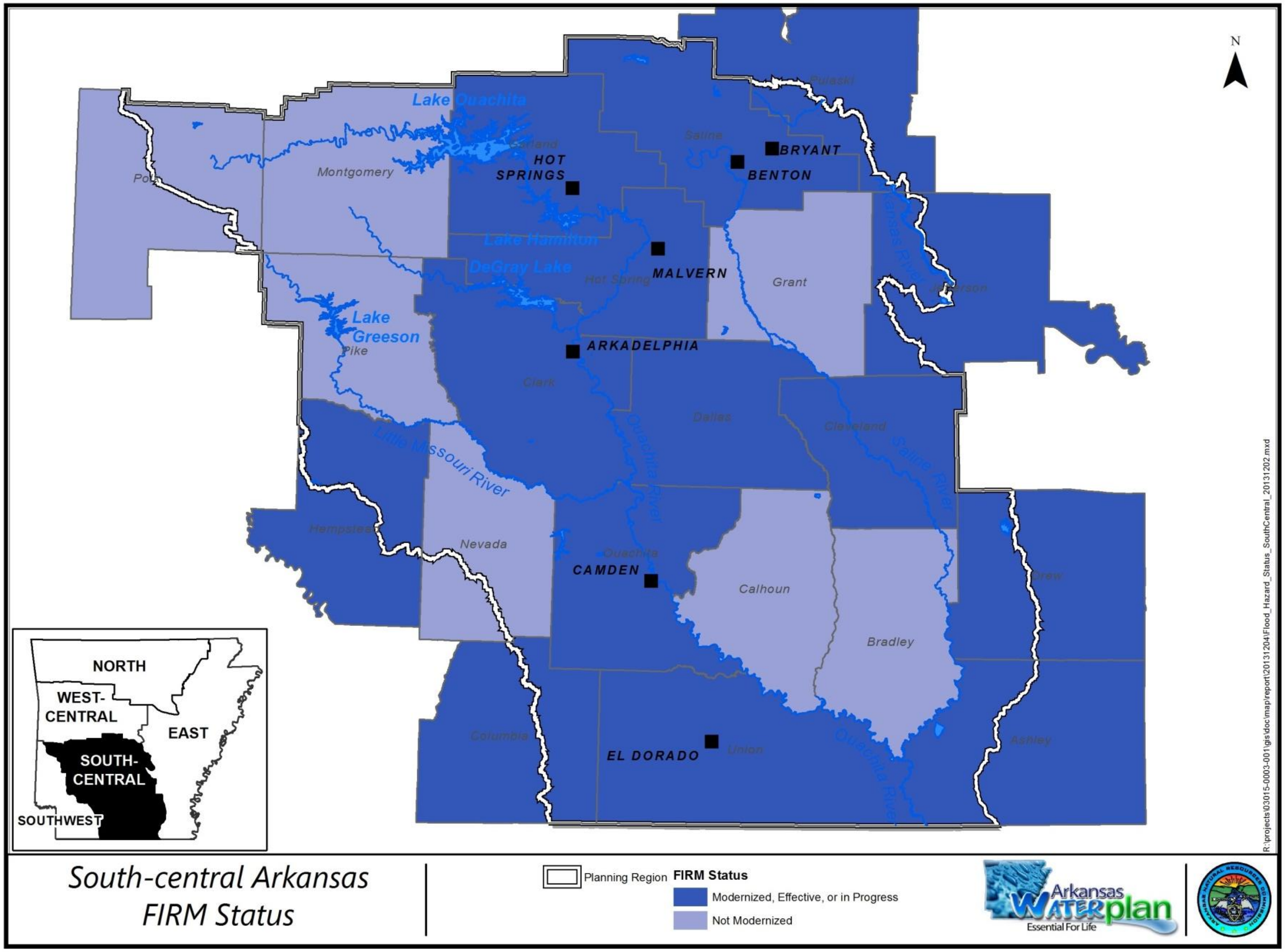

Figure 6.1. Status of flood hazard mapping in the SCAWRPR.

6.1.2 Federal Laws and Assistance Programs

Federal laws have also established a number of programs to provide technical and financial assistance for water resources management, that are available in Arkansas. Assistance programs for management of water quality and other aspects of water resources are discussed in the following sections.

6.1.2.1 Water Quality

Table 6.3 summarizes current federal assistance programs available in the SCAWRPR and the associated federal laws. The majority of the federal assistance programs listed in Table 6.3 originated through the Farm Bill. The Farm Bill has been amended four times since 1990, most recently in 2013 (National Agricultural Law Center 2012). New conservation programs that are intended to assist farmers in protecting and restoring water quality have been added with each amendment (see Table 6.3). In 2012, over 103,801 acres in the counties of the SCAWRPR were enrolled in Farm Bill programs, and over $7.7 million in funding provided to those counties for water quality practices (Table 6.4) (NRCS 2012).

The CWA authorizes EPA to provide federal funding assistance to states and local entities through three funding programs. Through the Clean Water State Revolving Fund, federal funds are provided to ANRC to fund a low interest loan program for wastewater treatment, nonpoint source pollution control, and watershed management projects in the state. Grants for nonpoint source pollution control projects are authorized under Section 319 of the CWA. Finally, Section 106 of the CWA authorizes federal funding assistance to states and interstate agencies through grants for pollution control programs such as discharge permitting and water quality monitoring.

There are additional federal laws that authorize programs that provide assistance for community waste treatment and management to protect water quality. HUD grants for construction and upgrading of wastewater infrastructure were also authorized by the Housing and Community Development Act. Several programs to provide financial assistance for wastewater systems and solid waste programs in rural areas were authorized by the Consolidated Farm and Rural Development Act.

Table 6.3. Federal laws and assistance programs that affect the SCAWRPR water quality.

Federal Law	Federal Water Quality Funding Assistance Programs	Responsible Federal Agency
CWA	Clean water state revolving fund	EPA
	Nonpoint source pollution management grants	
	Water pollution control program grants	
CERCLA	Hazardous waste site clean up	EPA
Cooperative Forestry Assistance Act	Forest Stewardship Program	USDA Forest Service
	Forest Legacy Program	
	Urban and Community Forestry Program	
Housing and Community Development Act	Community Development Block Grants	US Department Housing and Urban Development (HUD)
Farm Bill	Agricultural Water Enhancement Program	NRCS
	Conservation Reserve Program (CRP)	USDA Farm Services Agency
	Conservation Innovation Grants Program	NRCS
	Conservation Stewardship Program (CSP)	
	Cooperative Conservation Partnership Initiative	
	Environmental Quality Incentives Program (EQIP)	
	Farm and Ranch Land Protection Program	
	Grassland Reserve Program	
	Grazing Lands Conservation Initiative	
	Mississippi River Basin Healthy Watersheds Initiative	
	National Water Management Center	
	National Water Quality Initiative	
	Organic Initiative	
	Wetlands Reserve Program	
	Wildlife Habitat Incentives Program (WHIP)	
Consolidated Farm and Rural Development Act	Water and waste disposal systems for rural communities	USDA Rural Utilities Service
	Water and Waste Disposal Loans and Grants	USDA Rural Utilities Service
	Solid Waste Management Grants	
	Grant Program to Establish a Fund for Financing Water and Wastewater Projects	
American Recovery and Reinvestment Act	Funding for clean water state revolving fund and clean up of leaking underground storage tanks	Recovery Accountability and Transparency Board
Clean Vessel Act	Funding for pumpout stations and waste reception facilities for recreational boaters	USFWS

Note: Highlighted laws and programs were promulgated after the 1990 AWP update.

Table 6.4. NRCS conservation programs summary for 2012 for counties of the SCAWRPR (NRCS 2012).

County	CRP			EQIP			WHIP - Drought			Strike Force Initiative			Emergency Watershed
	Contracts	Acres	Funds Obligated	Contracts	Acres	Funds Obligated	Contracts	Acres	Funds Obligated	Contracts	Acres	Funds Obligated	Funds Obligated
Ashley	3	1,740	$45,314	9	8,415.5	$121,642	0	0	0	0	0	0	0
Bradley	0	0	0	7	291.5	$64,316	0	0	0	0	0	0	0
Calhoun	1	107.3	$1,991	4	803.4	$45,444	0	0	0	0	0	0	0
Clark	0	0	0	2	240.9	$22,019	0	0	0	0	0	0	0
Cleveland	2	1,095.3	$4,458	36	2,635.8	$616,685	0	0	0	0	0	0	0
Columbia*	1	209.2	$670	12	901.8	$168,901	2	130	$21,076	3	473.3	$38,287	0
Dallas	0	0	0	8	674.0	$62,095	2	60	$5,357	0	0	0	$570,364
Drew	3	4,870.4	$160,949	22	14,158.2	$404,132	0	0	0	6	490	$300,703	0
Garland	1	1,400.0	$5,675	10	687.3	$119,216	0	0	0	0	0	0	0
Grant	0	0	0	9	1,508.0	$66,606	0	0	0	0	0	0	0
Hempstead*	0	0	0	12	924.4	$222,331	0	0	0	2	52.2	$52,455	0
Hot Spring	0	0	0	9	555.0	$72,507	1	116	$11,142	0	0	0	0
Jefferson	34	36,081.1	$1,251,011	43	15,082.2	$2,258,878	0	0	0	0	0	0	0
Montgomery	0	0	0	12	1,962	$229,838	0	0	0	0	0	0	0
Nevada*	0	0	0	4	204.4	$25,067	0	0	0	0	0	0	0
Ouachita	0	0	0	9	417	$92,337	0	0	0	1	3	$18,483	0
Pike	0	0	0	5	189.3	$70,208	0	0	0	0	0	0	0
Polk*	0	0	0	38	5374.2	$531,347	0	0	0	0	0	0	0
Saline	0	0	0	4	308	$24,093	0	0	0	0	0	0	0
Union	2	662.0	$1,873	1	978.5	$86,957	0	0	0	0	0	0	0
Totals	**47**	**46,165.3**	**$1,471,941**	**256**	**56,311.4**	**$5,304,619**	**5**	**306**	**$37,575**	**12**	**1,018.5**	**$409,928**	**$570,364**

The American Recovery and Reinvestment Act was promulgated in 2009 to save and create jobs during the recession that began in 2008. This act initiated several programs that provide money to states for a range of activities, including improvements to wastewater treatment systems and clean up of leaking underground storage tanks and hazardous waste sites (EPA 2013e). Recovery money was awarded to the Arkansas State Clean Water Revolving Loan Fund, and the ADEQ Leaking Underground Storage Tank Program. Recovery money was awarded to one leaking underground storage tank remediation project in the planning region (EPA n.d.).

The Clean Vessel Act was promulgated in 1992. This act established a program to provide grants to states to pay for construction, maintenance, operation, or renovation of boat pumpout stations and waste reception facilities (US Congress 1992). Money from this program has been used to install and maintain pumpout facilities at the lakes and river ports in the SCAWRPR (USFWS 2013a).

Forestry assistance programs are included in Table 6.3 because forest improvement can improve water quality.

6.1.2.2 Water Resources Management

The federal assistance programs that address non-water quality aspects of water resources management are summarized in Table 6.5. These include programs that address flood control, water conservation, water supply systems, fisheries, and aquatic habitat for wildlife. Some of the programs that provide assistance for addressing water quality also address other aspects of water resources management. For example, HUD Community Development Block Grants can be used to finance drinking water projects as well as wastewater projects. As a result, there is some duplication in Tables 6.3 and 6.5.

Table 6.5. Federal assistance programs for aspects of SCAWRPR water resources other than water quality.

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
SDWA	Drinking water state revolving fund	EPA	Protects human health
Farm Bill	Agricultural Water Enhancement Program	NRCS	Water conservation
	Cooperative Conservation Partnership Initiative	NRCS	Water conservation
	Conservation Innovation Grants Program	NRCS	Water conservation
	Emergency Watershed Protection	NRCS	Flooding reduction, recovery
	Groundwater Decline Initiative	NRCS	Water Conservation
	National Water Management Center	NRCS	Waterbody protection/restoration
	On-farm Energy Initiative	NRCS	Water conservation
	Watershed protection and flood prevention	NRCS	Flooding management
	Wetlands Reserve Program	NRCS	Physical waterbody protection/restoration
	WHIP	NRCS	Physical waterbody protection/restoration
Cooperative Forestry Assistance Act	Urban and Community Forestry Program	USFS	Trees in communities reduce stormwater runoff, improving hydrology
	Forest Stewardship Program	USFS	Well-managed forestlands improve and protect water resources
	Forest Legacy Program		
Flood Control Act/WRDA	Habitat restoration	USACE	Water storage, water supply, flood reduction, flow management, restoration of physical aquatic habitat
	Basin studies		
Housing and Community Development Act	Community development block grants programs	HUD	Protects/improves public water supply
American Recovery and Reinvestment Act	Funding for drinking water revolving fund	Recovery Accountability and Transparency Board	Protects/improves public water supply

Table 6.5. Federal assistance programs for aspects of SCAWRPR water resources other than water quality (continued).

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Consolidated Farm and Rural Development Act	Water and waste disposal systems for rural communities, Water and waste disposal loans and grants, Household water well system grant program, Grant program to establish a fund for financing water and wastewater projects, Emergency community water assistance grants	USDA Rural Development	Protects/improves public water supply
Land and Water Conservation Fund Act	Matching grants for acquisition and development of public recreation areas and facilities	USDI National Park Service	Preservation of water resources for recreation
Pittman-Robertson Wildlife Restoration Act	Wildlife restoration grant programs	USFWS	Preservation of water resources for fish and wildlife habitat
Sport Fish Restoration Act	Boating infrastructure grants	USFWS	Recreational boating and fishing
	Multistate conservation grants	USFWS	Aquatic habitat research and education
	Sports fish restoration grants	USFWS	Preservation of water resources for fish and wildlife habitat

Note: Highlighted laws and programs were initiated after the 1990 AWP update.

The 1996 amendment of the Safe Drinking Water Act established the Drinking Water State Revolving Fund to assist drinking water utilities in financing infrastructure improvements. Using this fund, states can offer utilities low-cost loans and other types of assistance. Funds available through the American Recovery and Reinvestment Act were awarded to the Arkansas Drinking Water State Revolving Fund and used for two drinking water projects in the SCAWRPR (EPA n.d.).

Farm Bill amendments and associated assistance programs, as well as the Conservation Effects Assessment Program, the assistance programs associated with the Consolidated Farm and Rural Development Act, and the HUD Community Development Block Grant Program were discussed in Section 6.1.2.1. Farm Bill programs address water conservation (e.g., Groundwater

Decline Initiative), flood control (e.g., Watershed protection and Flood prevention), and conservation and restoration of aquatic habitat (e.g., Wetlands Reserve Program, WHIP). In 2012, over 103,801 acres in the counties of the SCAWRPR were enrolled in Farm Bill programs, and over $7.7 million in funding provided to those counties for water quality practices (Table 6.4) (NRCS 2012).

One project has been authorized under WRDA in the SCAWRPR since 1990, the Ouachita River watershed investigation in Arkansas and Louisiana. This project is ongoing; however, no funds were allocated for it in fiscal years 2012 and 2013 (USACE Vicksburg District 2013a, Ouachita River Valley Association 2011).

6.1.3 State Laws and Regulatory Programs

Arkansas has primary authority for regulation of water usage within the state. Many of the state laws and agency regulations related to water quality implement federal laws. The federal government has delegated authority to the state for a number of the regulatory administrative activities of both the CWA and the SWDA.

6.1.3.1 Water Use Regulations

State water use law is based on a policy where riparian land owners, i.e., persons owning land that abuts a waterbody, have the right to reasonable use of the water within that waterbody. The reasonable use policy means that all landowners along a stream have the right to free and unrestricted use of the stream flow, provided that their use does not negatively affect the availability of water for other riparian users. Similarly, landowners have the right to reasonable use of groundwater under their property, as long as that use does not adversely affect the ability of other landowners to use the groundwater. In addition to water rights related to water withdrawals and consumptive use, Arkansas regulations address water rights related to public recreational uses of surface water such as boating and fishing (ANRC 2011).

In Arkansas, at the state level, regulations and programs authorized by the General Assembly that are related to water use are generally administered by ANRC. In addition, the Arkansas Water Well Construction Commission promulgates rules for construction of water supply wells, and the Arkansas Public Services Commission regulates private water utility fees. State incentive programs for water conservation, as well as funding for water resources development projects, have also been legislated. Table 6.6 summarizes selected Arkansas water use regulations and water conservation and development incentive programs that apply in the SCAWRPR.

Table 6.6. State regulations related to water use.

State Water Use Regulations	Subjects Addressed by Regulations	Related State Legislation
Title 3: Rules for the Utilization of Surface Water[1]	Registration of surface water withdrawals	Arkansas Code §15-22-215
	Minimum streamflows	Arkansas Code §15-22-222
	Surface water transfers to non-riparian users	Arkansas Code §15-22-304
	Regulation of dam construction	Arkansas Code §15-22-210 - 214
	Allocation during periods of water shortage	Arkansas Code §15-22-217
Title 4: Rules for the Protection and Management of Groundwater[1]	Registration of groundwater withdrawals	Arkansas Code §15-22-302
	Groundwater protection program	Arkansas Groundwater Protection and Management Act (Arkansas Code §15-22-901 et seq.)
Arkansas Water Well Construction Commission Rules and Regulations[2]	Licensing of water well contractors Construction requirements Well reporting requirements	Arkansas Code §17-50-201 et seq.
Affiliate Transaction Rules[3]	Requirements for utility rates	Arkansas Code §23-2-101 et seq.
General Service Rules[3]	Standards of service for utilities	
Special Rules Water[3]	Standards of service for water utilities	

Note: Highlighted legislation was promulgated after the 1990 AWP update.
1. Enforcement by ANRC.
2. Enforcement by Arkansas Water Well Construction Commission.
3. Enforcement by Arkansas Public Service Commission.

State law requires ANRC to "establish and enforce minimum stream flows for the protection of instream water needs" (Arkansas Code §15-22-222). Minimum streamflow is defined by Arkansas Code §15-22-202(6) as "…the quantity of water required to meet the largest of [specified] instream flow needs as determined on a case-by-case basis." The needs to be met that are specified in the statute are interstate compacts, navigation, fish and wildlife, water quality, and aquifer recharge. This definition is used to set minimum streamflows by rulemaking under Arkansas Code §15-22-222. Where no minimum flow is set by rule, these factors are used to make a case-by-case determination of minimum flow.

The minimum streamflow, set by rule or determined on a case-by-case basis, represents the trigger point for a “shortage” requiring allocation of water use. Because of the critical low flow conditions which may exist at the minimum streamflow level, the 1990 AWP recommended taking steps to reduce water withdrawals before water levels drop to minimum streamflow levels. The ANRC may allocate water among uses during a shortage.

Prior to adoption of Act 593 of 2013, minimum streamflows were classified as a “reserved” use when allocating water during a shortage, along with drinking water use and federal water rights. The legislation removed this reserved status and demoted minimum streamflows to a position below agriculture and industry in the allocation hierarchy, and ahead of hydropower and recreation. The intent was to ensure that agricultural and industrial surface water use is not curtailed during a shortage in an effort to protect instream flow needs (interstate compacts, navigation, fish and wildlife, water quality, and aquifer recharge). This change, especially as it applies a state law limitation on federal interests in navigation, interstate compacts and water quality, including wastewater discharge permits for sewer systems and industries, has not been tested.

In 1985, the Arkansas General Assembly adopted a departure from traditional riparian law by allowing transfer of water for use on non-riparian land. Prior to determining how much water is available to transfer, ANRC must first calculate the amount of water that must remain in the stream. The amount of water that must remain in the stream must be enough to cover: (1) existing riparian water rights as of June 28, 1985; (2) water needs of federal water projects as they existed on June 28, 1985; (3) firm yield of all reservoirs in existence on June 28, 1985; (4) maintenance of instream flows for fish and wildlife, water quality, aquifer recharge requirements, and navigation; and (5) future water needs of the basin of origin as projected in the AWP. The General Assembly limited the amount of excess surface water that may be permitted for non-riparian transfer to 25% of the average annual yield from the watershed after the greatest of the instream needs listed above is met. In the White River Basin, Arkansas

Code §15-22-304(e) further limits excess to an amount not to "exceed on a monthly basis an amount which is 50% of the monthly average of each individual month of excess surface water."

Minimum streamflow is often mistakenly equated with fish and wildlife flow requirements. Fish and wildlife flows are one of the five elements of minimum streamflow, which also includes interstate compacts, navigation, water quality, and aquifer recharge. Two different methods are used to calculate fish and wildlife flows for different situations. For case-by-case determinations of minimum flow for use in characterizing shortage and allocating water during a shortage, fish and wildlife flow requirements are estimated using a modified Tennant Method (ASWCC 1988). To calculate fish and wildlife flow requirements when determining the amount of excess water available for transfer to nonriparian users, the "Arkansas Method" (Filipek, Keith and Giese 1987) is used.

In 1991, the Arkansas Ground Water Protection and Management Act (Arkansas Code §15-22-901 et seq.) was signed into law, providing ANRC with authority to designate critical groundwater areas. As of 2013, two critical groundwater areas have been designated in the SCAWRPR (Figure 5.2). This law also mandated that ANRC evaluate the condition of the state's aquifers on a biennial basis, and make recommendations concerning safe yield and the designation of critical groundwater areas (ANRC 2011). ANRC publishes annual reports on the condition of the state's groundwater resources, including recommendations concerning aquifer safe yield and designation of critical groundwater areas.

Legislation passed in 2001 (Arkansas Code §15-22-915) requires the use of water meters on all non-domestic wells withdrawing water from sustaining aquifers, beginning in 2006. Designated sustaining aquifers in the SCAWRPR include the Cane River, Carrizo, Cockfield, Nacatoch, Ozan, Sparta, Trinity, Tokio, and Wilcox aquifers (Figure 3.20).

6.1.3.2 Water Quality Regulations

Water quality regulations are promulgated by the General Assembly, APCEC, the State Board of Health, and ANRC. Table 6.7 identifies state regulations and laws, along with associated federal laws, that address water quality.

Table 6.7. State regulations that protect water quality.

	Subjects/Programs	Related State Legislation	Related Federal Legislation
Regulation 1: Prevention of Pollution by Salt Water and Other Oil Field Wastes Produced by Wells in All Fields or Pools[(a)]	Environmental protection during oil drilling	Arkansas Water and Air Pollution Control Act (Arkansas Code §8-4-201 et seq.)	CWA
Regulation 2: Water Quality Standards for Surface Waters of the State of Arkansas[(a)]	Water quality standards (designated uses and numeric criteria)	Arkansas Water and Air Pollution Control Act (Arkansas Code §8-4-201 et seq.)	CWA
Regulation 3: Licensing of Wastewater Treatment Operators[(a)]	Licensing program for wastewater treatment operators	Arkansas Water and Air Pollution Control Act (Arkansas Code §8-4-201 et seq.)	CWA
Regulation 4: Disposal Permits for Real Estate Subdivisions in Proximity to Lakes and Streams[(a)]	State wastewater permit	Arkansas Water and Air Pollution Control Act (Arkansas Code §8-4-201 et seq.)	CWA
Regulation 5: Liquid Animal Waste Systems[(a)]	State wastewater permit	Arkansas Water and Air Pollution Control Act (Arkansas Code §8-4-201 et seq.)	CWA
Regulation 6: Regulations for State Administration of the NPDES Program[(a)]	Federal wastewater permits (NPDES)	Arkansas Water and Air Pollution Control Act (Arkansas Code §8-4-201 et seq.)	CWA
Regulation 12: Storage Tank Regulations[1]	Petroleum storage tank trust fund	Petroleum Storage Tank Trust Fund Act (Arkansas Code §8-7-901 et seq.)	CWA, Underground Storage Tank Regulations, including Energy Policy Act of 2005
Regulation 15: Open-Cut Mining and Land Reclamation Code[(a)]	Environmental protection during non-coal mining activities, restoration of non-coal mining sites	Arkansas Open Cut Land Reclamation Act (Arkansas Code §15-57-301 et seq.) Arkansas Quarry Operation, Reclamation, and Safe Closure Act (Arkansas Code §15-57-401 et seq.)	None
Regulation 17: Underground Injection Control Code[(a)]	Underground injection of wastewater	Arkansas Water and Air Pollution Control Act (Arkansas Code §8-4-201 et seq.)	SDWA

Table 6.7. State regulations that protect water quality (continued).

	Subjects/Programs	Related State Legislation	Related Federal Legislation
Regulation 22: Solid Waste Management[a]	Landfill construction specifications, acceptable materials for landfill disposal, regional solid waste management districts, pollution prevention	Arkansas Solid Waste Management Act (Arkansas Code §8-6-201 et seq.), Arkansas Pollution Prevention Act (Arkansas Code §8-10-201 et seq.)	RCRA, Pollution Prevention Act
Regulation 23: Hazardous Waste Management[a]	Hazardous waste management, pollution prevention	Arkansas Hazardous Waste Act (Arkansas Code §8-7-201 et seq.), Arkansas Hazardous Materials Transportation Act (Arkansas Code §27-2-101 et seq.), Arkansas Pollution Prevention Act (Arkansas Code §8-10-201 et seq.)	RCRA, Pollution Prevention Act
Regulation 27: Licensing of Landfill Operators and Illegal Dumps Control Officers[a]	Licensing of landfill operators, licensing of illegal dumps control officers	Arkansas Code §8-6-901 et seq., Illegal Dump Eradication and Corrective Action Program Act (Arkansas Code §8-6-501 et seq.)	RCRA
Regulation 29: Brownfields Redevelopment[a]	Clean-up and redevelopment of contaminated sites	Arkansas Hazardous Waste Act (Arkansas Code §8-7-201 et seq.), Remedial Action Trust Fund Act, Arkansas Voluntary Clean-up Act (Arkansas Code §8-7-1101 et seq.)	CERCLA
Regulation 32: Environmental Professional Certification[a]	Certification program for professionals involved in clean-up of contaminated sites	Phase I Environmental Site Assessment Consultant Act (Arkansas Code §8-7-1301 et seq.)	CERCLA
Regulation 34: State water permit regulation[a]	Regulation of systems with the potential to pollute water resources, that are not otherwise regulated	Arkansas Water and Air Pollution Control Act (Arkansas Code §8-4-201 et seq.)	CWA
Rules and regulations pertaining to general sanitation[b]	Groundwater pollution, surface water pollution, sewage treatment	Arkansas Sewage Disposal Systems Act (Arkansas Code §14-236-101 et seq.)	CWA
Rules and regulations pertaining to public water systems[b]	Safety of drinking water supplied by public water systems	Arkansas Code §20-7-101 et seq.	SDWA
Rules and regulations pertaining to semi-public water systems[b]	Safety of drinking water supplied by semi-public water systems	Arkansas Code §20-7-101 et seq.	SDWA

Table 6.7. State regulations that protect water quality (continued).

	Subjects/Programs	Related State Legislation	Related Federal Legislation
Rules and regulations pertaining to water operator licensing[(b)]	Licensing for drinking water treatment systems	Arkansas Code §17-51-101 et seq.	SDWA
Rules and regulations pertaining to onsite wastewater systems, designated representative, and installers[(b)]	Permitting of onsite wastewater treatment systems (septic systems), licensing of designated representatives for onsite wastewater treatment systems, licensing of installers of onsite wastewater treatment systems	Arkansas Sewage Disposal Systems Act (Arkansas Code §14-236-101 et seq.)	CWA
Rules and regulations pertaining to mobile home and recreational vehicle parks[(b)]	Water supply, wastewater disposal, solid waste management	Arkansas Code §17-51-101 et seq.	CWA, SDWA, RCRA
Arkansas regulations on pesticide classification[(c)]	Pesticide classification	Arkansas Pesticide Control Act (Arkansas Code §2-16-401 et seq.), Arkansas Pesticide Use and Application Act (Arkansas Code §20-20-201 et seq.)	FIFRA
Arkansas regulations on pesticide applicator licensing[(c)]	Licensing of pesticide applicators	Arkansas Pesticide Use and Application Act (Arkansas Code §20-20-201 et seq.)	FIFRA
Arkansas Water Well Construction Commission Rules and Regulations	Specifications for construction of water wells to provide safe drinking water	Water Well Construction Act (Arkansas Code §17-50-101 et seq.)	SDWA
Rules and Regulations pertaining to outdoor bathing places[(b)]	Swim beach water quality	Arkansas Code §20-7-101 et seq.	CWA
Marine sanitation[(b)]	Marine sanitation	Arkansas Code §27-101-401 et seq.	Clean Vessel Act

Notes: Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update.

a. Responsible state agency is ADEQ.

b. Responsible state agency is Arkansas Department of Health.

c. Responsible state agency is Arkansas State Plant Board.

Table 6.7 illustrates that there are myriad state regulations, covering a range of activities, that address water quality. The most basic of these are the regulations that set criteria for the quality of state surface waters and groundwater. These regulations identify the uses that state waterbodies should support, and specify narrative and numeric criteria for water quality to ensure the identified uses can be supported. In Arkansas, numeric water quality criteria for DO, turbidity, temperature, and minerals are ecoregion-based (APCEC 2011). Arkansas is in the process of developing numeric criteria for nutrients in surface water to meet federal requirements (ADEQ 2012c). State numeric water quality criteria for groundwater are in development.

A summary of the designated uses assigned to surface waterbodies in the SCAWRPR under APCEC Regulation No. 2 is provided in Table 6.8. Ouachita Mountain and Gulf Coastal ecoregion numeric surface water quality criteria apply in the SCAWRPR. Numeric surface water quality criteria for the waterbodies in the planning region are listed in Tables 6.9 through 6.11. Figure 6.2 shows the ADEQ water quality planning segments that are located in the planning region.

To protect surface water and groundwater quality, there are state regulations and laws that regulate discharge of wastewater, discharge of stormwater, underground storage tanks, underground injection of fluids, management of livestock, and disposal of solid waste.

The state source water and wellhead protection programs address protection of the quality of surface waters and aquifers used as public drinking water supplies. There are approximately 140 active public water supply utilities in the SCAWRPR. Half of these utilities use groundwater from their own wells, and are subject to the state wellhead protection program. Approximately 15 of the water utilities in the planning region use surface water and are subject to the state source water protection program. The remainder of the water utilities in the planning region purchase groundwater and/or surface water to supply to their customers (ADH n.d.).

Table 6.8. State designated uses for surface waters in the SCAWRPR (APCEC 2011).

Designated Use	Waterbodies
Extraordinary Resource Waters	• Lake Ouachita • DeGray Reservoir • Saline River • Caddo River above DeGray reservoir • South Fork Caddo River • Little Missouri River above Lake Greeson
Ecologically Sensitive Waterbodies	• Ouachita River above Lake Ouachita • Ouachita River near Arkadelphia • South Fork Ouachita River • Caddo River and tributaries above DeGray Reservoir • Saline River including Alum, Middle, North, and South Forks • Tenmile Creek • Little Missouri River above Lake Greeson • Missouri River • Mayberry Creek
Natural and Scenic Waterway	• Little Missouri River above Lake Greeson • Saline River
Streams with substantial spring water influence	• L'Eau Frais • Cypress Creek • East and West Forks Tulip Creek
Primary Contact Recreation	All streams with watersheds > 10 square miles, and all lakes and reservoirs except: ○ Unnamed tributary to Smackover Creek ○ Unnamed tributary to Flat Creek ○ Coffee Creek ○ Mossy Lake
Secondary Contact Recreation	All waters except: ○ Unnamed tributary to Smackover Creek ○ Unnamed tributary to Flat Creek ○ Coffee Creek ○ Mossy Lake
Domestic Water Supply	All waters except: ○ Bluff Creek and unnamed tributary ○ Coffee Creek ○ Mossy Lake ○ Town Creek below Acme tributary ○ Unnamed tributary from Acme ○ Bayou de Loutre from Gum Creek to state line ○ Gum Creek ○ Walker Branch ○ Little Cornie Bayou from Walker Branch to state line ○ Alcoa unnamed tributary to Hurricane Creek ○ Hurricane Creek ○ Holly Creek ○ Dry Lost Creek and tributaries

Table 6.8. State designated uses for surface waters in the SCAWRPR (continued).

Designated Use	Waterbodies
Domestic Water Supply (cont.)	o Lost Creek o Albemarle unnamed tributary to Horsehead Creek o Horsehead Creek from unnamed tributary to mouth o Dismukes Creek o Big Creek o Boggy Creek from confluence of tributary from Clean Harbors to Bayou de Loutre o Unnamed tributary to Flat Creek from EDCC outfall to confluence with unnamed tributary A o Unnamed tributary A to Flat Creek from EDCC ditch to mouth o Flat Creek from unnamed tributary A to Haynes Creek o Haynes Creek from Flat Creek to Smackover Creek
Industrial and Agricultural Water Supply	All waters
Trout Fishery	• Lake Ouachita • Ouachita River from Blakely Mountain Dam to highway 270 bridge • Little Missouri River from Narrows Dam to confluence with Muddy Fork
Seasonal Fishery	All streams with watersheds < 10 square miles
Perennial Fishery	Lakes and reservoirs, all streams with watersheds of 10 square miles or larger except: o Unnamed tributary to Smackover Creek o Unnamed tributary to Flat Creek o Coffee Creek o Mossy Lake

Table 6.9. Temperature and turbidity numeric criteria in the SCAWRPR (APCEC 2011).

Waterbody	Temperature (ºF)	Base Flow Turbidity (NTUs)	All Flows Turbidity (NTUs)
Ouachita Mountain streams	86.0	10	18
Gulf Coastal streams	86.0	21	32
Trout waters	68.0	10	18
Lakes and reservoirs	89.6	25	45
Ouachita River from Little Missouri River to state line	89.6	21	32
Spring water streams	86.0	21	32
Bayou de Loutre from Chemtura outfall to Loutre Creek	96.0	21	32

Table 6.10. Dissolved oxygen numeric water quality criteria in the SCAWRPR (APCEC 2011).

Waterbody	Primary DO (mg/L)	Critical DO (mg/L)
Ouachita Mountain streams with watershed < 10 square miles	6	2
Ouachita Mountain streams with watershed ≥10 square miles	6	6
Trout waters	6	6
Gulf Coastal streams with watershed < 10 square miles Loutre Creek from railroad bridge to mouth	5	2
Gulf Coastal streams with watershed 10 – 100 square miles Dodson Creek, Loutre Creek from headwaters to railroad bridge, Jug Creek	5	3
Gulf Coastal streams with watershed > 100 square miles	5	5
Lakes and reservoirs	5	N/A
Prairie Creek from headwater to Briar Creek	6	4
Unnamed tributary to Smackover Creek, unnamed tributary to Flat Creek	2	2
Ouachita River from mile 223 to state line	5	3 (June & July), 4.5 (August), or naturally occurring value
All streams when water temperature ≤ 10 ºC, or when streamflow is 15 cubic feet per second (cfs) or greater during March through May	6.5	Not applicable

Table 6.11. Numeric water quality criteria for minerals in the SCAWRPR (APCEC 2011).

Waterbody	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
Big Cornie Creek	230	30	500
Little Cornie Creek	200	10	400
Three Creeks	250	10	500
Little Cornie Bayou above unnamed tributary	200	20	500
Unnamed tributary to Little Cornie Bayou from GLCC outfall 003	538*	35*	519*
Unnamed tributary to Little Cornie Bayou	305*	ER(41.3)	325*
Little Cornie Bayou from unnamed tributary to state line	215*	25*	500*
Walker Branch	180*	ER(41.3)	970*
Gum Creek	104*	ER(41.3)	311*
Bayou de Loutre above Gum Creek	250	90	500
Bayou de Loutre below Gum Creek	250	90	750
Ouachita River Camden to state line	160	40	350
Saline River	20	40	120
Saline River east bifurcation at Holly Creek	ER(15)	250	500
Hurricane Creek above Hurricane Lake dam	20	250	500
Hurricane Creek from Hurricane Lake dam to Ben Ball bridge	125	730	1,210
Hurricane Creek from Ben Ball bridge to Highway 270	125	700	1,200
Hurricane Creek from Highway 270 to mouth	100	500	1,000

Table 6.11. Numeric water quality criteria for minerals in the SCAWRPR (continued).

Waterbody	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
Alcoa unnamed tributaries to Hurricane Creek	125	700	1,100
Dry Lost Creek and tributaries	ER(15)	560	880
Lost Creek to Little Lost Creek	ER(15)	510	820
Lost Creek below Little Lost Creek	ER(15)	300	550
Holly Creek	30	860	1,600
Moro Creek	30	20	500
Smackover Creek	250	30	500
Unnamed tributary A to Flat Creek from EDCC 001 ditch to mouth	16*	80*	315*
Confluence with unnamed tributary A to Flat Creek	23*	125*	475*
Bayou de Loutre above Loutre Creek	180	ER(41.3)	970
UT004 to Bayou de Loutre	14*	ER(41.3)	311*
UT002 to Bayou de Loutre	278*	90*	500*
Loutre Creek from Highway 15 to mouth	256*	997*	1,756*
Bayou de Loutre from Loutre Creek to the discharge of City of El Dorado South facility	264*	635*	1,236*
Bayou de Loutre from discharge of the City of El Dorado South facility to Gum Creek	250*	431*	966*
Bayou de Loutre from Gum Creek to Boggy Creek	250*	345*	780*
Boggy Creek from discharge of Clean Harbors El Dorado to mouth	631*	63*	1,360*
Bayou de Loutre from Boggy Creek to Hibank Creek	250*	296*	750*
Bayou de Loutre from Hibank Creek to Mill Creek	250*	263*	750*
Bayou de Loutre from Mill Creek to Buckaloo Branch	250*	237*	750*
Bayou de Loutre from Buckaloo Branch to Bear Creek	250*	216*	750*
Bayou de Loutre from Bear Creek to final segment	250*	198*	750*
Bayou de Loutre final segment	250*	171*	750*
Ouachita River Carpenter Dam to Camden	50	40	150
Town Creek below Acme tributary	ER(18.7)	200	700
Unnamed tributary from Acme	ER(18.7)	330	830
Little Missouri River	10	90	180
Muddy Fork Little Missouri River	ER(15)	250	500
Bluff Creek and unnamed tributary	ER(15)	651*	1,033*
Garland Creek	250	250	500
South Fork Caddo	ER(15)	60	128
Back Valley Creek	ER(15)	250	500
Wilson Creek from UMETCO property line to mouth	56	250	500
Ouachita River and tributaries from headwaters to Blakely Mountain Dam (including reservoir)	10	10	100

*Based on ecoregion background flow of 4 cfs; ER = ecoregion criterion

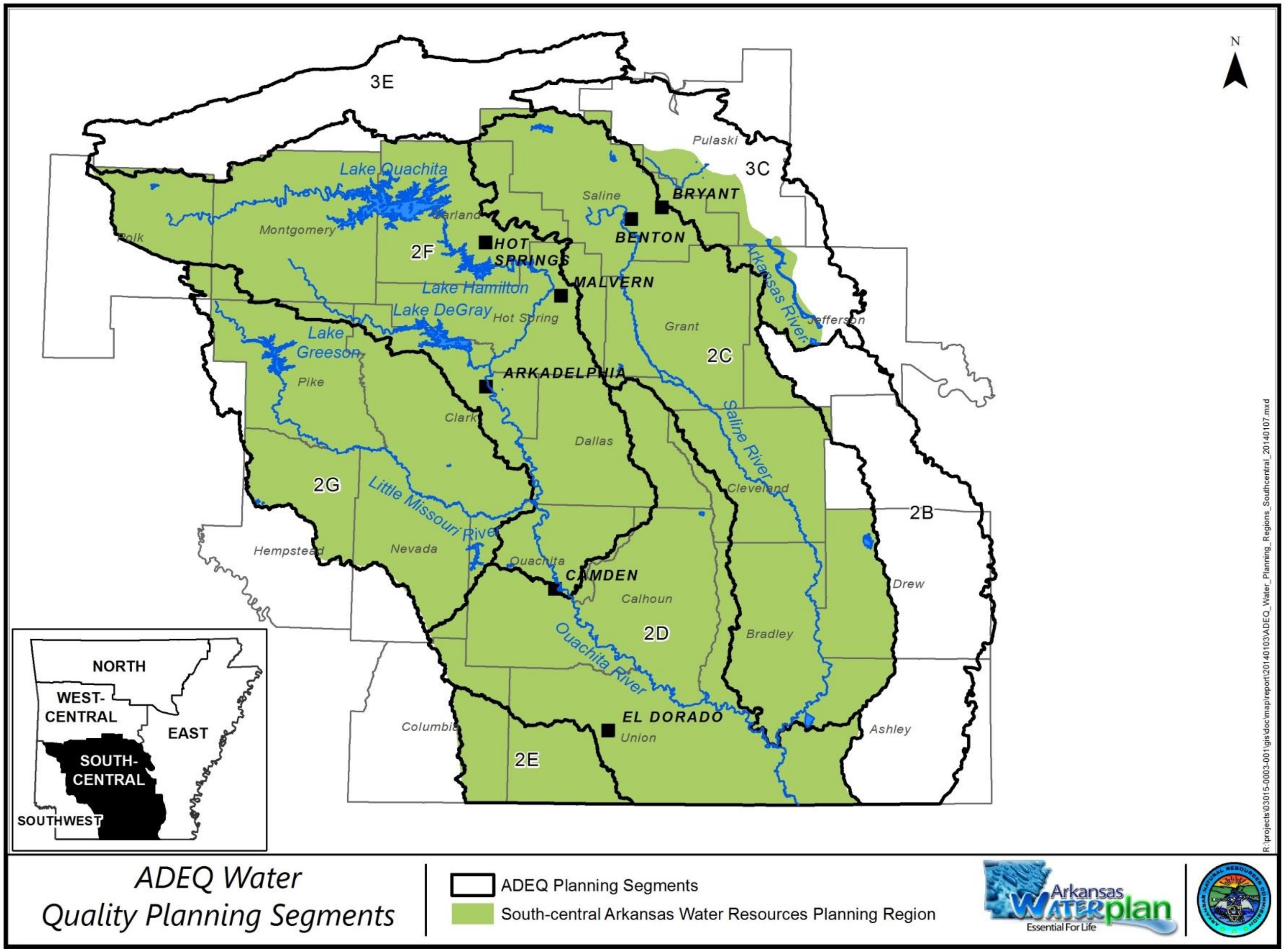

Figure 6.2. ADEQ water quality planning segments included in the SCAWRPR.

6.1.3.3 Floodplain Management Regulations

Arkansas Code provides that it is the policy of the state to encourage and support actions to prevent and lessen flood hazards and losses. The state has the authority to adopt measures that will discourage development in flood-prone land, assist in reducing damage caused by floods, and improve long-range land management in flood-prone areas (Arkansas Code §14-268-101 et seq.).

Arkansas statute also requires each county, city, or town that is participating in the NFIP to designate a "person to serve as the floodplain administrator to administer and implement the ordinance and any local codes and regulations relating to the management of flood-prone areas" (Arkansas Code §14-268-106[a]). The designated floodplain administrator must also be accredited by ANRC under the commission's authority regarding flood control. State accreditation of floodplain administrators is regulated under ANRC Title 18 rules. Continuing education for the floodplain administrator is an especially important component of the state's accreditation program (Arkansas Code §14-268-106, §15-24-102, and §15-24-109).

6.1.3.4 Water Management Regulations

Other state regulations and programs address additional aspects of water resources and their management. Table 6.12 summarizes these regulations, and the associated federal legislation. Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update.

The Arkansas Wetland Mitigation Banking Program (Arkansas Code §15-22-1002), authorized in 1995, is a state-sponsored initiative that promotes, in cooperation with federal, state, non-profit, and other interested entities, the restoration, creation, enhancement, and conservation of aquatic resources, including wetlands, streams, and deep-water aquatic habitat. This legislation authorizes ANRC to operate wetland and stream mitigation banks and to sell mitigation "credits" to private, nonprofit, and public entities required to provide mitigation for dredge and fill activities under the CWA. The "credits" represent the accrual or attainment of aquatic resource function at the mitigation bank site which results from restoration, creation, enhancement, or conservation efforts. The state wetland mitigation bank provides a cost-effective alternative for mitigating impacts. USACE regulates both public and private mitigation banking and is responsible for approving the number of "credits" available within any individual bank. When an individual or entity is required to provide compensatory mitigation for unavoidable loss of function, USACE can approve the purchase of "credits" from the state mitigation bank to satisfy all regulatory mitigation requirements. In 2013, there are no state-sponsored wetland mitigation banks in the SCAWRPR (USACE 2013).

Table 6.12. State regulations relating to water management.

Water Resources Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Title 6: Water plan compliance review procedures[1]	AWP	Arkansas Code §15-22-503 and 504	None
Title 7: Rules governing design and operation of dams[1]	Dam safety	Arkansas Code §15-22-201 et seq.	WRDA/Dam Safety and Security Act
Title 12: Rules governing the Arkansas wetland mitigation program	Wetland mitigation bank	Arkansas Wetland Mitigation Bank Act (Arkansas Code §15-22-1001 et seq.)	CWA, Rivers and Harbors Act
Rules and regulations of the Arkansas Natural Heritage Commission	Arkansas Natural and Scenic Rivers System	Arkansas Natural and Scenic Rivers System Act (Arkansas Code §15-23-301 et seq.)	Wild and Scenic Rivers Act
Arkansas Wildlife Resources Regulations[2]	Allowance for fish passage at dams.	Arkansas Code §15-44-110	
	Screens required on surface water intakes to protect fish	Arkansas Code §15-44-111	

Notes:
1. Enforcement by ANRC.
2. Enforcement by Arkansas Game and Fish Commission.

6.1.4 State Financial Assistance Programs

Arkansas has several state programs that provide financial incentives and assistance for water resources management. The federal government has delegated authority to the state to administer federal assistance programs of the CWA, the SDWA, and the Housing and Community Development Act.

6.1.4.1 Assistance for Public Water and Wastewater Projects

ANRC is responsible for managing and distributing monies from several federal assistance programs intended to assist communities in constructing and maintaining drinking water and wastewater systems (Table 6.13). There are also state-funded programs that provide financial assistance to water supply and wastewater systems (Table 6.14). Programs shown in both Tables 6.13 and 6.14 utilize both federal and state funds.

Table 6.13. Federal water supply assistance programs managed by ANRC.

Federal Program	Federal Funding Source	State Program
Community Development Block Grant Program	HUD	Arkansas Community and Economic Development Program
Safe drinking water state revolving fund, clean water state revolving fund	EPA	Water resources cost-share revolving fund program, construction assistance revolving loan fund

Table 6.14. State programs for public water system assistance (administered by ANRC).

State Water Use Regulations	State Assistance Programs	Related State Legislation
Title 5: Administrative rules and regulations for financial assistance	Water resources development general obligation bond fund; Water development fund program; Water resources cost-share revolving fund program; Water, sewer, and solid waste management system program; and Water, waste disposal, and pollution abatement facilities general obligation loan fund program	Arkansas Water Resources Cost Share Finance Act (Arkansas Code §15-22-801 et seq.), Arkansas Water, Waste Disposal, and Pollution Abatement Facilities Financing Act (Arkansas Code §15-20-1301 et seq.)
Title 15: Rules governing loans from the safe drinking water revolving loan fund	Safe drinking water revolving loan fund program, Construction assistance revolving loan fund	Arkansas Code §15-22-1101 et seq.
Title 16: Rules governing the Arkansas clean water revolving loan fund program	Clean water revolving loan fund program, Construction assistance revolving loan fund	Arkansas Code §15-5-901 et seq.
Title 23: Rules governing water and wastewater project funding through the Arkansas community and economic development program	Funding for construction or improvement of community treatment facilities for drinking water	Arkansas Code §15-5-901 et seq.

6.1.4.2 State Financial Incentive and Assistance Programs for Promoting Water Quality and Water Resources Management

ADEQ and ANRC administer a number of incentive and assistance programs related to water resources management (Table 6.15). These include programs to assist with clean-up of hazardous waste contamination, reduction of nonpoint source pollution, and management of solid wastes to protect water quality. In addition, there are state programs to encourage water conservation and preservation of wetlands. All but one of the programs listed in Table 6.15 are funded by state sources. The state nonpoint source pollution management grant program is federally funded under the authority of the Clean Water Act Section 319.

Table 6.15. State incentive and assistance programs that protect water quality.

State Regulation	State Assistance Programs	Related State Legislation	Related Federal Legislation
Regulation 11: Solid Waste Disposal Fees, Landfill Post-Closure Trust Fund, and Recycling Grants Programs[a]	Recycling fund	Solid Waste Management Recycling Fund Act (Arkansas Code §8-6-601 et seq.)	RCRA
Regulation 12: Storage Tank Regulations[a]	Petroleum storage tank trust fund	Petroleum Storage Tank Trust Fund Act (Arkansas Code §8-7-901 et seq.)	CWA, Underground Storage Tank Regulations, including Energy Policy Act of 2005
Regulation 29: Brownfields Redevelopment[a]	Clean-up funding	Arkansas Hazardous Waste Management Act (Arkansas Code §8-7-201 et seq.), Remedial Action Trust Fund Act (Arkansas Code §8-7-501 et seq.)	CERCLA
Regulation 30: Remedial Action Trust Fund, Site Priority List[a]	Clean-up funding, prioritization of contaminated sites for clean-up	Remedial Action Trust Fund Act (Arkansas Code §8-7-501 et seq.)	CERCLA
Title 5: Administrative rules and regulations for financial assistance[b]	Sewer and solid waste management systems program; Waste disposal and pollution abatement facilities general obligation bond program; Water, waste disposal, and pollution abatement facilities general obligation loan fund program	Arkansas Code §14-230-101 et seq., §15-22-601 et seq., §15-22-701 et seq.	None

Table 6.15. State incentive and assistance programs that protect water quality (continued).

State Regulation	State Assistance Programs	Related State Legislation	Related Federal Legislation
Title 10: Rules governing the Arkansas water resource agricultural cost-share program[(b)]	Arkansas water resources agricultural cost-share program	Arkansas Code §15-22-913 through 914, §15-22-507	
Title 13: Rules governing the tax credit program for the creation and restoration of private wetland and riparian zones[(b)]	Wetlands and Riparian Zone Tax Credit Program	Arkansas Private Wetland Riparian Zone Creation and Restoration Incentive Act (Arkansas Code §26-51-1501 et seq.)	None
Title 14: Rules for implementing the Water Resources Conservation and Development Incentives Act[(b)]	Groundwater conservation tax incentives	Water Resource Conservation and Development Incentives Act (Arkansas Code §26-51-1001 et seq.)	
Title 23: Rules governing water and wastewater project funding through the Arkansas community and economic development program[(b)]	Funding for construction or improvement of community treatment facilities for wastewater	None	Housing and Community Development Act
None	Nonpoint source pollution grant program[2]	None	CWA (Section 319)

Notes: Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update.

a. Responsible state agency is ADEQ.

b. Responsible state agency is ANRC.

6.1.5 Non-Regulatory State Water Management Programs

There are state agency programs for natural resources protection and management that apply to water resources. These include planning, guidance, and incentive programs. These programs do not necessarily have regulations associated with them. However, they guide the activities of state agencies related to water resources. The AWP is one such program. Others are described below.

6.1.5.1 Arkansas Nonpoint Source Pollution Management Plan

ANRC regularly prepares a state nonpoint source pollution management plan. The purpose of this plan to provide a guide and focus for public agencies, nonprofit organizations, interest groups, and other stakeholders to work together to “develop, coordinate, and implement programs to reduce, manage or abate” nonpoint source pollution. The plan is updated every 5 years. The current plan was updated in 2010.

6.1.5.2 Arkansas Forestry Best Management Practices

The Arkansas Forestry Commission has prepared a booklet of approved guidelines for conducting forest management practices in a way that minimizes water quality impacts. Implementation of these best management practices is voluntary. These management practices are applicable to commercial and private timber operations on public or private land.

6.1.5.3 State Wildlife Action Plan

A state wildlife action plan was prepared by AGFC and approved by USFWS in 2007. This plan prioritizes activities to protect species of greatest conservation need and their habitats throughout the state. This plan addresses amphibians, birds, fish, crayfish, insects, mammals, mussels, and reptiles. There are over 70 species of greatest conservation need identified in this plan that are found in the aquatic habitats in the SCAWRPR. The most highly recommended conservation activities for the ecoregions in this planning region are habitat restoration and protection (Anderson 2006).

6.1.5.4 State Wetland Strategy

A state wetland strategy was developed in 1995 by a team of Arkansas agencies. This strategy consisted of 10 elements that addressed conservation and restoration of wetlands, and improving understanding of wetlands, both by the scientific and natural resources community and by the public. Implementation of this strategy resulted in legislation that created the Arkansas Mitigation Banking Program, and the Arkansas Riparian Zone and Wetland Creation Tax Credit Program (Arkansas Multi-agency Wetlands Planning Team 1995).

6.1.6 Regional Water Resources Management Programs

Several agencies and organizations have developed water resources management or restoration programs for areas within the SCAWRPR. The purpose of some of these programs is to implement a state or federal regulation or policy, such as ambient water quality standards, no net loss of wetlands, or conservation of wildlife. These programs constitute a framework that provides opportunities for leveraging resources (personnel and funding) to accomplish water resources management goals. Examples of these regional water resources management programs are described below.

6.1.6.1 Nine-Element Watershed Plans

Watershed plans are required by the CWA to guide activities for reducing pollution in waterbodies for which TMDLs have been developed. EPA has prepared guidance describing the nine elements that should be included in watershed plans to achieve TMDLs calculated for impaired waterbodies. A nine-element watershed plan must be completed and approved by EPA before restoration projects in the watershed can receive funding from the CWA NPS Program (Section 319 funding). The Upper Saline River in the planning region has an updated NPS pollution management plan that addresses nutrient enrichment in the stream from both point and nonpoint sources (ANRC 2012a). Development of a nine-element watershed plan is a priority activity in priority watersheds designated by ANRC (see Section 5.3.5 for information on priority watersheds in the planning region).

6.1.6.2 Nonprofit Organizations

There are several nonprofit organizations that have active water resources programs within the SCAWRPR. These include The Nature Conservancy, Audubon Society, Ouachita River Valley Association, and Ducks Unlimited. Many of the water resources programs of these organizations involve state and federal agencies and their programs, along with public support.

The Nature Conservancy manages a natural area in the SCAWRPR where water resources are an important element of the ecology, Simpson Preserve at Trap Mountain. The

Nature Conservancy Ouachita Rivers Program and Conservation Forestry Program also protect and restore water resources in the planning region.

The Audubon Society has identified aquatic important bird areas in the SCAWRPR. These include a small island in Lake Ouachita, and the Felsenthal National Wildlife Refuge. These areas are important for supporting both resident and migrating waterfowl.

Ducks Unlimited has waterfowl habitat restoration projects in four counties in the SCAWRPR: Cleveland, Dallas, Hempstead, and Hot Spring.

The Ouachita River Valley Association promotes development of land and water resources in the Ouachita River basin in both Arkansas and Louisiana. The primary focus of this organization is the Ouachita-Black Rivers Navigation Project and its use for navigation, recreation, water supply, wildlife habitat, and flood control.

6.1.7 Local Regulations

There are also local regulations that influence management of water resources. These can include zoning laws; regulations promulgated by municipalities, counties, water and wastewater utilities; and regulations promulgated by irrigation, drainage, water, and sewer districts.

6.1.8 Interstate Compact

Arkansas is part of the Red River Compact, an interstate compact agreement among the states of Arkansas, Oklahoma, Texas, and Louisiana. One purpose of the compact is to promote the equitable apportionment and development of the water in the river basin among the participating states. According to Article II, Section 2.01 of the Red River Compact, each member state may use the water allocated to it by the compact in any manner deemed beneficial by that state. Each state may freely administer water rights and uses in accordance with the laws of that state, but such uses shall be subject to availability of water in accordance with the apportionments made by the compact.

There are five defined reaches in the Red River Basin covered by the compact (Figure 6.3). The SCAWRPR is included in Reach IV of the Red River. Guaranteed minimum flows are not set for the Ouachita River, nor other planning region streams in the compact. However, a flow criterion of 780 cfs is defined for the Ouachita River at the state line. When this flow is reached, Arkansas agrees to manage diversions from the Ouachita River to ensure an equitable portion of flow passes into Louisiana (Red River Compact Commission 1978).

6.2 Institutional Framework

Governmental responsibility for water resources management in the SCAWRPR is split among many agencies on three levels (federal, state, and local). As a result, management of water resources in the SCAWRPR can require coordination among a number of government entities. In addition, there are a number of non-governmental organizations that participate in water resources management in the planning region.

6.2.1 Federal Agencies

There are 17 federal agencies involved in water resources management in the SCAWRPR. These federal agencies are listed in Table 6.16, along with their respective activities in this planning region.

6.2.2 Arkansas Agencies

There are over 20 Arkansas agencies involved in water resources management in the SCAWRPR. These state agencies are listed in Table 6.17, along with a description of their water resources management responsibilities within the planning region.

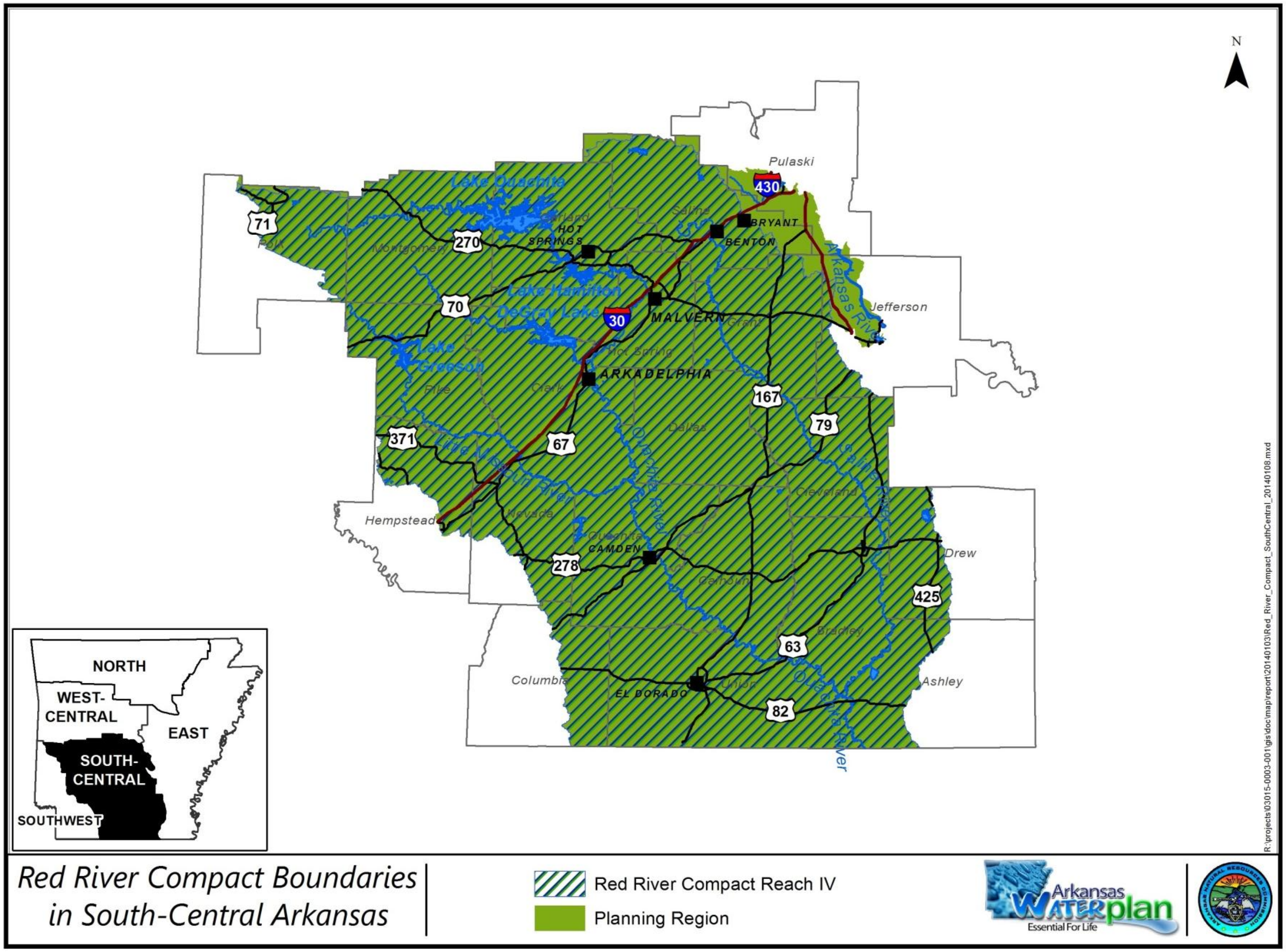

Figure 6.3. Red River Compact boundary within the SCAWRPR.

Table 6.16. Federal agencies with water resources-related responsibilities in the SCAWRPR.

Federal Agency	Responsibility in Arkansas
EPA	• Oversees state agencies in implementation of management and funding programs under: o CWA o SDWA o RCRA, o Superfund (CERCLA), o FIFRA, and o Surface Mining Control and Reclamation Act. • Conducts TMDL studies and other water quality studies in the state. • Implements programs under TSCA.
Federal Energy Regulatory Commission	• Oversees environmental matters related to natural gas and hydropower projects in the planning region.
FEMA	• Prepares flood hazard maps for the state and encourages state and local governments to guide development decisions away from defined flood hazard risk areas through participation in the NFIP.
HUD	• Provides funding for water and wastewater infrastructure improvements.
NOAA	• Participates in monitoring precipitation and climate in the planning region.
NRCS	• Implements over 20 Farm Bill erosion control and habitat restoration funding and technical assistance programs in the planning region. • Appraises the status and trends of soil, water, and related resources on non-federal land in the state and assesses their capability to meet present and future demands.
NRCS National Water Management Center	• Located in Little Rock. • Serves as a water resources information exchange. • Provides support and training related to: o Environmental compliance, o Hydrology and hydraulics, o Stream geomorphology and restoration, o Water quality and quantity, o Watershed and dam rehabilitation, and o Technology outreach.
Southwestern Power Administration	• Markets and delivers hydroelectric power produced at USACE hydropower projects in the planning region.
USACE	• Manages federal water, navigation, flood control, and hydropower projects in the planning region. • Implements sections of the CWA related to impacts to navigable waters and wetlands. • Constructs flood control, water supply projects, and conducts water resources studies authorized by the WRDA. • Oversees conducts water resources studies, dam safety for federal dams.

Table 6.16. Federal agencies with water resources-related responsibilities in the SCAWRPR (continued).

Federal Agency	Responsibility in Arkansas
USDA	• Conducts the Census of Agriculture. • Conducts the Natural Resources Inventory. • Manages Conservation Effects Assessment Projects (watershed and regional).
USDA Farm Services Agency	• Implements the CRP for erosion control and habitat restoration in the planning region.
USDA Rural Development	• Implements USDA rural utilities financial assistance programs
USDI National Park Service	• Manages one national park and associated water resources within the planning region. • Provides funds for land and water conservation projects.
USFS	• Manages the Ouachita National Forest and associated surface waters. • Forest management incentive programs. • Participates in forest inventory. • Manages Urban and Community Forestry Program.
USFWS	• Implements the Endangered Species Act and programs to: o Promote management of ecosystems, o Promote conservation of migratory birds, o Promote preservation of wildlife habitat, o Promote restoration of fisheries, o Combat invasive species, and o Promote international wildlife conservation. • Manages Felsenthal NWR in the planning region. • Implements the Partners For Wildlife Program for restoration of bottomland hardwood forests. • Conducts the National Wetland Inventory. • Oversees state wildlife planning through the State Wildlife Grant Program.
USGS	• Flow and stage monitoring of rivers and streams. • Groundwater level monitoring. • Water quality monitoring. • Groundwater modeling. • Water quality modeling. • Water data storage and management.
US Army	• Manages water resources associated with Pine Bluff Arsenal.

Table 6.17. State agencies and entities with responsibilities related to water resources in the SCAWRPR.

State Agency	Responsibility
ADEQ	• Implements state water quality policy and the NPDES program. • Develops and enforces water quality standards. • Investigates citizen complaints regarding water pollution. • Oversees solid waste management. • Operates the hazardous waste management program. • Manages contaminated site clean-up and redevelopment programs. • Develops and enforces mining and mine site reclamation regulations. • Manages the storage tank regulation program. • Permits no-discharge facilities and underground injection operations. • Water quality monitoring and assessment.
ANRC	• Regulates, permits, and tracks water use and dam construction. • Monitors climate. • Administers federal water resources funding programs. • Prepares water resources and nonpoint source pollution management plans. • Develops and maintains mitigation banking and restoration incentive programs for aquatic resources. • Supports conservation districts. • Registers poultry feeding operations. • Certifies nutrient management planners and applicators. • Promotes public health and safety and minimize flood losses through: o Training, o Education, o Technical assistance in floodplain management, and o Accrediting floodplain administrators.
ADH	• Regulates public water supply systems. • Implements the SDWA source water protection programs. • Issues fish consumption advisories. • Implements state health rules and regulations that apply to water resources. • Regulates septic tanks and licenses septic tank cleaners. • outdoor bathing and swimming. • Implements state marine sanitation program.
Arkansas Department of Parks and Tourism	• Manages the 11 state parks and associated water resources in the planning region. • Prepares comprehensive outdoor recreation plan. • Manages outdoor recreation grant program.
Arkansas Forestry Commission	• Provides guidelines for protection of water resources in forestry operations. • Monitors use of forestry BMPs. • Participates in forest inventory. • Implements forest management incentive programs. • Implements Urban and Community Forestry program. • Designates and manages state forests for a variety of purposes, including: o Watershed protection, and o Erosion and flood control.

Table 6.17. State agencies and entities with responsibilities related to water resources in the SCAWRPR (continued).

State Agency	Responsibility
AGFC	• Manages protection, conservation and preservation of fish and wildlife in the planning region through: o Habitat management, o Wildlife management areas, o Fish stocking, o Hunting and fishing regulations, and o Education and outreach programs. • Prepares state Wildlife Action Plan. • Implements conservation grant programs. • Manages over 5,000 acres of public waters in the planning region.
Arkansas Geological Survey	• Participates in research of, and provides information and education about, state water resources. • Performs mapping. • Maintains water well construction records.
Arkansas Livestock and Poultry Commission	• Regulates disposal of livestock carcasses.
Arkansas Multi-agency Wetland Planning Team	• Developed the state wetland strategy and is the lead for developing state numeric nutrient criteria for wetlands.
ANHC	• Surveys and conducts research on natural communities in the state. • Acquires natural areas for preservation. • Manages the Arkansas Natural and Scenic Rivers system.
Arkansas Oil and Gas Commission	• Provides technical assistance related to protection of water resources from wastes associated with production of the following: o Oil, o Natural gas, and o Brine. • Issues permits for drilling and operation of the following: o Oil, natural gas, and brine production wells, and o Injection and disposal wells.
APCEC	• Environmental policy-making body for the state.
Arkansas Public Service Commission	• Regulates rates and services of private water utilities, as well as utilities water crossings.
Arkansas State Board of Health	• Promulgates health rules and regulations for the state.
Arkansas State Highway and Transportation Department (AHTD)	• Issues hazardous waste transportation permits. • Provides stormwater management. • Develops and implements construction BMPs.

Table 6.17. State agencies and entities with responsibilities related to water resources in the SCAWRPR (continued).

State Agency	Responsibility
Arkansas State Plant Board	• Implements Insecticide, Fungicide, and Rodenticide Act programs, including: o Pesticide registration, o User and applicator training, and o Dealer licensing. • Implements state pesticide management plan for groundwater protection. • Provides groundwater quality monitoring, and • Provides climate/weather monitoring
Arkansas Water Well Construction Commission	• Regulates development of groundwater for drinking water through licensing water well contractors and registering drillers and pump installers. • Regulates specifications for construction of water wells. • Maintains water well construction records.
Arkansas Waterways Commission	• Studies and promotes navigable waterways for transportation and economic development.
U of A Cooperative Extension Service	• Provides technical assistance to Arkansans related to water conservation, and protection and restoration of water quality.
U of A Water Resources Center	• Participates in research related to water resources, and in water resources management projects.

6.2.3 Federal-State Organizations

There are at least three federal-state organizations involved in water resources management in the SCAWRPR:

- Red River Compact Commission,
- Arkansas Conservation Partnership, and
- Arkansas Watershed Advisory Group.

The Red River Compact Commission administers the Red River Compact, which applies to the entire planning region (see Section 6.1.6). The commission is made up of one representative from the water agency of each of the member states (ANRC in Arkansas), a resident from each state chosen by the governor, and a federal representative appointed by the US president (Oklahoma Water Resources Board n.d.).

The Arkansas Conservation Partnership supports locally led natural resources conservation through coordination of education, financial, and technical assistance to landowners. Water resources and implementation of Farm Bill programs are two of the six natural resource issues that are the focus of the partnership. Members of the partnership include NRCS, other federal agencies, as well as ANRC, Arkansas Association of Conservation Districts, U of A Cooperative Extension, U of A at Pine Bluff, and Arkansas Forestry Commission. This partnership was formed in 1992 (ANRC 2012c, Cooperative Conservation America n.d.).

The Arkansas Watershed Advisory Group (AWAG) provides technical assistance to form local watershed groups, hosts an annual water quality conference, and facilitates quarterly discussions of voluntary water quality management approaches. AWAG is a consortium of federal and state agencies with private citizens (ANRC 2012c).

6.2.4 Regional and Local Entities

There are numerous regional and local entities in the SCAWRPR that are involved in activities related to water resources management. Examples of the types of local and regional entities present in this planning region are shown in Table 6.18, along with descriptions of their activities related to water resources management.

Table 6.18. Some of the regional and local government entities involved in water resources management in the SCAWRPR.

Regional or Local Entity	Water Resources Involvement
Local Conservation Districts	• Work with state and federal agencies to implement measures for the control of erosion and flooding, and conservation of soil and water resources.
County Government	• Responsible for unincorporated areas, sometimes including floodplain management and zoning.
Drainage Districts	• Plan, construct, and maintain a system to drain lands; usually created by circuit court order.
Improvement Districts	• Implement federal projects for improvement of any river, tributary, or stream bordering the state. • Created by circuit court order.
Irrigation Districts	• Distribute water resources. • Created by circuit court order.

Table 6.18. Some of the regional and local government entities involved in water resources management in the SCAWRPR (continued).

Regional or Local Entity	Water Resources Involvement
Levee Districts	• Provide for the construction and maintenance of levees for flood protection.
Red River Compact Commission	• Administers the Red River Compact.
Regional Planning and Economic Development Districts	• Improve water supply and wastewater infrastructure. • Assist Regional Solid Waste Management Districts.
Regional Solid Waste Management Districts	• Manage collection, disposal, and recycling of solid waste.
Regional Water Distribution Districts	• Public nonprofit organizations for distribution of water from USACE water projects.
Southeast Arkansas Regional Planning Commission	• Provides stormwater management education and outreach.
Universities	• Perform water resources and management research, education, and outreach.
Water districts and associations	• Water supply planning and management. • Supply water and wastewater services.

6.2.5 Nonprofit Groups

There are several nonprofit interest groups that conduct activities in the SCAWRPR that are related to water resources management. Some of these organizations are listed in Table 6.19 with a description of their water resources-related activities in the planning region.

6.2.6 Institutional Interactions in Water Resources Management

As noted at the beginning of this section, water resources management in the SCAWRPR involves numerous entities at multiple scales. Examples of the interactions among federal, state, and local entities that occur in water resources management in the SCAWRPR are presented in Table 6.20.

Table 6.19. Examples of nonprofit groups involved in water resources management in the SCAWRPR.

Nonprofit	Water Resources Involvement
Arkansas Farm Bureau	• Advocates for agriculture.
Arkansas Waterways Association	• Promotes and protects Arkansas inland transportation waterways.
Arkansas Wildlife Federation	• Promotes conservation of aquatic habitat for fish and wildlife.
Audubon Arkansas	• Promotes three aquatic Important Bird Areas in the planning region.
Ducks Unlimited	• Promotes conservation and restoration of aquatic habitat for waterfowl at several sites in the planning region.
Stream teams	• Provides water quality monitoring, stream bank rehabilitation, and restoration of fish habitat.
The Nature Conservancy	• Provides/implements the following: o Ouachita Rivers Program. o Bauxite Natural Areas. o Lorance Creek Natural Area. o Ouachita River Nature Preserve. o Simpson Preserve.
Ouachita River Valley Association	• Oversees Ouachita-Black Rivers Navigation Project.
Arkansas Water Works and Water Environment Association	• Support of water and wastewater utilities.
Arkansas Rural Water Association	• Support of rural water and wastewater utilities.
Arkansas Environmental Federation	• Advocates for industry.

Table 6.20. Examples of interactions of federal, state, and local entities in water resources management within the SCAWRPR.

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
Water use registration	USGS (houses registration database)	ANRC (program lead)	Water utilities, irrigation districts, industry (water withdrawers)
Dam safety	USACE (federal dams) FEMA (oversight)	ANRC (program lead), AGFC (dam builder), Arkansas Department of Parks and Tourism (dam builder)	Water and electric utilities, municipalities, counties (dam builders)
State climate monitoring	NOAA National Weather Service, NOAA National Climatic Data Center, USGS (precipitation monitoring), USACE (climate monitoring)	ANRC (State Climatologist), Arkansas State Plant Board (monitoring)	Community Collaborative Rain, Hail & Snow Network
Safe Drinking Water Act funding	EPA (funding)	ANRC (program lead)	Water utilities, municipalities/ communities, water districts

Table 6.20. Examples of interactions of federal, state, and local entities in water resources management within the SCAWRPR (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
Interstate water compacts	NRCS, USGS, USACE	ANRC (state representative)	Red River Compact Commission
Water Resources Conservation Tax Incentives	NRCS	ANRC (program lead), U of A Cooperative Extension Service	Conservation districts
Conservation district grants program	None	ANRC (program lead)	Conservation districts
Community development block water and wastewater grants	HUD (funding)	ANRC (program lead), Arkansas Economic Development Commission	Water utilities, wastewater utilities, water districts, sewer districts
Floodplain management	FEMA	ANRC (certification)	Levee districts, counties, and municipalities
Nonpoint source pollution management	EPA (funding), NRCS (conservation programs), USFS (BMPs), The Nature Conservancy (projects), USDA Farm Services Agency (conservation program)	ANRC (program lead), Universities, Arkansas Water Resources Center, Audubon Arkansas, U of A Cooperative Extension Service, Arkansas Farm Bureau, ADEQ (TMDLs)	Watershed organizations, conservation districts, water districts, stream teams
Clean Water Act funding program (including nonpoint source and clean water revolving fund)	EPA (funding)	ANRC (program lead)	Watershed organizations, sewer districts, municipalities, land owners, nonprofit organizations
Groundwater protection and management – critical groundwater areas	USGS, USACE (water projects)	ANRC (program lead), Water Well Construction Commission	Counties, irrigation districts (water projects)
Wetland and riparian zone tax credit program	None	ANRC (program lead)	Watershed organizations, land owners, communities
Wetland and stream mitigation	USACE (lead)	ANRC (program lead), AHTD, AGFC, ADEQ, ANHC	Land owners/developers
Non-riparian water use certification	None	ANRC (program lead)	Water utilities
Arkansas Recovery Act water and wastewater funding	Recovery Accountability and Transparency Board	ANRC (program lead)	Water utilities, wastewater utilities, water districts, sewer districts
State water utility funding	None	ANRC (program lead)	Water utilities, water districts
State wastewater utility funding	None	ANRC (program lead)	Wastewater utilities, sewer districts
NPDES discharge permits	EPA (oversight, guidance)	ADEQ (program lead)	Dischargers
Underground injection control	EPA	ADEQ (program lead), Arkansas Oil and Gas Commission (program lead)	Dischargers
Wastewater pretreatment program	EPA	ADEQ (program lead)	Dischargers

Table 6.20. Examples of interactions of federal, state, and local entities in water resources management within the SCAWRPR (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
Water quality standards	EPA	APCEC (regulations), ADEQ (implementation, enforcement), ANRC (groundwater standards), Multi-agency Wetland Planning Team (nutrient criteria for wetlands)	Local governments, regulated entities, interest groups
Water quality assessment	EPA (oversight, guidance), USGS (data), USACE (data)	ADEQ (implementation), ANRC (data)	None
TMDLs	EPA (oversight, guidance), USGS (data), USACE (data)	ADEQ (program lead)	None
Storage tank regulation	EPA	ADEQ (program lead)	Tank owners
Solid waste management	EPA (oversight)	ADEQ (program lead)	Regional solid waste management districts
Landfill post-closure trust fund	None	ADEQ (program lead)	Regional solid waste management districts
Hazardous waste management	EPA	ADEQ (program lead), AHTD (transport)	Interest groups
Remedial action trust fund	None	ADEQ	Interest groups
Brownfields	EPA	ADEQ	Municipalities
Superfund	EPA	ADEQ	Interest groups
Mining reclamation	USDI	ADEQ	Interest groups, mining companies
Water quality monitoring	EPA (oversight, studies), USGS (monitoring, studies), USACE (monitoring, studies)	ADEQ, ANRC, U of A Arkansas Water Resources Center (studies), AGFC (stream teams), Arkansas State Plant Board (groundwater monitoring), ANRC, universities	Stream teams (monitoring), water utilities (monitoring)
Fish tissue sampling	EPA (mercury), US Food and Drug Administration (guidelines)	ADEQ (program lead), ADH (consumption advisories), AGFC (sampling)	None
Stormwater management	EPA	ADEQ, U of A Cooperative Extension Service	Counties, municipalities
Spill prevention	EPA	ADEQ	Industry
Finished drinking water criteria	EPA	ADH	Water utilities, water districts
Source Water Protection	EPA	ADH, Arkansas Water Well Construction Commission	Water utilities (planning)
Drinking Water Consumer Information	EPA	ADH	Water utilities
Regulation of drinking water utilities	EPA	ADH, Arkansas Public Service Commission	Water utilities

Table 6.20. Examples of interactions of federal, state, and local entities in water resources management within the SCAWRPR (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	**State Entities**	**Regional or Local Entities**
Pesticide registration, labeling and classification	EPA	Arkansas State Plant Board	Pesticide distributors and users
Community Forestry	USFS	Arkansas Forestry Commission, Arkansas Urban Forestry Council	Municipalities
Forest stewardship	USFS, USDA Farm Services Agency, NRCS	Arkansas Forestry Commission, AGFC, ANRC, Arkansas Historic Preservation Program, U of A Cooperative Extension Service, ANHC	Landowners
Forest Legacy	USFS (funding), Land Trust Alliance	Arkansas Forestry Commission	Landowners
State parks	USACE, National Park Service (funding)	Arkansas Department of Parks and Tourism	Interest groups
Stream teams	None	AGFC	Stream teams
Wildlife management areas, refuges	USFWS	AGFC	Nonprofit organizations
Fishing and boating programs	USACE, USFWS	AGFC, Arkansas Department of Parks and Tourism	None
Pollution prevention program	EPA	ADEQ	Industry
Commercial navigation	USACE Memphis and Little Rock Districts	Arkansas Waterways Commission	Ouachita River Valley Association
Wild/Natural and scenic river systems	USFS	Arkansas Natural and Scenic Rivers Commission, ANHC, ADEQ	Watershed organizations

7.0 REFERENCES

Ackerman, D. 1987. *Generalized Potentiometric Surface of the Aquifers in the Cockfield Formation, Southeastern Arkansas, Spring 1980* [Water Resources Investigations Report 87-4212]. US Geological Survey.

ADEQ. (no date). "Treatment/Storage/Disposal Facilities in Arkansas." *Arkansas Department of Environmental Quality.* Accessed January 21, 2014, at http://www.adeq.state.ar.us/hazwaste/branch_tech/pdfs/tsds.pdf

ADEQ. 2005. *2005-2009 NPS Management Program Update: Upper Saline River Priority Watershed.* Little Rock, AR: ADEQ.

ADEQ. 2008. *Integrated Water Quality Monitoring and Assessment Report - 2008.* Little Rock, AR: Arkansas Department of Environmental Quality.

ADEQ. 2009. *Approved Arkansas 2008 Section 303(d) List.* Little Rock, AR: Arkansas Department of Environmental Quality.

ADEQ. 2011a. *Timeline of Historical Events of Arkansas Solid Waste Management, 1971 - 2011.* Little Rock, AR: Arkansas Department of Environmental Quality.

ADEQ. 2011b. *Regional Solid Waste Managment Boards (RSWMB).* (accessed September 27, 2013).

ADEQ. 2012a. *2012 Integrated Water Quality Monitoring and Assessment Report.* Little Rock, AR: Arkansas Department of Environmental Quality.

ADEQ. 2012b. *Arkansas TMDLs.* Accessed April 12, 2013, at http://www.adeq.state.ar.us/water/tmdls/default.asp#Display

ADEQ. 2012c. *State of Arkansas Nutrient Criteria Development Plan.* Little Rock, AR: Arkansas Department of Environmental Quality.

ADEQ. 2013a. *Arkansas's Remedial Trust Fund.* Accessed November 5, 2013, at http://www.adeq.state.ar.us/hazwaste/branch_tech/ratf.aspx

ADEQ. 2013b. *Solid Waste Illegal Dumps Data Files.* Accessed May 13, 2013, at http://www.adeq.state.ar.us/solwaste/branch_enforcement/illegal_dumps.asp

ADEQ. 2013c. *Surface Water Quality Monitoring Station Data Search Page.* Accessed October 1, 2013 at http://www.adeq.state.ar.us/techsvs/water_quality/water_quality_station.asp

ADEQ. 2014a. *ADEQ Facility and Permit Summary.* Accessed January 22, 2014, at http://www.adeq.state.ar.us/home/pdssql/pds.asp

ADEQ. 2014b. *Arkansas Hazardous Waste Generators Facility Summary.* Accessed January 21, 2014, at http://www.adeq.state.ar.us/hazwaste/rcra2/facil_sum.aspx

ADEQ. 2014c. *NPDES Construction Storm Water Permits Searchable Database.* Accessed January 22, 2014, at http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/construction/npdes_constructionstormwater_permit_tracking.aspx

ADEQ. 2014d. *NPDES Industrial Storm Water Permits Searchable Database.* Accessed January 22, 2014, at http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/industrial/npdes_industrial_permit_tracking.aspx

ADEQ. 2014e. *NPDES MS4 Small Storm Water Permits Searchable Database.* Accessed January 22, 2014, at http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/ms4/npdes_ms4_stormwater_permit_tracking.aspx

ADH. (no date). *Drinking Water Information for Arkansans.* Accessed March 20, 2013, at http://www.healthy.arkansas.gov/eng/autoupdates/pwslist0.htm

ADH. 2012. "Arkansas Public Water System Compliance Summary." *Arkansas Department of Health, Environmental Health, Engineering, Reports and Forms.* December 2012. Accessed July 30, 2013, at http://www.healthy.arkansas.gov/programsServices/environmentalHealth/Engineering/Documents/Reports/Compliance/ComplianceSummary.pdf

ADH, AGFC, & ADEQ. 2011. *Fish Consumption Notice - Mercury in Fish.* Little Rock, AR: Arkansas Department of Health.

ADPCE. 1990. *Arkansas Water Quality Inventory Report.* Little Rock, AR: Arkansas Department of Pollution Control & Ecology.

Advameg, Inc. 2010. *Arkansas Economy.* Accessed June 1, 2013, at http://www.city-data.com/states/Arkansas-Economy.html

AGFC. 2009. "Wildlife Management Area Boundary (polygon), Arkansas." *Geocommons.* November 18, 2009. Accessed April 25, 2013, at http://geocommons.com/overlays/18197

AGFC. 2011. *Where to Fish.* Accessed December 17, 2013, at http://www.agfc.com/fishing/Pages/FishingWheretofish.aspx

AGFC. 2013a. *General Fishing Regulations.* Accessed 2013 at http://www.agfc.com/fishing/pages/fishingregulations.aspx

AGFC. 2013b. *The Great Outdoors, A $1.8 Billion Business in Arkansas* [brochure]. Little Rock, AR: Arkansas Game and Fish Commission.

AGFC. 2013c. *T&E Species by County.* December 10, 2013. Accessed January 2014 at http://www.fws.gov/arkansas-es/te_cty_list.html

AHTD. 2006. "Public Land Boundary (polygon)." *GeoStor.* August 29, 2006. Accessed April 25, 2013, at http://www.geostor.arkansas.gov/G6/Home.html?q=public+land+boundary

Albin, D.R. 1964. *Geology and Ground-water Resources of Bradley, Calhoun, and Ouachita Counties, Arkansas* [Water Supply Paper 1779-G]. Little Rock, AR: US Geological Survey.

Albin, D.R. 1965. *Water-resources Reconnaissance of the Ouachita Mountains, AR* [Water Supply Paper 1809-J]. Little Rock, AR: US Geological Survey.

Anderson, J.E. (editor). 2006. *Arkansas Wildlife Action Plan.* Little Rock, AR: Arkansas Game and Fish Commission.

ANHC. 2010. *Natural Areas.* Accessed March 22, 2013, at http://www.naturalheritage.com/natural-area/default.aspx

ANHC. 2013. *Rare Species Search Engine: Find Arkansas Endangered Species.* Accessed July 2013 at http://www.naturalheritage.com/research-data/rarespecies-search.aspx

ANRC. 1996. "The designation of the Sparta aquifer within Bradley, Calhoun, Columbia, Ouachita, and Union Counties as a Critical Ground Water Area." Accessed May 31, 2013, at http://www.anrc.arkansas.gov/Rules%20and%20Regulations/orders/1995-1_designation_of_sparta_as%20cgwap.pdf

ANRC. 2010. "Facts About Critical Groundwater Designation." Arkansas Natural Resources Commission Water Resources Management Division. Accessed May 16, 2013, at http://www.anrc.arkansas.gov/groundwater/gw_designation_graphic.pdf

ANRC. 2011.*Water Law in Arkansas.* Little Rock, AR: Arkansas Natural Resources Commission.

ANRC. 2012a. “Section 19: Upper Saline River Watershed.” *2011-2016 NPS Pollution Managment Plan.* Accessed December 7, 2013, at http://arkansaswater.org/index.php?option=com_content&task=view&id=354&Itemid=98

ANRC. 2012b. *Arkansas Ground-Water Protection and Management Report for 2011.* Little Rock, AR: Arkansas Natural Resources Commission.

ANRC. 2012c. "Interagency Coordination Teams." *Arkansaswater.org.* Accessed July 2013 at http://arkansaswater.org/index.php?option=com_content&task=view&id=241

ANRC. 2012d. *Rules and Regulations.* Accessed May 24, 2013, at http://www.anrc.arkansas.gov/Rules%20and%20Regulations/rules_and_regulations.html

APCEC. 2011. *Regulation No. 2, Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas.* Little Rock, AR: Arkansas Pollution Control and Ecology Commission.

Arkansas Department of Parks and Tourism. 1991. *1990 Arkansas Travel and Tourism Report.* Little Rock: Arkansas Department of Parks and Tourism.

Arkansas Department of Parks and Tourism. 2012a. "2012 Annual Report." *Arkansas Tourism Official Site.* Accessed June 2013 at http://www.arkansas.com/!userfiles/editor/docs/apt-annual-report-financials-2012.pdf

Arkansas Department of Parks and Tourism. 2012b. "DeGray Lake Resort State Park." *The Encyclopedia of Arkansas History & Culture.* May 24, 2012. Accessed October 30, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=1220

Arkansas Department of Parks & Tourism. 2013. *Little Missouri River.* Accessed October 30, 2013, at http://www.arkansas.com/places-to-go/lakes-rivers/river.aspx?id=8

Arkansas Geological Survey. 2012a. *Mineral Commodity Search/Map.* Accessed November 2013 at http://www.geology.ar.gov/minerals/mining_map.htm

Arkansas Geological Survey. 2012b. *Ouachita Mountains.* Accessed March 12, 2013, at http://www.geology.ar.gov/education/ouachita_mtns.htm

Arkansas Geological Survey. 2013. *Annual Report of Production 2012.* Little Rock, AR: Arkansas Geological Survey.

Arkansas Multi-agency Wetlands Planning Team. 1995. *Arkansas Wetland Resource Information System, Arkansas State Wetland Strategy.* Accessed March 2013 at http://awrims.cast.uark.edu/home/ar-wetland-strategy.aspx

Arkansas River Compact Committee. 1970. *Arkasnas River Basin Compact, Arkansas-Oklahoma, 1970.* Austin: Office of U.S. Representative.

Arkansas Soil and Water Conservation Commission. 1988. *Arkansas State Water Plan Eastern Arkansas Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

Arkansas Soil and Water Conservation Commission. 1987a. *Arkansas State Water Plan, Upper Ouachita Basin.* Little Rock: Arkansas Soil and Water Conservation Commission, 1987a.

Arkansas Soil and Water Conservation Commission. 1987b. *Arkansas State Water Plan Lower Ouachita Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

Arkansas Waterways Commission. 2013. *2011-2012 Biennial* [biennial report]. Little Rock, AR: Arkansas Waterways Commission.

Arthur, J.K., and R.E. Taylor. 1990. *Definition of the Geohyrologic Framework and Preliminary Simulation of the Ground-water Flow in the Mississippi Embayment Aquifer System, Gulf Coastal Plain, United States* [Water Resources Investigation Report 86-4364]. US Geological Survey.

Association of Arkansas Counties. 2013. *Association of Arkansas Counties.* Accessed October 16, 2013, at http://www.arcounties.org/

ASWCC. 1981. *Arkansas State Water Plan, Lakes of Arkansas.* Little Rock, AR: Arkansas Soil and Water Conservation Commission.

ASWCC. 1987a. *Arkansas State Water Plan, Lower Ouachita Basin.* Little Rock, AR: Arkansas Soil and Water Conservation Commission.

ASWCC. 1987b. *Arkansas State Water Plan, Upper Ouachita Basin.* Little Rock, AR: Arkansas Soil and Water Conservation Commission.

ASWCC. 1988. *Arkansas State Water Plan Eastern Arkansas Basin.* Little Rock: Arkansas Soil and Water Conservation commission.

ASWCC. 1990. *Arkansas Water Plan Executive Summary.* Little Rock, AR: Arkansas Soil and Water Conservation Commission.

Baker, R.C., Hewitt, F. A., and Billingsley, G.A. 1948. Ground-water resources of the El Dorado Area, Union County, Arkansas. University of Arkansas Bulletin 42(12):39.

Balogh, G.W. 2013. "Timber Industry." *The Encyclopedia of Arkansas History and Culture.* April 2, 2013. Accessed July 23, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2143

Bolton, S.C. 2012. "Louisiana Purchase through Early Statehood, 1803 through 1860." May 22, 2012. Accessed February 13, 2013, at http://www.encyclopediaofarkansas.net

Boswell, E.H., and R.L. Hosman. 1964. *General Geology of the Mississippi Embayment* [Professional Paper 448-B]. Little Rock, AR: US Geological Survey.

Boswell, E.H., G.K. Moore, L.M. MacCary, H.G. Jeffery, and others. 1965. *Water Resources of the Mississippi Embayment; Cretaceous Aquifers in the Mississippi Embayment, with Discussions on Quality of the Water* [Professional Paper 448-C]. Little Rock, AR: US Geological Survey.

Brandeis, C., T.G. Johnson, M. Howell, and J.W. Bentley. 2011. *Arkansas' Timber Industry - An Assessment of Timber Product Output and Use, 2009* [Resource Bulletin SRS-183]. Asheville, NC: USDA Forest Service Southern Research Station.

Branyan, S. 2013. "Floods." *The Encylopedia of Arkansas History & Culture.* May 10, 2013. Accessed October 31, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=5148

Brenton, A.L., and others. 2002. *Water for Saline County: A Tale of Two Futures.* Little Rock. AR: University of Arkansas at Little Rock.

Bridges, K. 2011. "Oil Industry." *The Encyclopedia of Arkansas History and Culture.* July 29, 2011. Accessed June 21, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=383

Broom, M.E., T.F. Kraemer, and W.V. Bush. 1984. *A reconnaissance study of the saltwater contamination in the El Dorado Aquifer, Union County, Arkansas* [Water-Resources Investigations Report 84-4012]. US Geological Survey.

Buckner, E. 2011. "Climate and Weather." *The Encyclopedia of Arkansas History and Culture.* December 16, 2011. Accessed March 15, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=4579

Census State Data Center. 2013. *1990 Arkansas Census Data.* Accessed May 31, 2013, at http://www.aiea.ualr.edu/arkansas-census-data.html?id=150:1990-arkansas-census-data&catid=1

Central Arkansas Water. (no date). *Lake Winona* [brochure]. Little Rock, AR: Central Arkansas Water. Available online at http://www.carkw.com/wp-content/uploads/2011/07/lake_winona_brochure-_2007.pdf

Central Arkansas Water. 2010. *Regionalism and Future Water Source.* Accessed January 2014 at http://www.carkw.com/water-source-info/regionalism-future-water-source/

Clark, B.R., and R.M. Hart. 2009. *The Mississippi Embayment Regional Aquifer Study (MERAS): Documentation of a Groundwater-Flow Model Constructed to Assess Water Availability in the Mississippi Embayment* [Scientific Investigations Report 2009-5172]. Reston, VA: US Geological Survey.

Clark, B.R., R.M. Hart, and J.J. Gurdak. 2011. *Groundwater availability of the Mississippi embayment* [Professional Paper 1785]. US Geological Survey.

Clark, P., and L. Karklis. 2012. "USDA Upgrades Plant Hardiness Zone Map." *Washington Post.* January 25, 2012. Accessed March 2013 at http://www.washingtonpost.com/wp-srv/special/local/planthardinesszones/index.html

Cole, E.F., and E.E. Morris. 1986. *Water Resources of the Ouachita National Forest, AR* [Water Resources Investigations Report 86-4166]. Little Rock, AR: US Geological Survey.

Cooperative Conservation America. (no date). *Cooperative Conservation Case Study, Arkansas Conservation Partnership.* Accessed July 29, 2013, at http://www.cooperativeconservation.org/viewproject.asp?pid=103

Cottingham, J. 2012. "Arkansas' Bromine Industry Sees Rebound." *Arkansas Business.* September 10, 2012.

Counts, H.B., D.B. Tait, H. Klein, and G.A. Billingsley. 1955. *Ground-water Resources in a Part of Southwestern Arkansas* [Water Resources Circular No. 2]. Little Rock, AR: Arkansas Geological Commission.

Crist Engineers, Inc. 2013. *Water Supply Study, City of Hot Springs, AR.* Little Rock, AR: Crist Engineers, Inc.

Department of Arkansas Heritage. 2013a. *Discover Arkansas History, Regions - Gulf Coastal Plain.* Accessed March 12, 2013, at http://www.arkansasheritage.com/discover/natural_environments/regions/coastalplain.aspx

Department of Arkansas Heritage. 2013b. *Discover Arkansas History, Regions - Ouachita Mountains.* Accessed March 12, 2013, at http://www.arkansasheritage.com/discover/natural_environments/regions/ouachitas.aspx

Dollof, J.H., R.A. Rozendal, E.N. Siratovich, F.M. Swain, and J. Woncik. 1967. Subsurface Upper Cretaceous stratigraphy of southwestern Arkansas. *Gulf Coast Association of Geological Survey Transactions* 17: 76-104.

Early, A.M. 2010. "Salt Making." *The Encyclopedia of Arkansas History and Culture*. June 21, 2010. Accessed April 2, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=567

Early, A.M. 2012. "Prehistoric Caddo." *The Encyclopedia of Arkansas History and Culture*. May 2, 2012. Accessed April 2, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=548

EPA. 2008. *Handbook for Developing Watershed TMDLs.* Washington, DC: US Environmental Protection Agency.

EPA. 2009. *2009 edition of the drinking water standards and health advisories* [EPA 822-R-09-011]. Washington, DC: US Environmental Protection Agency, Office of Water.

EPA. 2012a. *Landfills.* November 15, 2012. Accessed June 3, 2013, at http://www.epa.gov/osw/nonhaz/municipal/landfill.htm

EPA. 2012b. *Large Quantity Generators.* July 24, 2012. Accessed July 9, 2013, at http://www.epa.gov/osw/hazard/generation/lqg.htm

EPA. 2012c. *Small Quantity Generator.* July 24, 2012. Accessed July 9, 2013, at http://www.epa.gov/osw/hazard/generation/sqg/index.htm

EPA. 2012d. *Arkansas Site Status Summaries.* July 10, 2012. Accessed November 5, 2013, at http://www.epa.gov/region6/6sf/6sf-ar.htm

EPA. 2012e. *Basic Information.* June 6, 2012. Accessed June 11, 2013, at http://water.epa.gov/infrastructure/drinkingwater/pws/dwoperatorcert/basicinformation.cfm

EPA. 2013a. *Western Ecology Division.* www.epa.gov/wed/pages/ecoregions.htm (accessed June 2013).

EPA. 2013b. *Compensatory Mitigation.* February 22, 2013. Accessed June 17, 2013, at http://water.epa.gov/lawsregs/guidance/wetlands/wetlandsmitigation_index.cfm

EPA. 2013c. *Consumer Confidence Reports.* January 3, 2013. Accessed at http://water.epa.gov/lawsregs/rulesregs/sdwa/ccr/

EPA. 2013d. *Nutrient Policy Data, What EPA is Doing.* April 17, 2013. Accessed July 12, 2013, at http://www2.epa.gov/nutrient-policy-data/what-epa-doing

EPA. 2013e. *EPA Information Related to the American Recovery and Reinvestment Act of 2009*. EPA. http://www.epa.gov/recovery/basic.html (accessed April 1, 2014).

EPA. n.d. *EPA Recovery Mapper.* http://epamap17.epa.gov/arra/# (accessed April 2014).

Filipek, S., W.E. Keith, and J. Giese. 1987. *The Status of the Instream Flow Issue in Arkansas, 1987*. Proceedings Arkansas Academy of Science 41: 43-48.

Foshee, D.R. 2013. "Narrows Dam." *The Encylopedia of Arkansas History & Culture.* May 10, 2013. Accessed October 30, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=6028

Foti, T. 2008. *The Natural Divisions of Arkansas.* Little Rock, AR: Arkansas Natural Heritage Commission.

Foti, T. 2011. "Ouachita Mountains." *The Encyclopedia of Arkansas History and Culture.* February 4, 2011. Accessed March 12, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=442

Fry, J. et al. 2011. "Completion of the 2006 national land cover database for the conterminous United States." *PE&RS* 77(9): 858-864.

Galloway, J.M., B.E. Haggard, M.T. Meyers, and W.R. Green. 2005. *Occurence of Pharmaceuticals and Other Organic Wastewater Constituents in Selected Streams in Northern Arkansas, Scientific Investigations Report 2005-5140.* Reston, VA: USGS.

GCGW. 2008. *Arkansas Governor's Commission on Globla Warning Final Report.* Little Rock, AR: Arkansas Governor's Commission on Global Warming.

Gore, G. 2009. "Ouachita River." *The Encyclopedia of Arkansas History and Culture.* Accessed April 9, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2392

Grappe, M.F. 2011. *Combined Regional Solid Waste Management Plan Regional Needs Assessment Annual Waste Tire Site Report and Annual Recycling Program Report for Saline County Regional Solid Waste Management District.* Little Rock, AR: Arkansas Department of Environmental Quality.

Gray, J. 1993. *Arkansas Forest History.* Accessed June 3, 2013, at http://arkforests.org/foresthistory.html

Halberg, H.N., and Stephens, J.W. 1966. Use of water in Arkansas, 1965. Little Rock, AR: State of Arkansas Geological Commission. Water Resources Summary Number 5.

Halberg, H.N., C.T. Bryant, and M.S. Hines. 1968. *Water Resources of Grant and Hot Spring Counties, AR* [Water Supply Paper 1857]. Little Rock, AR: US Geological Survey.

Hale, H., Baker, R.C., Walling, I.W., Parrish, D.M., Billingsley, G.A. 1947. Public Water Supplies of Arkansas. Fayetteville, AR: University of Arkansas. Bulletin, Research Series No. 11.

Haley, B.R., and Arkansas Geologic Commission Staff. 1993. *Geologic Map of Arkansas.* Little Rock: Arkansas Geological Survey.

Hart, R.M., B.R. Clark, and S.E. Bolyard. 2008. *Digital Surfaces and Thicknesses of Selected Hydrogeologic Units within the Mississippi Embayment Regional Aquifer Study (MERAS)* [Scientific Investigation Report 2008-5098]. US Geological Survey.

Hawkins, V. 2011. "Cotton Industry." *The Encyclopedia of Arkansas History and Culture.* April 8, 2011. Accessed February 13, 2013, at http://www.encyclopediaofarkansas.net

Hays, P.D., J.K. Lovelace, and T.B. Reed. 1998. *Simulated response to pumping stress in the Sparta aquifer of southeastern Arkansas and north-central Louisiana, 1998-2027* [Water-Resources Investigations Report 98-4121]. US Geological Survey.

Hewitt, F.A., R.C. Baker, and G.A. Billingsley. 1949. *Ground-water resources of Ashley County, Arkansas* [Research Series 14]. University of Arkansas, Institute of Science and Technology.

Hill, J. 2010. "Bromine." *The Encyclopedia of Arkansas History and Culture.* November 12, 2010. Accessed November 2013 at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=4514

Holmes, R.R., and D.M. Wagner. 2011. *Flood of June 11, 2010, in the Upper Little Missouri River Watershed, Arkansas* [Scientific Investigations Report 2011-5194]. Little Rock, AR: US Geological Survey.

Hosman, R.L. 1982. *Outcropping Tertiary Units in Southern Arkansas* [Miscellaneous Investigations Series I-1405]. US Geological Survey.

Hosman, R.L., and J.S. Weiss. 1991. *Geohydric Units of the Mississippi Embayment and Texas Coastal Uplands Aquifer Systems, South-central United States* [Professional Paper 1416-B]. Little Rock, AR: US Geological Survey.

Hosman, R.L., A.T. Long, T.W. Lambert, H.G. Jeffery, and others. 1968. *Tertiary Aquifers in the Mississippi Embayment with Discussions of Quality of the Water by H.G. Jeffery* [Professional Paper 448-D]. Little Rock, AR: US Geological Survey.

Joseph, R.L. 1998. *Potentiometric Surfaces of Aquifers in the Cockfield Formation in Southeastern Arkansas and the Wilcox Group in Southern and Northeastern Arkansas, October 1966-July 1997* [Water Resources Investigation Report 98-4084]. Little Rock, AR: US Geological Survey.

Key, J.P. 2012. "European Exploration and Settlement, 1541 through 1802." *The Encyclopedia of Arkansas History and Culture.* May 22, 2012. Accessed March 25, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2916&type=Time+Period&item=European+Exploration+and+Settlement+%281541+-+1802%29&parent=&grandparent=

Klimas, C.V., E.O. Murray, J. Pagan, H. Langston, and T. Foti. 2005. *A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Funchtions of Forested Wetlands in the West Gulf Coastal Plain Region of Arkansas* [ERDC/EL TR-05-12]. Vicksburg, MS: US Army Corps of Engineers.

Kresse, T.M., and Fazio, J.A. 2002. Pesticides, water quality, and geochemical evolution of ground water in the alluvial aquifer, Bayou Bartholomew Basin, Arkansas. Little Rock, AR: Arkansas Department of Environmental Quality. Water Quality Report WQ02-05-1.

Kresse, T.M., and J. Fazio. 2003. *Occurrence of Arsenic in Ground Waters of Arkansas and Implications for Source Release Mechanisms.* Little Rock, AR: Arkansas Department of Environmental Quality.

Kresse, T.M, and P.D Hays. 2009. *Geochemistry, Comparative Analysis, and Physical and Chemical Characteristics of the Thermal Waters East of Hot Springs National Park, Arkansas, 2006-09* [Scientific Investigations Report 2009-5263]. Little Rock, AR: US Geological Survey.

Kresse, T.M., P.D. Hays, K.R. Merriman, J.A. Gillip, D.T. Fugitt, J.L. Spellman, A.M. Nottmeirer, D.A. Westerman, and J.M. Blackstock. 2013. *Aquifers of Arkansas: protection, management, and hydrologic and geochemical characteristics of Arkansas' groundwater resources* (in review). Little Rock, AR: US Geological Survey.

lakeouachita.org. 2013. *Lake Ouachita History.* January 2013. Accessed October 31, 2013, at http://www.lakeouachita.org/lake-ouachita-history.htm

Lancaster, G. 2011. "Little Missouri River." *The Encyclopedia of Arkansas History and Culture.* May 18, 2011. Accessed October 2013 at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=6342

Lancaster, G. 2012a. "Blakely Mountain Dam." *The Encyclopedia of Arkansas History and Culture.* October 17, 2012. Accessed June 21, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=5815

Lancaster, G. 2012b. "Carpenter Dam." *The Encyclopedia of Arkansas History and Culture.* October 17, 2012. Accessed December 2013 at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=4731

Lancaster, G. 2012c. "DeGray Dam and Lake." *The Encyclopedia of Arkansas History and Culture.* October 17, 2012. Accessed June 21, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2615

Lancaster, G. 2012d. "Hot Springs (Garland County)." *The Encyclopedia of Arkansas History and Culture.* October 17, 2012. Accessed December 2013 at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=887

Leidy, V.A., and R.E. Taylor. 1992. *Overview of Suscetibility of Aquifers to Contamination, Union County, Arkansas* [Water Resources Investigations Report 92-4094]. US Geological Survey.

Little Rock District Army Corps of Engineers. 1988b. *Arkansas State Water Plan Upper White River Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

Ludwig, A.H. 1972. *Water Resources of Hempstead, Lafayette, Little River, Miller, and Nevada Counties, Arkansas* [Water Supply Paper 1998]. Little Rock, AR: US Geological Survey.

Ludwig, A.H. 1992. *Flow Duration and Low-Flow Characteristics of Selected Arkansas Streams.* Water-Resources Investigations Report 92-4026, Little Rock, AR: US Geological Survey.

May, Dennis M. 1990. *Development and Status of Arkansas Primary Forest Products Industry*. [Resource Bulletin 50-152]. New Orleans: US Forest Service Southern Forest Experiment Station.

Mayfield, W. 2001. "Arkansas Mineral Resources" (map). Little Rock, AR: Arkansas Geological Commission.

McFarland, J.D. 2004. "Stratigraphic summary of Arkansas." *Arkansas Geological Commission Information Circular 36*.

McNeill, M. 2013. "Lower White Oak Lake refilling after gate work." *Magnolia Reporter.*February 18, 2013. Accessed January 8, 2014, at http://www.magnoliareporter.com/sports/individual_team_sports/article_8d5e9c32-7997-11e2-b67a-0019bb2963f4.html

Moneyhon, C.H. 2013. "Post-Reconstruction through the Gilded Age, 1875 through 1900." *The Encyclopedia of Arkansas History and Culture.* May 14, 2013. Accessed July 23, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=402

Morrow, L. 2013. "A 'Duck and Goose Shambles': Sportsmen and market hunters at Big Lake, Arkansas." *Big Muddy.* Accessed September 16, 2013, at http://www6.semo.edu/universitypress/bigmuddy/NF/A_Duck_and_Goose_Shambles.htm

Moseley, Ron. 2011. "Parnell Springs." *The Encyclopedia of Arkansas History and Culture.* August 11, 2011. Accessed January 2014, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=2849

Nachtmann, H. 2002. *Economic Evaluation of the Impact of Waterways on the State of Arkansas.* Fayetteville, AR: University of Arkansas.

National Agricultural Law Center. 2012. *United States Farm Bills.* Accessed June 11, 2013, at http://www.nationalaglawcenter.org/farmbills/

National Weather Service. 2013. *National Weather Service Weather Forecast Service, Little Rock, AR.* http://www.srh.noaa.gov/lzk/?n=pns071112txt.htm (accessed May 15, 2013).

The Nature Conservancy. 2013. *Arkansas Places We Protect.* Accessed March 22, 2013, at http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/arkansas/placesweprotect/index.htm

NatureServe. 2002. *States of the Union: Ranking America's Biodiversity.* Arlington: The Nature Conservancy.

NOAA NCDC. (no date). "Climate of Arkansas." *National Climatic Data Center.* Accessed May 15, 2013, at http://hurricane.ncdc.noaa.gov/climatenormals/clim60/states/Clim_AR_01.pdf

NOAA NCDC. 2013a. *Climate at a Glance.* Accessed September 12, 2013, at http://www.ncdc.noaa.gov/cag/

NOAA NCDC. 2013b. *Climate Data Online: Text and Map Search.* Accessed May 2013 at http://www.ncdc.noaa.gov/cdo-web/#t=secondTabLink

NOAA NCDC. 2013c. *Plot Time Series.* 2013b. Accessed June 2013 at http://www.ncdc.noaa.gov/temp-and-precip/time-series/index.php

NOAA. 2012. "The Palmer Drought Severity Index." *NOAA's Drought Information Center.* Accessed June 12, 2013, at http://www.drought.noaa.gov/palmer.html

NRCS. 2012. *Arkansas Annual Report 2012.* Accessed July 15, 2013, at http://www.ar.nrcs.usda.gov/news/annual_report_2012.html

Oklahoma Water Resources Board. (no date). *Red River Compact Commission.* Accessed June 14, 2013, at http://www.owrb.ok.gov/rrccommission/graphics/reach_2_5.jpg

Oklahoma Water Resources Board. 2013. *Title 785 Chapter 45 Oklahoma's Water Quality Standards.* Oklahoma City: Oklahoma Water Resources Board.

Onellion, F.E., and Criner, J.H., Jr. 1955. Ground-water resources of Chicot County, Arkansas. Little Rock, AR: Arkansas Geology and Conservation Commission. Water Resources Circular No. 3.

Ouachita River Valley Association. 2013. *ORVA News*, *Fall 2013.*

Ouachita River Valley Association. 2011. *Ouachita-Black Navigation Project Funding and Future.* Accessed January 2014 at http://www.orva.org/fundingfuture.htm

Payne, N.J. 1972. *Hydrology Significant of Lithofacies of the Cane River Formation or Equivalen of Arkansas, Louisiana, Mississippi, and Texas* [USGS Professional Paper 569-C]. US Geological Survey.

Payne, N.J. 1975. *Geohydric Significance of Lithofacies of the Carrizo Sand of Arkansas, Louisiana, and Texas and the Meridian Sand of Mississippi* [USGS Professional Paper 569-D]. US Geological Survey.

Petersen, J.C., M.E. Broom, and W.V. Bush. 1985. *Geohydrologic Units of the Gulf Coastal Plain in Arkansas* [Water Resources Investigation Report 85-4116]. US Geological Survey.

Petrimoulx, D. 2013. *Deal to Sell Water Rights Irks LR City Directors*. October 15, 2013. Arkansasmatters.com.

Plebuch, R.O., and M.S. Hines. 1969. *Water Resources of Clark, Cleveland, and Dallas Counties, Arkansas* [Water Supply Paper 1879-A]. Little Rock, AR: US Geological Survey.

PRISM Climate Group. 2004. Corvallis: Oregon State University.

Pugh, A. 2010. *Potentiometric Surfaces and Water-level Trends in the Cockfield (Upper Claiborne) and Wilcox (Lower Wilcox) Aquifers of Southern and Northeastern Arkansas, 2009* [Scientific Investigations Report 2010-5014]. US Geological Survey.

Pugh, A.L., D.A. Westerman. 2014. *Mean Annual, Seasonal, and Monthly Precipitation and Runoff in Arkansas, 1951-2011.* US Geological Survey Scientific Investigations Report 2014-5006. Reston, VA: USGS.

Pulaski County Regional Solid Waste Management District. 2011. *Regional Solid Waste Management Plan.* Little Rock, AR: Arkansas Department of Environmental Quality.

Red River Compact Commission. 1978. "Red River Compact." Red River Compact Commission.

Renken, R.A. 1998. "Arkansas, Louisiana, Mississippi HA 730-F." In *Groundwater Atlas of the United States, HA 730*, by US Geological Survey. Reston, VA: US Geological Survey.

Reynolds, J. 2013. "Hydroelectricity." *The Encyclopedia of Arkansas History and Culture.* October 4, 2013. Accessed October 2013 at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=5527

Robison, H.W., and T.M. Buchanan. 1988. *Fishes of Arkansas.* Fayetteville, AR: University of Arkansas Press.

Scheiderer, R.M., and D.A. Freiwald. 2006. *Monitoring the Recovery of the Sparta Aquifer in Southern Arkansas and Northern Louisiana* [Fact Sheet 2006-3090]. US Geological Survey.

Schrader, T.P. 1998. *Status of Water Levels in Aquifers in the Nacatoch Sand and Tokio Formation of Southwestern Arkansas, 1996* [Water Resources Investigation Report 98-4130]. Little Rock, AR: US Geological Survey.

Schrader, T.P. 1999. Status of Water Levels in Aquifers in the Nacatoch Sand of Southwestern and Northeastern Arkansas and the Tokio Formation of Southwestern Arkansas, 1999. U.S. Geological Survey. Water-Resources Investigations Report 99-4208-A.

Schrader, T. P. 2007a. Potentiometric Surfaces and Water-Level Trends in the Cockfield and Wilcox Aquifers of Southern and Northeastern Arkansas, 2006. U.S. Geological Survey. Scientific Investigations Report 2007-5218.

Schrader, T. P. 2007b. Status of Water Levels in Aquifers in the Nacatoch Sand of Southwestern and Northeastern Arkansas and the Tokio Formation of Southwestern Arkansas, February 2005. U.S. Geological Survey. Scientific Investigations Report: 2007-5024.

Schrader, T.P., and J.M. Blackstock. 2010. *Water Levels in Aquifers in the Nacatoch Sand of Southwestern and Northeastern Arkansas and the Tokio Formation of Southwestern Arkansas, Spring 2008* [Scientific Investigations Report 2010-5238]. Little Rock, AR: US Geological Survey.

Schrader, T.P. and K.D Rodgers. 2013. Water levels in aquifers in the Nacatoch Sand of southwestern and northeastern Arkansas and the Tokio Formation of southwestern Arkansas-March 2011. U.S. Geological Survey. Scientific Investigations Report 2013-5130.

Schrader, T.P. and R. M. Scheiderer, 2004. Status of water levels in aquifers in the Nacatoch Sand of southwestern and northeastern Arkansas and the Tokio Formation of southwestern Arkansas, 2002. U.S. Geological Survey. Water-Resources Investigations Report 2003-4284.

Scott, H.D., J.A. Ferguson, L. Hanson, T. Fugitt, and E. Smith. 1998. *Agricultural Water Management in the Mississippi Delta Region of Arkansas. Research Bulletin 959.* Fayetteville, AR: University of Arkansas Press.

Shugart, S. 2013. "Hot Springs National Park." *The Encyclopedia of Arkansas History and Culture.* December 18, 2013. Accessed December 2013 at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=2547

Smethers, W.H. 2012. “Remmel Dam.” *The Encyclopedia of Arkansas History & Culture.* October 17, 2012. Accessed October 29, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2319

Southard, R.E. 1992. *Flood of May 19-20, 1990, in the Vicinity of Hot Springs, Arkansas* [Water-Resources Investigations Report 92-4007]. Little Rock, AR: US Geological Survey.

Southeast Arkansas Regional Solid Waste Management District. 2011. *Regional Solid Waste Management Plan Update for Southeast Arkansas Regional Solid Waste Management District.* Pine Bluff, AR: Southeast Arkansas Regional Solid Waste Management District.

Southwest Arkansas Planning and Development District. 2013. *Needs Assessment.* Magnolia, AR: Southwest Arkansas Solid Waste Management District.

Speed, A.W. 2007. "Mountain Valley Spring Water." *The Encyclopedia of Arkansas History and Culture.* July 2, 2007. Accessed December 2013 at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=2148

Stephenson, L.W., and A.F. Crider. 1916. *Geology and Ground Waters of Northeastern Arkansas* [Water Supply Paper 399]. US Geological Survey.

Stone, C.G., and W.V. Bush. 1984. *General Geology and Mineral Resources of the Caddo River Watershed* [Information Circular 29]. Little Rock, AR: Arkansas Geological Commission.

Stroud, H.B. 2011. "West Gulf Coastal Plain." *The Encyclopedia of Arkansas History and Culture.* 2011. Accessed March 20, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=443

Tait, D.B., R.C. Backer, and G.A. Billingsley. 1953. *The Ground-Water Resources of Columbia County, Arkansas - A Reconnaissance* [USGS Circular 241]. US Geological Survey.

Terracon. 2013. *2013 Needs Assessment, Upper Southwest Regional Solid Waste Management District, Nashville, AR.* Nashville, AR: Southwest Regional Solid Waste Management District.

Terry, J.E., C.T. Bryant, A.H. Ludwig, and J.E. Reed. 1986. *Water-Resources Appraisal of the South-Arkansas Lignite Area* [Information Circular 28-D]. Little Rock, AR: Arkansas Geological Commission.

Townsend, C.H. 1902. *Statistics of the Fisheries of the Mississippi River and Tributaries.* Washington, DC: Government Printing Office.

U of A Divison of Agriculture. 2012. *Economic Contribution of Arkansas Agriculture.* Little Rock, AR: University of Arkansas Division of Agriculture.

U of A Sam Walton College of Business. 2009. *Describing the Economic Impact of the Oil and Gas Industry in Arkansas.* Fayetteville, AR: University of Arkansas Press.

Unknown. 2011. “Felsenthal National Wildlife Refuge.” Accessed October 29, 2013, at http://en.wikipedia.org/wiki/Felsenthal_National_Wildlife_Refuge

US Census Bureau. (no date [a]). *DP03 - Selected Economic Characteristics, 2007-2011 American Community Survey 5-year Estimates.* Accessed March 18, 2013, at http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_11_5YR_DP03

US Census Bureau. (no date [b]). "DP05 ACS Demographic and Housing Estimates 2007-2011 American Community Survey 5-year Estimates." *American FactFinder.* Accessed March 2013 at http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_11_5YR_DP05&prodType=table

US Census Bureau. 1989. 1987 Census of Agriculture Volume 1 Geographic Area Series Part 4 Arkansas State and County Data. Washington, DC: US Department of Commerce US Census Bureau. 2011. "Urban Area Criteria for the 2010 Census." *Federal Register* 76 (164): 53033-53043.

US Census Bureau. 1993. "1992 Economic Census Area Profiles - Arkansas." *US Census* . http://www.census.gov/epcd/www/92profiles/www/EC92AR.HTM (accessed July 9, 2013).

US Census Bureau. 2011a. *Urban Area Criteria for the 2010 Cenus.* Federal Register 76 (164): 53033-53043.

US Census Bureau. 2011b. *1997 Economic Census: Comparative Statistics for Arkansas 1987 SIC Basis: Service Industries.* Accessed May 2014, https://www.census.gov/epcd/ec97sic/E97SARI.HTM.

US Census Bureau. 2012a. *Arkansas 2010: Population and Housing Unit Counts.* Washington, DC: US Department of Commerce.

US Census Bureau. 2012b. "Table 20. Large Metropolitan Statistical Areas - Population 1990 to 2010." *www.census.gov.* Accessed March 12, 2013, at http://www.census.gov/compendia/statab/2012/tables/12s0020.pdf

US Commisison of Fish and Fisheries. 1895. *Report of the Commissionerfor the Year Ending June 30, 1895.* Washington, DC: Government Printing Office.

US Congress. 1992. "Clean Vessel Act of 1992." *Digest of Federal Laws of Interest to the US Fish and Wildlife Service.* Accessed July 12, 2013, at http://www.fws.gov/laws/lawsdigest/clenves.html

US Department of Commerce Bureau of the Census. 1989. *1987 Census of Agriculture, Volume 1, Geographic Area Series, Part 4, Arkansas State and County Data.* Washington, DC: US Government Printing Office.

USACE. (no date [a]). *Lake Ouachita - History.* Accessed October 29, 2013, at http://ftp.mvk.usace.army.mil/lakes/AR/Ouachita/index.php?p=history

USACE. (no date [b]). *DeGray Lake.* Accessed October 30, 2013, at http://www.mvk.usace.army.mil/Missions/Recreation/DeGrayLake.aspx

USACE. 2011. *Value to the Nation State Level Report - Arkansas.* Accessed October 2013 at http://www.corpsresults.us/recreation/fastfacts/stateReport.cfml?State=12

USACE. 2013. *RIBITS (Regulatory In-lieu Fee and Bank Information Tracking System).* Accessed October 22, 2013, at https://rsgisias.crrel.usace.army.mil/ribits/f?p=107:158:607386398458358::NO:RP:P27_BUTTON_KEY:1

USACE Institute for Water Resources. (no date) "Locks by Waterway Lock Commodity CY 1993 - 2012." *Waterborne Commerce Statistics Center.* Accessed November 19, 2013, at http://www.navigationdatacenter.us/lpms/cy2012comweb.htm

USACE Little Rock District. 2009. *Water Supply Storage Reallocation Report, Reallocation of Storage at Greers Ferry Lake and Lake Ouachita, Arkansas for the Mid-Arkansas Water Alliance.* Little Rock, AR: USACE Little Rock District.

USACE Vicksburg District. 2013a. *Arkansas Project Status.* Vicksburg, MS: USACE Vicksburg District.

USACE Vicksburg District. 2013b. *Welcome to the Ouachita/Black River Area.* Accessed May 2, 2013, at http://www.mvk.usace.army.mil/Missions/Recreation/OuachitaBlackRiver.aspx

USDA National Agricultural Statistics Service. n.d. *2007 Census Publications State and County Profiles Arkansas.* http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/Arkansas/index.asp (accessed January 2014).

USDA National Agricultural Statistics Service. 2009. *2007 Census of Agriculture, Arkansas State and County Data, Volume 1, Geographic Area Series, Part 4.* Washington, DC: USDA National Agricultural Statistics Service.

USFS. 2013. *Forest Inventory Data Online (FIDO).* Accessed September 13, 2013, at http://apps.fs.fed.us/fia/fido/index.html

USFWS. 2013. *National Wildlife Refuge System.* http://www.fws.gov/southeast/refuges/refuges-by-state.html#arkansas (accessed September 16, 2013).

USFWS. 2013a. *Clean Vessel Act Grant Program - Funding.* Accessed January 2014 at http://wsfrprograms.fws.gov/Subpages/GrantPrograms/CVA/CVA_Funding.htm

USFWS. 2013b. *Endangered Species Act: Overview.* Accessed March 13, 2013, at http://www.fws.gov/endangered/laws-policies/index.html

USFWS. 2013c. *Felsenthal National Wildlife Refuge.* Accessed October 29, 2013, at http://www.fws.gov/felsenthal/

USFWS; US Census Bureau. 1993. *1991 National Survey of Fishing, Hunting, and Wildlife-associated Recreation, Arkansas.* Washington, DC: US Government Printing Office.

USSFWS; US Census Bureau. 2013. *2011 National Survey of Hunting, Fishing, and Wildlife-associated Recreation - Arkansas.* Washington, DC: US Fish and Wildlife Service.

USGS. (no date). *Arkansas Online Reports.* http://ar.water.usgs.gov/data-bin/publications (accessed December 2013).

USGS. 2009. "National Hydrography Dataset." Reston, VA: US Geological Survey.

USGS. 2013a. *2009 Minerals Yearbook, Arkansas [Advanced Release].* Reston, VA: US Geological Survey.

USGS. 2013b. *NAS - Nonindigenous Aquatic Species Database Search.* Accessed October 2013 at http://nas.er.usgs.gov/queries/

USGS. 2014. *USGS Water Data for Arkansas.* Accessed January 2014 at http://waterdata.usgs.gov/ar/nwis/nwis

Veatch, A.C. 1906. *Geology and Underground Water Resources of Northern Louisiana and Southern Arkansas.* Professional Paper 46, Little Rock, AR: US Geological Survey.

Warner, Nathaniel R. et al. 2013. "Geochemical and isotopic variations in shallow groundwater in areas of the Fayetteville shale development, north-central Arkansas." *Applied Geochemistry.* http://dx.doi.org/10.1016/j.apgeochem.2013.04.013 (accessed May 31, 2013).

Weeks, W. 1938. "South Arkansas stratigraphy with emphasis on the older coastal plain beds." *American Association of Petroleum Geologists Bulletin, vol. 22* (American Association of Petroleum Geologists): 972-978.

West Central Arkansas Planning & Development District, Inc. 2011. *Southwest Central Regional Solid Waste Management District Regional Solid Waste Management Plan Annual Update.* Little Rock, AR: Arkansas Department of Environmental Quality.

Westfall, B.C. 2010. "Caddo River." *The Encylopedia of Arkansas History & Culture.* August 18, 2010. Accessed October 28, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=2614

Williams, J. 1995. "Battle for River Designations Drying Up." March 20, 1995. *Arkansasbusiness.com*.

Woodard, J. 2012. "Saline River." *The Encyclopedia of Arkansas History & Culture.* Accessed October 28, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=2649

Woods, A.J. et al. 2004. *Ecoregions of Arkansas (color poster with map, descriptive text, summary tables, and photographs).* Reston, VA: US Geological Survey.

Worley, F. 2013. "Blakely Mountain Dam Lake Ouachita gets new seepage monitoring system." *Lake Ouachita.* Accessed January 2014 at http://www.lakeouachita.org/blakely-dam-lake-ouachita-gets-new-seepage-system.htm

Zachary, D.L., K.F. Steele, L.J. Wood, and D.H. Johnston. 1986. *Stratigraphy and Hydrology of Upper Cretaceous and Tertiary Strata, Columbia and Union Counties, Arkansas.* Fayetteville, AR: University of Arkansas.

Zbinden, V. 2011. "St. Louis Southwestern Railway." *The Encyclopedia of Arkansas History and Culture.* Accessed August 20, 2013, at http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=5104

APPENDIX A

2008 303(d) List of Impaired Waterbodies in the SCAWRPR

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
2C – Saline River & tributaries	576.3	527.2	Aquatic life	140.9	Sediment/siltation	68.7	Erosion
					Copper	72.2	Unknown
					Lead	63	unknown
					pH	28.9	Unknown
			Drinking water supply	95.7	beryllium	95.7	unknown
			Agriculture & industrial water supply	119.5	TDS	119.5	unknown
			Fish Consumption	89.9	Mercury	89.9	
			Total	158.4			
2D – Lower Ouachita River & tributaries	394.2	345.6	Agriculture & industrial water supply	49.9	TDS, sulfate	49.9	Resource extraction, industrial point source
			Aquatic life	271.3	Copper	148.6	Industrial point source, municipal WWTP
					DO	43.9	Unknown
					Lead	77.9	Unknown, municipal WWTP
					Sediment/siltation	113.8	Erosion
					Zinc	255.3	Unknown, resource extraction, industrial point source
					pH	8	Industrial point source
			Drinking water supply	8.5	Nitrate	8.5	Industrial point source
			Aquatic life & drinking water	32.5	Ammonia	8.5	Industrial point source
					Chloride & TDS	32.5	Industrial point source
					Sulfate	24.5	Industrial point source
			Fish Consumption	229.7	Mercury	229.7	
			Total	345.6			

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
2E – Upper Cornie Bayou & tributaries	44	44	Aquatic life	44	Sediment/siltation	44	Resource extraction
					Zinc	44	Resource extraction
			Agriculture & industrial water supply	44	Sulfate	44	Resource extraction
					beryllium	15	unknown
			total	44			
2F – Ouachita River & tributaries: headwaters to Two Bayou	642.2	576	Aquatic life	116.4	Zinc	68.3	Resource extraction, unknown
					Sediment/siltation	10	Erosion
					pH	42.8	Resource extraction, unknown
					Cadmium	2.5	Resource extraction
					Copper	29.1	Resource extraction, unknown
					DO	10	Unknown
			Primary contact	22.5	Pathogens	22.5	Unknown
			Drinking water supply	19.5	beryllium	47.3	Resource extraction
					Sulfate	2.5	Resource extraction
					Zinc	19.5	Resource extraction
			Agriculture & industrial water supply	12.5	Sulfate	14.3	Resource extraction
					TDS	12.1	Resource extraction
			Total	158.4			
2G – Little Missouri and Antoine River	427.5	427.5	Aquatic life	47.7	Copper	19.6	Unknown
					Lead	10.5	Unknown
					Zinc	47.7	Unknown

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
Total	2084.2	1920.3		754.1			

FTN Associates Ltd.
water resources / environmental consultants

Arkansas Water plan
Essential For Life

ARKANSAS WATER PLAN UPDATE
TASK NO. 6 - SOUTHWEST ARKANSAS WATER RESOURCES PLANNING REGION

AUGUST 11, 2014

ARKANSAS WATER PLAN UPDATE
TASK NO. 6 - SOUTHWEST ARKANSAS
WATER RESOURCES PLANNING REGION

Prepared for

Arkansas Natural Resources Commission
101 East Capitol Avenue, Suite 350
Little Rock, AR 72201-3813

Prepared by

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, Arkansas 72211

FTN No. 03015-0003-001

August 11, 2014

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF APPENDICES

LIST OF FIGURES

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF ACRONYMS

ACS	American Community Survey
ADEM	Arkansas Department of Emergency Management
ADEQ	Arkansas Department of Environmental Quality
ADH	Arkansas Department of Health
ADPCE	Arkansas Department of Pollution Control and Ecology (now ADEQ)
AGFC	Arkansas Game and Fish Commission
AHTD	Arkansas State Highway and Transport Department
ANHC	Arkansas Natural Heritage Commission
ANRC	Arkansas Natural Resources Commission
APCEC	Arkansas Pollution Control and Ecology Commission
ASWCC	Arkansas Soil and Water Conservation Commission (now ANRC)
AWAG	Arkansas Watershed Advisory Group
AWP	Arkansas Water Plan
BCE	Before The Common Era, same as B.C.
CE	During The Common Era, same as A.D.
CRP	Conservation Reserve Program
CWA	Clean Water Act
DO	Dissolved Oxygen
E. coli	*Eschericia coli*
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FEMA	Federal Emergency Management Agency
GCGW	Governor’s Commission on Global Warming
gpm	Gallons Per Minute
HUD	United States Department Of Housing And Urban Development
MCL	Maximum Contaminant Level
mg/L	Milligrams Per Liter
mgd	Million Gallons Per Day
MS4	Municipal Separate Storm Sewer System
n.d.	No Date
NCDC	National Climatic Data Center
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	United Stated Department of Agriculture Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
NWIS	National Water Information System
NWR	National Wildlife Refuge
PCB	Polychlorinated Biphenyl
PDSI	Palmer Drought Severity Index

LIST OF ACRONYMS (CONTINUED)

RCRA	Resource Conservation and Recovery Act
RSWMD	Regional Solid Waste Management District
SAWRPR	Southwest Arkansas Water Resources Planning Region
SDWA	Safe Drinking Water Act
SFHA	Special Flood Hazard Area
SGCN	Species of Greatest Conservation Need
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
U of A	University of Arkansas
US	United States
USACE	United States Army Corps of Engineers
USDA	United Stated Department of Agriculture
USDI	United States Department of The Interior
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WHIP	Wildlife Habitat Incentives Program
WMA	Wildlife Management Areas
WRDA	Water Resources Development Act

1.0 INTRODUCTION

The Arkansas Natural Resources Commission (ANRC) is responsible for preparing and periodically updating a statewide water resources planning document. The previous update of the Arkansas Water Plan (AWP) was completed in 1990. In 2012, ANRC initiated an update of the 1990 AWP to be completed in 2014.

This document was prepared as part of the 2014 update of the AWP (Project Task 6). This document provides background information about the Southwest Arkansas Water Resources Planning (SAWRPR) region that will be used in the 2014 AWP update. The SAWRPR is one of five state water resources planning regions being addressed in the 2014 AWP update. The information in this document will serve as background for updated discussion and analysis of state water supplies, water demand, and alternatives for meeting the water resources needs in this region. This background information includes a description of the history of the region, its physical characteristics, natural resources, water resources, demographics, and economy. Finally, the regulatory and institutional framework for water resources management in this region is outlined.

2.0 GEOGRAPHY AND HISTORY

This section provides a general description of the geography of the SAWRPR, a brief history of the regional culture, and an overview of historical water resources management.

2.1 Geography

The SAWRPR encompasses approximately 4,500 square miles in extreme southwest Arkansas (Figure 2.1). This region is bounded on the west by Texas and Oklahoma, and to the south by Louisiana. The eastern boundary of the SAWRPR roughly corresponds to the hydrologic boundary between the Red River and Ouachita River basins. All or part of nine counties fall within the planning region. Table 2.1 lists these counties, the area of each county that is in the Planning region, and the corresponding percentage of the county in the planning region. Major cities in the planning region include Texarkana, Magnolia, Hope, Ashdown, and DeQueen.

Table 2.1. Counties in the SAWRPR.

County	County Area in Planning region (square miles)	Percentage of County Area in Planning region
Columbia	504.6	65.9%
Hempstead	416.9	56.3%
Howard	595.2	100.0%
Lafayette	545.7	100.0%
Little River	563.0	100.0%
Miller	637.8	100.0%
Nevada	150.1	24.2%
Polk	541.4	62.9%
Sevier	581.0	100.0%
Total	**4,535.7**	

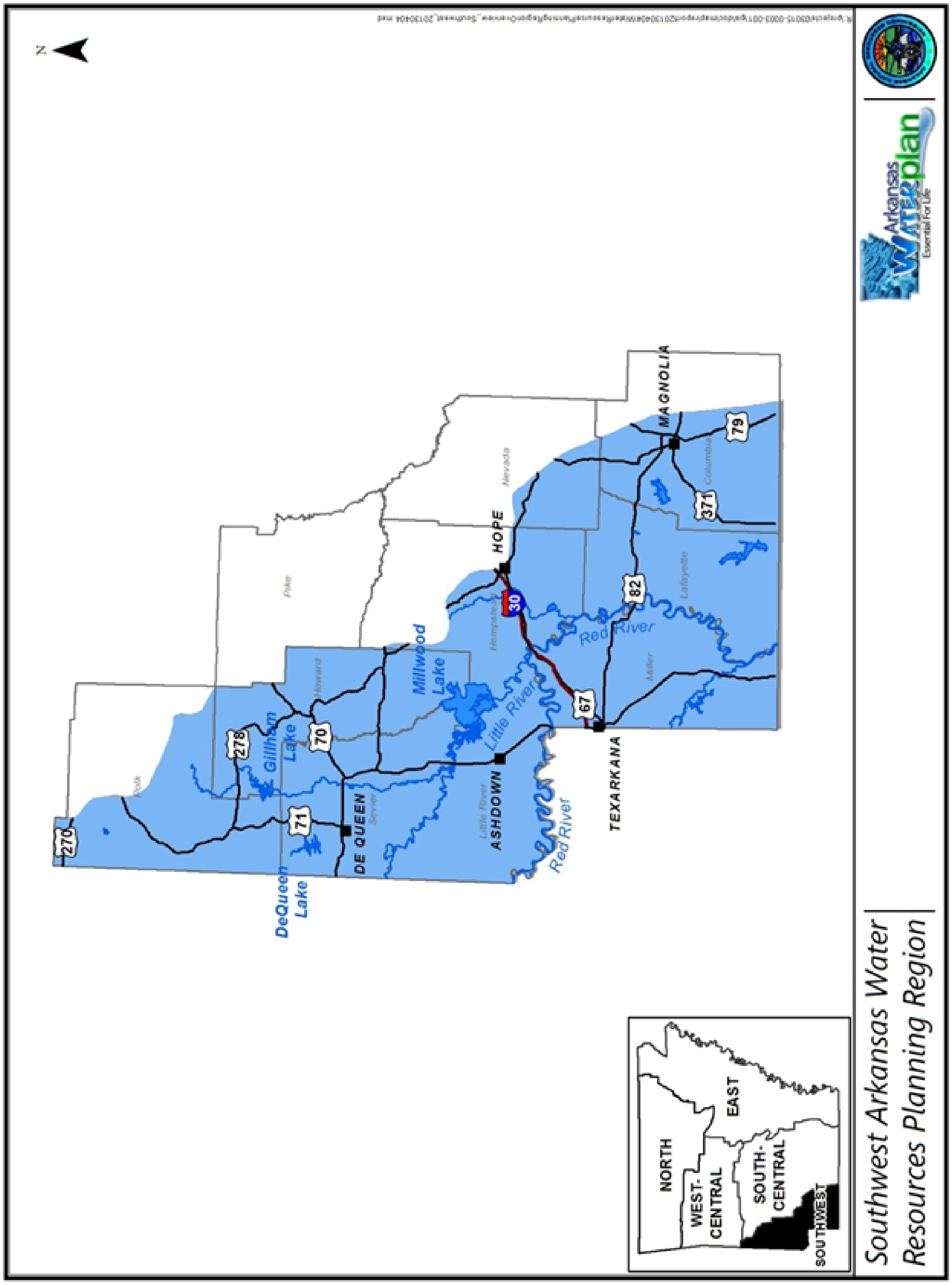

Figure 2.1. Map of the SAWRPR.

2.2 History

Water resources have influenced the history of this region, and the current condition of water resources in the region is a product of human activities throughout its history. The cultural history of the region is outlined below. The history of water resources development in the planning region is summarized separately.

2.2.1 Cultural

Native Americans settled the SAWRPR prior to European exploration and settlement. There is archeological evidence in the region of the presence of sophisticated native cultures from the Woodland Period and Mississippian Period, i.e., from 600 BCE through 1600 CE. During these periods, the mound-building Caddo Culture was active in the region. The Caddo constructed several large mound centers in the Red River valley in southwest Arkansas and established salt works along several Red River tributaries (Early 2011, Lancaster 2011).

Hernando de Soto's Spanish expeditionary force were the first Europeans in the region, passing through in 1542, after de Soto's death. After this, Europeans did not return to the region until the late 1600s and early 1700s, when the French established trading posts on the Red River (Lancaster 2011). In 1719, Bernard de La Harpe founded the St. Louis des Caddodches trading post, garrison, and agricultural colony on the Red River near present-day Fulton. The French were allies with the Caddo tribes of the region (Arnold 1991). The St. Louis des Caddoches post was abandoned in 1778, except for a small garrison of soldiers. In 1782, a small Spanish settlement expedition travelled up the Red River to near present-day Camden, but finally settled in Louisiana (Key 2012). Around 1790, the Caddo moved out of Arkansas into Louisiana (Lancaster 2011).

The Southwest Trail from southeast Missouri to northeast Texas passed through the SAWRPR, crossing the Red River near Fulton. This trail was used by settlers entering the region beginning about the time of the Louisiana Purchase (1803) (Akridge 2011). In 1806, the Freeman and Custis Expedition was charged by president Thomas Jefferson with finding the headwaters of the Red River. The expedition managed to proceed up river into the territory that would become Arkansas, before being turned back by Spanish soldiers (Spurgeon 2010). Several early

Arkansas settlements were established in the SAWRPR. Around 1818, a tavern was built on the trail in Hempstead County. The tavern was designated the county seat for Hempstead County in 1824. The town of Washington was incorporated at this location in 1830. Washington is credited as the location where the first Bowie knife was made in 1831 (Teske 2011a). Washington was a major center of information and trade in the state until the 1870s (Department of Arkansas Heritage 2013).

Cherokee moved into the SAWRPR around 1818, coming from the settlement on the Arkansas River (Stewart-Abernathy 2011). In 1835, the Caddo sold their land in the Arkansas Red River valley to the United States (US) government (Lancaster 2011). Two Trail of Tears routes passed through the SAWRPR. These routes were used by Cherokee, Choctaw, Creek, Chickasaw, and Seminole Indians traveling from their eastern lands to the west during the 1830s (Arkansas Department of Parks and Tourism 2013).

Early settlers in the SAWRPR cleared the forests of the Red River bottomlands for farming. By 1840, large-scale, southern-style cotton plantations covered the bottomlands of the region (Bolton 2012, Foti 2008). The rise in cotton prices during the 1850s brought economic prosperity to the region (Key 2012). Plantation owners in this region held the same economic and political power as their brothers in the Delta region of the state (DeBlack 2012, Key 2012).

The economic fortunes of the SAWRPR were reversed during the first year of the Civil War when the functioning of civil society in the state was seriously disrupted. In 1863, the Confederate state capitol moved to the town of Washington in Hempstead County. No major battles occurred in the region during the war (DeBlack 2012).

After the Civil War, in the 1870s, railroads were built in the SAWRPR, connecting the region to Texas and Missouri. The transportation system provided by the railroads and navigation improvements on the Red River spurred resurgence in cotton production in the region and expansion of agricultural lands. However, improved transportation and nationalization of markets reduced commodity prices, resulting in economic decline in the state (DeBlack 2012). The town of Washington declined after it was by-passed by the local railroad line (Teske 2011a).

Timber industry began to expand in the SAWRPR after the Civil War. The railroads brought lumber entrepreneurs to this region from the north to cut and process the virgin timber there. Around 1900, the Dierks Lumber and Coal Company established offices in the region and began harvesting the virgin forests (Teske 2013). The railroads and timber industry resulted in the expansion of a number of communities in this region including Dierks, Nashville, and Ashdown (Trusley 2011; Teske 2013, 2011b). By the early 1920's nearly all the virgin timber in the state had been cut. Taking advantage of the relatively rapid regrowth rate of timber, local lumber companies began operating pine plantations in the region. By the end of the 1960's, local lumber companies had been taken over by national and international companies like Weyerhaeuser (Balogh 2013, Moneyhon 2013).

In 1938, the Dillard's store chain was born in this region when Mr. Dillard opened his first store in Nashville (Teske 2011b).

In the 1920s oil boom, oil production began in five of the counties within the SAWRPR; Columbia, Hempstead, Lafayette, Miller, and Nevada. The last major oil pool in the planning region was discovered in 1971 in Columbia County west of Magnolia (Bridges, Encyclopedia of Arkansas History and Culture 2011). In the late 1950s, it was discovered that the brine water waste associated with oil production in Columbia County contained high levels of the valuable mineral bromine. As a result, bromine production began in the vicinity of Magnolia (Hill 2010).

2.2.2 Water Resources Development

A range of water resources development activities have occurred in this region throughout its history, as attitudes and policies have changed. Historically, human activities that have affected water resources in this planning region have included levee building, river transportation and navigation, development of surface water and ground water, changes in cropping, wildlife habitat and wetland conservation, and development of the recreation industry in the region.

2.2.2.1 Navigation

During the territorial period, rivers were important means of transportation throughout Arkansas. However, the presence of a permanent logjam on the Red River south of Arkansas restricted the utility of the Red River for transportation of goods into and out of the state. The first attempt to remove the raft was undertaken in 1832 and completed in 1838. This task was funded by the US government. However, the raft reformed shortly thereafter, upstream of the original location. Removal of the second raft was undertaken after the Civil War and completed in 1873. As part of this project, dams were placed along tributary bayous to prevent the raft from reforming (Lancaster 2011).

After the raft was cleared, steamboat traffic on the Red River increased. The US Army Corps of Engineers (USACE) developed and maintained a navigation channel on the Red River from the Mississippi River into Arkansas until 1900. During that time, the Red River in Arkansas was navigable year-round to the town of Garland in Miller County (Lancaster 2011).

Today, the USACE maintains a navigation channel on the Red River only to Shreveport, Louisiana, and commercial navigation no longer occurs on the Red River in Arkansas. The USACE recently conducted a feasibility study of extending navigation on the Red River into Arkansas, concluding that the project was not economically feasible. The economic feasibility is being reviewed in light of the increase in gas prices that has occurred since that feasibility study was completed.

2.2.2.2 Flood Control

The 1946 Flood Control Act authorized construction of Millwood Lake dam on the Little River in Little River County. The Millwood Lake project faced considerable opposition. As a result, construction of the dam was not initiated until 1961. The dam was completed in 1966. In addition to flood control, this reservoir provides recreation and water supply to the region (Lancaster 2013).

Construction of reservoirs on the Cossatot, Rolling Fork, and Saline Rivers was authorized by the 1958 Flood Control Act. Construction of Gilham Lake dam on the Cossatot River was initiated in 1963, and completed in 1975. In addition to flood control, this project was authorized for the purposes of water supply, water quality, and fish and wildlife conservation. Gilham Lake also provides recreation. Construction of DeQueen Lake on the Rolling Fork River was initiated in 1966 and completed in 1977. In addition to flood control, this project was authorized for the purposes of water supply, water quality, recreation, and fish and wildlife conservation. Construction of Dierks Lake on the Saline River in Saline and Howard Counties was initiated in 1968 and completed in 1975. In addition to flood control, this project was authorized for the purposes of water supply, water quality, recreation, and fish and wildlife conservation (USACE Little Rock District 2013).

2.2.2.3 Irrigation

Irrigation of cropland was first reported in counties within the SAWRPR in the 1954 Census of Agriculture (US Census Bureau 1956).At this time, 1.7% of the cropland in these counties was irrigated. Expansion of irrigation into the Red River valley was a result of the increased acceptance of irrigation as a useful tool for high-yield agriculture (Green 1986). Irrigated acreage increased dramatically in this region in the late 1970s and early 1980s (Figure 2.2). Improvements in irrigation pumps and pipe around this time led to expansion of the use of irrigation throughout the State (Green 1986). Almost all (96%) of the irrigation water used in the planning region in 1987 was groundwater (US Census Bureau 1989). Use of irrigation in the planning region dropped off dramatically in the mid 1980s and has fluctuated around 5% of the cropland since that time (Figure 2.2).

In 2001, the US Department of Agriculture Natural Resources Conservation Service (NRCS), with the Walnut Bayou Irrigation District, initiated a project to provide surface water from the Red River for irrigation of 23,500 acres in Little River County. In 2009, this project was in the planning stages (Robinson 2009, NRCS 2011).

2.2.2.4 Commercial Fishing

Commercial fishing was an important activity during early settlement and development in the SAWRPR (Lochmann 2013). In the late 1800's concern over the decline of natural fisheries resulting from commercial fishing resulted in the passage of state laws to limit commercial fishing. Commercial fishing on the Red River continues (Robison and Buchanan 1988). In the present, commercial fishing is greatly reduced. Regulations prevent the sale of most wild caught game fish in the state. One exception is paddlefish, which are commercially fished for their eggs for caviar (Lochmann 2013). Other fish that may still be caught in the wild and sold include buffalo, catfish, carp, drum, gar, suckers, and shovelnose sturgeon (AGFC 2013a).

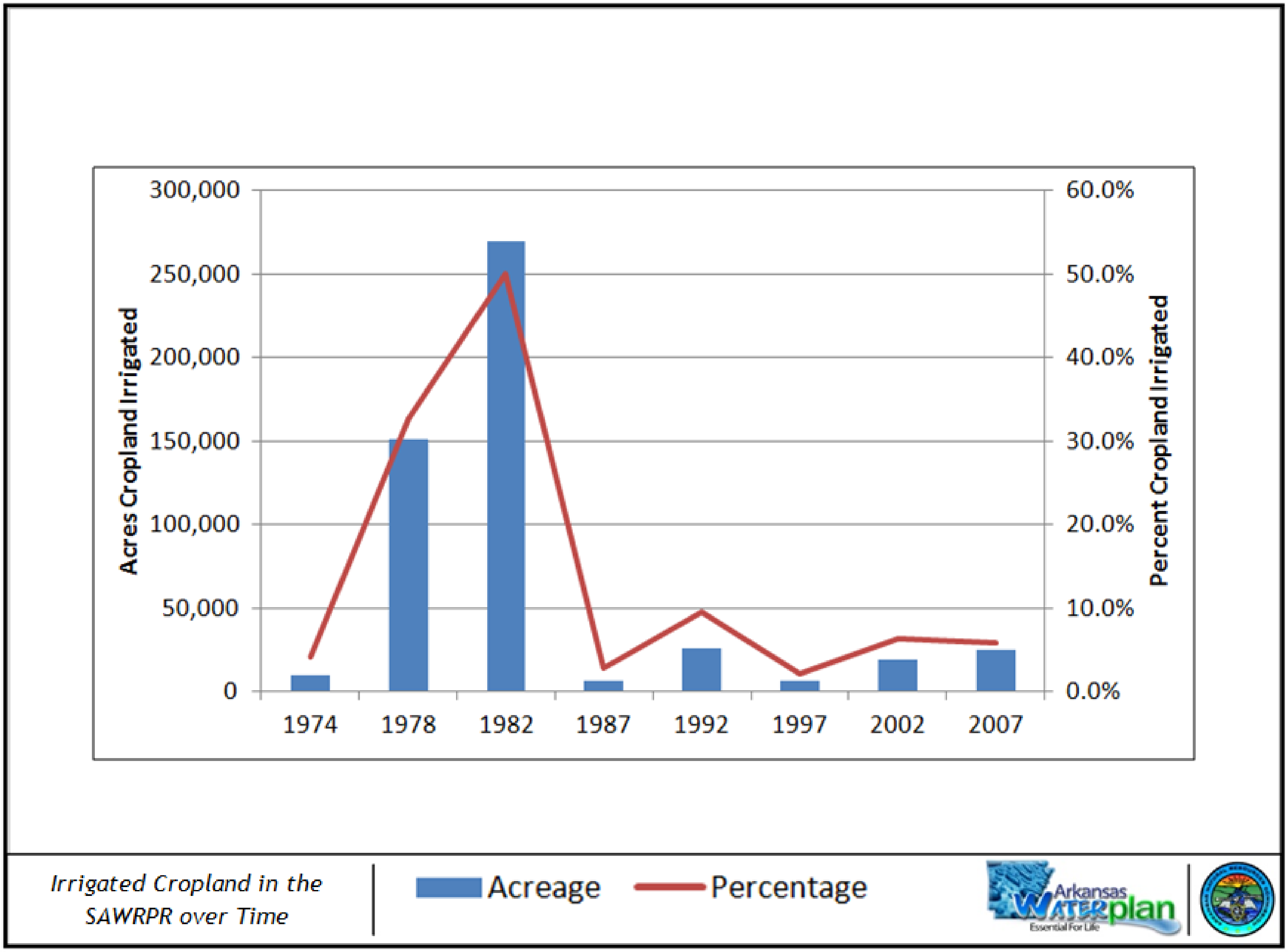

Figure 2.2. Irrigated cropland in the SAWRPR over time (USDA National Agricultural Statistics Service 2013).

2.2.2.5 Waterfowl and Aquatic Habitat

Just after the turn of the Twentieth Century, preservation of migratory waterfowl became a national priority (Morrow n.d.). The Arkansas Game and Fish Commission (AGFC) began establishing wildlife management areas (WMAs) in the region in the 1950s (Table 2.2). The US Fish and Wildlife Service (USFWS) established a National Wildlife Refuge (NWR) in the area for protection of habitat migratory waterfowl, in 1994. The Arkansas Natural Heritage Commission (ANHC) has established several state natural areas in the planning region to protect aquatic and wetland habitats. A number of recent Farm Bill programs have encouraged conservation and enhancement of waterfowl habitat in the region with economic incentives for activities such as setting up wetland conservation easements, and flooding fields in the winter (NRCS 2013).

In 1968, the National Wild and Scenic Rivers System was created to preserve free-flowing rivers with outstanding recreational, cultural, and/or natural features. In 1979, the Arkansas Natural and Scenic Rivers System was created to protect selected rivers from damming and channel alterations (ANHC 2012). A section of the Cossatot River was listed in the Arkansas Natural and Scenic Rivers System in 1985 (Arkansas Code 15-23-313). In 1992, a different portion of the Cossatot River was added to the National Wild and Scenic Rivers System (Table 2.3) (Interagency Wild and Scenic Rivers Council n.d.).

Table 2.3. History of Wild/Natural and Scenic Rivers in the SAWRPR (ANHC 2012, Interagency Wild and Scenic Rivers Council n.d.).

River	System	Length (miles)	County	Year designated	Agency
Cossatot River	State	26	Howard	1985	ANHC
Cossatot River and Brusshy Creek	National	30.8	Polk, Howard	1992	USFS, USACE, Arkansas Department of Parks and Tourism

Table 2.2. History of. WMAs in the SAWRPR(AGFC 2011, USFWS n.d.).

Name	Type	Area, acres	Counties	Year established	Management	Purpose	Other
Falcon Bottoms Natural Area	WMA	3,210.8	Columbia, Lafayette, Nevada	1991	Arkansas Natural Heritage Commission	Preserve wetland and aquatic habitats	Bayou Dorcheat is one of the most unaltered streams in the region
Dr. Lester Sitzes III Bois D'Arc	WMA	13,626	Hempstead	1950s	AGFC, International Paper, Potlatch	Wildlife habitat, public hunting	
Little River	WMA	590	Hempstead	1991	AGFC	Wildlife habitat, public hunting	Transferred from USFWS
Ozan	WMA	580	Hempstead	1991	AGFC		
Caney Creek	WMA	85,000	Howard, Polk	1968	US Forest Service	Enhance wildlife species management	
Lafayette County	WMA	13,696	Lafayette	1970	Private companies	Wildlife habitat, public hunting	
Spring Bank	WMA	701	Lafayette	1992	AGFC	Wildlife habitat, public hunting	
Palmetto Flats Natural Area	WMA	1,848	Little River	2008	ANHC	Wetland habitat	Largest contiguous tract of alluvial terrace forest in Arkansas Red River valley
Sulphur River	WMA	16,000	Miller	1950s	AGFC	Wildlife habitat, public hunting, ecosystem protection	One of few remaining large tracts of bottomland hardwood forest in Red River valley
DeQueen Lake	WMA	8,792	Sevier		USACE		
Pond Creek	NWR	30,000	Sevier	1994	USFWS	Wildlife habitat, public recreation	
Iron Mountain Natural Area	Natural Area	260.5	Polk	1979	ANHC	Ecosystem protection, wildlife habitat	Endemic southern red-backed salamander
Fenwood Seep Natural Area	Natural Area	9.59	Polk	2002	ANHC	Ecosystem protection	
Cossatot River State Park Natural Area	Natural Area	4470.2	Howard, Polk	1989	ANHC, Arkansas State Parks	Ecosystem protection, public recreation, wildlife habitat	Endemic fish

2.2.2.6 Red River Compact

In 1955, the US Congress authorized Texas, Oklahoma, Arkansas, and Louisiana to begin negotiating a compact to resolve disputes over rights to water in the Red River and its tributaries, as well as preventing future disputes. In 1978, after 23 years of negotiations, representatives of Texas, Oklahoma, Arkansas, and Louisiana signed the Red River Compact (Lancaster 2011). The purpose of the compact is to provide for equitable apportionment of the waters of the Red River and its tributaries among the four states to ensure conservation and protection of this shared resource.

3.0 PHYSICAL CHARACTERISTICS

This section summarizes the physical and biological characteristics of the SAWRPR. This includes the physiography, geology, climate, and land use, as well as descriptions of the ecological, surface water, and groundwater resources within the planning region.

3.1 Physiography

Arkansas is typically divided into two major physiographic regions. These are the Interior Highlands of northern Arkansas, and the Gulf Coastal Plain of southern and eastern Arkansas. These regions are further divided into smaller physiographic provinces based on topography and geology. The “fall line” is where the two major physiographic regions in Arkansas meet.

The SAWRPR is located primarily in the Gulf Coastal Plain physiographic region, with an area of the Interior Highlands included in the northern portion of the region. The physiographic province of the Gulf Coastal Plain that occurs in the planning region is the West Gulf Coastal Plain (Figure 3.1). The physiographic province of the Interior Highlands that occurs in the planning region is the Ouachita Mountains (Figure 3.1) (T. Fugitt, ANRC, personal communication, April 9, 2013).

3.1.1 West Gulf Coastal Plain Province

The West Gulf Coastal Plain physiographic province accounts for the largest area of the planning region. This province is characterized as a south sloping, plain with gently rolling hills and broad, level to nearly level stream valleys. This area is moderately dissected by streams. Elevations range from over 500 feet above sea level in the northern uplands to around 175 feet above sea level along the Red River at the Louisiana border (NRCS 2006; Woods et al. 2004).

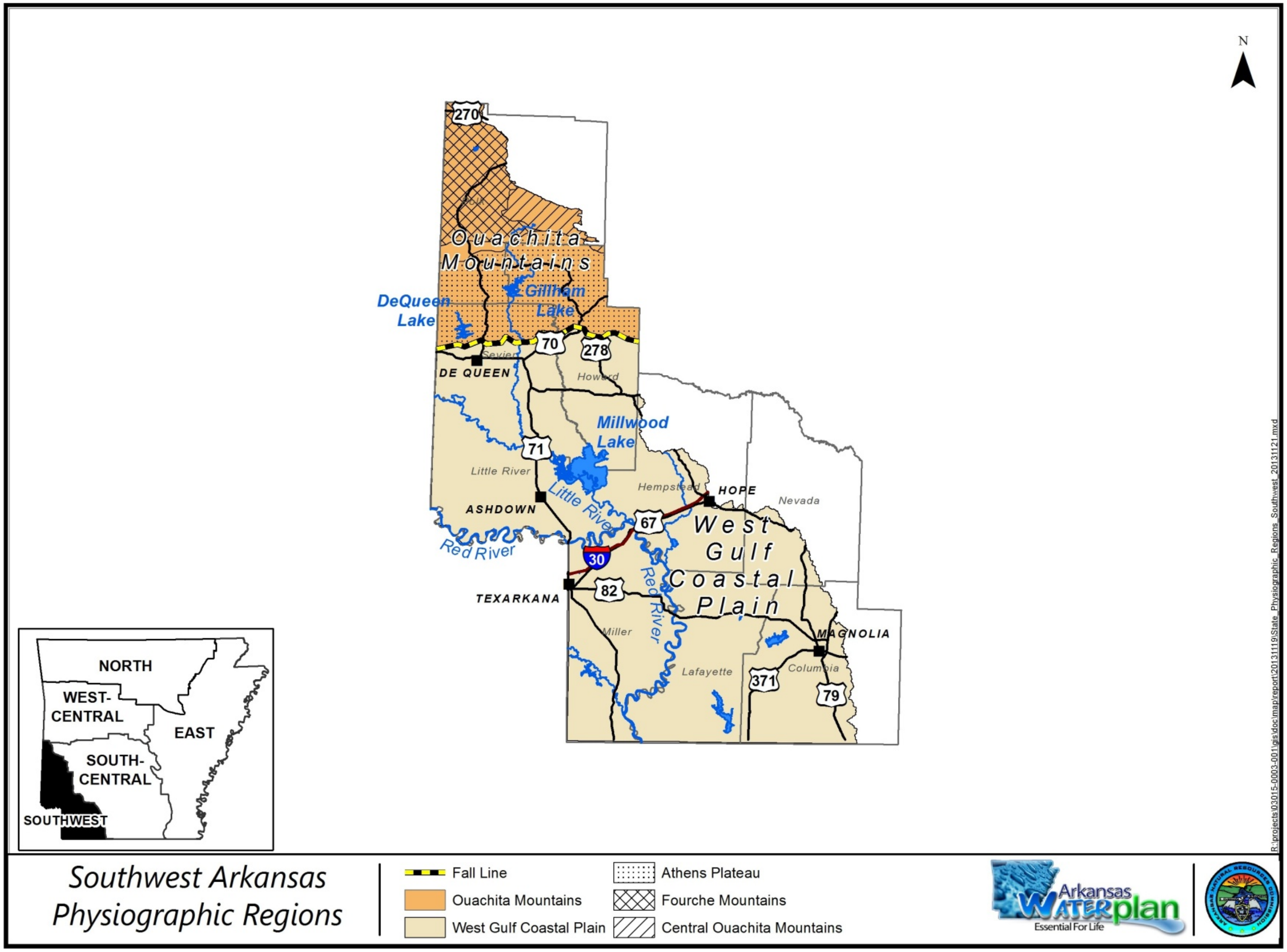

Figure 3.1. Physiographic regions within the SAWRPR.

3.1.2 Ouachita Mountain Province

The SAWRPR extends north into the Ouachita Mountain physiographic province. Three physiographic subdivisions of the Ouachita Mountain province are present in the planning region: the Fourche Mountains, the Central Ouachita Mountains, and the Athens Plateau (Figure 3.1). The physiography of these subdivisions consist of generally parallel ridges and valleys oriented east to west. The three physiographic subdivisions are differentiated primarily by the spacing of the mountain ridges (Foti 2011; T. Fugitt, ANRC, personal communication, 4/9/2013).

In the northernmost area of the planning region are the Fourche Mountains. The Fourche Mountains contain several major ridges. The highest elevations in the planning region, over 2,000 feet above sea level, occur in this physiographic subdivision. The highest peak in the planning region, Rich Mountain, is part of the Fourche Mountains. The elevation of Rich Mountain is 2,681 feet above sea level. Valleys in the Fourche Mountains tend to be broad with minimum elevations around 1,000 feet above sea level (T. Fugitt, ANRC, personal communication, 4/9/2013).

The Central Ouachita Mountains physiographic subdivision is east of the Fourche Mountains in this planning region (Figure 3.1). The ridges of the Central Ouachita Mountains are very close, separated by narrow valleys with steep gradients. These ridges are east-west oriented, long, even-crested, and steep-sloped. Elevations of 2,000 feet above sea level are common, and local relief is between 300 and 900 feet.

South of these subdivisions in the planning region is the Athens Plateau subdivision of the Ouachita Mountains. The Athens Plateau is a very narrow belt extending along the southern edge of the Interior Highlands. The majority of the area of the SAWRPR within the Ouachita Mountains is within this physiographic subdivision (Figure 3.1). Elevation is little above 500 feet and it has an undulating appearance. Occasional hills are remnants of an older surface (T. Fugitt, ANRC, personal communication, 4/9/2013). The low ridges of the Athens Plateau are generally oriented east to west.

3.2 Geologic Setting

Geologic formations in the SAWRPR range in stratigraphic order from the earliest deposited layers of the Ordovician Period to the Quaternary alluvium. The Quaternary alluvial and terrace deposits are located along major rivers in the planning region. The planning region is split by the “fall line” (see Figure 3.1), which generally is defined in geologic terms as the contact of the consolidated Paleozoic formations of the Interior Highlands with the unconsolidated formations of the Cretaceous, Tertiary, and Quaternary Systems in the Gulf Coastal Plain (Figure 3.2).

The varied geology of the SAWRPR makes it rich in economically important minerals. Industrial minerals available in the Ouachita Mountain province include crushed stone and shale. In the West Gulf Coastal Plain province, bromine, chalk, clay, crushed stone, gypsum, oil, sand and gravel are extracted (Mayfield 2001, USGS 2013a).

3.2.1 Geology of the West Gulf Coastal Plain Province

The West Gulf Coastal Plain in the SAWRPR generally consists of unconsolidated to semi-consolidated deposits of Cretaceous through Quaternary age sand, clay, marl, and gravel. Surface materials are generally unconsolidated to semi-consolidated sand and clay. Recent alluvial deposits are also associated with the Red River and its tributaries.

Geologic formations comprising the West Gulf Coastal Plain province in Arkansas are contained within the Mississippi Embayment, is a low lying basin that is filled with Cretaceous age to recent sediments. The Mississippi Embayment is a structural trough (syncline) formed from downwarping and rifting related to the Ouachita orogeny. This activity resulted in a deep catch basin for sediment deposition. The axis of this syncline plunges southward, with the axis roughly parallel to the Mississippi River (Clark et al. 2011).

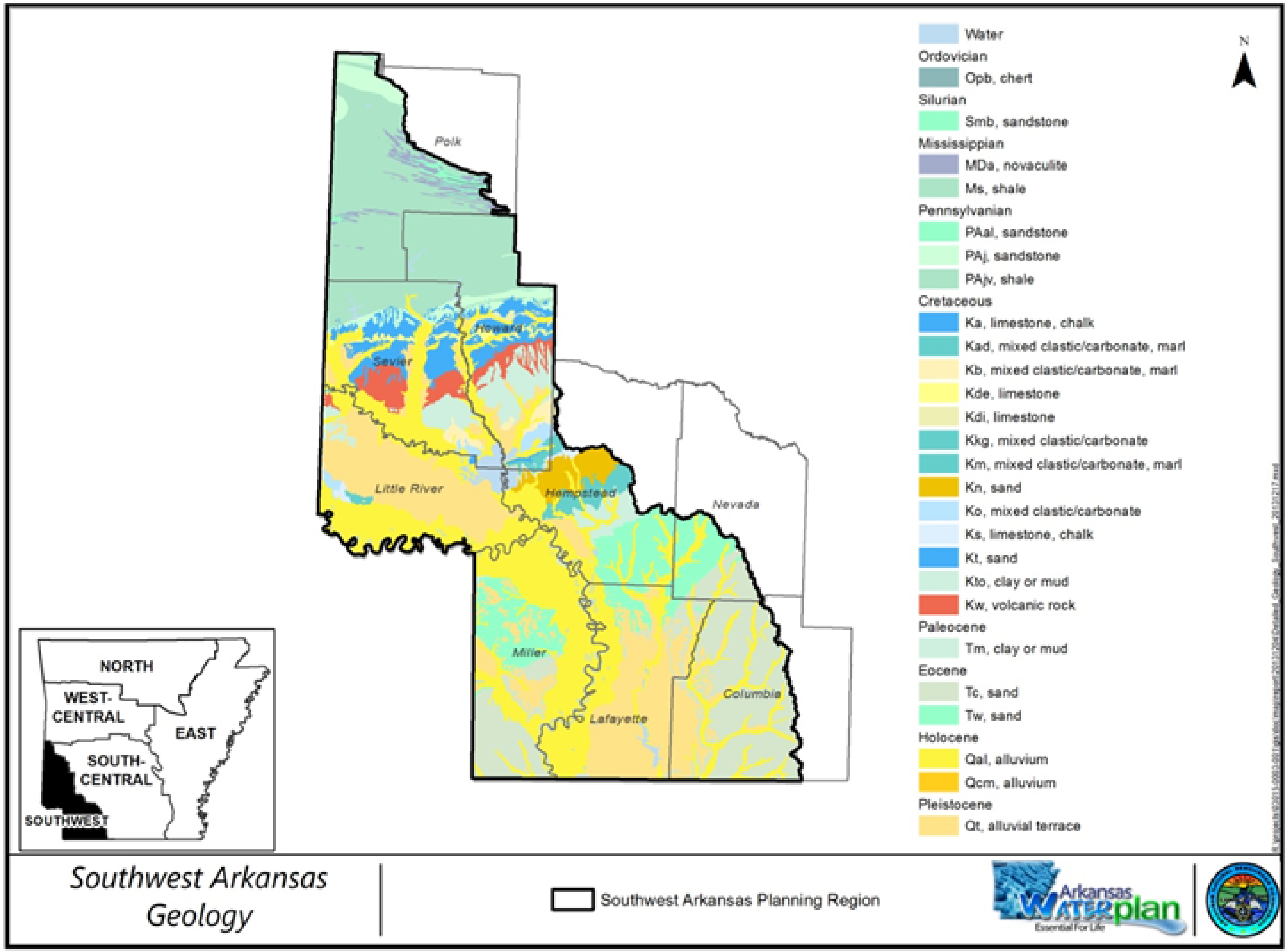

Figure 3.2. Surface geology of the SAWRPR (Haley et al 1993).

Cycles of rising and falling sea levels from the Cretaceous through the Tertiary periods resulted in older deposits cropping out on the periphery of the embayment, in bands of varying widths roughly parallel to the Fall Line, and dipping gently to the south and southeast. The Cretaceous-age deposits, consisting of sand, clay, gravel, marl, limestone, and chalk, represent shallow, marginal, and usually restricted marine environments. Most of the beds are coarse sand, clay, or gravel. The lowermost formation is the Trinity Group which also contains gypsum. The Tokio and Ozan Formations represent the middle Cretaceous and contain some lignite. The upper Cretaceous is represented by the Brownstown marl, which is fossiliferous, calcareous clay, and the Nacatoch Sand. Petroleum reservoir rocks are widely distributed in Cretaceous and Jurassic sandstones and limestones underlying the planning region.

The Tertiary-age deposits, mostly sand, silt, and clay, represent marginal marine and alluvial deposits. Scattered deposits of lignite are found also, especially in the Wilcox Group. The Midway Group contains some semi-consolidated white limestone.

The hydrogeology of the West Gulf Coastal Plain can be described as layers of unconsolidated silt, sand, and gravel which function as aquifers, yielding large quantities of water to wells. These aquifers are separated by clays which store greater volumes of water but have relatively low hydraulic conductivity, and therefore do not yield adequate volumes of water to wells. The aquifers of the West Gulf Coastal Plain consist of strata with high volumes of sand which has a high hydraulic conductivity and; therefore, a high specific yield of water to wells. Groundwater resources of the SAWRPR are described in detail in Section 3.8.

3.2.2 Geology of the Ouachita Mountain Province

The Ouachita Mountains consist of folded sedimentary rock. The sedimentary rocks of the Ouachita Mountains consist of a thick sequence of shale, chert, sandstone, conglomerates, novaculite, and volcanic tuff deposited during the Paleozoic Era within an elongate, subsiding trough (Renken 1998).

The Ouachita Mountains are true geosynclinal mountains formed from strata deposited in deep water settings and uplifted and deformed by the compressional events associated with continental collision. The general structure of the Ouachita Mountains is a broad uplift with complex folds and numerous complex faults (McFarland 2004). Sediments of the Ouachita Mountains are well indurated and generally well cemented as a result of deep burial, intense compression, and complex rock-forming history (Renken 1998).

In the Fourche Mountains and the Athens Plateau, the Jackfork Sandstone is particularly important in the major mountain ridges. The Stanley Shale is the most widespread formation. The Central Ouachita Mountains are made up of Ordovician and Silurian sandstone and shale. Two prominent formations of the Central Ouachita Mountains are the Crystal Mountain sandstone which is overlain by the Mazarn shale. Arkansas novaculite is exposed along the outer edge of the Central Ouachitas, sometimes referred to as the Novaculite Uplift. The novaculite is Devonian in age and is situated below the Hot Springs sandstone. It is a very hard, fine-grained silica-rich rock, which has been broken by the folding of the Ouachita Mountains.

Generally, the hydrogeology of the Interior Highlands can be described as an area of consolidated formations which yield relatively low volumes of water to wells. The low specific capacity in these wells is a direct result of the lithological nature of the strata itself. The consolidated formations typically are confined with most of the water yielded to wells coming through secondary porosity found in fractures and bedding plains. The broken novaculite of the Central Ouachita Mountains exhibits a large amount of secondary porosity that contains groundwater. The Atoka Formation is significant as a source of shallow domestic wells in the Ouachita Mountains, but yields are typically small. Groundwater resources of the SAWRPR are further described in Section 3.8.

3.3 Ecoregions

Ecoregions are areas within which ecosystems, and the type, quality, and quantity of environmental resources, are generally similar (EPA 2013a). The US Environmental Protection Agency (EPA) has defined 10 ecoregions within the SAWRPR (Figure 3.3). The high number of ecoregions in this relatively small area is a result of the variability in elevation, orientation, and geology present in this region. There are four Ouachita Mountains ecoregions within the SAWRPR: Athens Plateau, Central Mountain Ranges, Fourche Mountains, and Western Ouachitas. There are six ecoregions within the West Gulf Coast Plain (classified as the South

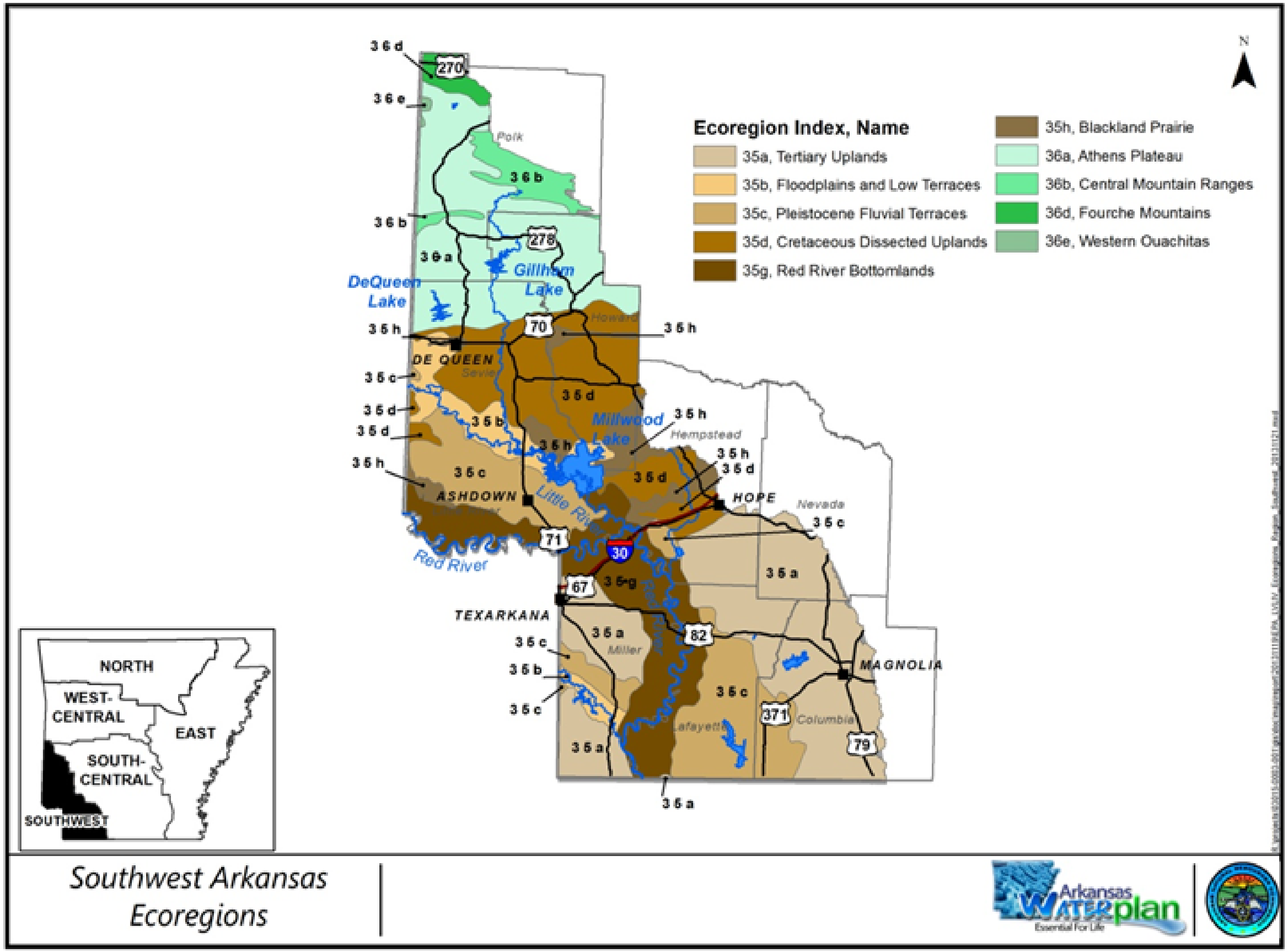

Figure 3.3. Ecoregions of the SAWRPR (Woods et al 2004).

Central Plains Level III ecoregion): Blackland Prairie, Cretaceous Dissected Uplands, Floodplains and Low Terraces, Pleistocene Fluvial Terraces, Red River Bottomlands, and Tertiary Uplands. Characteristics of each of these ecoregions are summarized in Table 3.1.

Table 3.1. Characteristics of ecoregions within the SAWRPR (Woods et al. 2004, Foti 2008, Anderson 2006, The Nature Conservancy 2013a).

Level III Ecoregion	Level IV Ecoregion	Native Vegetation	Hydrology	Other
Ouachita Mountains	Athens Plateau	Oak-hickory-pine forest	High gradient streams, white water on Cossatot River	
Ouachita Mountains	Central Mountain Ranges	Oak-hickory-pine forest, novaculite glades, mixed pine and upland deciduous forest on uplands	High gradient streams with gravel, cobbles, boulders, or bedrock substrates	Perennial springs and seeps are common
Ouachita Mountains	Fourche Mountains	Mixed shortleaf pine and upland deciduous forest on south-facing slopes, sugar maple and magnolia on north-facing slopes, oak-hickory-pine forest in valleys, loblolly pine in wet lowland sites along rivers, stunted oak forest and other mountain vegetation on highest ridges, e.g., Rich Mountain	High gradient streams with gravel, cobbles, boulders, or bedrock substrates	
Ouachita Mountains	Western Ouachitas	Mixed pine – oak and oak woodlands in uplands, riparian forest on floodplains including sweet gum, sycamore, willow, elm, maple, and birch	High gradient streams with gravel, cobbles, boulders, or bedrock substrates	Contains the greatest concentration of imperiled and critically imperiled species in North America
South Central Plains	Blackland Prairie	Woodland, savannah, and prairie	Moderate gradient streams	21 globally imperiled plant communities, rare birds
South Central Plains	Cretaceous Dissected Uplands	Oak-hickory-pine forest, mixed pine and upland deciduous forest	Highest drainage density of the South Central Plains, moderate gradient streams	

Table 3.1. Characteristics of ecoregions within the SAWRPR (continued).

Level III Ecoregion	Level IV Ecoregion	Native Vegetation	Hydrology	Other
South Central Plains	Floodplains and Low Terraces	Southern floodplain forest and oak-hickory-pine forest	Low gradient streams, oxbow lakes, frequently flooded land	
South Central Plains	Pleistocene Fluvial Terraces	Pine flatwoods of loblolly pine and oak, hardwood wetlands, pine savannah, prairie	Low gradient streams, wetlands	
South Central Plains	Red River Bottomlands	Southern floodplain forest	Low gradient streams, oxbow lakes, backswamps	
South Central Plains	Tertiary Uplands	Oak-hickory-pine forest, mixed shortleaf pine-loblolly pine forest, upland deciduous forest, bottomland forest along rivers, stunted sandhill forest occurs	Low gradient streams with sandy substrates, most ephemeral, some spring-fed perennial streams in sandhills	

Streams in the Ouachita Mountains have high gradients, and substrates are made up of gravel, cobbles, boulders, or bedrock. Fish communities in these streams are dominated by sensitive species (Woods et al. 2004).

Streams are generally sluggish in the West Gulf Coastal Plain because the gradients of the stream channels are relatively flat. In the uplands and terraces, streams are highly incised. Water tends to be turbid or stained and substrates are sandy and soft. Fisheries are composed of diverse species but few sensitive species. The Red River fishery consists of a fish community typical of large rivers (Woods et al. 2004).

The Cretaceous chalks and marls that occur south of the Ouachita Mountains have a relatively low permeability and do not yield much water to streams. Therefore, streams in the Cretaceous Dissected Uplands and Black1and Prairie generally have lower sustained flows during low-flow periods than streams in the rest of the South Central Plain area, which usually exhibit sustained base flow conditions as a result of the higher permeability of soils in the area that favor the transmission of water (ASWCC 1987).

3.4 Aquatic Biodiversity

The complexity of the drainages and geologic history that occurs in the SAWRPR translates into high aquatic biodiversity. Of the 268 aquatic and semi-aquatic animal species that have been identified as being of greatest conservation need in Arkansas, 109 are present in the SAWRPR (Anderson 2006).Figure 3.4 provides a summary of the aquatic and semi-aquatic species of greatest conservation need found in the planning region. Of the over 180 aquatic and semi-aquatic plant species tracked by ANHC, over 60 occur in the SAWRPR (ANHC 2013). Of the 42 Arkansas endemic species (found nowhere else in the world), 8 occur in the planning region (Figure 3.5) (Anderson 2006). There are 117 miles of streams in the planning region that have been designated by the Arkansas Department of Environmental Quality (ADEQ) as Ecologically Sensitive Waterbodies because they provide habitat for endemic, threatened, or endangered species (Figure 3.6) (APCEC 2011). Additional information on threatened and endangered species in the planning region is provided in Section 5.3.7.

3.5 Climate

The climate in the SAWRPR is humid with warm summers. Temperature, precipitation, and evaporation data were obtained from the National Weather Service, National Oceanic and Atmospheric Administration National Climatic Data Center (NOAA NCDC), and the PRISM Climate Group and reviewed. These data are available for each of the climate divisions in Arkansas (Figure 3.7). Data for climate division 7 were used to characterize the climate for the SAWRPR. Summaries of these data are presented below, along with discussions of factors that influence climate in the SAWRPR and long-term climate trends in the region.

3.5.1 Temperature

The average annual temperature in the SAWRPR is approximately 63.3 degrees Fahrenheit. Average daytime maximum temperatures range from 93 degrees Fahrenheit in August to 54 degrees Fahrenheit in January (Figure 3.8). Average minimum nighttime air temperatures range from 70 degrees Fahrenheit in July to 32 degrees Fahrenheit in January. The average difference between the monthly normal minimum and maximum air temperatures is 23 degrees Fahrenheit.

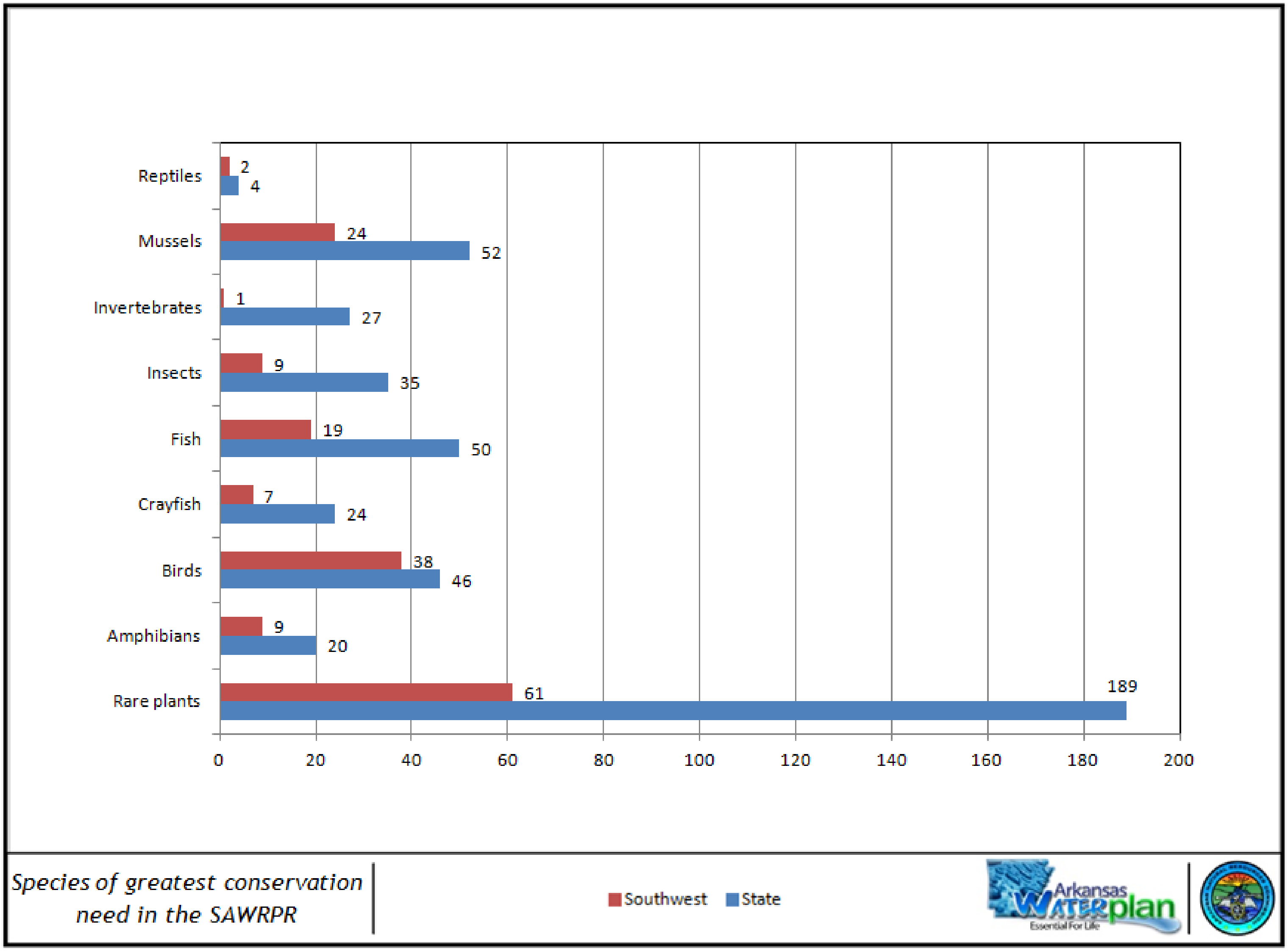

Figure 3.4. Species of greatest conservation need found in the SAWRPR (J. Anderson 2006, ANHC 2013).

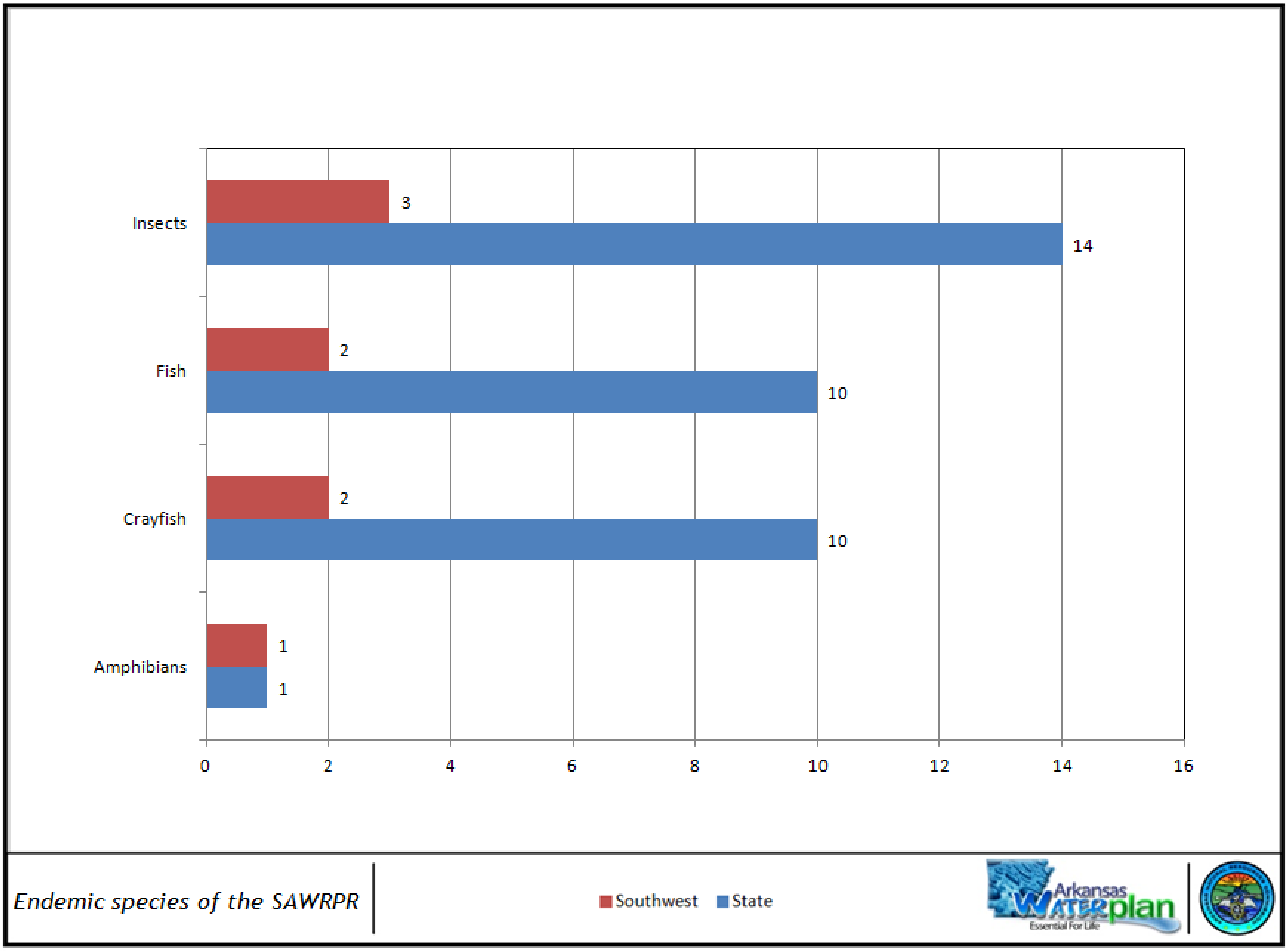

Figure 3.5. Endemic species of the SAWRPR (Anderson 2006).

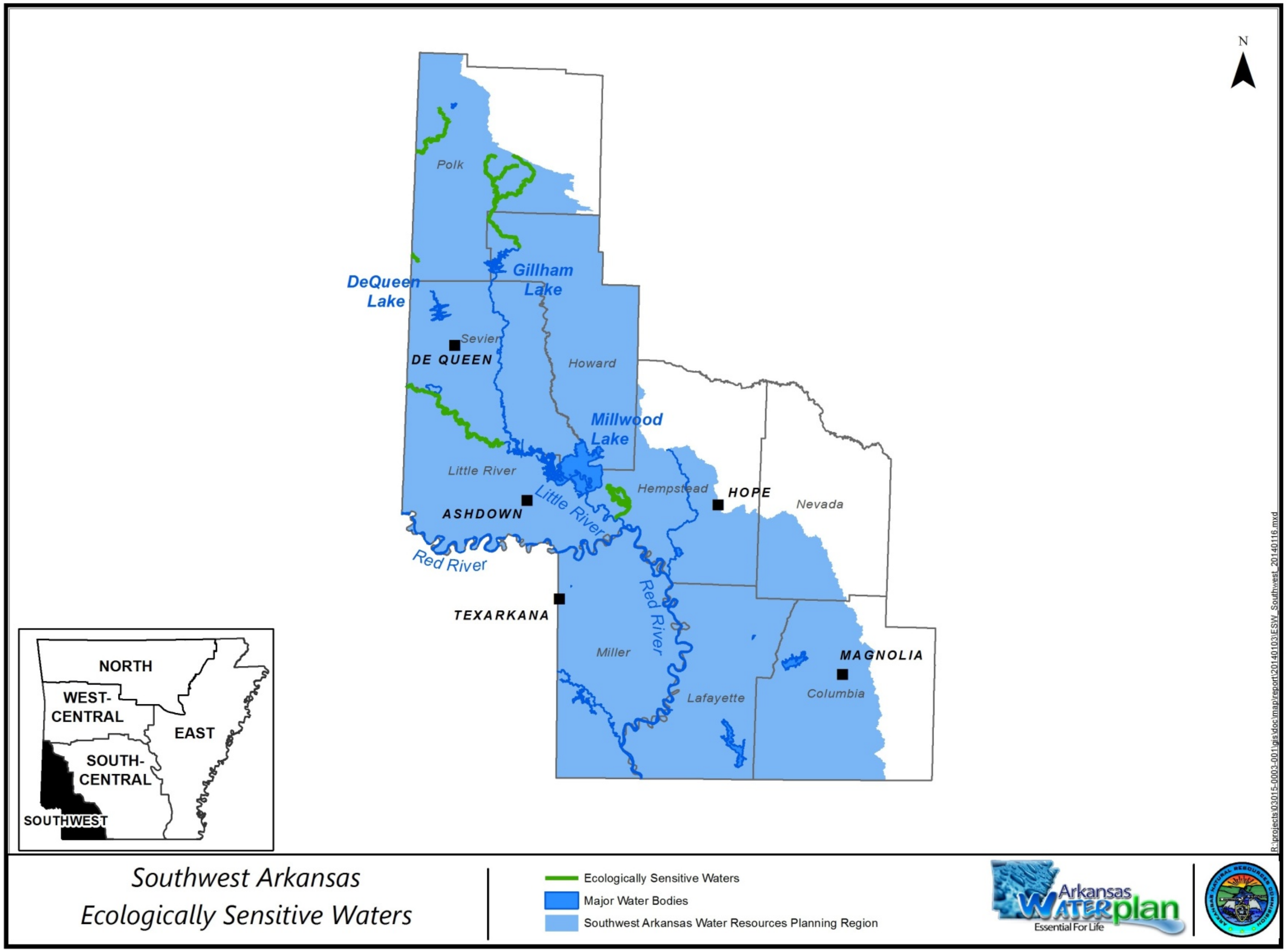

Figure 3.6. Designated ecologically sensitive waterways within the SAWRPR.

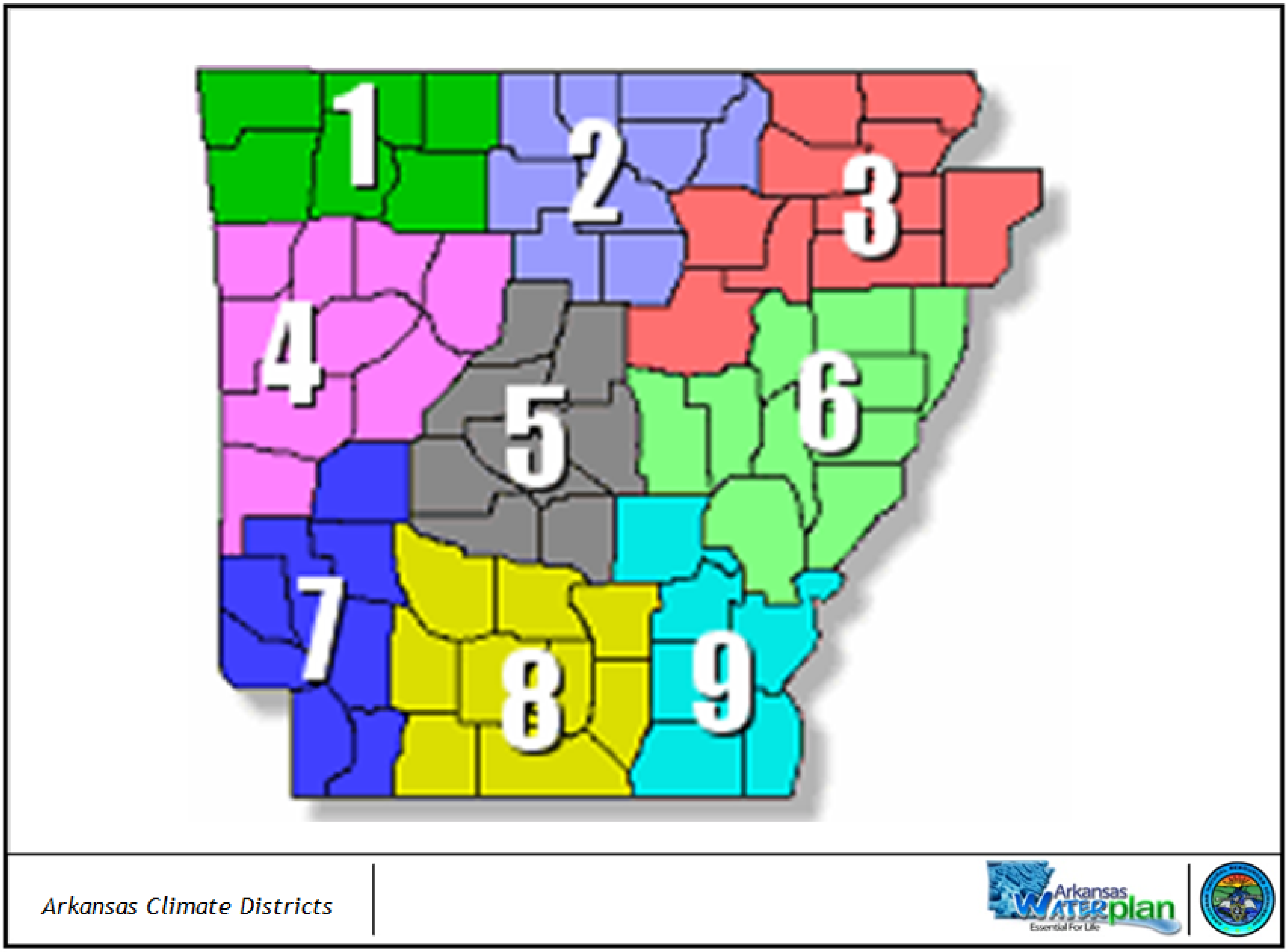

Figure 3.7. Arkansas climate divisions (Natinal Weather Service 2013).

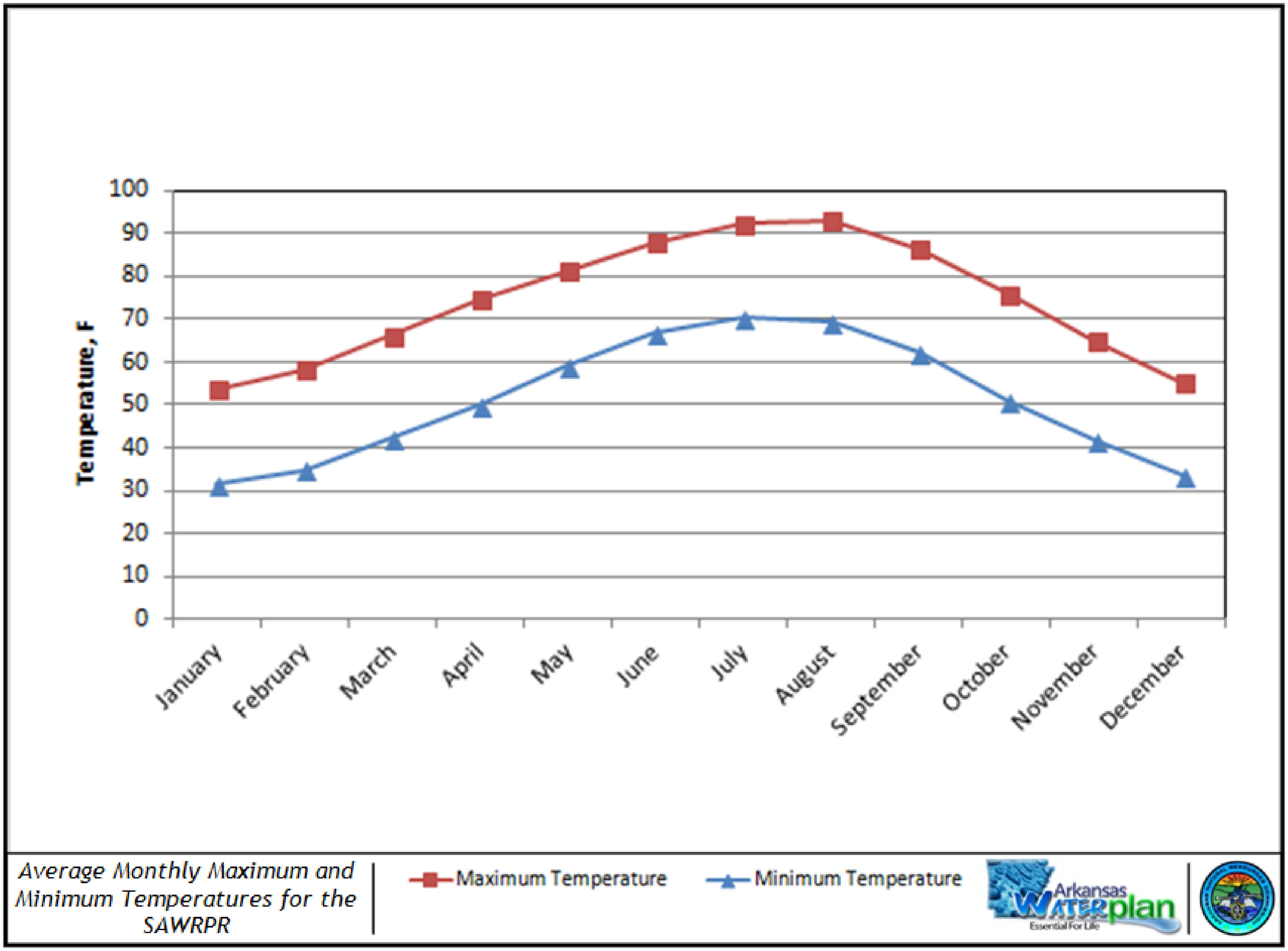

Figure 3.8. Average monthly maximum and minimum temperatures for the SAWRPR 1981 - 2010 (PRISM Climate Group 2004).

Variations in annual maximum daily temperatures across the planning region are shown in Figure 3.9. Temperatures are generally cooler in the higher elevations in the north. The growing season (frost free days) in the planning region ranges from 190 to 233 days in the Ouachita Mountains to 200 to 245 days in the West Gulf Coastal Plain (Woods et al. 2004).

3.5.2 Precipitation

Mean annual precipitation in the SAWRPR ranges from 66 inches in the north to 48 inches in the south (Woods et al. 2004). The area of the Ouachita Mountains within the planning region receives the highest precipitation amounts in the state due to the influence of their high elevations (Figure 3.10). When moist south winds from the Gulf of Mexico reach the Ouachita Mountains, the air is forced to rise, causing the air to cool so that the moisture condenses into clouds and rain that falls on the mountains. Rich Mountain, located in the extreme northern portion of the planning region, as one of the highest east-west ridges in the Ouachita Mountains, particularly affects regional precipitation patterns (Foti 2011).

Mean monthly precipitation for the SAWRPR for the period from 1981 through 2010 is shown in Figure 3.11. The months in late spring and late fall to early winter are generally the wettest. Average precipitation amounts are highest in May, and October through December. Precipitation is lowest in January and during the summer, July through September.

Summer precipitation primarily occurs during rainstorms, where locally high rainfall amounts can occur over a short period of time. During the fall, winter, and early spring, precipitation events are usually less intense and of longer duration. The majority of the precipitation in the SAWRPR falls as rain; snow occurs here only occasionally, more frequently at the higher elevations in the Ouachita Mountains (NOAA NCDC n.d., Buckner 2011).

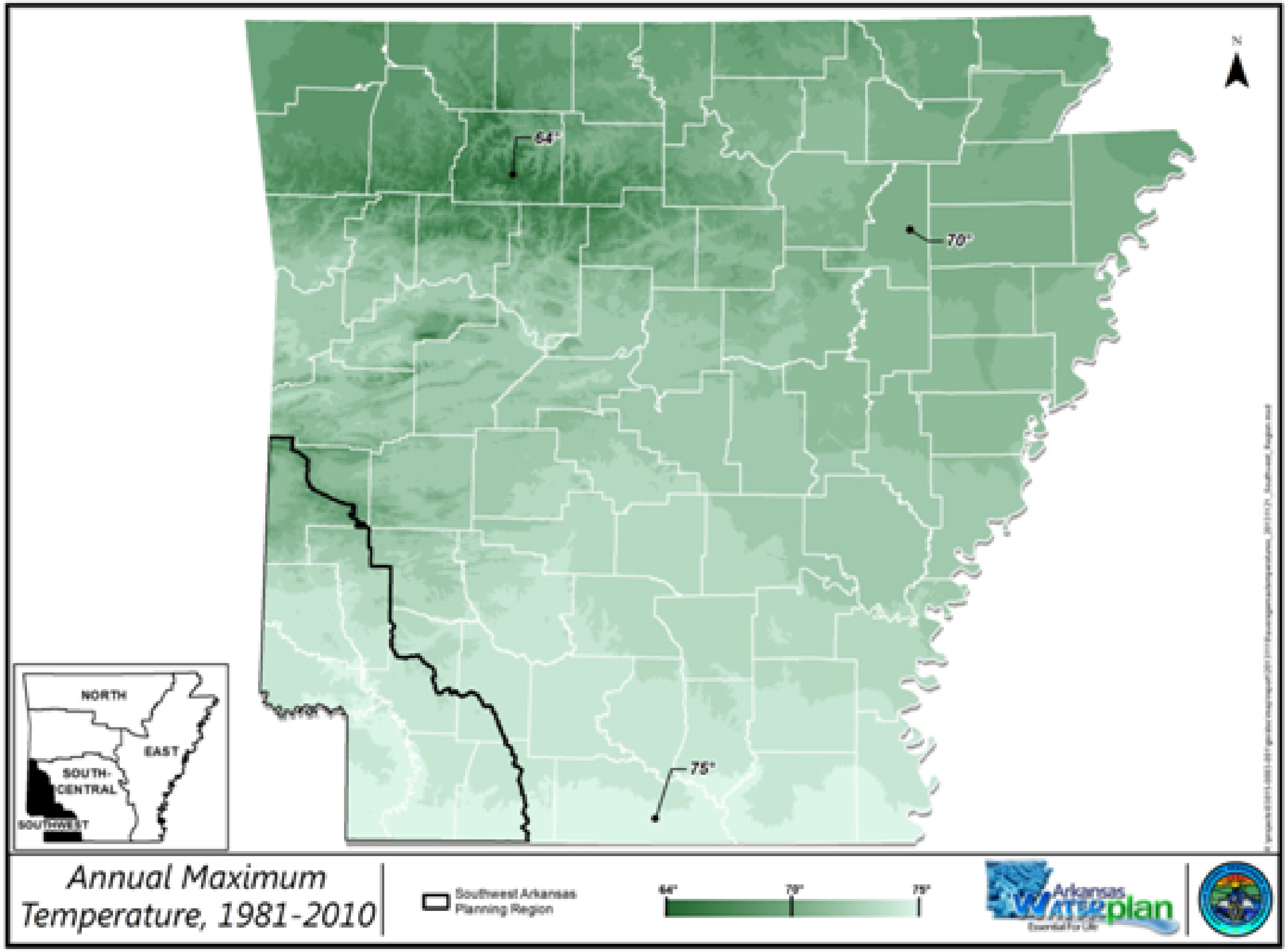

Figure 3.9. Average annual maximum temperatures (degrees F) across the SAWRPR., 1981 – 2010 (PRISM Climate Group 2004).

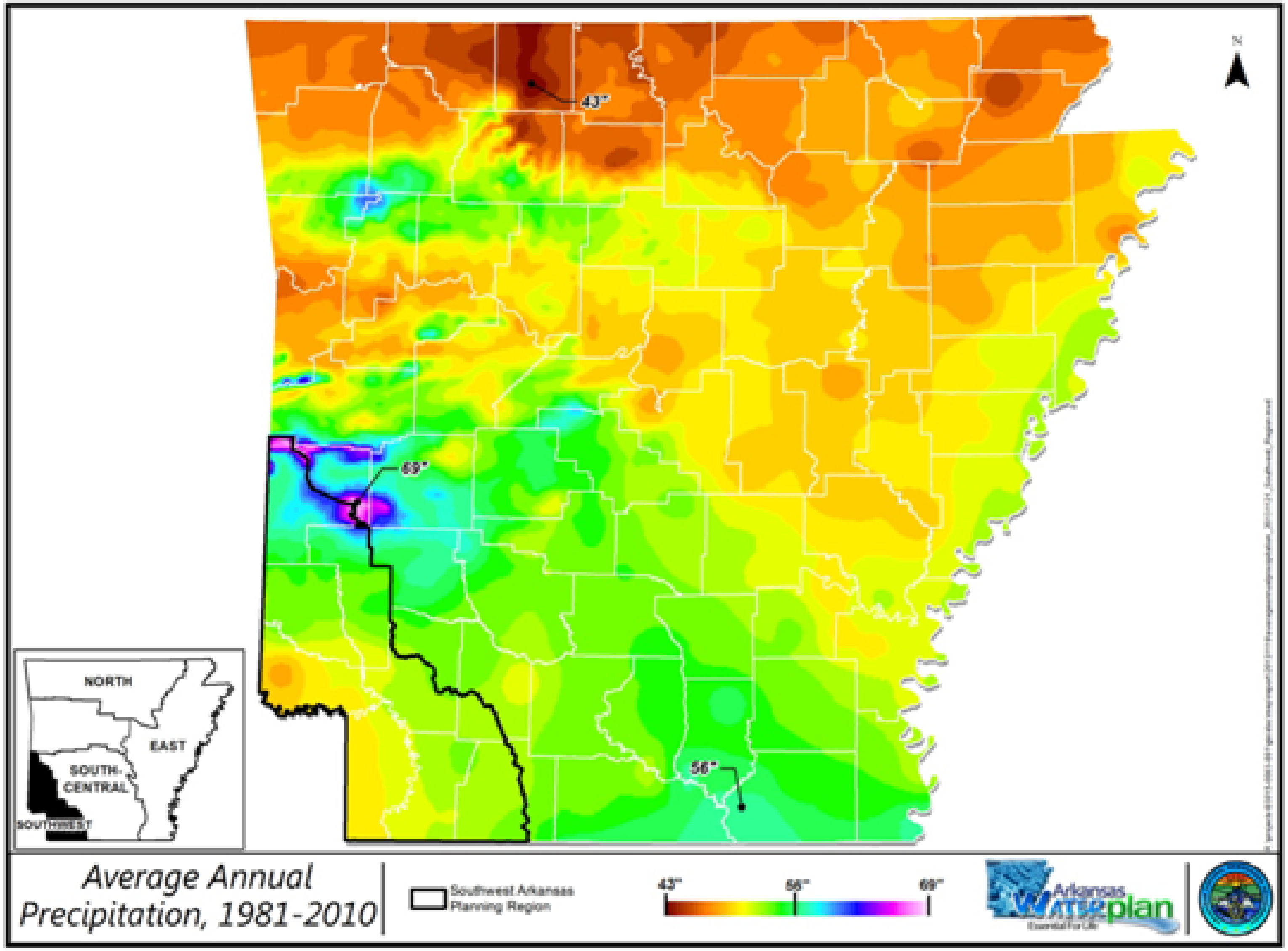

Figure 3.10. Average annual precipitation (inches) in the SAWRPR (PRISM Climate Group 2004).

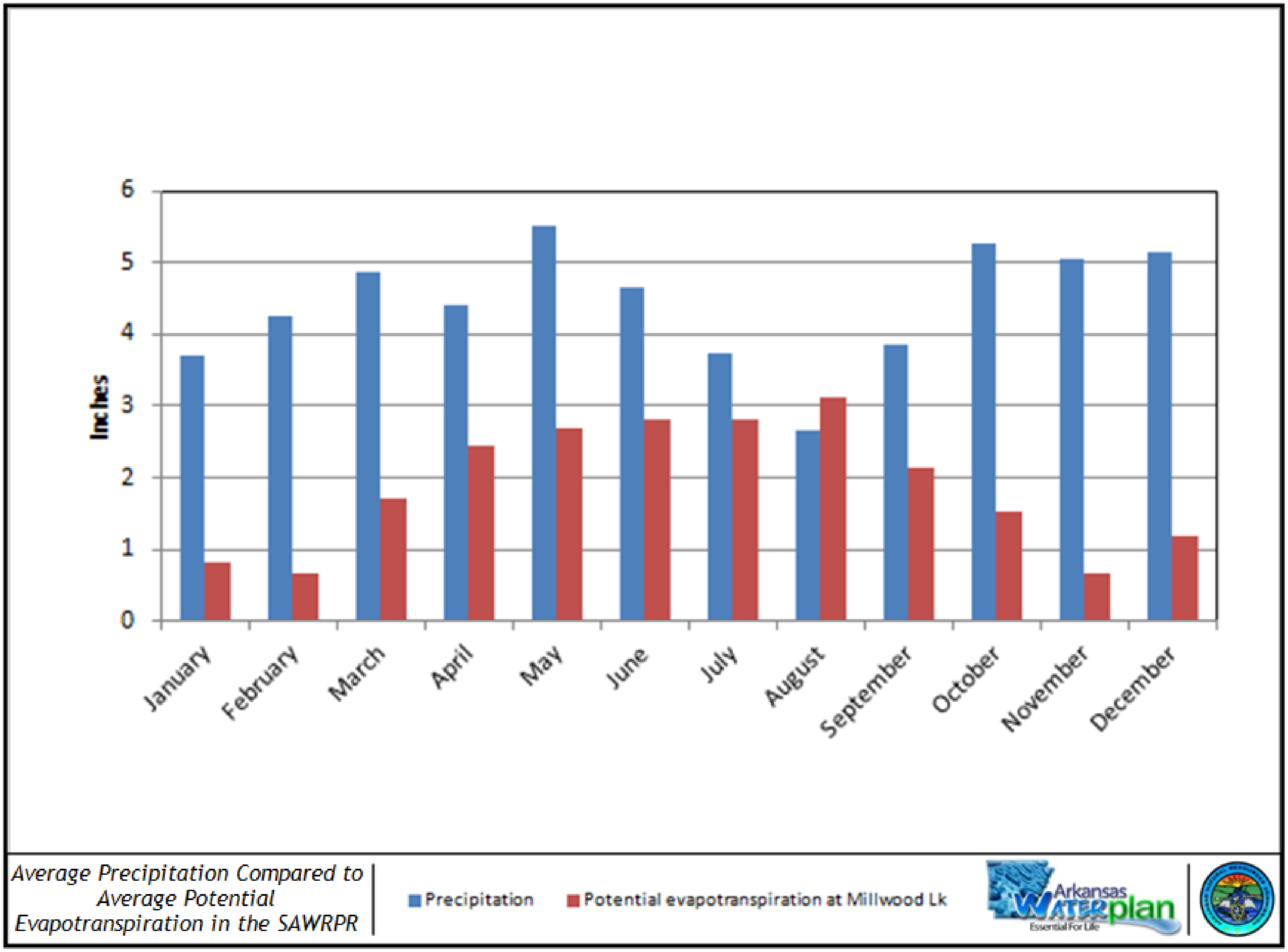

Figure 3.11. Average precipitation compared to average potential evapotranspiration in the SAWRPR (PRISM Climate Data Group 2004, NOAA NCDC 2013a).

3.5.3 Evaporation

Evaporation is the process by which water changes from liquid in soil to gaseous water vapor. When the conversion from liquid to water vapor occurs on leaves, the process is called transpiration. Evapotranspiration is the combination of these processes. The amount of evapotranspiration is controlled primarily by sunlight, but is influenced by humidity and wind (Scott et al. 1998).

Potential evapotranspiration is the maximum rate at which water in soil and on plants would change to water vapor, assuming there is no shortage of water to be changed. Actual evapotranspiration is usually less than the potential. Potential evapotranspiration is difficult to measure, but can be estimated from the meteorological measurement, pan evaporation. Pan evaporation is the rate of evaporation of water from a specific style of open pan at a weather station. In humid regions like Arkansas, potential evapotranspiration is similar to pan evaporation. Based on data from eastern Arkansas, the ratio of potential evapotranspiration to pan evaporation is assumed to be 0.85. Evaporation exhibits less variation from year to year and place to place than precipitation (Scott et al. 1998). Figure 3.11 shows monthly average potential evapotranspiration estimated from pan evaporation measurements at Millwood Lake Dam in Hempstead County for the period 1995 – 2010 (the available period of record for this station). The estimated potential evapotranspiration exceeds the normal precipitation in only one month, August.

3.5.4 Drought

Although the SAWRPR receives precipitation throughout the year, drought conditions occur in the region. One of the tools NOAA uses to determine when drought conditions exist is the Palmer Drought Indices. These indices are based on the differences of precipitation and temperatures from normal. The Palmer Drought Severity Index (PDSI) also takes into account the length of time that drought conditions last. PDSI values less than zero indicate drought conditions. An index of -2 indicates moderate drought, -3 indicates severe drought, and -4 indicates extreme drought (NOAA 2012). Figure 3.12 shows a time series plot of PDSI values for climate division 7 in Arkansas (see Figure 3.7 for a map of Arkansas climate divisions).

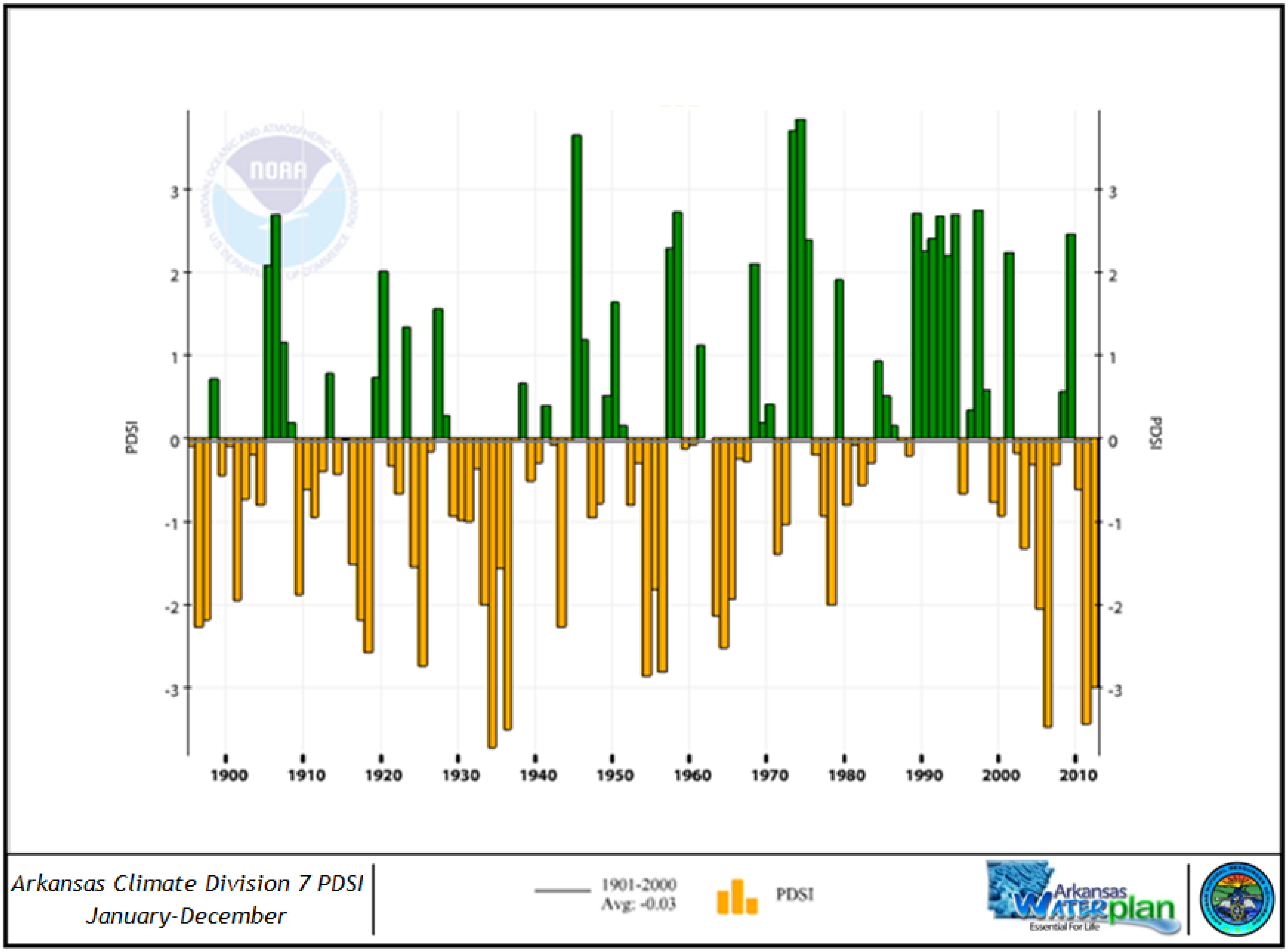

Figure 3.12. Historical values of the Palmer Drought Severity Index for climate division 7 (NOAA NCDC 2013b).

Periods with multiple consecutive years of drought have occurred in southwest Arkansas (Figure 3.12). This region is currently experiencing a period of drought that began in 2009 (NOAA NCDC 2013b).

3.5.5 Climate Variability

In 2007, the Arkansas Governor's Commission on Global Warming (GCGW) was established to, among other tasks, evaluate the potential impacts of global warming on the state citizens, natural resources, and economy. The literature review conducted by the GCGW identified the following climate change effects anticipated for the state (GCGW 2008):

- Increased incidence of severe weather events,
- Increased incidence of flooding,
- Increased incidence of drought,
- Possible saltwater intrusion into aquifers resulting from sea level rise, and
- Changes in climatic zones.

Plots of annual average temperature and total annual precipitation from 1895 to 2013 for the climate division 7 are shown in Figures 3.13 and 3.14, respectively. The temperature data appear to exhibit a cycle of change, where temperatures in the first half of the 20th century were warmer than the second half, but appear to be warming again in the early 21st century (Figure 3.13). The US Department of Agriculture (USDA) develops a plant hardiness zone map which shows annual average minimum winter temperature. The 2012 update of the USDA map shows warmer minimum temperatures in the region as compared to the 1990 zone map. This relationship follows the cycle shown on Figure 3.13 (Clark and Karklis 2012). Precipitation totals for climate divisions 7 appear to exhibit a slight long-term increasing trend (Figure 3.14). A detailed analysis of long-term precipitation trends across the state is being prepared as part of the 2014 water plan update.

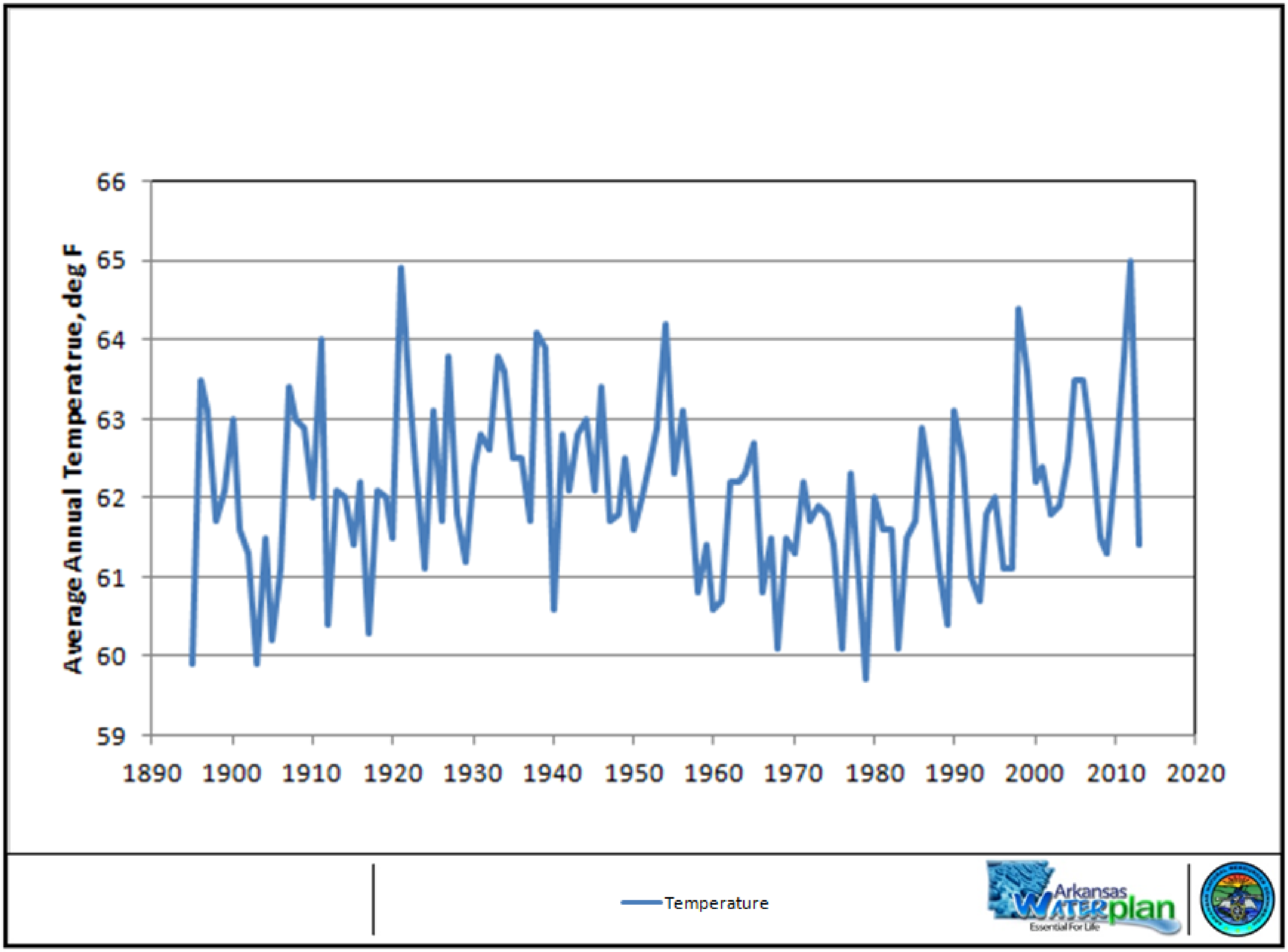

Figure 3.13. Historical average annual temperatures for the SAWRPR (NOAA NCDC 2013c).

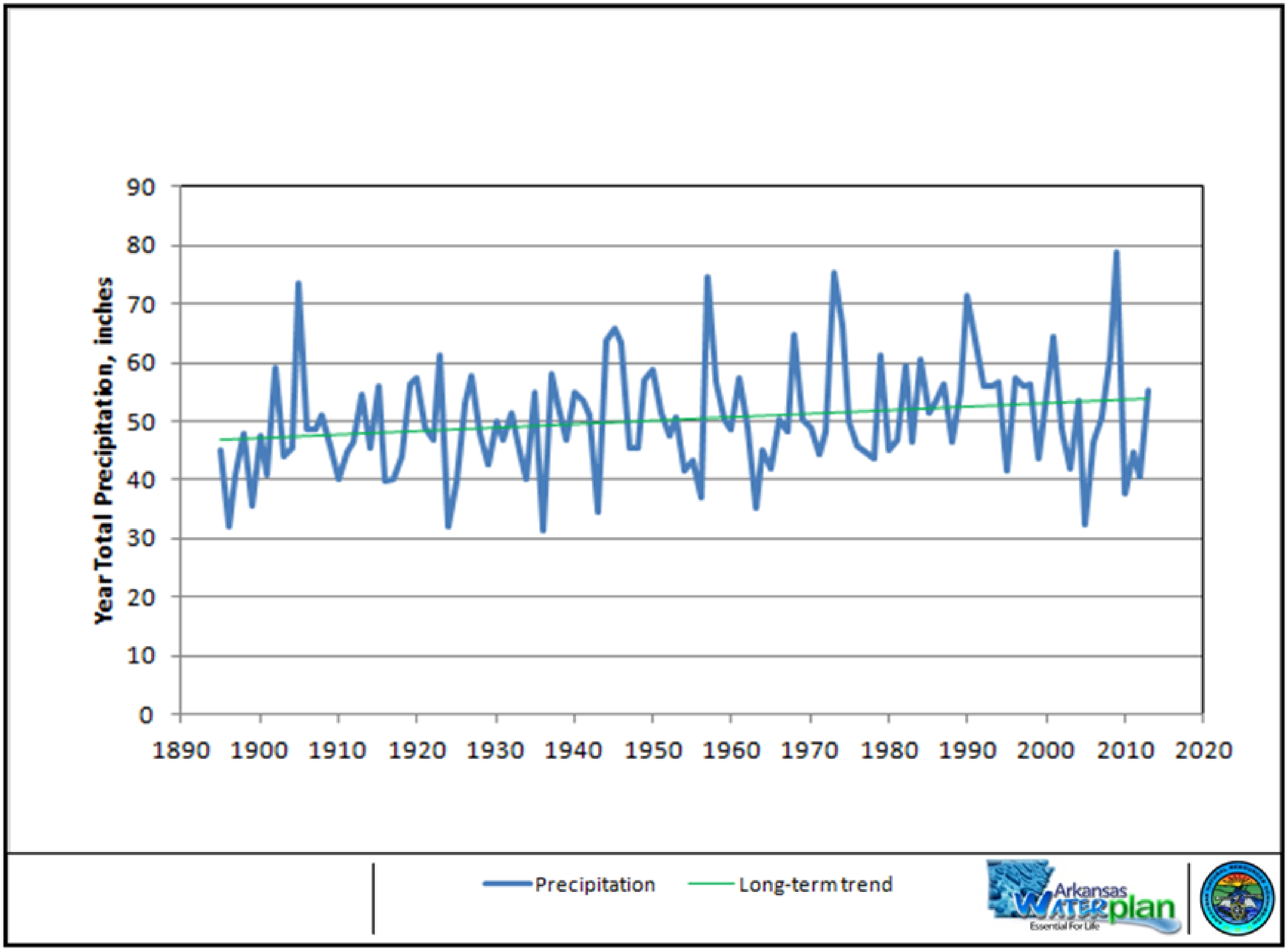

Figure 3.14. Historical annual precipitation totals for the SAWRPR (NOAA NCDC 2013c).

3.6 Land Use

Land use in the SAWRPR is summarized in Figure 3.15 and mapped in Figure 3.16. Major land use categories are discussed in the sections below, including present day extent, and changes since the 1990 AWP.

3.6.1 Forest

The SAWRPR is primarily forested (Figures 3.15 and 3.16). The majority of the forest land in the counties within the planning region (93%) is classified by the USDA Forest Service (USFS) as timberland, or commercial forest land, and the majority of timberland in the region is privately owned (USFS 2013). The timber industry is active in this region, particularly south of the Ouachita Mountains (Stroud 2011). Less than 1% of the forest in the SAWRPR is in National Forest.

Forest land acreage reported in the 1990 AWP basin reports is also included in Table 3.2. Because these data are from different sources, their comparability is uncertain, however, overall, the amount of forest land in the SAWRPR appears to have remained relatively unchanged since the 1990 AWP. The greatest increase in extent of forest land appears to have occurred in Nevada County, over 300%. The 1990 AWP reported that over 95% of the forest land in the Red River basin was commercially managed (USDA Soil Conservation Service 1987a,b).

Table 3.2 Forest land comparison for the SAWRPR (USFS 2013).

County	1990 AWP Forest Land (acres)	Forest Land 2012 (acres)	Change
Columbia*	400,835[a,c]	438,645	-
Hempstead*	262,007[a,d]	299,503	+
Howard	262,678[b,d]	275,600	+
Lafayette	206,817[a]	207,707	+
Little River	172,546[b]	189,473	+
Miller	214,044[a]	208,222	-
Nevada*	101,987[a,c]	330,803	+
Polk*	433,657[b,d]	431,058	-
Sevier	243,318[b]	244,395	+
Total	2,299,889	2,625,406	+

*Part of the county is in another planning region.

a (USDA Soil Conservation Service 1987b)
b (USDA Soil Conservation Service 1987a)
c (ASWCC 1987b)
d (ASWCC 1987a)

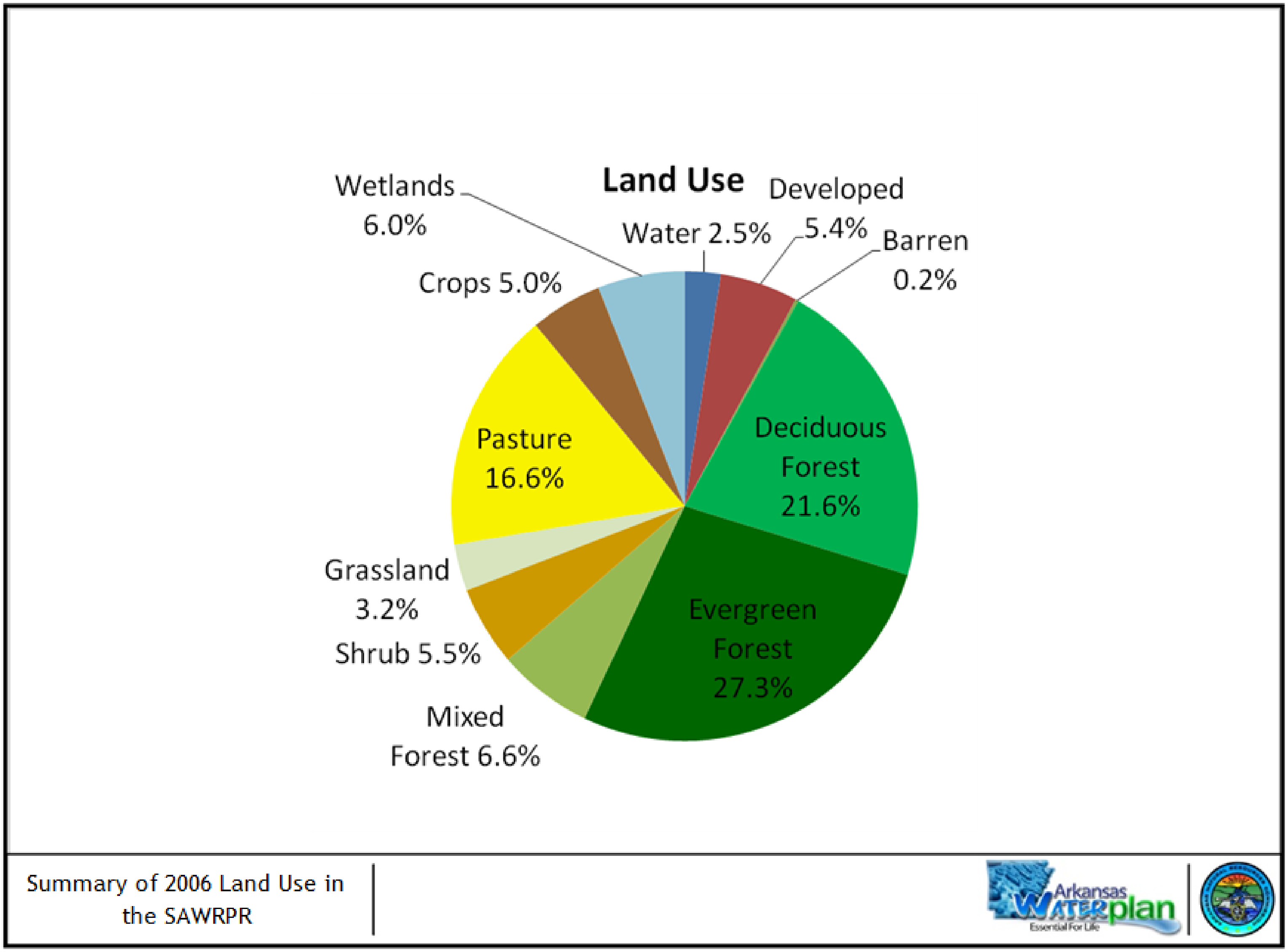

Figure 3.15. Summary of 2006 land use in the SAWRPR (Fry et al. 2011).

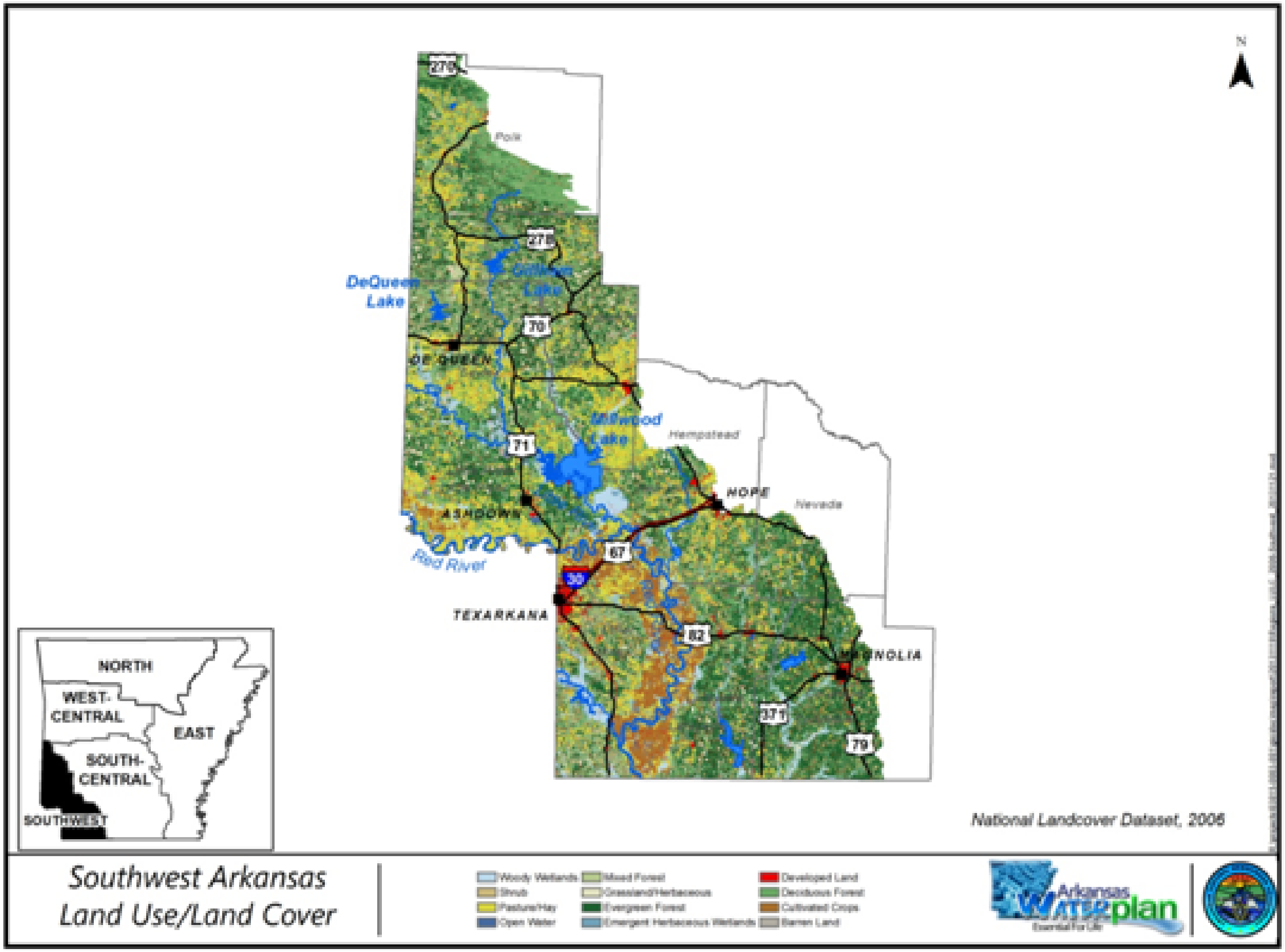

Figure 3.16. Land use map of the SAWRPR (Fry et al. 2011).

3.6.2 Agriculture

Agriculture accounts for the next largest proportion of the land use in the SAWRPR, 21.6% (Figure 3.15). Pasture and haylands account for the majority of this land use category. Cropland is concentrated in the bottomlands along the Red River (Figure 3.16). The 2007 Census of Agriculture reported 321,329 acres of cropland (harvested and other) in the counties of the SAWRPR, and 672,766 acres of pasture (USDA National Agricultural Statistics Service 2009). In the 1990 AWP, the amount of cropland in the counties of the planning region was reported as 256,637 acres, and grassland was 837,004 acres (USDA Soil Conservation Service 1987a,b). Because these data are from different sources, their comparability is uncertain (see Table 3.3). As a check, the 1987 Census of Agriculture reported that there was 328,892 acres of cropland (harvested and other) and 826,180 acres of pasture in these counties. Comparing the 2007 values to those from the 1990 AWP update and the 1987 Census of Agriculture indicates that there has been little change in the amount of cropland in the counties within the SAWRPR, but a definite decline in pasture area (Table 3.3).

Table 3.3. Agricultural land comparison for the SAWRPR (ASWCC 1987a,b; USDA Soil Conservation Service 1987a,b; US Census Bureau 1989; USDA National Agricultural Statistics Service 2009).

County	Cropland (acres)			Pasture		
	1987 Census of Agriculture[a]	**1990 AWP**	**2007 Census of Agriculture[a]**	**1987 Census of Agriculture[b]**	**1990 AWP**	**2007 Census of Agriculture[b]**
Columbia*	10,952	0	10,922	51,563	62,929	26,133
Hempstead*	52,718	34,023	47,922	136,608	146,832	137,992
Howard	18,685	2,415	27,318	99,917	115,885	79,811
Lafayette	54,037	56,868	44,646	58,604	63,116	50,505
Little River	53,386	51,772	42,840	90,253	102,294	78,617
Miller	83,127	92,055	75,776	96,829	78,034	97,435
Nevada*	18,743	14,717	17,868	64,619	66,841	36,152
Polk*	16,337	2,359	31,026	103,692	81,251	92,129
Sevier	20,907	2,428	23,011	124,095	119,822	73,992
Total	**328,892**	**256,637**	**321,329**	**826,180**	**837,004**	**672,766**

*Part of the county is in another planning region.
a Note: sum of cropland harvested and other cropland reported in census
b Note: sum of pastureland, all types and cropland used only as pasture reported in census

The major crops reported for counties along the Red River in the 2007 Census of Agriculture included hay, corn, wheat, and soybeans (Table 3.4). Based on data from the 2007 Census of Agriculture, around 8% of the harvested cropland was irrigated (USDA National Agricultural Statistics Service 2009). In the 1990 AWP, the major crops reported for the Red River basin were soybeans, rice, and sorghum with between 8% and 10% of the cropland irrigated (USDA Soils Conservation Service 1987a,b).

In the 2007 Census of Agriculture, approximately 8% of the cropland in the counties of the SAWRPR was irrigated (USDA National Agricultural Statistics Service 2009). In the 1990 AWP, it was reported that 9.8% of the cropland in the Red River basin was irrigated (USDA Soil Conservation Service 1987a,b). In the 1987 Census of Agriculture, approximately 1.9% of the cropland was irrigated (note that the amount of irrigated land was not reported for 4 of the 9 counties in 1987 to protect farmers' privacy) (US Census Bureau 1989). Because these numbers are from different sources, their comparability is uncertain. As a result, it is unclear whether there has been any change in the amount of irrigated land in the SAWRPR since the 1990 AWP.

3.6.3 Wetlands

Wetlands account for the next largest proportion of the land use in the SAWRPR; 231,750 acres, or 6% (Figure 3.15). Wooded wetlands, i.e., bottomland hardwoods, account for the majority of this land use area (224,651 acres or 97%). In the 1990 AWP update, the area of wetlands in the Red River basin was estimated to be 147,600 acres (USDA Soil Conservation Service 1987a, b). Although the comparability of these numbers is uncertain, it appears that the area of wetlands in the SAWRPR may have increased since the 1982 National Resource Inventory. Wetland resources of the planning region are further described in Section 3.7.3.

Table 3.4. Acreage for major crops for counties along the Red River (US Census Bureau 1989, USDA National Agricultural Statistics Service 2009).

	Hempstead*		Howard		Lafayette		Little River		Miller		Sevier	
	1987	2007	1987	2007	1987	2007	1987	2007	1987	2007	1987	2007
Corn	1,057	-	-	-	1,437	11,518	550	5,891	2,736	18,304	-	-
Cotton	560	-	-	-	7,246	3,683	-	-	3,852	-	-	-
Peaches	D	-	258	D	11	-	12	-	43	-	99	18
Pecans	D	571	D	D	49	-	1,831	5,041	1,096	-	D	D
Sorghum	2,182	-	D	-	3,442	-	1,837	-	6,131	4,069	D	-
Soybeans	9,659	464	-	-	7,345	4,583	15,960	5,376	14,060	13,571	D	D
Vegetables	141	79	-	D	175	-	178	-	-	-	-	6
Wheat	3,722	-	-	-	6,941	9,483	9,215	4,102	8,581	20,997	-	-
Rice	-	-	-	-	4,555	85,986	1,192	D	4,788	D	-	-
Hay	15,413	42,210	11,302	26,029	5,427	10,613	6,928	18,111	10,070	17,707	14,739	21,865
Total cropland	38,970	44,412	15,626	26,185	37,471	41,784	40,359	39,717	54,860	69,523	18,512	22,018

D= information.withheld to protect privacy.

3.6.4 Public Land

There are approximately 311,000 acres of public land in the SAWRPR, around 11% of the land in the planning region. Table 3.5 reports the number of each type of public land as reported by the Arkansas State Highway and Transport Department (AHTD), along with the total acreage for each. National Forest and wildlife management areas account for the majority of this public land. There are also state parks, natural areas, wilderness areas and a national wildlife refuge in the planning region. A few of the public land types overlap in some areas of the region. For example, the Cossatot River State Park is also a Natural Area.

Table 3.5. Public lands in the SAWRPR (AHTD 2006, AGFC 2009).

Land Use	Acreage	Percent of SAWRPR Area	Count
City Park	571.1	<1%	35
County Park	1341.0	<1%	6
Local Park	16.3	<1%	2
National Forest	141465.7	5.0%	1
National Wildlife Refuge	28410.2	1.0%	1
Natural Area	3458.9	<1%	10
Natural Area - State Park	4401.2	<1%	3
Park	459.6	<1%	5
Park / Public Use Area	45.6	<1%	2
Public Use Area	1121.4	<1%	16
Recreation Area	0.2	<1%	1
State Park	1337.5	<1%	5
Wayside Park	0.3	<1%	6
Wayside Park - Information	0.2	<1%	1
Wilderness Area	22268.4	<1%	4
Wildlife Management Area	106484.6	3.7%	16
Total	**311382.2**	**11.0%**	

3.7 Surface Water

Surface water resources of the SAWRPR include over 3,200 miles of rivers and streams, and around 85,000 acres of lakes and impoundments, and 231,000 acres of wetlands (ASWCC 1981, Fry et al. 2011, USGS 2009). Major rivers in the planning region include the Red River, Little River, Cossatot River, Saline River, Bodcau Creek, Sulphur River, and Bayou Dorcheat.

The largest impoundment in the region is Millwood Lake (Figure 2.1). Surface water availability issues, related to both water quality and water quantity and demand, are discussed in Section 5.

3.7.1 Rivers and Streams

The Red River is the major river that flows through this region. The Red River originates outside of the state, and forms part of the southwest border of Arkansas with Texas. At Fulton, the east-flowing Red River turns south, crossing the Louisiana border as the boundary between Miller and Lafayette Counties (Figure 2.1). Overall, a total of approximately 156 miles of the Red River is within Arkansas.

Major tributaries that join the Red River in Arkansas include the Little River and the Sulphur River, both of which originate in Oklahoma. The Saline River and Cossatot River originate in the Ouachita Mountains in the northern area of the planning region, and flow south to join the Little River. Bodcau Creek and Bayou Dorcheat originate in the West Gulf Coastal Plain in the SAWRPR and flow south to join tributaries to the Red River in Louisiana.

The historical average annual surface runoff in the SAWRPR ranges from approximately 17 inches in the north-central area of the planning region to approximately 12 inches in far southeastern area of the planning region (Figure 3.17). Seasonal variation in surface runoff mirrors seasonal variation in precipitation (Pugh and Westerman 2014).

Average monthly flows for several streams in the SAWRPR are shown in Figures 3.18 and 3.19. The locations of the stream gages that recorded these flows are shown in Figure 3.20. Streamflow in the unregulated streams in the SAWRPR is generally highest in February and March (Dorcheat, Bodcau, and Little River in Figure 3.18) when precipitation amounts are relatively high, and there is no uptake by vegetation. The lowest flows in these streams usually occur in August (Figure 3.18) when precipitation is generally lowest and evapotranspiration tends to exceed precipitation (Figure 3.11). In the Red River, where flow is regulated somewhat by the Dennison Dam in Texas and dams on several tributaries, the highest flows occur in March through May, and the lowest flows in September (Figure 3.19).

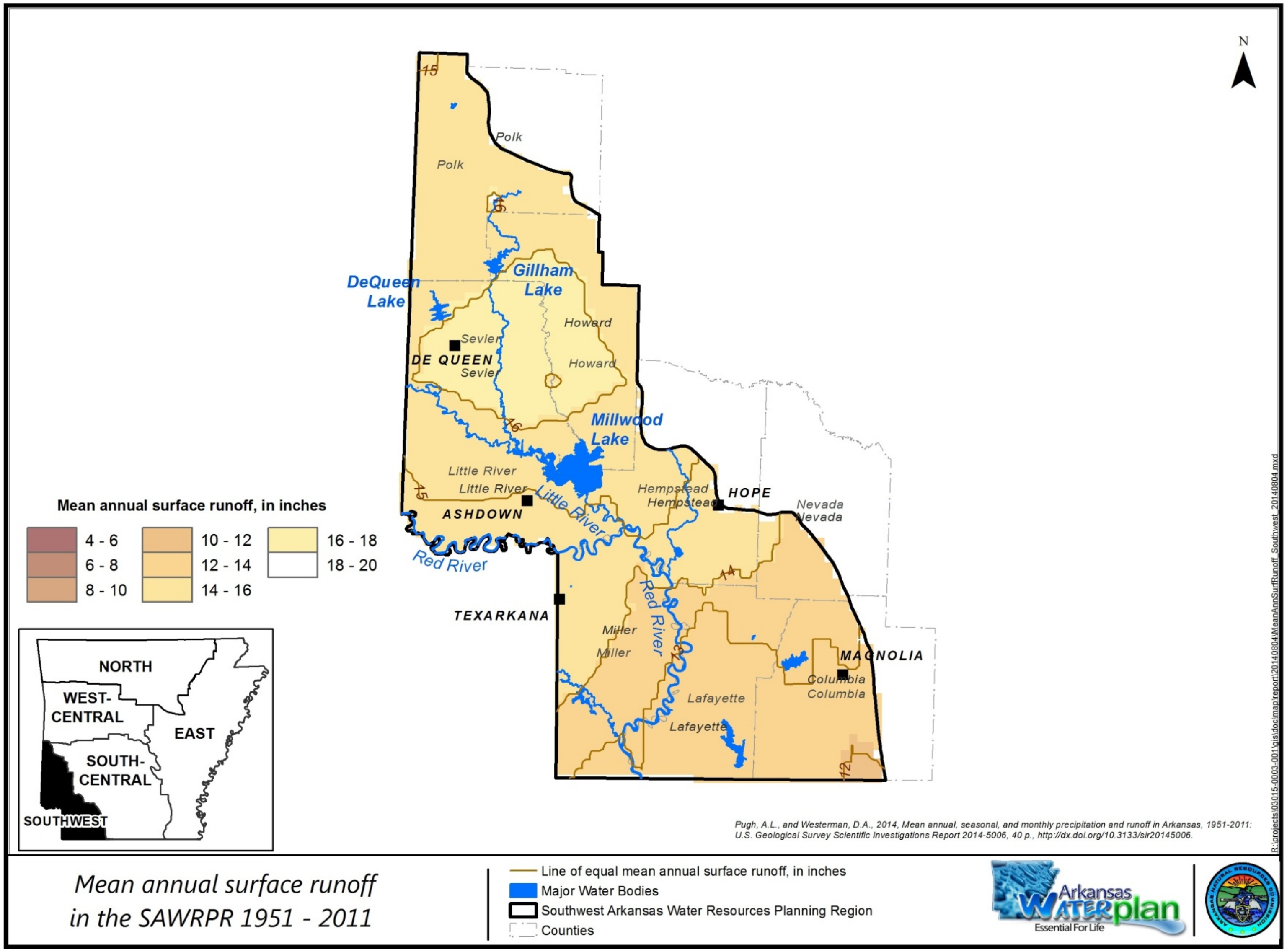

Figure 3.17 Average annual surface runoff in the SAWRPR, 1951 to 2011 (Pugh and Westerman 2014).

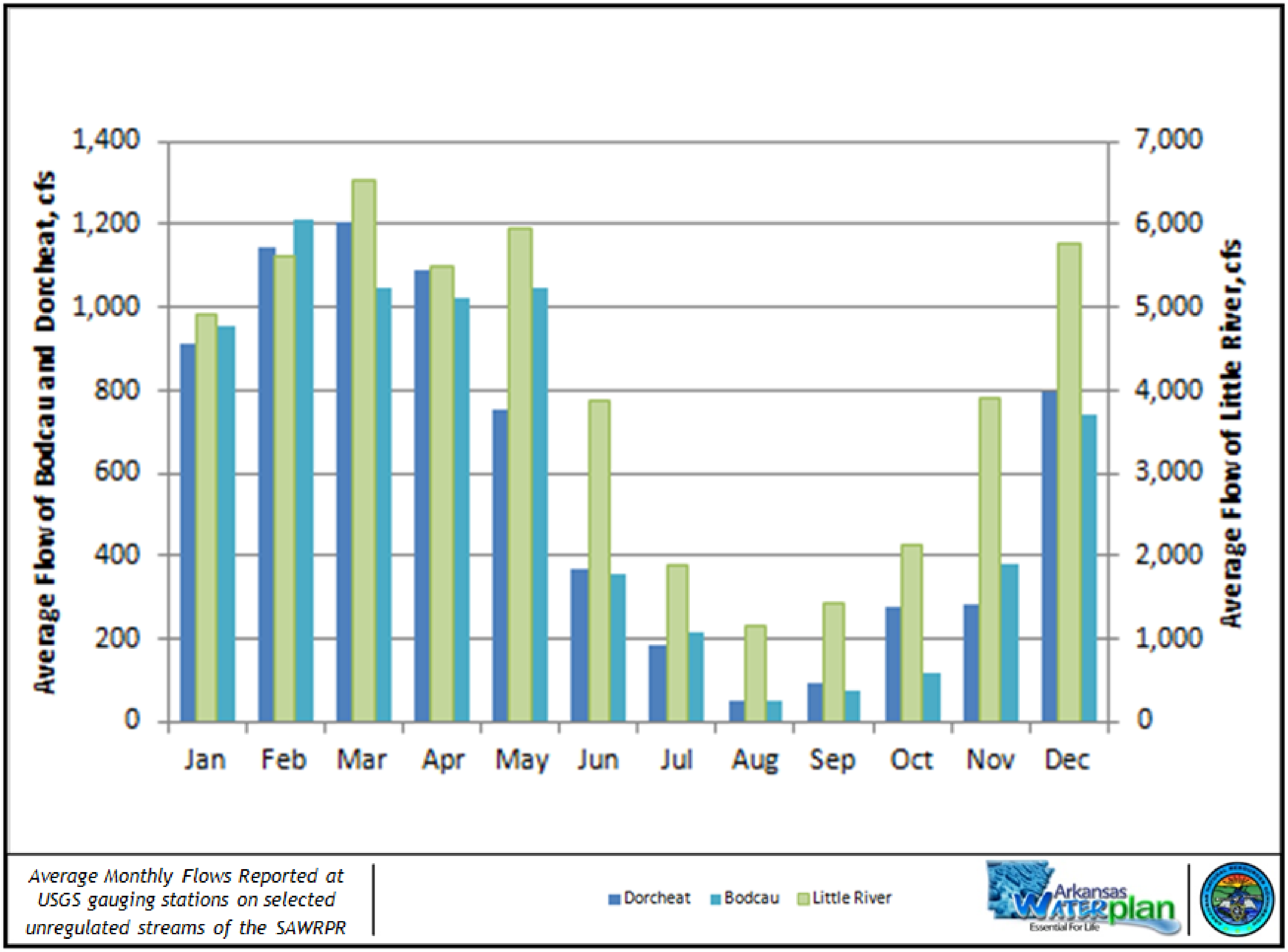

Figure 3.18. Average monthly flows reported at USGS gauging stations on selected unregulated streams of the SAWRPR.

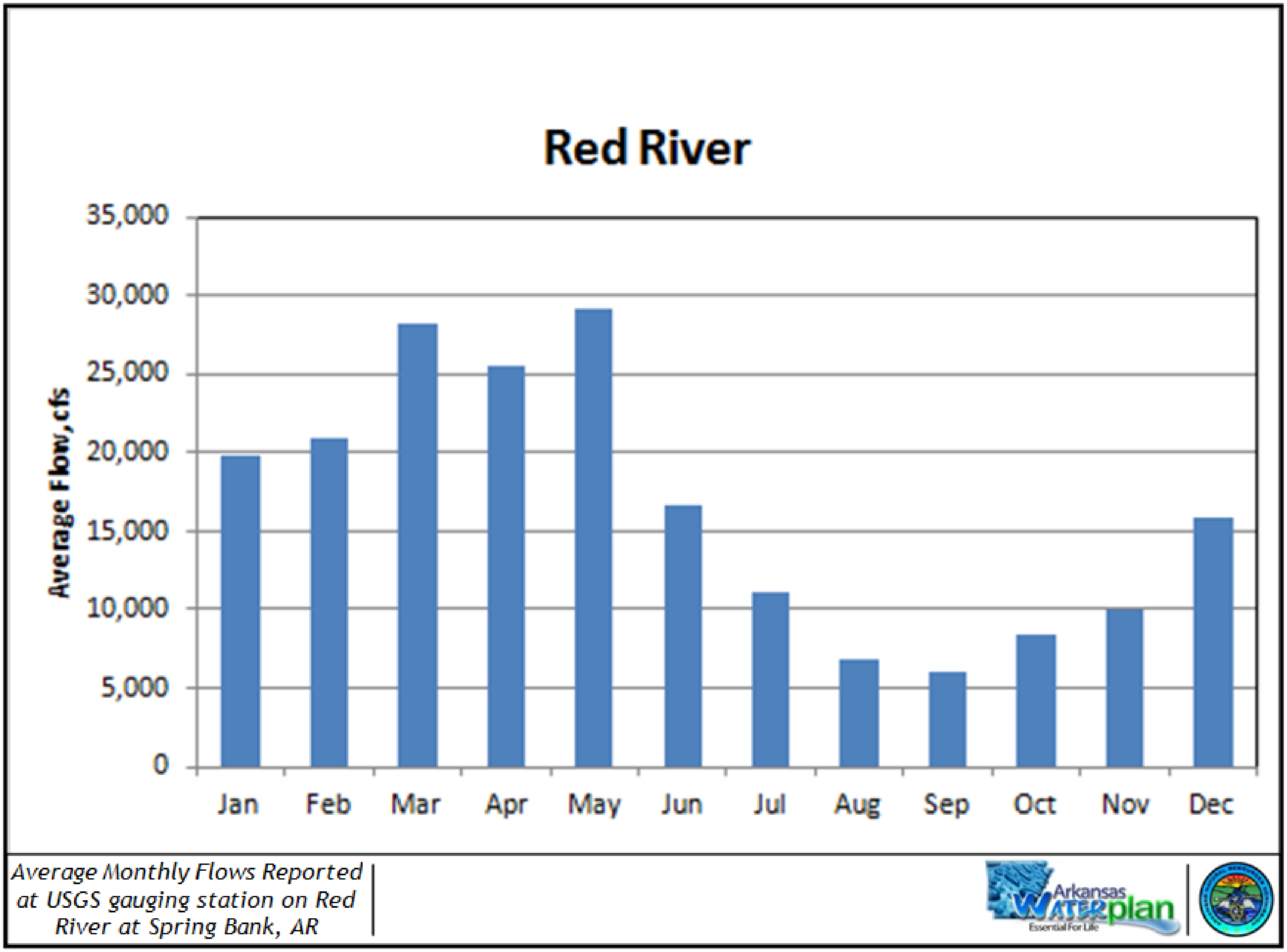

Figure 3.19. Average monthly flows reported at USGS gauging station on the Red River at Spring Bank, AR.

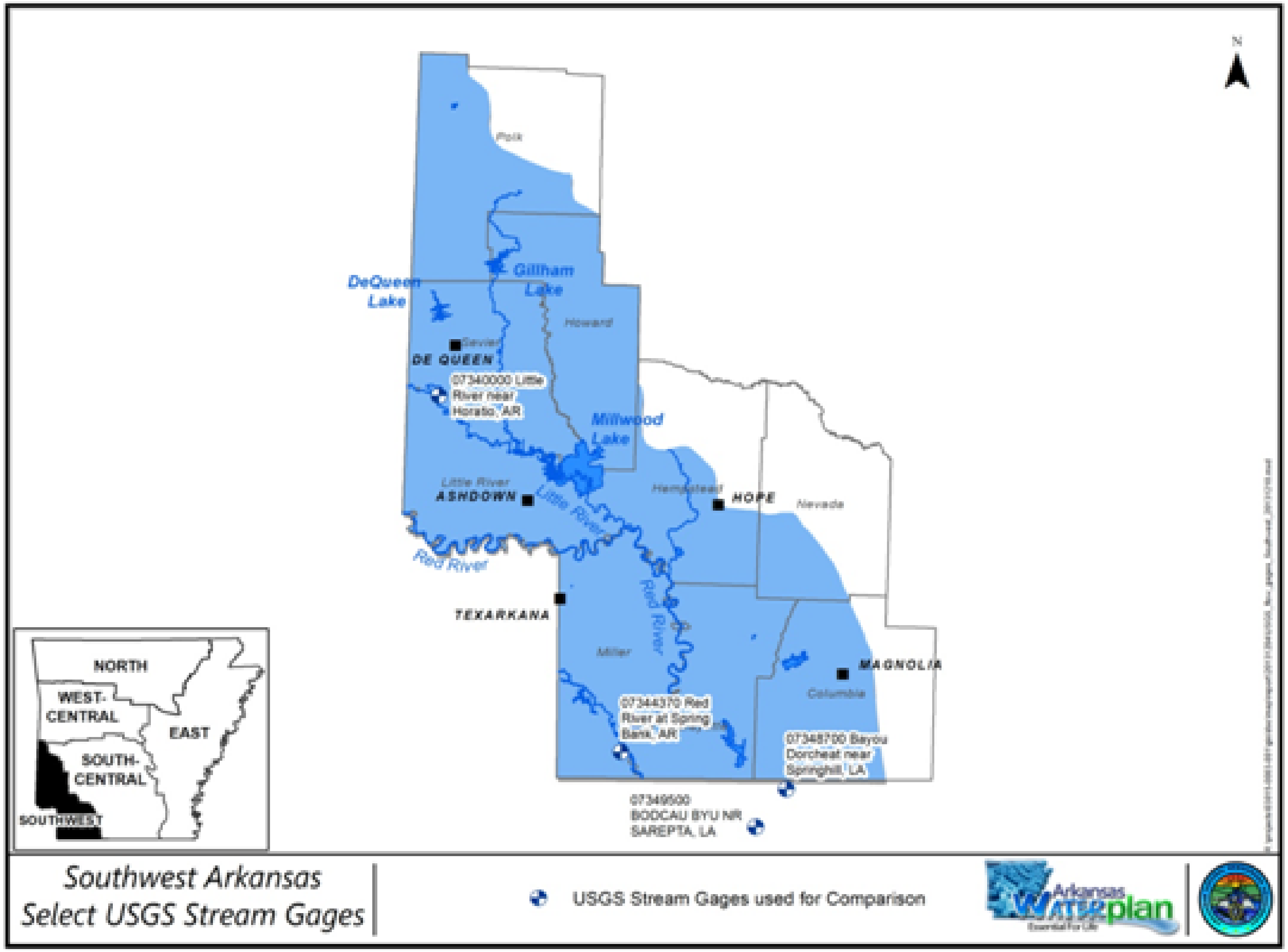

Figure 3.20. Locations of USGS gauging stations for data in Figure 3.15.

Long term flow records in the SAWRPR have recently been analyzed for trends. The analysis did not find any long term flow trends on gaged streams in the planning region (Ludwig 1992). An updated state-wide analysis of long term trends in flow runoff is being conducted by the USGS and USACE as part of the 2014 AWP update.

3.7.2 Lakes and Impoundments

In 1981 there were 58,803 acres of lakes and impoundments in the counties within the SAWRPR (Table 3.6). The majority of these impoundments were farm ponds (ASWCC 1981). An updated state-wide inventory of impoundments is being prepared for the 2014 AWP update. The Arkansas Department of Environmental Quality (ADEQ) has identified 10 significant publicly owned lakes in the planning region (ADPCE 1990). Information for the significantly publicly owned lakes within the SAWRPR is summarized in Table 3.7

Table 3.6. Summary of lakes and impoundments in the SAWRPR (ASWCC 1981).

	Number of Lakes and Impoundments	**Area (acres)**	**Capacity (acre-feet)**
Columbia County*	1,331	1,923	10,213
Hempstead County*	2,695	4,563	18,310
Howard County	1,509	1,030	5,039
Lafayette County	431	9,727	62,155
Little River County	1,075	1,533	6,470
Miller County	479	1,451	5,684
Nevada County*	1,531	883	4,763
Polk County*	1,915	1,520	7,617
Sevier County	1,466	757	2,140
USACE	4	33,910	305,740
AGFC	8	1,506	7,611
Total	**12,444**	**58,803**	**435,742**

*Part of the county is in another planning region.

Table 3.7 Information for significant publicly owned lakes in the SAWRPR (ADEQ 2012a).

Name	County	Lake type	Surface area (acres)	Average depth (feet)	Capacity (acre-feet)	Purpose
Dierks	Howard	Reservoir	1,360	22	68,130	Flood control
Gillham	Howard	Reservoir	1,370	21	188,750	Flood control
Dequeen	Sevier	Reservoir	1,680	21	101,250	Flood control
Wilhelmina	Polk	Reservoir	200	10	2,000*	Fishing
June	Lafayette	Reservoir	60	5	300	Fishing
First old river	Miller	Oxbow	200	4	720	Fishing
Bois d'arc	Hempstead	Reservoir	750	4	3,000	Fishing
Columbia	Columbia	Reservoir	2,950	11	32,450*	Water supply
Erling	Lafayette	Reservoir	7,000	7	49,000	Water supply
Millwood	Little River	Reservoir	29,500	5	1,649,960	Flood control
Total			**45,070**		**2,095,560**	

* capacity = surface area * average depth, info from ADEQ

3.7.3 Wetlands

In 2006, there were 231,750 acres of wetlands within this planning region, located primarily along tributaries of the Red River (Figure 3.16) (Fry et al. 2006). These wetlands perform important functions, including storage of floodwaters, filtering of water to improve water quality, and storage of carbon. In addition, these wetlands provide habitat for a number of important bird and animal species, including migrating waterfowl and shorebirds that use the Mississippi River and Central flyway in the spring and fall (North American Migration Flyways n.d.).

3.7.4 Surface Water Quality

Surface water quality in the SAWRPR is influenced by geology and land use. Surface waters in the northern portion of the planning region, within the Ouachita Mountains, tend to have lower levels of nutrients, sediment, and minerals and higher dissolved oxygen (DO) levels. Streams in the plains portion of the planning region tend to be stained by organic matter, have higher levels of organic carbon, and may be slightly acidic. Levels of turbidity, suspended solids, hardness, and dissolved solids vary with the local geology and land use. Relatively high levels of suspended solids, turbidity, and chloride occur in the Red River (Woods et al. 2004). Surface water quality issues are discussed in detail in Section 5.

3.8 Groundwater

The largest and most productive of the State's major aquifers are in the Gulf Coastal Plain. The SAWRPR is located primarily in the West Gulf Coastal Plain, which is underlain by aquifers consisting of various geologic units mainly of poorly consolidated formations that are blanketed with Quaternary age alluvium along the Red River. Water is withdrawn from these aquifers for domestic, industrial, irrigation, and public-water supply use.

3.8.1 Aquifers

There are 11 recognized aquifers in the SAWRPR, listed in Table 3.8 and mapped on Figure 3.21. Some of these aquifers are designated as regional aquifers and encompass parts of several states, whereas others are considered minor aquifers and are only important as local sources of water. For a detailed description of the geologic formations that comprise the aquifers in the SAWRPR, refer to (McFarland 2004). Kresse and others (2013) provide a comprehensive review of the aquifers of Arkansas that includes the geologic setting, hydrologic characteristics, water levels, water use, and water quality. Much of the information presented in this section was taken or summarized from the Kresse and others (2013) report.

From youngest to oldest, the following formations serve as aquifers in the West Gulf Coastal Plain section of the SAWRPR: alluvium associated with the Red River, the Cockfield Formation, the Sparta Formation, the Cane River Formation, the Carrizo Sand, the Wilcox Formation, the Nacatoch Sand, the Ozan Formation, the Tokio Formation, the Trinity Group, and the Ouachita Mountains aquifer. All but the Ozan aquifer have been or are used as a significant source of water supply in the region. The Cretaceous Formations (Nacatoch Sand, Ozan Formation, Tokio Formation and Trinity Group) are not designated as regional aquifers but are considered to be important local groundwater supplies (Kresse et al. 2013). Of the aquifers underlying the SAWRPR, the Red River alluvium, Sparta, Cane River, Wilcox, Tokio, and Trinity were being used as water supplies within the planning region in 2010.

Table 3.8. Nomenclature, geologic age, and use for aquifers in the SAWRPR.

Major Division	Province	Section	Formation or Group of Formations	Geologic Age	Hydrogeologic Unit Name	Aquifer Use[1]
Gulf Coastal Plain	Gulf Coastal Plain	Mississippi Alluvial Plain and West Gulf Coastal Plain	Alluvium and terrace deposits	Quaternary	Red River alluvial aquifer	IR, PS, IN
			Cockfield Formation	Tertiary	Cockfield aquifer	PS
			Sparta Sand	Tertiary	Sparta aquifer	PS, IN
			Cane River Formation	Tertiary	Cane River aquifer	PS, d
			Carrizo Sand	Tertiary	Carrizo aquifer	D
			Wilcox Group	Tertiary	Wilcox aquifer	IR, IN
			Nacatoch Sand	Cretaceous	Nacatoch aquifer	PS
		West Gulf Coastal Plain	Ozan Formation	Cretaceous	Ozan aquifer	
			Tokio Formation	Cretaceous	Tokio aquifer	PS, IN
			Trinity Group[2]	Cretaceous	Trinity aquifer	PS, IN
Interior Highlands	Ouachita Province	Ouachita Mountains	Johns Valley Shale Jackfork Sandstone Stanley Shale Arkansas Novaculite Missouri Mountain Shale Blaylock Sandstone Polk Creek Shale Bigfork Chert Womble Shale Blakeley Sandstone Mazarn Shale Crystal Mountain Sandstone Collier Shale	Ordovician through Pennsylvanian	Ouachita Mountains aquifer	D

[1]IR= irrigation, PS = public supply, IN = industrial, D = domestic. Listed in order of highest use by volume. Primary use in capital letters; secondary use in small caps.
[2]Includes the Paluxy Sand, Dequeen Limestone, Holly Creek Formation, Dierks Limestone, Delight Sand, and Pike Gravel

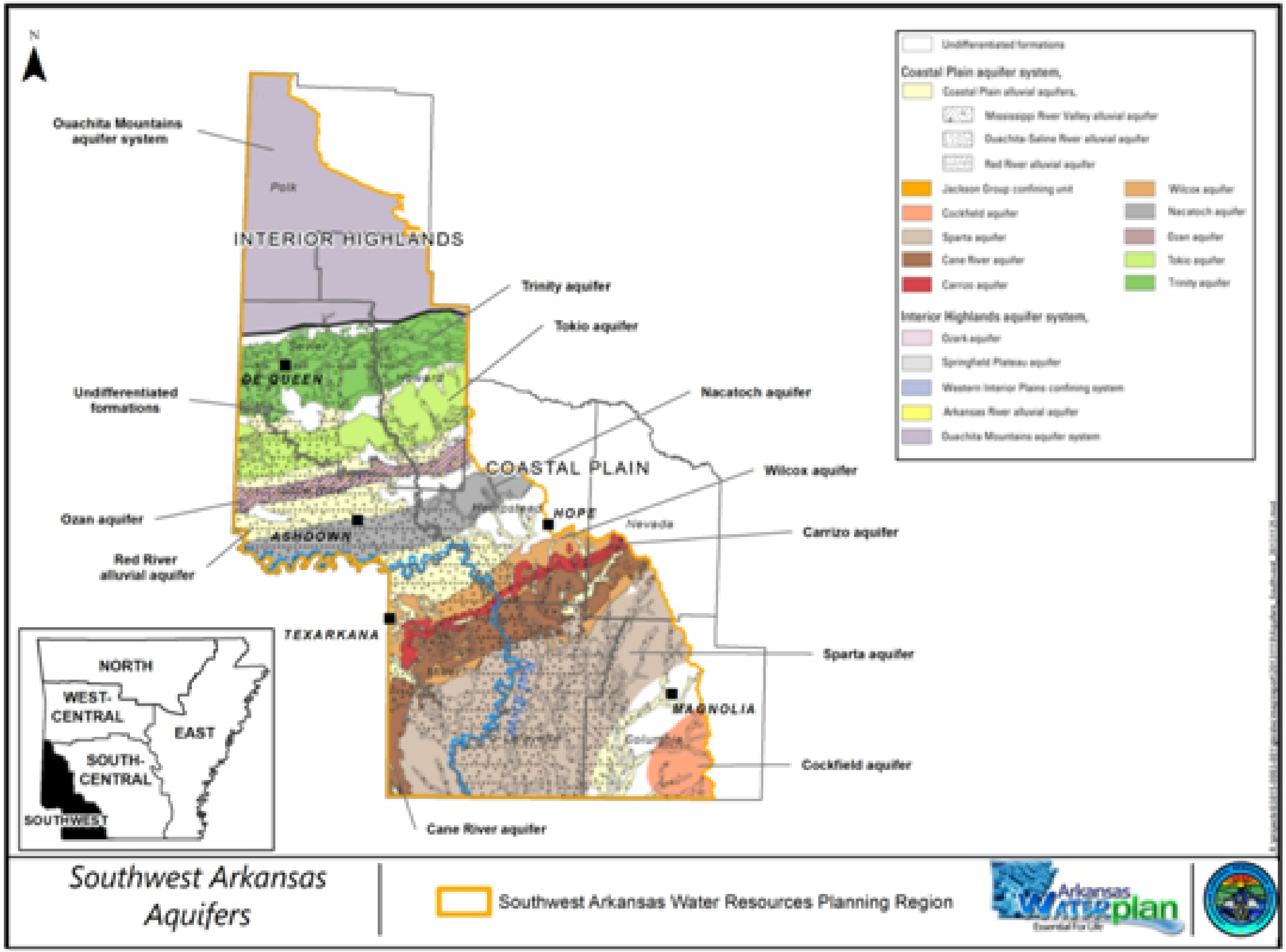

Figure 3.21. Aquifers of the SAWRPR (Kresse et al. 2013).

The unconsolidated sand and gravel that comprise the Quaternary alluvial aquifer of the Red River have intergranular porosity, and the aquifer contains water primarily under unconfined or water-table conditions. The hydraulic conductivity of this aquifer is variable, depending on the sorting of aquifer materials and the amount of silt and clay present, but generally it is high. The alluvial aquifer is susceptible to contamination because of the generally high hydraulic conductivity. Groundwater in the Red River alluvial aquifer flows along relatively short flow paths from recharge to discharge areas, typical of local flow systems.

The remainingWest Gulf Coastal Plain aquifers consist of semi-consolidated and unconsolidated sand interbedded with silt, clay, and minor carbonate (limestone) rocks. Porosity is intergranular, and the hydraulic conductivity of the aquifers is moderate to high. The aquifers are in a thick wedge of sediments that dips and thickens toward the Arkansas-Louisiana border. Groundwater in topographically high recharge areas is unconfined, but, it becomes confined as it moves downdip. Discharge may occur by upward leakage from deeper to shallower aquifers. These aquifers typically have lengthy regional flow paths, and, because flow is sluggish near the ends of regional flow paths, the aquifers commonly contain unflushed saline water in their deeply buried, downdip parts.

3.8.1.1 Red River Valley Alluvial Aquifer

Groundwater contained in the Red River Valley alluvial aquifer is an important source of water in the planning region. The Red River Valley alluvial and terrace deposits underlie an area of about 540 square miles in the planning region and consist of clay, silt, sand, and gravel, up to 90 feet thick. The aquifer is comprised of a coarsening downward sequence of clay, silt, sand, and gravel, (Ludwig 1973, Counts et al. 1955, Terry et al. 1986). Tait et al. (1953) report that in western Columbia County, the alluvial deposits of tributaries to the Red River are as thick as 80 feet and are comprised of silt and clay with a 5 to 10 foot thick layer of coarse sand or gravel at the base. Ludwig and Terry (1980) report a thickness for the Red River alluvium in Louisiana of 75 to 200 feet, thickening to the south.

Irrigation wells completed in the Red River alluvial aquifer were reported to yield between 200 and 1,200 gallons per minute (gpm). Ludwig (1973) estimated that wells in Little

River County could yield as much as 750 gpm, and wells in Miller and Lafayette Counties could yield up to 1,500 gpm. Counts and others (1955) reported well yields as high as 150 gpm in Little River County and as high as 400 gpm in Miller County. In general, groundwater flows in the direction of the Red River from the Arkansas border with Texas to the southern border with Louisiana. The principal source of recharge to Red River alluvial aquifer is precipitation (Boswell et al. 1968).

3.8.1.2 Sparta Aquifer

The Tertiary-age Sparta Sand is the thickest sand in the Mississippi embayment and its importance as an aquifer is recognized by the fact that it is second in use only to the Mississippi River Valley alluvial aquifer. The Sparta aquifer is present throughout most of the southern section of the planning region (Figure 3.21). Kresse and others (2013) noted that the term "Sparta aquifer" is applied to a sequence of hydraulically connected sands that are often separated by silts and clays and is not an absolutely equivalent term with "Sparta Sand", the formal name for the geologic formation. This distinction is important because by Arkansas law, Critical Groundwater Area designation criteria for the Sparta aquifer are based on the top of the geologic formation rather than the top of the aquifer (ANRC 1996). This has been an important distinction in management of the Sparta aquifer. In areas where clays and silts in the Sparta Sand (the geologic formation) occur above productive sands, the top of the Sparta aquifer does not coincide with the top of the Sparta Sand. In this report, the term "Sparta Sand" always will refer to the geologic formation (comprising sands, silts, and clays), and the term "Sparta aquifer" will refer to the sequence of productive, hydraulically connected sands that constitute a part of the geologic formation.

The Sparta Sand consists of varying amounts of sand and occasionally gravel interspersed with layers of silt, clay, shale, and lignite. The lower half of the unit generally contains more sand and the upper part of the Sparta Sand generally contains more clay and shale (Hosman et al. 1968, Petersen et al. 1985). The occurrence, continuity, and thickness of the sand beds which constitute the aquifer are quite variable but in general appear to be hydraulically connected. Hydraulic properties in the Sparta aquifer vary widely, and groundwater appears to be more easily transmitted in the thickest sand intervals. Reported well yields range from hundreds to thousands of gallons per minute (Kresse et al. 2013).

The Sparta Sand outcrops in the planning region, and the Sparta aquifer is unconfined here. The Sparta aquifer becomes confined towards the axis of the Mississippi Embayment and southward towards the Gulf of Mexico by the overlying Cook Mountain Formation and the underlying Cane River Formation (Kresse et al. 2013). The Sparta aquifer is recharged by direct infiltration in the outcrop, from rivers in the outcrop, and by leakage from overlying aquifers. Natural discharge occurs by leakage through the confining units and discharge to rivers within the outcrop area. Natural groundwater flow is generally down dip toward the axis of the embayment and southward toward the Gulf of Mexico (Kresse et al. 2013).

3.8.1.3 Cane River Aquifer

The Cane River Formation (hereinafter referred to as the Cane River aquifer when referring to the saturated part of the formation) is a sequence of marine clays and shale that includes minor amounts of marls, silts, and marine sand. Payne (1972) reported that the formation thickness ranged from 200 to 750 feet thick. The Cane River Formation overlies the Carrizo Sand and is overlain by the Sparta Sand. The Cane River Formation is considered an important aquifer within the planning region, where locally extensive, water-producing sands occur within the formation. Because the sand units are thin and discontinuous regionally as compared to thicker, regionally extensive sand units in adjacent formations, the clay-dominated lithology of the Cane River Formation in southern Arkansas was listed as part of a regional confining system, termed the lower Claiborne confining unit (Hosman and Weiss 1991, Arthur and Taylor 1990, Hart et al. 2008, Clark and Hart 2009).

The Cane River aquifer is composed of poorly connected sand bodies 25 feet or more in thickness. Hydraulic properties in the Cane River aquifer vary widely, and groundwater appears to be more easily transmitted in the thickest sand intervals. Near the outcrop and subcrop areas in the planning region, the aquifer is under water-table conditions; however, the aquifer becomes confined by overlying and underlying beds downdip and is under artesian conditions (Petersen et al. 1985). The aquifer yields between 50 and 920 gpm (Ludwig 1972, Plebuch and Hines 1969, Tait et al. 1953). Two municipal wells for 3 cities in Lafayette County historically produced up to 920, 300, and 120 gpm (Ludwig 1972). Wells in Columbia County may yield up to 300 gpm (Tait et al. 1953). Although yields are variable, they are more than sufficient for smaller towns in the planning region. Shallow wells in the outcrop area generally yield between 5 and 10 gpm (Hosman et al. 1968).

The principal source of recharge to the aquifer is infiltration of precipitation through exposures in the outcrop areas (Hosman et al. 1968). Recharge may occur through younger sedimentary materials, where the Cane River Formation outcrop is covered. A minor amount of recharge takes place by upward movement from the underlying Carrizo Sand and the upper Wilcox aquifer. Water is lost from the aquifer from pumping wells and through natural discharge by upward leakage though confining units. A very minor component of natural discharge may occur as base flow into streams incised into the Cane River Formation (Payne 1972, Hosman et al. 1968).

Regional flow of water is generally south and southeast downdip toward the Gulf of Mexico and the Mississippi River valley. Upward flow occurs through leaky confining units above the Cane River Formation. This occurs where the head of the Cane River Formation exceeds the head of the overlying Sparta Sand (Payne 1972, Petersen et al. 1985).

3.8.1.4 Carrizo Aquifer

The saturated part of the Carrizo Sand comprises an aquifer of limited use only in and near the outcrop area in southwestern Arkansas. The Carrizo Sand consists predominately of massive-bedded quartz sands with minor amounts of interbedded clays and silts and occasional lenses of lignite. The lithology is almost uniform, being composed of more than 80% sand in the majority of Arkansas. The Carrizo Sand is discontinuous, notably in parts of Columbia County, where thicknesses of 30 feet or less occur, and is highly variable in thickness. The Carrizo Sand crops out in a narrow band, 2 to 5 miles wide, through central Miller, southern Hempstead, and central Nevada Counties (Figure 3.18). The formation ranges in thickness from a few feet in the outcrop area to about 100 feet in Lafayette County (Ludwig 1973).

Recharge to the Carrizo Sand in the planning region comes from rainfall on the outcrop, and discharge from the Carrizo Sand occurs by withdrawals from wells and by natural leakage through the overlying confining beds. Regional flow of water is generally downdip, toward the axis of the Mississippi embayment (Hosman et al. 1968, Payne 1975). The Carrizo aquifer is not considered to be a major aquifer in Arkansas due to its erratic distribution, and therefore available hydrologic data are limited. There is an increase in permeability with increasing thickness of sand units in the Carrizo aquifer. A well in Miller County yielded 100 gpm and had a specific capacity of 3 gpm per foot (Ludwig 1973). Except in the outcrop area, water in the Carrizo Sand is under artesian conditions and the regional flow is downdip to the east and southeast (Payne 1975). In southern Arkansas, the groundwater flow in the Carrizo aquifer is confined by the Wilcox Group below and the Cane River Formation above (Hosman et al. 1968).

3.8.1.5 Wilcox Aquifer

The Wilcox Group is present throughout the Gulf Coastal Plain of Arkansas. Three aquifer units are used to represent the Wilcox Group: lower Claiborne-upper Wilcox aquifer [hereafter referred to as the upper Wilcox, or minor Wilcox aquifers after Hosman and others (1968)], the middle Wilcox aquifer, and the lower Wilcox aquifer. The upper Wilcox Group predominates in the SAWRPR (Figure 3.18).

In the SAWRPR, the upper Wilcox Group overlies the Midway Group, crops out in a discontinuous band 1 to 3 miles wide (Joseph 1998), and commonly is overlain by terrace deposits and alluvium of Quaternary age. The upper Wilcox Group in the planning region, becomes progressively thicker downdip from the outcrop (Albin 1964), and it dips toward the axis of the Mississippi Embayment at about 50 feet per mile (Hosman et al. 1968). Zachary and others (1986) report that the upper Wilcox Group crops out in northern Nevada and Hempstead Counties and underlies the Cane River Formation throughout Columbia County. In this area, the upper Wilcox Group is composed dominantly of clay with thin erratic sand units and thin lignite beds in some areas. The sand units serve as the upper Wilcox aquifers (Hosman et al., 1968). In the area of Columbia County within the planning region, the Wilcox Group ranges from 350 to 550 feet in thickness (Kresse et al. 2013).

Recharge to the upper Wilcox Group aquifer in the planning region is from precipitation in the outcrop areas, or from leakage through the confining clays (Hosman et al. 1968). The potentiometric surface of the aquifers is below land surface (Hosman et al. 1968). Kresse and others (2013) provided no information about well yields within the planning region, but wells completed in the Wilcox aquifer in southeast Hot Springs County and southwestern Grant County yield 300 gpm (Halberg et al. 1968). The direction of groundwater flow is either downdip (southeast) or by pumping induced gradients.

3.8.1.6 Nacatoch Aquifer

The Nacatoch Sand in the SAWRPR is a Cretaceous-age formation of interbedded lithologies, predominately generally unconsolidated sands with local lenses and beds of fossiliferous sandy limestone (Counts et al. 1955, Plebuch and Hines 1969). Formation thickness ranges from 150 to nearly 600 feet (Boswell et al. 1965, Zachry et al. 1986). The Nacatoch Sand outcrops in the planning region along a belt 3 to 8 miles wide that extends from southern Little River County to central Hempstead County (Figure 3.18). In Little River County, the Nacatoch Sand is covered by Quaternary alluvial and terrace deposits (Counts et al. 1955). The Nacatoch Sand dips south and southeast into the subsurface at a rate of about 30 feet per mile (Boswell et al. 1965, Ludwig 1973, Veatch 1906). The Nacatoch Sand is faulted downdip in Miller, Little River, Lafayette, Hempstead, and Nevada Counties (Petersen et al. 1985).

Most wells completed in the Nacatoch aquifer are relatively low-yield wells. Throughout the planning region, Counts and others (1955) reported well yields from 1 to greater than 300 gpm. Flowing (artesian) wells in the lower stream valleys of Nevada County yield less than 5 gpm. Wells in Hempstead and Nevada counties can be expected to yield from 150 to 300 gpm (Counts et al. 1955, Ludwig 1973). The presence of artesian wells indicates that away from the outcrop the Nacatoch aquifer is under confined conditions.

The Nacatoch aquifer receives direct recharge from precipitation in the area of its outcrop. The regional direction of groundwater flow is to the southeast (Schrader and Blackstock 2010). The flow directions may be locally controlled by clay content and faulting (Boswell and Hosman 1964).

3.8.1.7 Ozan Aquifer

The Cretaceous-age Ozan Formation comprises an aquifer that is used solely in isolated areas of the SAWRPR. This aquifer is not listed in any regional reports, is one of the least-used aquifers, and contains some of the poorest-quality groundwater of any aquifer in the State.

The Ozan Formation is a mixed limey, clayey, and primarily sand unit that ranges in thickness from 0 to about 200 feet. The Ozan Formation changes facies from a sandy clay and marl to a chalk and marl in Little River County (Counts et al. 1955). The Ozan Formation outcrops in the planning region in Little River and Hempstead Counties (Figure 3.18). The outcrop ranges from 1 to 4 miles wide and through the majority of its occurrence in the planning region is covered by terrace and alluvial deposits (Boswell et al. 1965).

Hydrologic data for the Ozan aquifer are limited because it is not important as a regional water supply. Most wells completed in the Ozan aquifer are used as a domestic water supply (Boswell et al. 1965) of limited capacity and yield highly mineralized water (Counts et al. 1955). A few wells are completed in the Ozan aquifer in Hempstead and Sevier Counties, but the water is not suitable as a drinking water source. A flowing artesian well yielding approximately 1 gpm was noted in Sevier County, Arkansas (Counts et al. 1955). The Ozan aquifer primarily receives recharge in the outcrop area.

3.8.1.8 Tokio

The Tokio Formation of Cretaceous-age crops out in the planning region in a narrow band from southeastern Sevier County through southern Howard County, with a small, isolated outcrop located in extreme western Little River County and attains a maximum width of about 10 miles in Howard County (Figure 3.18) (Schrader and Blackstock 2010). Most producing wells are located within the larger outcrop belt. Ludwig (1972) listed extensive variation in well depth, ranging from less than 30 feet to 1,200 feet below ground surface for parts of Hempstead, Lafayette, and Little River Counties

The Tokio Formation consists of discontinuous, interbedded gray clay and poorly sorted sands, lignite, scattered carbonaceous materials, and in some areas a prominent basal gravel (Counts et al. 1955, Boswell et al. 1965, Dollof et al. 1967, Plebuch and Hines 1969, Petersen et al. 1985). In southern Sevier County and parts of Howard and Hempstead counties, the Tokio Formation comprises three distinct aquifers, including a basal sand that grades to gravel to the east, and two upper sands (Boswell et al. 1965). Toward the east the clay layers separating the sands thin and the sands merge into a massive sand, which is prevalent over most of Hempstead County. The formation dips at about 60 feet per mile to the southeast away from the outcrop and ranges in thickness from 50 to more than 300 feet (Boswell et al. 1965), attaining its maximum thickness in Miller County (Dollof et al. 1967). A fault zone through the Tokio Formation occurs across Miller, Little River, Lafayette, Hempstead, and Nevada Counties (Petersen et al. 1985: Plate 8).

The Tokio aquifer receives direct recharge at its outcrop and from the overlying alluvial deposits where it subcrops (Boswell et al. 1965). At its outcrop, the Tokio Formation weathers into a sandy soil, facilitating percolation of surface and rain water into the sand (Counts et al. 1955). Flow of groundwater in the Tokio aquifer is generally toward the south or southeast away from the outcrop area (Schrader 1998).

Most wells constructed in the Tokio Formation are low-yield wells, but some wells produce 150-300 gpm. Many wells are flowing artesian wells (found in northeastern Hempstead County) that typically produce less than 20 gpm under natural flowing conditions. The Tokio Formation is the most important source of water from artesian wells in the planning region. Wells in central Hempstead County yield up to 300 gpm. Wells flowing as much as 90 gpm occur in the bottom-land areas adjacent to streams (Counts et al. 1955). Wells in the vicinity of Winthrop in northwestern Little River County penetrated a 15- to 20-foot thick fresh water-bearing sand that produced yields of less than 10 gpm (Ludwig 1972). The prevalence of artesian wells indicates that away from the outcrop the Nacatoch is under confined conditions.

3.8.1.9 Trinity

The Trinity aquifer crops out in an east-west trending band from western Sevier County through central Howard County (Figure 3.18). The Trinity Group is a sequence of clastic rocks ranging in thickness from less than 100 feet in outcrop areas to more than 1,000 feet at downdip locations. The Trinity is a locally important aquifer within the planning region and comprises six distinct units (Table 3.8) (Counts et al. 1955). The three significant aquifers of the Trinity Group are the Pike Gravel (the thickest and most persistent gravel unit of the Trinity Group), the Ultima Thule Gravel Member of the Holly Creek Formation, and the Paluxy Sand (Boswell et al. 1965). These formations achieve maximum thicknesses of 50 feet, 40 feet, and 900 feet, respectively. The Paluxy Sand, which generally consists of well-sorted, fine white sand interbedded with clay and limestone and local gravel lenses (Boswell et al. 1965), is the principal aquifer in the Trinity Group, and is present in southern Howard and Sevier Counties (Boswell et al. 1965).

Well yields in the Paluxy Sand range from 0 to 200 gpm, and flowing artesian wells were common at lower elevations. A flowing artesian well in the Saline River bottoms in Sevier County yielded about 100 gpm. Counts and others (1955) reported that 16 of 35 wells in this formation were listed as “flowing” under the heading of “well depth.” Municipal wells in western Sevier County generally are completed in the upper and lower gravels at depths of 145 to 450 feet, and have reported yields as high as 200 gpm. Flowing artesian wells yielding from 1 to 50 gpm were reported in Howard County (Counts et al. 1955). Aquifers in the Trinity Group receive recharge in the outcrop area and the direction of groundwater flow is southward (Boswell et al. 1965).

3.8.1.10 Ouachita Mountains Aquifer

A thick sequence of Paleozoic rock formations in the Ouachita Mountains serves as an important source of groundwater supply for domestic users, in addition to a limited number of small commercial and community water supply systems. The shallow saturated section of the combined formations in the Ouachita Mountains is referred to as the Ouachita Mountains aquifer (Kresse et al. 2013). Formations comprising the aquifer are predominately thick sequences of shale, siltstones, sandstones, and other quartz formations (i.e., chert, novaculite), with minor occurrences of carbonates and other rocks.

For this system, recharge occurs as precipitation that infiltrates the ground in upland areas and percolates to the water table. Groundwater flow paths are defined by small-scale topographic features where flow occurs from elevated areas to valley floors, terminating in small stream systems. Groundwater storage in these aquifers is limited primarily to fractures and faults.

Quartz formations such as the Bigfork Chert and Arkansas Novaculite are very brittle and prone to dense fracturing. Most researchers working in the Ouachita Mountains identified the Bigfork Chert as the most productive aquifer in the region (Albin 1965, Halberg et al. 1968, Stone and Bush 1984, Cole and Morris 1986, Kresse and Hays 2009).

Yields from wells completed in the Ouachita Mountains aquifer have a fairly large range depending on individual formations and lithology, but are typically low. Albin (1965) noted that most wells in the Ouachita Mountains aquifer yielded less than 10 gpm, and yields greater than 50 gpm were rare; however, one well completed in the Bigfork Chert was recorded as yielding 350 gpm (Kresse et al. 2013). In spite of the upper range for reported yields and other hydrologic characteristics for various formations constituting the Ouachita Mountains aquifer, caution was expressed by all authors that for planning and management purposes, this groundwater should not be considered as a source of supply for municipal growth and economic development unless the required quantity was small (Albin 1965, Halberg et al. 1968, Stone and Bush 1984).

Most wells in the Ouachita Mountains aquifer are less than 100 feet deep, but can range up to approximately 700 feet deep, with static water levels generally less than 20 feet below land surface, and flowing-artesian wells found throughout the region (Albin 1965, Kresse and Hays 2009). Pumping water levels may be as much as 150 feet below land surface in deeper wells. Seasonal water-level fluctuations in wells generally are less than 10 feet; however, larger fluctuations are common in abnormally wet or dry years because the groundwater reservoirs generally have small storage capacities and are recharged by rapid infiltration of local precipitation (Albin 1965).

3.8.2 Ground Water Quality

General water quality characteristics of the above aquifers are discussed below. Issues with groundwater quality are discussed in detail in Section 5.

3.8.2.1 Red River Alluvial Aquifer

Groundwater-quality data from the Red River alluvial aquifer show a strongly calcium-bicarbonate water type except as affected by salinity issues in Miller County.

3.8.2.2 Sparta Aquifer

The quality of groundwater from the Sparta aquifer throughout the SAWRPR is very good. The groundwater generally is a sodium-bicarbonate water type throughout most of the extent of the aquifer; however, a calcium-bicarbonate water type is found in the outcrop area for the Sparta Sand. Elevated iron and nitrate groundwater concentrations are found dominantly in the outcrop area of the Sparta Sand, with lower concentrations in the downgradient direction of flow. Generally, pH values, in addition to bicarbonate and dissolved solids concentrations, increase in the Sparta aquifer with increased residence time along the flow path moving downgradient from the outcrop area for the Sparta Sand; effects attributed to increased dissolution of carbonates (Kresse et al. 2013).

3.8.2.3 Cane River Aquifer

Water quality from the Cane River aquifer is good with respect to Federal drinking water standards. Groundwater from the Cane River aquifer generally is a calcium-bicarbonate water type in the outcrop area, but transitions at short distances from the outcrop area to a sodium-bicarbonate water type as a result of cation exchange processes. Nitrate concentrations were less than the maximum contaminant level of 10 milligrams per liter (mg/L) as nitrogen for all samples. Salinity increases downdip of the outcrop area, and chloride concentrations can exceed the Federal secondary drinking water regulation of 250 mg/L in some areas. Similar to other Tertiary aquifers in the West Gulf Coastal Plain, iron, nitrate, and sulfate are relatively higher in the outcrop areas (Kresse et al. 2013).

3.8.2.4 Carrizo Aquifer

Groundwater in the Carrizo aquifer is of overall good quality. The aquifer has a sodium-bicarbonate groundwater with low iron concentrations as compared to many other aquifers of the West Gulf Coastal Plain. Reported nitrate concentrations are extremely low throughout the extent of the aquifer. Sulfate and chloride concentrations generally are low for areas near the outcrop, but increase appreciably at large distances from the outcrop area (Kresse et al. 2013).

3.8.2.5 Wilcox Aquifer

The Wilcox aquifer is a viable groundwater supply only in the outcrop area within the planning region; the water becomes brackish or saline within a short distance downdip of the outcrop and is unfit for most purposes (Plebuch and Hines 1969, Ludwig 1972, Terry et al. 1986). Ludwig (1972) describes groundwater from the Wilcox aquifer as a soft to moderately hard, sodium-bicarbonate type for most of Hempstead, Lafayette, Miller, and Nevada Counties. The southern extent of fresh water coincides with a fault system extending through central Miller, Lafayette, and Nevada Counties, and groundwater south of the fault zone contained more than 1,000 mg/L dissolved solids based on electric logs (Ludwig 1972). Hosman and others (1968) note that water type varies with dissolved-solids content: where dissolved-solids concentrations are low, water is either a calcium-magnesium-bicarbonate or sodium-bicarbonate type; increases in dissolved solids up to 400 mg/L are attributed to predominantly sodium and bicarbonate; and above 400 mg/L, the increase is attributed to sodium, bicarbonate, and chloride (Kresse et al. 2013).

3.8.2.6 Nacatoch Aquifer

In the SAWRPR, fresh water mainly is obtained from the Nacatoch aquifer in or near to the area of outcrop, especially for the western parts (Little River and Miller Counties) of the outcrop area, and salinity increases in a downgradient direction from the outcrop area to a point where the groundwater is not suitable for most uses. Gradients of increasing chloride concentration are sharpest in the western and eastern parts of the outcrop, with a larger area of fresh water downgradient of the outcrop area in the central part of the aquifer (Hempstead County and Nevada Counties). Concentrations of sulfate, iron, and nitrate generally are very low throughout the extent of the Nacatoch aquifer, where water-quality data were available from producing wells (Kresse et al. 2013).

3.8.2.7 Ozan Aquifer

Groundwater from the Ozan aquifer represents some of the least used and poorer quality water of any aquifer in the State. Several historical reports mentioned that aquifer was used as a domestic source because in many areas no other water source was available. High chloride concentrations can occur in groundwater within the outcrop area of the Ozan aquifer, which is atypical of most Cretaceous and Tertiary aquifers of the West Gulf Coastal Plain. Chloride concentrations over 1,000 mg/L, which exceed the Federal secondary drinking water regulation 250 mg/L (EPA 2009), occur in one well that is situated in northeastern Little River County. The highest median sulfate concentration of any aquifer in the State are found in the Ozan aquifer. Sulfate concentrations can exceed 500 mg/L (the Federal secondary drinking water regulation is 250 mg/L)(Kresse et al. 2013).

3.8.2.8 Tokio Aquifer

Good quality water is obtained from the Tokio aquifer throughout much of its outcrop area. Sharp increases in salinity downdip of the outcrop area are noted in Sevier County, limiting use at distances greater than approximately 5 miles downdip of the outcrop area. Sulfate concentrations approach 400 mg/L and chloride concentrations are greater than 1,200 mg/L near the western extent of the outcrop area. These concentrations exceed the Federal secondary drinking water standard of 250 mg/L for these constituents. In the central part of the aquifer, salinity increases are more gradual (with concentrations in the aquifer at less than 300 mg/L as far as 20 miles from the outcrop area), affording a larger area of low-salinity, high-quality water for multiple uses. In the southwestern part of the aquifer, sulfate is the dominant anion in the aquifer. Dedolimitization is a likely process that may account for the high-sulfate, low-bicarbonate groundwater in this area of the aquifer; however, this theory requires further analysis to achieve greater confidence (Kresse et al. 2013).

3.8.2.9 Trinity Aquifer

Similar to other Cretaceous aquifers in the planning region, use of the Trinity is limited to the outcrop areas. Wells for which water-quality data were available were located only in Sevier and Howard Counties. Generally, water quality from the Trinity aquifer is good. Chloride and sulfate can be somewhat elevated in certain parts of the aquifer, although concentrations are less than the 250 mg/L secondary drinking water standard. All chloride concentrations, except one, are less than 15 mg/L as much as 15 miles from the outcrop area, demonstrating the low overall salinity in the aquifer (Kresse et al. 2013).

3.8.2.10 Ouachita Mountains Aquifer

Groundwater quality in the Ouachita Mountains aquifer is good with respect to Federal primary drinking water standards. Problems in regard to taste, staining, and other aesthetic properties are related to elevated levels of iron, which is a common complaint among domestic users of this aquifer. Water quality and type generally are defined by the two major rock types in the Ouachita Mountains: quartz rocks (sandstone, chert, and novaculite) and shale. Groundwater from quartz formations tends to have low pH values, low dissolved solids concentrations, and is very soft water of a mixed water type representative of precipitation concentrated by evapotranspiration processes. Groundwater from shale rock in the system is characterized as a strongly calcium- to sodium-bicarbonate water type, with varying constituent concentrations defined by residence time along the flow path. Sulfate and chloride concentrations tend to be elevated in some areas for groundwater from shale formations. No spatial relation was noted, however, for the distribution of iron concentrations, and high and low concentrations occurred in shale and quartz formations. Iron is abundant in numerous mineral forms in sedimentary rocks throughout Arkansas, and elevated iron in the Ouachita Mountain aquifer are attributed to microbially mediated processes (Kresse et al. 2013).

3.9 Groundwater-Surface Water Connections

Surface water in the area of outcrop is a potential recharge source for aquifers within the planning region (Hosman et al. 1968). In general, surface waters receive discharge from aquifers in the planning region depending upon river-aquifer head relations (Kresse et al. 2013).

4.0 SOCIO-ECONOMIC CHARACTERISTICS

The socio-economic characteristics of the SAWRPR include demographics, income, employment, and industries. This section describes these characteristics and presents changes in these regional characteristics since the 1990 AWP update. In addition, the wastes generated by the communities and industries in the SAWRPR are characterized. These wastes must be properly managed to protect water quality in the SAWRPR.

4.1 Demographics

Demographic information from the 2010 US census for the counties within the SAWRPR are presented below. Demographic data presented include population totals, the percentages of people living in urban and rural areas, above or below selected ages, and of different races. Information from the 2010 census is compared to information from the 1990 census, to identify population changes that have occurred since the 1990 AWP update. Although the 1990 AWP update reported population data from the 1980 census, the 1990 census data better represents conditions at the time of the previous update. Population changes affect the need and demand for water resources, not just for drinking water, but also for recreation, food supply, irrigation, and aesthetics. Population demographics also affect the potential tax base to pay for water infrastructure upgrades, expansion, and repairs.

4.1.1 2010 Population

Population data from the 2010 census for the counties within the SAWRPR are summarized in Table 4.1 and mapped in Figure 4.1. The population of the counties in the SAWRPR in 2010 was over 170,000. Miller County, the location of Texarkana, had the highest 2010 population. Lafayette County had the lowest 2010 population.

Table 4.1. 2010 county populations in the SAWRPR (US Census Bureau 2012a, Census State Data Center 2013)

County	Total Population			Percent Urban Population		
	1990	2010	Change 1990 to 2010 (%)	1990	2010	Change in Percent urban population 1990 to 2010
Columbia*	25,691	24,552	-4%	43.4%	42.5%	-0.9
Hempstead*	21,621	22,609	5%	44.6%	44.2%	-0.4
Howard	13,569	13,789	2%	34.2%	32 5%	-1.7
Lafayette	9,643	7,645	-21%	0	0	0
Little River	13,966	13,171	-6%	36.9%	31 5%	-5.4
Miller	38,467	43,462	13%	59.3%	60 0%	0.7
Nevada*	10,101	8,997	-11%	36.4%	30.8%	-5.6
Polk*	17,347	20,662	19%	31.6%	26.6%	-5.0
Sevier	13,637	17,058	25%	34.0%	36 4%	2.4
Total	166,032	171,945	5%	40.9%	40.5%	-0.4

*Part of this county is in another planning region

There is one Urbanized Area identified in the 2010 census that is located in the SAWRPR; Texarkana (Figure 4.2). Urbanized Areas are areas with population of at least 50,000 people at a density of 1,000 to 500 people per square mile (US Census Bureau 2011). In addition, five areas within the planning region were identified as Urban Clusters in the 2010 census (Figure 4.2). Urban Clusters are areas with population densities of 500 to 1,000 people per square mile, which contain a total of 25,000 to 50,000 people (US Census Bureau 2011, US Census Bureau 2012a). The majority of the population in the SAWRPR (60%) lives in rural areas (Table 4.1). The percentage of the county population living in urban areas varies from 60% in Miller County, to 26% in Polk County (Table 4.1) (US Census Bureau 2012a).

Demographic data on race for the counties within the SAWRPR from the 2007-2011 American Community Survey (ACS) are summarized in Table 4.2. The racial make-up of the population is primarily white non-Hispanic (68%), black non-Hispanic (22%), and Hispanic (7%). Other races each account for 1% or less of the population. Demographic data on age, sex, and education level for the counties within the SAWRPR are summarized in Table 4.3. The majority of the population in this region is between the ages of 18 and 65, 34% of adults are high school graduates, and 12% have college degrees.

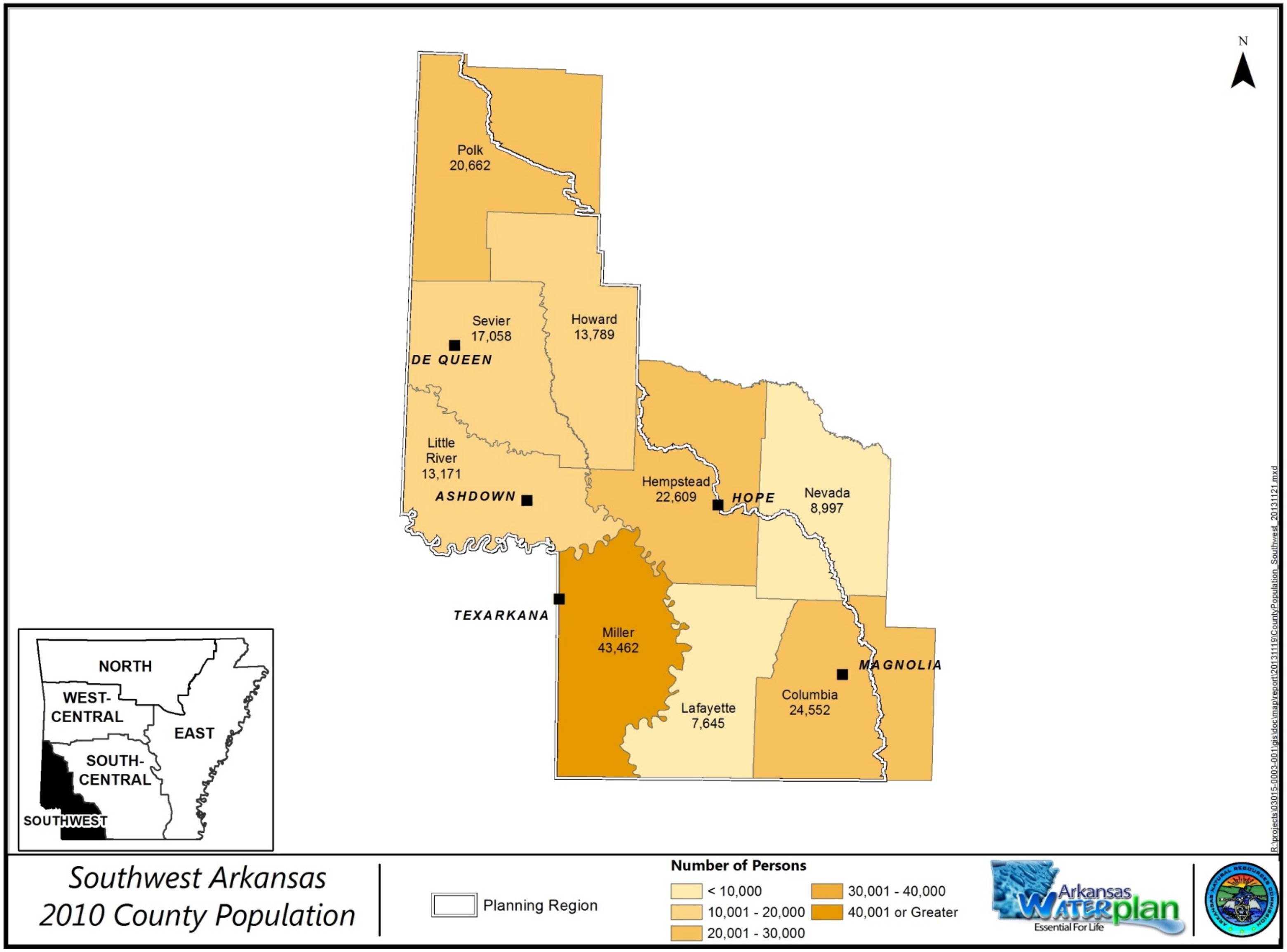

Figure 4.1. 2010 county population in the SAWRPR (US Census Bureau 2012a).

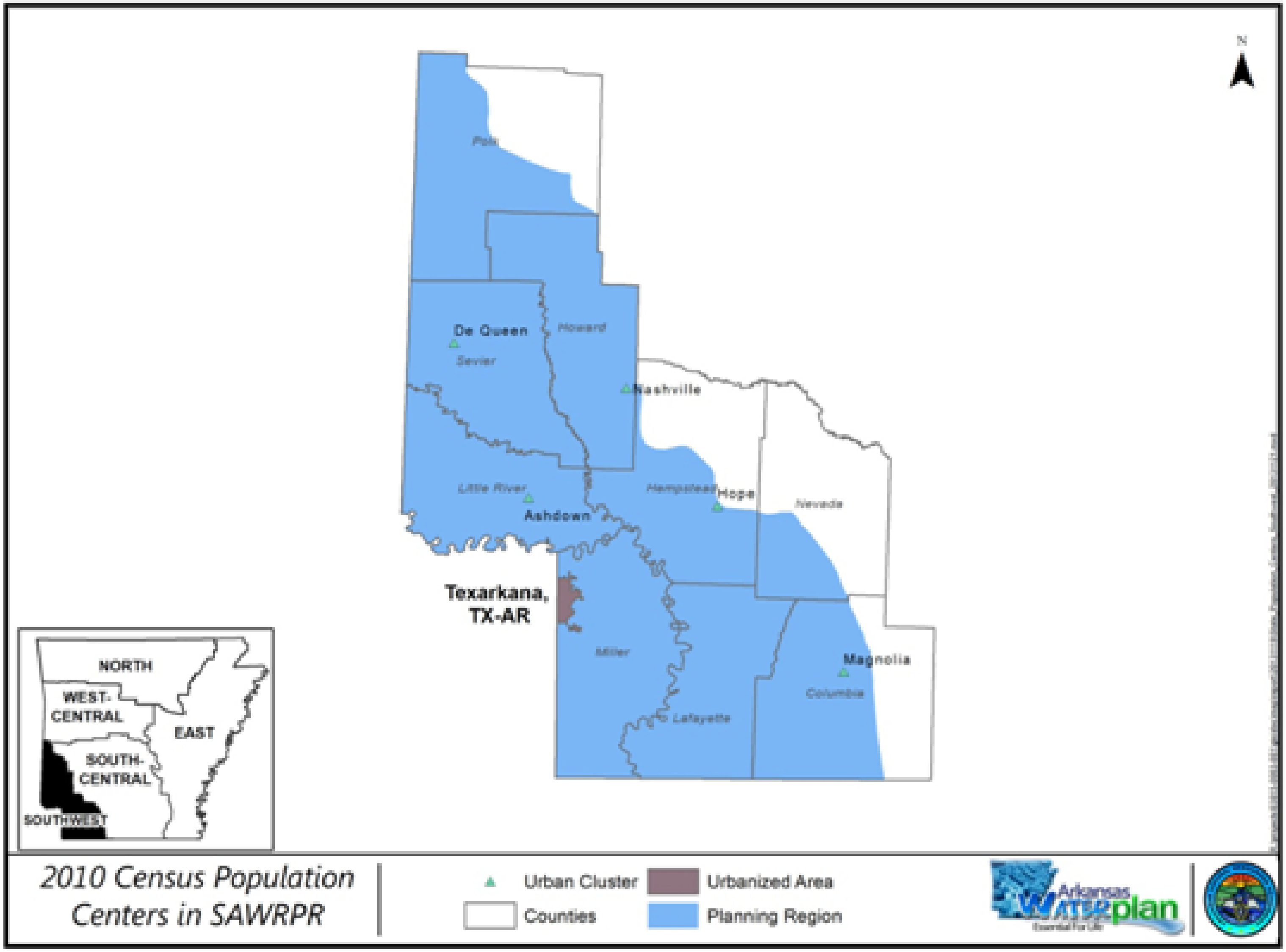

Figure 4.2. 2010 population centers in the SAWRPR (US Census Bureau 2012b).

4.2. Demographic summary for counties in the SAWRPR (US Census Bureau n.d.a).

County	White non-hispanic	Black	Hispanic	Asian	American Indian	Pacific Islander	Other Single race	Multiple race
Columbia*	14,545	9,006	533	171	62	3	23	209
Hempstead*	12,770	6,623	2,713	82	77	17	20	307
Howard	9,292	2,813	1,349	84	94	9	10	138
Lafayette	4,583	2,837	131	26	11	0	2	55
Little River	9,831	2,508	357	39	186	2	13	235
Miller	30,691	10,589	1,038	196	280	17	33	618
Nevada*	5,861	2,758	220	23	28	1	0	106
Polk*	18,549	54	1,190	88	348	5	8	420
Sevier	10,416	717	5,220	62	324	2	19	298
Total	**116,538**	**37,905**	**12,751**	**771**	**1410**	**56**	**128**	**2386**
Percentage	68%	22%	7%	< 1%	< 1%	< 1%	< 1%	1%

*Part of this county is in another planning region.

4.3. Additional demographic characteristics of counties in the SAWRPR (US Census Bureau n.d.a).

County	Total female population	Total population under 18 years	Total population over 65 years	High school graduates	College graduates
Columbia*	12,837	5,594	3,928	5,676	3,133
Hempstead*	11,704	5,878	3,396	5,623	2,136
Howard	7,133	3,623	2,104	3,732	1,139
Lafayette	3,952	1, 776	1,483	2,282	654
Little River	6,768	3,137	2,253	3,718	1,125
Miller	22,061	10,549	5,982	11,388	3,693
Nevada*	4,588	2,131	1,588	2,346	645
Polk*	10,499	4,921	4,025	5,460	1,506
Sevier	8,594	5,040	2,147	3,757	963
Total	**88,136**	**42,649**	**26,906**	**43,982**	**14,994**
Percentage	51%	25%	16%	34%+	12%+

*Part of this county is in another planning region; + Percentage calculated based on population 18 years of age or older

4.1.2 Changes from 1990

The population of the counties of the SAWRPR increased by 5% between the 1990 and 2010 census (Table 4.1). In 1990, Miller and Columbia counties had the greatest total populations in the region. Four of the nine counties within the SAWRPR experienced population declines between 1990 and 2010. Declines ranged from 4% in Columbia County to 21% in

Lafayette County. Five of the counties in the SAWRPR experienced population increase between 1990 and 2010, ranging from 2% in Howard County to 25% in Sevier County (Table 4.1).

In six of the nine counties, the proportion of the population living in urban areas has declined since 1990. In Miller County and Sevier County the proportion of the population living in urban areas has increased since 1990. There are no urban areas, as defined by the US Census Bureau, in Lafayette County.

4.2 Income and Employment

Income and employment data are available by county from the US Census Bureau. Recent data are presented below to characterize the current income and employment levels within the SAWRPR. Data from 1990 are also presented for comparison, to provide insight into changes that have occurred in the region since the 1990 AWP update.

4.2.1 Current Income and Employment Levels

Median household incomes reported by the US Census Bureau in the 2007 – 2011 ACS for counties in the SAWRPR are shown in Table 4.4. The average median income in the region is $35,867, less than the state-wide median household income of $40,149. Lafayette County had the lowest median household income in the planning region, $30,152. Miller County had the highest median household income in the planning region $40,200. This was the only county in the SAWRPR with a median household income greater than $40,000.

4.4. Income and employment characteristics for counties in the SAWRPR (Census State Data Center 2013 [US Census Bureau n.d.b]).

	Median Household Income		Families With Income Below Poverty Level		Population Below Poverty Level		Unemployment	
County	1990	2007 - 2011	1990	2007 – 2011	1990	2007 – 2011	1990	2007 – 2011
Columbia*	$18,470	$36,163	19.1%	17.9%	24.4%	24.8%	8.0%	5.6%
Hempstead*	$16,986	$34,885	18.4%	17.8%	22.7%	22.5%	7.6%	5.3%
Howard	$21,277	$37,146	13.7%	17.7%	18.6%	22.6%	6.2%	7.1%
Lafayette	$13,849	$30,152	27.9%	17.4%	34.7%	21.6%	10.6%	11.6%
Little River	$21,791	$38,564	16.2%	10.2%	19.3%	16.6%	6.1%	7.8%
Miller	$20,232	$40,200	18.7%	15.5%	22.4%	20.3%	7.6%	8.8%

4.4. Income and employment characteristics for counties in the SAWRPR (continued).

County	Median Household Income		Families With Income Below Poverty Level		Population Below Poverty Level		Unemployment	
	1990	2007 - 2011	1990	2007 – 2011	1990	2007 – 2011	1990	2007 – 2011
Nevada*	$18,919	$38,006	15.9%	18.5%	20.3%	23.1%	6.3%	8.4%
Polk*	$17,789	$32,395	14.7%	14.8%	18.5%	20.2%	5.5%	3.1%
Sevier	$19,208	$35,289	13.7%	15.6%	18.6%	21.3%	5.8%	10.0%
Average	$18,724	$35,867	17.6%	16.2%	22.2%	21.4%	7.1%	7.5%

*Part of this county is in another planning region.

Based on data from the 2007-2011 ACS, the average percentage of families with income below poverty level in the counties within the SAWRPR is 16.2%, but county values range from 10.2% in Little River County to 18.5% in Nevada County. The percentage of families with income below poverty level for Arkansas as a whole is 13.8%. The average percentage of county population with income below poverty level in the planning region is 21.4%, with values ranging from 16.0% in Little River County to 24.8% in Columbia County. The percentage of Arkansas population with income below poverty level is 18.4%. The unemployment rates for all but one of the counties in the SAWRPR are higher than the overall state unemployment rate of 5%. The unemployment rate in Polk County is 3.1%.

4.2.2 Changes in Income and Employment from 1990

Information on income and employment from the 1990 census (1989 data) for the counties in the SAWRPR is included in Table 4.4. This information indicates that the income characteristics of this region have not changed significantly over the past two decades. The average median income in the SAWRPR in 1990 was less than the state-wide median income of $21,147. Median incomes have increased since 1990, and there have been slight reductions in percentages of families and population with incomes below the poverty level. However, the unemployment rate is slightly higher than in 1990.

4.3 Economic Drivers

Agriculture, timber, and tourism are important economic drivers in the SAWRPR (Association of Arkansas Counties 2013). The US Census Bureau conducts an economic census every 5 years. This includes information on the value of sales, and the number of people employed by economic sector and county. Information from the 1992 and 2007 economic census, as well as the 1990 and 2010 census, are presented below.

4.3.1 Current Regional Economic Drivers

The value of sales and receipts reported for the counties within the SAWRPR in the 2007 economic census is summarized in Figure 4.3. Manufacturing and retail trade contribute the most value to the economy of the counties in the planning region. Agriculture and forestry are not economic sectors reported in the economic census. However, agriculture and forestry contribute value to manufacturing, real estate, wholesale trade, and transportation and warehousing economic sectors (U of A Divison of Agriculture 2012).

The number of people employed in the SAWRPR by economic sectors, as reported in the 2007-2011 ACS and the 2007 Economic Census, are summarized in Figure 4.4. The economic sectors for which employment is reported in these two sources are slightly different. However, both sources indicate that manufacturing, health care and education, and retail trade provide the majority of employment in the SAWRPR. Agriculture and forestry generate jobs in every economic sector, particularly manufacturing, health care, and retail trade (U of A Divison of Agriculture 2012).

4.3.1.1 Timber

The timber industry is important to the economy of the SAWRPR. Arkansas is the 4th largest producer of saw logs in the South (U of A Divison of Agriculture 2012). Weyerhauser Company, a large forest products company, owns timberland in the planning region and has a mill operation near DeQueen. A pulp and paper manufacturing plant is located in Ashdown (Cottingham 2011). The total revenue from forestry reported for 2007 in the counties of the SAWRPR was over $3.6 million (Table 4.5).

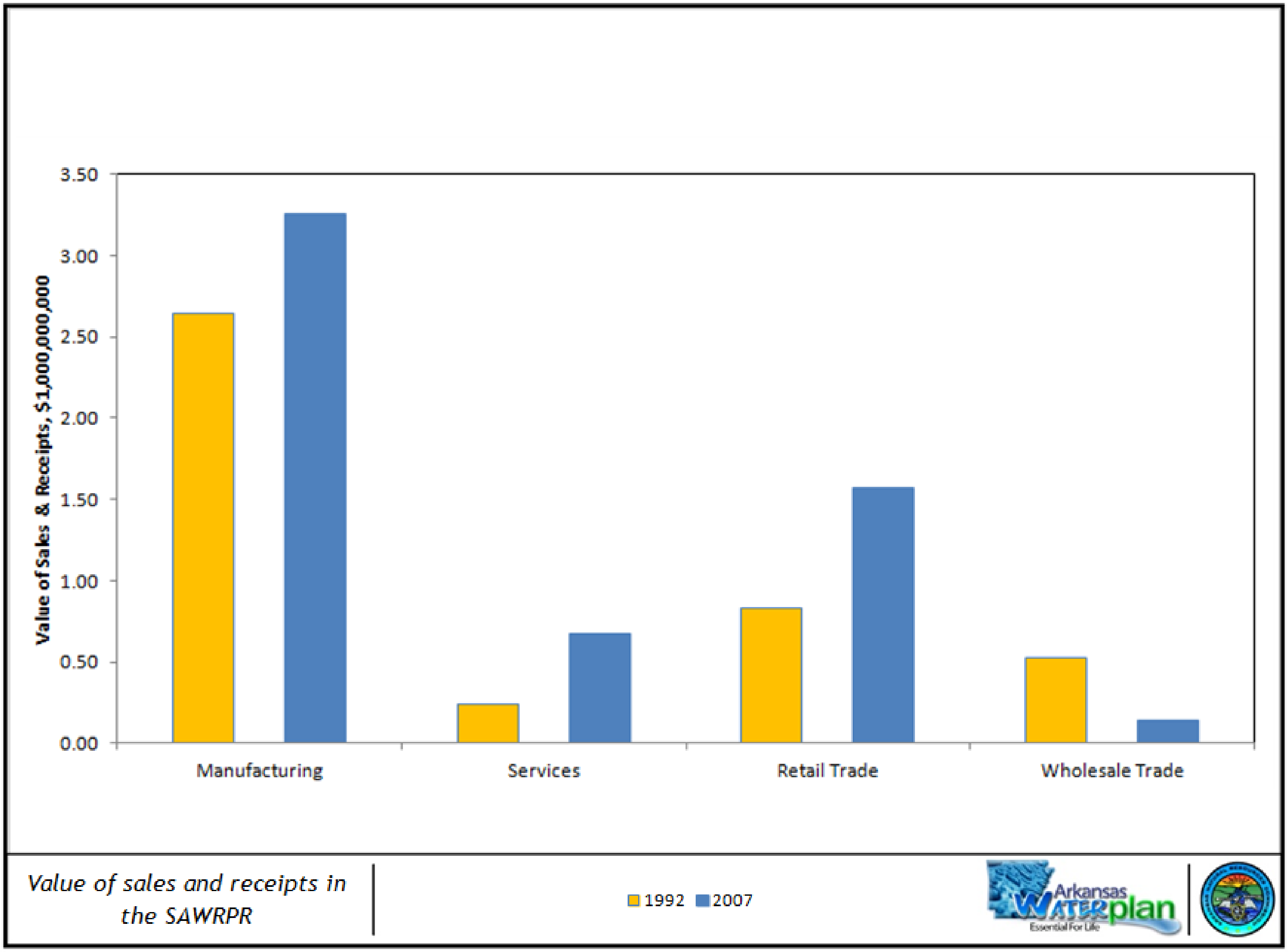

Figure 4.3. Value of sales and receipts in the SAWRPR (US Census Bureau 1993, 2011b).

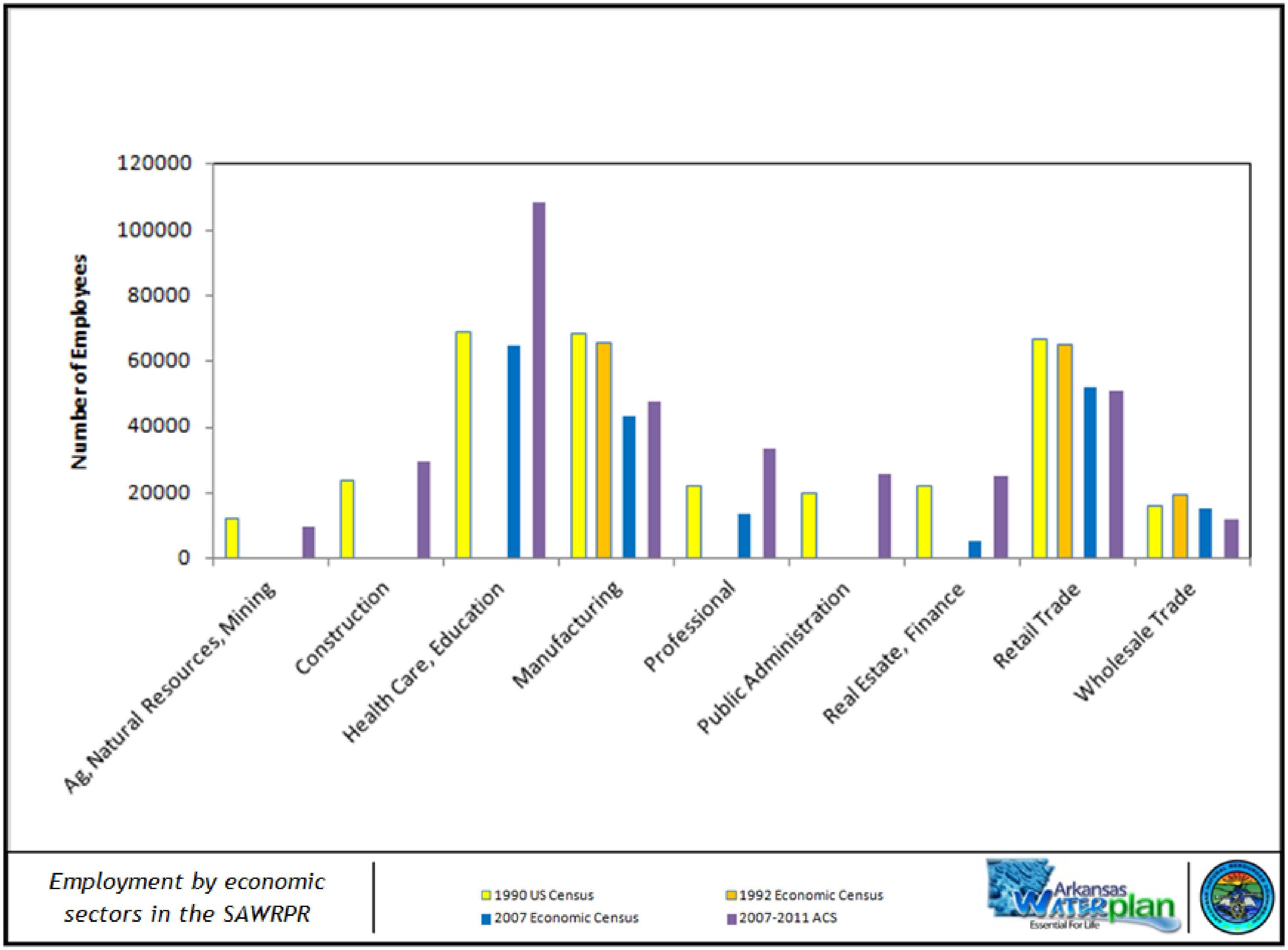

Figure 4.4. Employment by economic sectors in the SAWRPR (Census State Data Center 2013; US Census Bureau n.d.b 1993, 2011b).

Table 4.5. Value of agricultural sales in the counties of the SAWRPR (US Census Bureau 1989, USDA National Agricultural Statistics Service 2009).

County	Forest Products (Thousand $)		Crops (Thousand $)		Livestock (Thousand $)		Fish (Thousand $)
	1987	2007	1987	2007	1987	2007	2007
Columbia*	$197	$319	$1,997	$9,772	$17,789	$35,369	0
Hempstead*	$147	$642	$2,543	$5,000	$105,071	$162,118	0
Howard	$72	$606	$243	$1,809	$69,840	$182,252	0
Lafayette	D	D	$7,078	$16,175	$25,539	$75,089	$3,454+
Little River	$60	$471	$3,809	$8,744	$12,537	$57,771	D
Miller	$41	$535	$6,962	$20,408	$24,029	$28,330	D
Nevada*	$189	$361	$839	$1,266	$25,883	$47,224	D
Polk*	$60	$268	$228	$1,687	$63,589	$133,842	D
Sevier	D	$398	$144	$883	$57,937	$148,081	0
Total	$766	$3,600	$23,843	$65,744	$280,688	$870,076	$3,454+

*Part of this county is in another planning region.
D information withheld to protect privacy.

Water use in the timber industry is primarily during processing. Timberlands are not generally irrigated. Timberlands can impact water quality through erosion of forest roads, stream crossings, and harvested areas; and runoff of chemicals used in timber management.

4.3.1.2 Agriculture

Agriculture is also a major economic driver in the SAWRPR. This includes cattle production, poultry and egg production, row crop agriculture (including vegetables), orchards (including peaches and pecans), and food processing. Arkansas is first in the nation in terms of rice production, second in broiler production, and third in cotton and catfish production, all of which are produced in the SAWRPR. Arkansas is in the top 25 states in the US for the production of a number of other agricultural commodities produced in the region, including soybeans, eggs, pecans, cattle, watermelons, peaches, corn, and swine (U of A Divison of Agriculture 2012).

The total value for sale of crops produced in the counties of the SAWRPR during 2007 was over $65 million (Table 4.5). The total value for sale of fish produced in these counties was over $3.4 million. Catfish accounted for the majority of fish sales from these counties, but baitfish, crawfish, ornamental fish, and game fish were also produced (USDA National Agricultural Statistics Service 2009). The 2007 Census of Agriculture reported that there were

22 aquaculture farms in counties of the planning region. The majority, 16, were in Lafayette County, with three more in Miller County, two in Polk County, and one in Nevada County (Arkansas Farm Bureau 2012). Livestock sales accounted for the majority (92%) of the 2007 revenues from sale of agricultural products in the counties in the planning region. The total value for sale of livestock produced in these counties during 2007 was over $870 million (Table 4.5).

Row crop agriculture, aquaculture, and food processing can use significant volumes of water (USDA National Agricultural Statistics Service 2009). Livestock require water, but not in as large volumes as crops. Runoff from cattle, poultry, and swine operations has the potential to affect water quality of surface waters in the planning region.

4.3.1.3 Tourism

The SAWRPR offers a wide variety of recreation and tourism opportunities, making this industry another economic driver for the region. Water resources in this planning region are an important element of many of the recreation and tourism opportunities. These include eight public lakes for fishing and boating, five state parks, the Ouachita National Forest, 16 wildlife management areas, and 10 natural areas.

ADEQ has designated over 61 miles of streams in the planning region as Extraordinary Resource Waterbodies for “scenic beauty, aesthetics, …broad scope recreation potential, and intangible social values” (Figure 4.5). Over 44 miles of streams in the planning region are designated by ADEQ as Natural and Scenic Waterways (Figure 4.6) (APCEC 2011). The Cossatot River, is a designated National Wild and Scenic River with the reputation of being the most challenging whitewater stream in Arkansas. Part of the Cossatot River (26 miles) is also designated as an Arkansas Natural and Scenic River (ANHC 2012).

The Arkansas Department of Parks and Tourism reports that, in 2012, over $250 million of travel expenditures were made in the counties within the SAWRPR, and tourism generated over $19 million in tax revenue (Table 4.6). The USACE has estimated economic impacts of the reservoirs located in the SAWRPR. Overall, the four USACE reservoirs in the planning region generate over 300 jobs, and over $36 million in revenue, wages, and taxes (Table 4.7). The USFWS estimates that the Pond Creek NWR generates $969,220 in expenditures annually (USFWS n.d.).

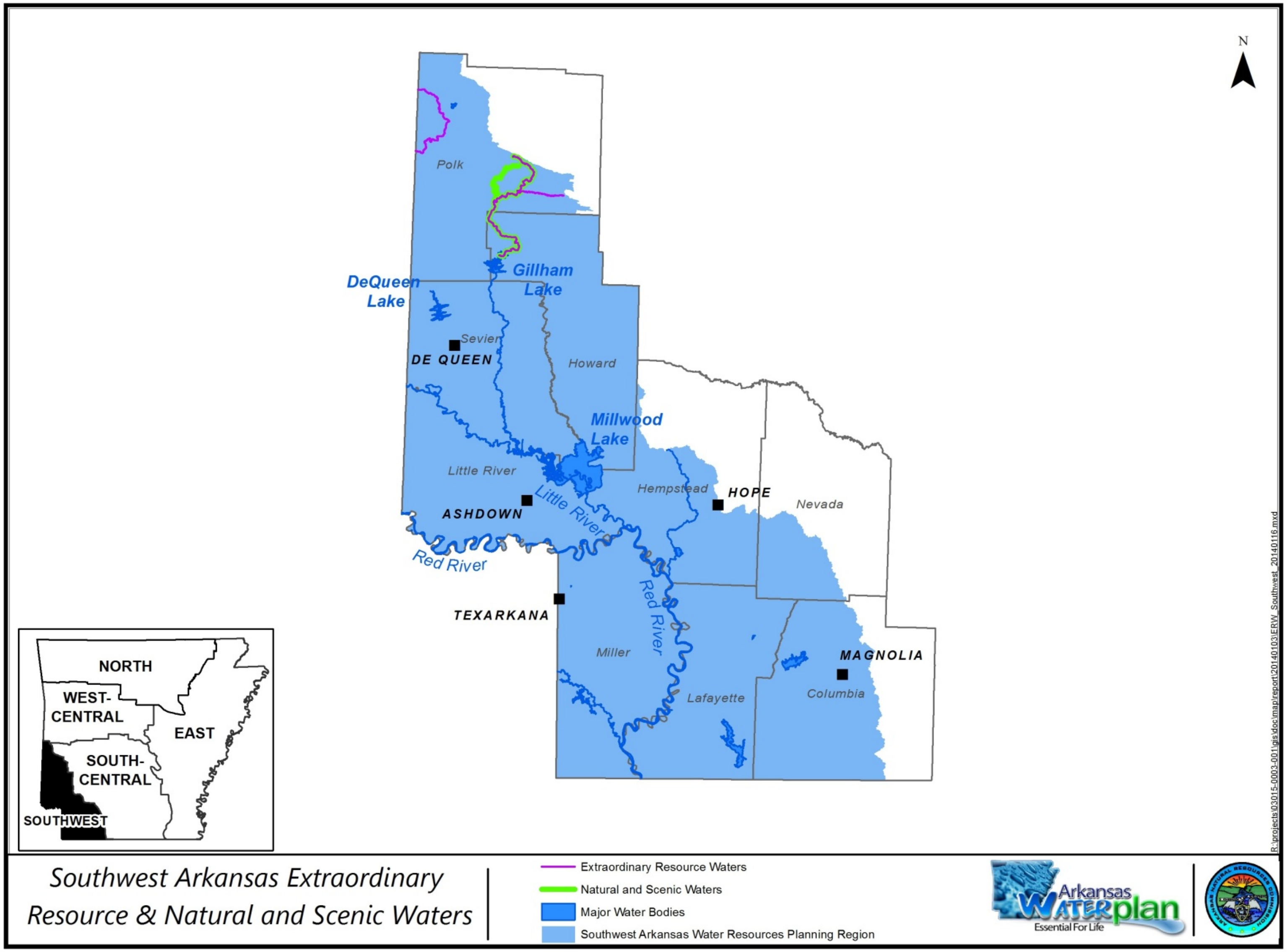

Figure 4.5. Outstanding resource waters within the SAWRPR.

Table 4.6. 2012 Tourism revenues (Arkansas Department of Parks and Tourism 2012)

County	Visitors		Travel expenditures		Payroll		Employment		Tax revenue	
	1990	2012	1990	2012	1990	2012	1990	2012	1990	2012
Columbia*	86,583	99,512	$12,062,964	$23,830,162	$2,183,396	$4,236,833	251	275	$711,715	$1,932,859
Hempstead*	152,629	197,347	$20,644,723	$47,579,879	$3,736,695	$8,936,209	430	518	$1,218,039	$4,051,871
Howard	22,842	14,585	$3,369,936	$3,282,714	$609,958	$404,822	70	21	$198,826	$274,263
Lafayette	41,745	98,493	$5,798,288	$25,633,502	$4,049,490	$3,346,937	121	210	$342,099	$2,279,920
Little River	51,062	84,626	$6,719,910	$21,039,728	$1,216,304	$3,019,438	140	186	$396,475	$1,924,206
Miller	522,059	307,628	$74,078,565	$73,757,006	$13,408,220	$13,199,755	1,541	672	$7,370,636	$4,571,799
Nevada*	36,629	57,386	$5,109,778	$20,652,272	$924,870	$3,706,355	106	154	$301,477	$1,200,779
Polk*	80,967	82,515	$11,252,278	$20,362,835	$2,036,662	$3,713,437	234	232	$663,884	$1,674,082
Sevier	50,097	55,107	$6,972,476	$13,979,143	$1,262,018	$2,250,844	145	141	$411,376	$1,127,157
Total	1,044,613	997,199	$146,008,918	$250,117,241	$29,427,613	$42,814,630	3,038	2,409	$11,614,527	$19,036,936

* Part of this county is included in another planning region

Table 4.7 Economic benefits from USACE reservoirs in the SAWRPR in 2010 (USACE 2011).

Reservoir	Total Sales	Jobs	Payroll	Value Added[1]
DeQueen	$2,710,461	53	$98,8831	$1,548,443
Dierks	$2,710,064	49	$1,014,216	$1,599,182
Gillham	$1,697,880	32	$634,640	$992,134
Millwood	$10,826,531	173	$4,377,270	$6,799,036
Total	$17,944,936	307	$7,014,957	$10,938,795

1 includes wages, salaries, payroll benefits, profits, rents, and indirect business taxes

Hunting, fishing, and wildlife watching associated with rivers, lakes, and wetlands in the region, also contribute to the economy of the SAWRPR. In 2011, Arkansas ranked seventh in the nation in hunting-related sales, and more mallard ducks were harvested in Arkansas than any other state (AGFC 2013b). The SAWRPR is located where the Central and Mississippi River Flyways overlap. Economic contributions from wildlife recreation in Arkansas are summarized in Table 4.8. Regional data are not available.

Table 4.8. Economic contributions from wildlife recreation in Arkansas.

Activity	Total Expenditures (Million $)		2011 Retail Sales (Million $)[c]	2011 State/Local Tax Revenue (Million $)[c]	2011 Federal Tax Revenue (Million $)[c]
	1991[a] (Million $)	2011[b] (Million $)			
All Hunting	$85.0	$1,018.8	$877.4	$99.2	$99.5
Waterfowl Hunting	Not Reported	$288.0	$236.7	$29.1	$23.9
Sport Fishing	$216.9	$495.6	$508.0	$49.4	$49.8
Wildlife Watching	Not Reported	$216.1	Not Reported	Not Reported	Not Reported

a USFWS, US Department of Commerce Bureau of the Census 1993
b USFWS, US Department of Commerce Census Bureau 2013
c AGFC 2013b

4.3.1.4 Resource Extraction

Economically important minerals occur in the SAWRPR, making resource extraction another important economic driver in the planning region. Bromine, natural gas and petroleum are the top three minerals produced in Arkansas (Table 4.9). Bromine is produced in Columbia County (Hill 2010). This industry in a major employer and influence on the economy in Columbia County (Cottingham 2012).

Table 4.9. 2012 oil, gas, and brine production in counties of the SAWRPR (Arkansas Geological Survey 2013).

County	Oil production, (barrels)	Gas production, (million cubic feet)	Bromine brine (barrels)
Columbia*	36,079	0	128,086,440
Hempstead*	2,484	0	0
Nevada*	254,546	734	0
Miller	335,960	650,350	0
Lafayette	564,446	728,760	0
Total	1,193,515	1,379,844	128,086,440

*Part of the county is in another planning region.

Oil is produced in Columbia, Hempstead, Lafayette, Miller, and Nevada Counties in the planning region. Oil companies are one of the leading employers in the planning region (Bridges, Encyclopedia of Arkansas History and Culture 2011).

Other nonfuel minerals produced in the planning region include crushed stone, sand and gravel, and shale (USGS 2013a). Mineral extraction and processing in the planning region do not generally require large quantities of water. They do have the potential to impact water quality, however (see Section 5.4).

In 2009, the value of nonfuel mineral production in Arkansas was $636 million (USGS 2013a). Approximately half of the bromine brine produced in the State during 2012 was produced in Columbia County (Arkansas Geological Survey 2013). The market value of crude oil produced in Arkansas in 2008 was $413 million (University of Arkansas Sam Walton College of Business 2009). In 2012, the counties of the SAWRPR accounted for approximately 20% of the state oil production (Arkansas Geological Survey 2013).

Spring water is another natural resource of the SAWRPR that contributes to the regional economy. There is one company that bottles spring water in the planning region, in Polk County, Caddo Water Works Corporation (Arkansas Geological Survey 2012).

4.3.2 Comparison to 1990 Regional Economy

Figure 4.3 also shows the value of sales and receipts reported in the 1992 economic census. Note that the 1992 economic census reported values by county only for the manufacturing, services, retail trade, and wholesale trade sectors. The 2007 value for services shown on Figure 4.3 is a summation of values reported for economic sectors that reportedly were included in the 1992 value for services (US Census Bureau 2011c). As in 2007, the economic sectors with the greatest value of sales and receipts in the region in 1992 were manufacturing and retail trade. It appears that wholesale trade in the region has declined, while the manufacturing, retail trade, and service economic sectors have expanded.

Employment data from the 1990 census and 1992 economic census are included in Figure 4.4. The economic sectors used to report employment are slightly different for the two sources and the different time periods shown in Figure 4.4. While these differences make direct comparisons uncertain, using the information from different sources during similar time periods allows us to have greater confidence when identifying changes over time. For the most part, it does not appear that there have been significant changes in employment level for the majority of the economic sectors. There does appear to have been a decline in employment in the manufacturing and retail trade sectors, which is the opposite of the apparent increase in sales and receipts in those sectors since 1992 (Figure 4.3). It appears there may have been an increase in the number of people employed in healthcare and education in the planning region since 1990.

4.3.2.1 Timber

Table 4.5 includes information on the value of forestry products from the 1987 Census of Agriculture, which was significantly lower than in 2007. As today, in the 1990s, forestry was an important economic driver, contributing over $4 billion annually to the state economy (Gray 1993). Lumber and wood products companies dominated the manufacturing sector of the state economy during this period (Advameg, Inc. n.d.). Timber production and timber products output in Arkansas expanded between 1987 and 2005. State timber product output declined between 2005 and 2009 to below the 1987 level (Brandeis et al. 2011, May 1990). However, based on the sales numbers in Table 4.5, the timber economy of the SAWRPR was stronger in 2007 than in 1987.

4.3.2.2 Agriculture

As noted in Section 3.5.1, there has been little change in the crops grown in the SAWRPR between 1987 and 2007. Table 4.5 includes information on the value of crops and livestock from the 1987 Census of Agriculture, which were lower than in 2007. The area of cropland in the planning region has not increased significantly since 1987; however, the area of pasture has increased significantly, suggesting expansion of livestock production in the region. Comparison of livestock inventories from the 1987 and 2007 census of agriculture indicate that there have been moderate increases in the numbers of cattle and swine in the region (Table 4.10). The number of poultry in the planning region counties, however, was 72% greater in 2007 than in 1987.

Table 4.10. Livestock inventories for the counties of the SAWRPR (US Census Bureau 1989, USDA National Agricultural Statistics Service 2009)

	Cattle and Calves		Swine		Poultry			
					1987		2007	
County	**1987**	**2007**	**1987**	**2007**	**All**	**Broilers**	**All**	**Broilers**
Columbia	13,634	11,828	593	56	1,618,391	1,391,077	2,431,691	2,241,500
Hempstead*	38,737	62,759	3,452	4,870	10,039,415	5,573,081	9,552,624	8,806,49
Howard	27,647	56,978	7,697	42,907	7,930,633	7,276,349	9,520,196	8,370,004
Lafayette	25,683	24,523	284	80	2,112,942	2,112,810	4,085,459	3,893,952
Little River	24,380	30,054	628	D	499,466	498,915	3,541,003	D
Miller	26,964	23,610	2,065	53	2,016,724	1,937,200	1,520,603	1,441,588
Nevada*	20,654	17,042	531	D	2,793,509	1,829,236	2,836,540	2,305,218
Polk*	29,707	45,060	14,067	17,133	12,263,013	5,276,442	6,995,968	6,225,614
Sevier	29,835	35,285	3,472	23,028	6,546,730	6,345,932	8,211,694	7,972,976
Total	**237,241**	**307,139**	**32,789**	**40,161**	**45,820,823**	**32,241,042**	**78,695,778**	**17,945,396**

*Part of the county is in another planning region.
D= information withheld to protect privacy.

4.3.2.3 Tourism

Overall, the economic contribution of tourism in the SAWRPR was greater in 2012 than in 1990 (Table 4.6). However, the number of visitors and people employed in tourism were lower overall in 2012 than in 1990. Declines in visitors, revenue and employment occurred in Howard and Miller Counties. In Polk and Sevier Counties, the number of visitors, revenue, and tourism employment was not very different in 2012 compared to 1990. The 2012 numbers were higher than 1990 for the rest of the counties. Lafayette County saw the largest percent increase in trips, visitors, and tourism revenue in the region. The economic contribution of hunting and fishing in the state has increased since 1990 (Table 4.7). Note that seven WMAs and a NWR have been established in the SAWRPR since the 1990 AWP update (Table 2.2), increasing opportunities for outdoor recreation in the planning region.

4.3.2.4 Resource Extraction

Oil and natural gas production in South Arkansas was greater in 1990 than in 2012. Brine production in South Arkansas was slightly less in 1990 than in 2012. There have been 11 oil/gas/brine fields developed in the planning region since 1990, and 28 that have been abandoned (Arkansas Geological Survey 2013).

4.4 Waste Generation and Disposal

Industries and communities in the SAWRPR produce wastes that must be properly managed to protect water quality, which contributes to water availability for the water users of the SAWRPR. ADEQ is the state agency responsible for regulating solid waste, hazardous waste, and wastewater. These three waste streams are managed through separate permitting programs overseen by the EPA. Waste management in the SAWRPR is quantified below, along with changes in waste management that have occurred since the 1990 AWP update.

4.4.1 Solid Waste

There are parts of two Regional Solid Waste Management Districts (RSWMDs) within the SAWRPR. Information on solid waste generation and disposal for each of these districts for 2010 is summarized in Table 4.11. For the most part, the RSWMDs report that their solid waste disposal facilities and collection services are sufficient to meet demand. However, illegal dumping that occurs in the districts could pose local threats to water quality.

Table 4.11. 2012 solid waste generation and disposal information for RSWMDs in the SAWRPR (Terracon 2013, Southwest Arkansas Planning and Development District 2013, ADEQ 2013b).

RSWMD Name	Number Of Counties In RSWMD	Counties In Planning Region	Number Of Landfills In Planning Region	2012 Solid Waste Generated In-District (Tons)	2012 Solid Waste Disposed In-District (Tons)	Number Illegal Dump Sites Identified 2011 - 2013
Upper Southwest	9	7	3	128,824	139,332	14
Southwest	6	2	1	94,673	67,418	11

There have been significant changes in the solid waste arena since 1990, driven by the need to protect water quality. In 1991, federal regulations changed, requiring improvements in the way landfills were constructed in order to protect groundwater quality. In addition, the new regulations required monitoring of groundwater quality around landfills (EPA 2012a, ADEQ 2011). At the same time, state regulations set up programs to fund cleanup of groundwater contamination from landfills, and for collection and recycling of batteries and waste oil, both of which pose risks to surface and groundwater quality when disposed of improperly. Around 1995, the Arkansas General Assembly established a policy to eliminate illegal dumping, another threat to surface and groundwater quality. State legislation to implement this policy was passed in 1997. In 2005, state legislation was passed that resulted in the development and implementation of a comprehensive mercury minimization program for the state. Mercury is a surface water quality issue throughout the state (ADEQ 2011). State programs initiated since 1990 for the collection and recycling of electronics, and collection of household hazardous wastes also protect water quality.

4.4.2 Hazardous Waste

There are 57 permitted hazardous waste generators in the counties within the SAWRPR (Table 4.12). Thirty-three of the facilities in the counties within the SAWRPR are classified as large quantity generators, meaning they generate at least 1,000 kilograms of hazardous waste per month (EPA 2012b). Twenty-four of the facilities are classified as small quantity generators, meaning they generate between 100 and 1,000 kilograms of hazardous waste per month (EPA

2012c). There are also two hazardous waste treatment/storage/disposal facilities in the region; one in Little River County and one in Sevier County (ADEQ 2013b).

Table 4.12. Permitted hazardous waste generators in counties within the SAWRPR (ADEQ 2013b).

County	Large Quantity	Small Quantity
Columbia*	6	6
Hempstead*	0	3
Howard	2	2
Lafayette	2	0
Little River	4	2
Miller	5	5
Nevada*	2	0
Polk*	3	5
Sevier	9	1
Total	**33**	**24**

*Part of this county is in another planning region.

Hazardous waste generation data is compiled annually, but this program was not implemented in Arkansas until after 1990. Information from 1990 on the number of hazardous waste generators is also not readily available. Therefore, a comparison with 1990 conditions is not made in this document.

4.4.3 Wastewater and Stormwater

There are 354 point sources permitted to discharge wastewater and stormwater in the SAWRPR (Table 4.13). These discharges are permitted by ADEQ through the federal National Pollutant Discharge Elimination System (NPDES). Industrial, municipal, and domestic wastewater discharges are permitted through NPDES as well as discharges of stormwater and runoff associated with industrial sites, municipalities (MS4s), and temporary construction sites. See Section 6 for more details on wastewater regulations and permitting in Arkansas.

Approximately 43 surface water bodies in the planning region receive discharges from permitted entities. Several of these water bodies receive discharges from more than one point source (ADEQ 2012a).

Table 4.13. NPDES permitted discharges in the SAWRPR (ADEQ 2013c, d, e, f).

County	NPDES Industrial	NPDES Municipal	NPDES Domestic	NPDES Large MS4	NPDES Small MS4	NPDES Construction Stormwater[1]	NPDES Industrial Stormwater	NPDES Other[2]	Total
Columbia*	20	5	3	0	0	4	18	5	55
Hempstead*	16	6	4	0	0	10	27	4	67
Howard	10	4	0	0	0	3	14	1	32
Lafayette	6	4	4	0	0	5	5	3	27
Little River	7	4	3	0	0	3	9	4	30
Miller	15	3	2	0	1	16	26	3	66
Nevada*	4	2	5	0	0	2	3	2	18
Polk*	8	3	3	0	0	3	14	2	33
Sevier	5	4	2	0	0	1	11	3	26
Total	91	35	26	0	1	47	127	27	354

*Part of this county is in another planning region.
[1]Construction stormwater permits are temporary.
[2]Includes filter backwash, process water, agricultural, cooling water, toxics, and saltwater discharges.

Table 4.14 compares the number of NPDES permits for municipal, domestic, and industrial wastewater reported for the SAWRPR in the 1990 state-wide water quality assessment with the current numbers for the same categories of NPDES permits. Overall, the number of permitted wastewater discharges in the SAWRPR has increased by over 200% since the 1990 AWP update. Note that the state-wide water quality assessment reports do not include permits for municipal, industrial, or construction stormwater runoff. The first industrial and construction stormwater runoff NPDES permits were issued by ADEQ in 1992 (ADEQ 2013d,e). ADEQ did not issue permits for small municipalities’ stormwater runoff until 2004 (ADEQ 2013f).

Table 4.14. Numbers of NPDES wastewater permits reported for the SAWRPR in 1990 and 2013 (ADPCE 1990, ADEQ 2013c).

Permit Type	1990	2013	Change
Industrial	9	91	82
Municipal	31	35	4
Domestic	11	26	15
Cooling Water	1	0	-1
Filter Backwash	1	15	14
Process Water	1	7	6
Agricultural	0	0	0
Other	2	6	4
Total	56	180	124

5.0 WATER RESOURCES ISSUES

Water resources issues in the SAWRPR include concerns about the amount of water that is available, how the water is used, and the chemical and biological quality of water resources. In addition, there are concerns in the region about how water is managed in terms of flood control, water supply infrastructure, and wastewater treatment infrastructure. These issues are discussed and, to some extent, quantified below. Changes in regional water resources issues since the 1990 AWP update are also discussed.

5.1 Flooding

Flood events routinely occur in the SAWRPR, along the Red River and its tributaries. Flooding occurs as a result of intense local thunderstorms that produce isolated flood events affecting small areas or just a few watersheds. Since 1957, there have been 34 major disaster declarations involving flooding in the State of Arkansas. Between 2003 and 2010 some or all of the counties included in the Southwest Region of Arkansas have been included in 7 flooding declarations (ADEM 2010).

The most recent significant flood event in the SAWRPR occurred in May 1998 when from 10 to 14 inches of rain fell in an 8-hour span in Texarkana resulting in widespread flooding and damage (FEMA 2009). The more significant flooding on the Red River occurred in May of 1990 when, as a result of heavy rains over the western half of the State, the Red River was at flood stage from May 1 to 22 (ADEM 2010).

5.2 Red River Waterborne Transportation

The J. Bennet Johnston Waterway on the Red River extends upstream as far as Shreveport, Louisiana. Waterborne transportation of commercial goods does not currently occur on the Red River in Arkansas. A USACE feasibility study of extending the Red River navigation system into Arkansas to Index Bridge at US Highway 71 (between Texarkana and Ashdown, Arkansas) was authorized in the Water Resources Development Act of 1996, and has been completed. Variations calling for navigation to Garland City and Fulton, Arkansas were also considered. At that time, the cost/benefit ratio of extending navigation on the Red River did not meet the minimum requirement set by

USACE. In 2011, a project was initiated to update the cost/benefit ratios to account for increased fuel costs, with the hope that the updated ratios will meet the USACE minimum requirement (NRCS 2009, Arkansas Waterways Commission 2013). As of May 2013, there is no federal or state funding allocated for this study (McLemore 2013, Red River Valley Association 2013).

5.3 Water Supply

Although there are 11 recognized aquifers within the SAWRPR, only some of these aquifers are considered to be sustaining aquifers. Other aquifers in the planning region can only support limited domestic use. Water level declines are occurring in several of the aquifers in the planning region. This is a somewhat localized issue as water use, groundwater recharge rates, and hydraulic conductivity of these aquifers vary throughout the planning region.

No issues have been identified with the quantity of surface water available within the planning region.

5.3.1 Monitoring

ANRC sponsors monitoring of water levels in six study areas throughout the West Gulf Coastal Plain. Water-level monitoring is a cooperative effort between the ANRC, USGS, NRCS, and local water-resources agencies. Each spring approximately 300 water levels collected from wells in the Sparta-Memphis aquifer. Measurements are collected in the spring to minimize effects of groundwater drawdown from seasonal irrigation. Results of the monitoring program are published in the annual Arkansas Groundwater Protection and Management Report available on the ANRC website.

The USGS also conducts water-level monitoring independently as part of the National Water Information System (NWIS). Since 2007, the USGS has operated a continuous groundwater-level recorder at a real-time station near Magnolia, in Columbia County. This station measures water levels in the Sparta aquifer. Surveys of water levels in the Nacatoch, Tokio, and Wilcox aquifers present in the planning region are conducted approximately every four years, beginning in 1997 (USGS n.d.). The results of these surveys are published by the USGS. These data provide a valuable dataset for improved understanding of water resources of the State. Data from this program may be retrieved at the NWIS website (Kresse et al. 2013).

5.3.2 Red River Alluvial Aquifer

Use of the Red River alluvial aquifer has increased since 1965 in the planning region, especially in Little River, Miller and Lafayette Counties. No use has been recorded for Hempstead County since 2000, and only a slight amount of use (0.11 million gallons per day [mgd]) occurred in Sevier Count in 2010 (Kresse et al. 2013). Lafayette County generally uses the greatest amount of water from the Red River alluvial aquifer. In 2010 use of the Red River alluvial aquifer was estimated to be approximately 31 mgd—83% of which was for use as irrigation supply (Kresse et al. 2013).

Most irrigation use of the Red River alluvial aquifer occurs in southern Lafayette and northwestern Miller Counties. Irrigation pumpage from the Red River alluvial aquifer was estimated at 6.9 mgd in 1965 (Ludwig 1972). Irrigation pumpage from the Red River alluvial aquifer has increased 277% to 26.0 mgd in 2010 (Kresse et al. 2013). The number of irrigation wells in Miller County has increased from two in 1955 to 40 in 2010 (Kresse et al. 2013). Common crops in the area mirror what is grown in eastern Arkansas: rice, cotton, soybeans, and other minor crops. At one time rice irrigation used as much as 50% of the water pumped from the Red River alluvial aquifer (Ludwig 1972), but as of 2010, the percentage of irrigation water for rice production was about 12% (Kresse et al. 2013). In 2010, 15% of the aquifer's total use was for flooding fields for duck hunting (Kresse et al. 2013).

Numerous towns throughout SAWRPR used the Red River alluvial aquifer as source of public supply in the late 1880s, but with the development of the surface-water reservoirs in the early 1900s (Hale 1926), including the Southwest Arkansas Water District, surface water is now the predominant source for public supply water. As of 2010, there was only a small amount of public supply use from the Red River alluvial aquifer in Little River and Sevier Counties. In 2010, 0.24 mgd was withdrawn for this purpose (Kresse et al. 2013). The availability of other water sources and water quality issues in groundwater from the Red River alluvial aquifer has restricted domestic and industrial use of the Red River alluvial aquifer (Ludwig 1972).

5.3.3 Sparta Aquifer

The Sparta aquifer is an extremely important aquifer in Arkansas, generally providing water of excellent quality, with wells often yielding hundreds to thousands of gallons per minute. The Sparta aquifer provided approximately 197 mgd in 2010 with 700 wells reported in use (Kresse et al. 2013). The Sparta aquifer ranks first in groundwater used for public supply in Arkansas, with municipalities withdrawing 57.4 mgd from the Sparta aquifer in 2010 (Kresse et al. 2013). The principal areas for groundwater withdrawal from the Sparta aquifer are located outside the planning region; however, the aquifer has been a significant source of water for public water supply, oil and gas development, and the chemical industry within the planning region.

Magnolia (Columbia County) tapped the Sparta aquifer for public water supply as early as 1928 (Hale et al. 1947) and both the town and county experienced increased groundwater withdrawals for public supply and industrial use to support oil production and refining (Fancher and Mackay 1946, Tait et al. 1953). Prior to the oil boom, Columbia County used 0.25 mgd from the Sparta aquifer for all purposes. By 1950 use had grown to an estimated 2.7 mgd (Tait et al. 1953). Tait and others (1953) suggested that 3 mgd is the optimum withdrawal rate of the Sparta aquifer at Magnolia. Use of the Sparta aquifer rose from 0.33 mgd in 1950 to 3.03 mgd in 1965 and increased to 7.22 mgd in 1980.

A larger proportion of surface water has been consumed by Magnolia since Lake Columbia was constructed and connected to the town's water supply in 1993. Correspondingly, Sparta aquifer water use in Columbia County decreased by almost 20% from 1990 (6.5 mgd) to 1995 (5.2 mgd), and decreased further, to 2.9 mgd, from 1990 to 2005 (Kresse et al. 2013). Use of the Sparta aquifer has since risen in Columbia County. In 2010 use was 9.4 mgd, corresponding with an increase in industrial use. Public supply withdrawals in 2010 were 1.3 mgd (Kresse et al. 2013). Industrial use of the Sparta aquifer in Columbia County increased 75% from 2005 to 2010 (Kresse et al. 2013). Major industries in Columbia County currently include lumber, chemical and steel companies.

Water-level declines in the Sparta aquifer are a major concern for users in Arkansas and have been noted throughout the Sparta aquifer in Arkansas. Severe water-level declines have been noted in southern and east-central Arkansas since development of the Sparta aquifer for primarily municipal and industrial uses in these areas. The reader is referred to Kresse and others (2013) for a discussion of the historical use of the Sparta, a general overview of changing water levels over time, and development of cones of depression throughout the extent of the Sparta aquifer in Arkansas. Within the planning region, significant water level declines have been observed at Magnolia (Columbia County).

5.3.4 Cane River Aquifer

Although present in many areas of southern Arkansas, water quality concerns have restricted use of the Cane River aquifer to primarily southwest Arkansas. Historically, the Cane River aquifer has used been for domestic supply within the planning region, and was a source of public supply water in Lafayette County (Ludwig 1972).Wells capable of producing smaller yields were present in northern and western Columbia County (Baker et al. 1948, Tait et al. 1953). Twenty-three wells were reported with use from the Cane River aquifer in 2010. Also, irrigation wells were reported for the first time to this formation in 2007 in Lafayette County (Kresse et al. 2013).

Lafayette County has consistently been the largest user of this aquifer, primarily for public supply. Municipalities using the Cane River aquifer included Lewisville, Stamps, and Bradley (all Lafayette County) whose wells were drilled in the early 1930s (Hale et al. 1947). The combined use of the Cane River aquifer in 2010 was 0.65 mgd (Kresse et al. 2013).

Kresse and others (2013) note that while historical water level measurements have been made on this aquifer, further research on water levels in the Cane River has not been compiled. Ludwig (1972) indicated that water levels in the aquifer have not been affected by pumping.

5.3.5 Carrizo Aquifer

The Carrizo aquifer serves only as a minor aquifer in Arkansas, mainly used for domestic supply in southwestern Arkansas. Older reports state that the aquifer was not commonly utilized, due perhaps to limited information available on the aquifer’s extent and water availability and/or high iron contents (Halberg et al. 1968, Plebuch and Hines 1969). Most withdrawals from the

Carrizo aquifer were by domestic users within 5 to 10 miles of its outcrop (Albin 1964, Terry et al. 1986).

Published water use data for the Carrizo aquifer are only available from 1965 to 1980. Ludwig (1972) reported 0.23 mgd was withdrawn from Miller County wells in 1965, slightly more than what was reported in Halberg and Stephens (1966), but Ludwig (1972) attributed most use of the Carrizo aquifer to domestic users in Miller County. No wells currently are recorded in the Arkansas Water Use Database for this aquifer; however, a few commercial enterprises that do not meet the reporting requirements for this database use the aquifer in Miller and Nevada Counties (Lyle Godfrey, Arkansas Department of Health, written communication., 2012).

5.3.6 Wilcox Aquifer

The Wilcox aquifer is very important in the planning region for domestic supply near its outcrop area. Many residences have wells completed in the Wilcox aquifer and depend on it for drinking water. Schools and small businesses are also reported to use water from the Wilcox aquifer in this area (Counts et al. 1955, Onellion and Criner 1955, Albin 1964, Halberg et al. 1968, Plebuch and Hines 1969, Ludwig 1972, Terry et al. 1986). Domestic use has declined in recent years as more residents convert to municipal water supplies; however, small amounts still are assumed to be withdrawn for domestic supply by users in Miller, Lafayette, and Nevada Counties. Irrigation wells into the Wilcox aquifer are present in Lafayette County (Kresse et al. 2013). The extent and water quality of the aquifer in some areas prevent its use. Pumping from minor Wilcox aquifers has caused localized declines in groundwater levels and changes in groundwater flow direction in some areas.

5.3.7 Nacatoch Aquifer

Use of the Nacatoch aquifer occurs in areas near its outcrop within the planning region. Poor water-quality has restricted the aquifer’s use further away from its outcrop in southwestern Arkansas (Terry et al. 1986). Primary use of the aquifer has been public and industrial supply. Hempstead County has generally accounted for the majority of the use of the Nacatoch aquifer in southwestern Arkansas. Other counties in the planning region that have historically used the aquifer as a water supply include Howard, Little River, and Miller Counties. Southwestern Arkansas users pumped the most water from this aquifer in 1980 (6.46 mgd). Water-use rates for the Nacatoch aquifer have decreased in southwestern Arkansas since 1980 to a reported level of 1.5 mgd, with wells located in Hempstead and Nevada Counties (Kresse et al. 2013).

Hope (Hempstead County) is the largest user of this aquifer for public supply in the planning region, using 15% of the total water withdrawn from the aquifer. Hope also uses water from wells completed in the Tokio aquifer and supplements this supply with surface water (Kresse et al. 2013). Also, Spring Hill School district (Hempstead County) continues to use a well drilled in 1948 to the Nacatoch aquifer (Kresse et al. 2013).

Industrial use of water from the Nacatoch aquifer occurs in Hempstead County. The current (2010), largest single use of the aquifer is for cooling water at a power plant in Hempstead County.

Southwestern Arkansas has experienced water-level declines in the Nacatoch aquifer since its early and intense development. During early development, many flowing artesian wells were not shut in and allowed to flow freely, causing a decline in water levels of approximately 7 feet over 17 years near Prescott (Veatch 1906).

ANRC and USGS monitor the Nacatoch aquifer as part of a long-term, State-wide groundwater water-level program (Schrader 1998, 1999, 2007; Schrader and Scheiderer 2004; Schrader and Blackstock 2010; Schrader and Rogers 2013). In the planning region, recent water-level contours have shown that water levels gradually decrease from the aquifer’s outcrop north to south (Schrader and Blackstock 2010). Water levels were reported to have declined approximately 40 feet at Hope from 1942 to 1969, due to large groundwater withdrawals mostly for public supply and industry, and a cone of depression has been documented for this area since 1967 (Ludwig 1972, Schrader 1999, Schrader and Scheiderer 2004, Schrader and Blackstock 2010, Kresse et al. 2013). An increase in water levels near the depression at Hope was recorded in 2010 corresponding to decreasing groundwater use in Hempstead County.

5.3.8 Ozan Aquifer

Wells completed in the Ozan aquifer are found mainly in Clark County, where other water sources are not available. Primary use of this aquifer has been for domestic supply; however, use has been restricted due to high chloride concentrations (Counts et al. 1955, Boswell et al.1965). Two domestic wells were recorded in Hempstead and Sevier County but their use was restricted due to high chloride (Counts et al. 1955). Published water use data for the Ozan aquifer only is available from 1965 to 1980, and no use has been reported for this aquifer after this period.

5.3.9 Tokio Aquifer

The Tokio aquifer dominantly was used as a source of domestic water supply. Counts and others (1955) recorded 143 domestic wells into the Tokio aquifer in six counties in southwestern Arkansas: Pike, Nevada, Clark, Hempstead, Howard and Sevier. Many of these wells originally were flowing artesian wells, and an estimated 66% of water was lost from the total 3 mgd that was withdrawn in southwestern Arkansas (Boswell et al. 1965). Use for domestic supply and livestock wells continued into the late 1960s and early 1970s in northwestern Little River County, near Winthrop (Plebuch and Hines 1969, Ludwig 1972). Also, domestic wells are in use in Hempstead County, and users in Howard County continue to depend upon the aquifer for livestock water supply. Approximately 0.9 mgd of water from the Tokio was used in 2010. Approximately 73% of water used from the Tokio aquifer is for public supply, 7% for industrial, and the remainder for domestic and livestock (Kresse et al. 2013).

Several towns in SAWRPR have used the Tokio aquifer for municipal supply. Hope (Hempstead County) reported the most public supply use in 2010, withdrawing 1.83 mgd, which was 64% of total water use of this aquifer (Kresse et al. 2013). Hope also uses water from the Nacotoach aquifer and supplements this use with surface water sources. Other smaller communities in the area including Mineral Springs (Howard County) and Ben Lomond (Sevier) tap the Tokio aquifer for public supply. A small amount of industrial use, including a cement company in Howard County and a handful of lumber operations, has occurred in the past (Counts et al. 1955). Currently (2010), industrial use of the aquifer is only seen in Miller County at a chicken processing plant. Wells were also historically used at several schools in the area (Counts et al. 1955, Kresse et al. 2013).

Long-term ANRC and USGS cooperative monitoring has documented water-level changes in the Tokio aquifer (Schrader 1998, 1999, 2007; Schrader and Scheiderer 2004; Schrader and Blackstock 2010; Schrader and Rogers 2013). No appreciable changes in water levels were noted at the map scale between the 1996, 1999, and 2001 investigations (Schrader and Scheiderer, 2004), but a cone of depression in southern Howard County appeared in the 2011 data (Kresse et al. 2013). Many reports cite the possibility of a cone of depression forming 5 miles northwest of Hope; however, not enough water-level data have been available in the southern part of the study area to confirm this situation (Schrader and Blackstock 2010). However, water levels in a well near the possible depression northwest of Hope (Hempstead County) have fallen with increasing use. A large drop was documented for this well between 1990 and 2000, when water use increased 215%, from 1.10 mgd to 3.46 mgd in Hempstead County. Water levels additionally appear to have slowly declined at Prescott.

5.3.10 Trinity Aquifer

The Trinity aquifer is present in many counties in southwestern Arkansas, but the clayey sediments common throughout the extent of the aquifer impede its use from both a water quality and yield standpoint. The Trinity aquifer has been used for domestic and public water supply, including the public supply wells at Murfreesboro (Pike County), DeQueen, Horatio, Locksburg (Sevier County), and Mineral Springs (Howard County). Horatio and Lockburg continue to use the Trinity aquifer, while Murfreesboro uses the Little Missouri River, Mineral Springs uses groundwater from the Tokio aquifer, and DeQueen uses a reservoir on the Rolling Fork River. Use of the Trinity aquifer has been restricted to the SAWRPR. Estimated use of the Trinity aquifer in 2010 was only in Sevier and Columbia Counties and totaled 0.86 mgd (Kresse et al. 2013). Sevier County generally had the most use, and although no data were published for Sevier County from 1985—1995, Horatio and Locksburg were assumed to have continued withdrawal for public supply from the Trinity aquifer. Approximately 20% of water used from the Trinity aquifer in Sevier County is for public supply (Kresse et al. 2013). Domestic use of the Trinity aquifer is still widespread and common. Usage is assumed to be underestimated because domestic wells are not required to be registered, and livestock wells generally do not meet the use requirement for registration. In 1990-2000, use reported for Howard County (total of 0.73 mgd) is attributed to those two purposes (Kresse et al. 2013).

Water levels of the Trinity aquifer are highest near the outcrop of the aquifer, and water levels decline from north to south with the direction of groundwater flow. Boswell and others (1968) produced the most recent potentiometric surface map for the aquifer, and water levels have not been monitored following that publication. High rates of withdrawal from the Trinity aquifer probably contributed to potentiometric head declines in formerly flowing artesian wells, with water-level declines of greater than 40 feet below the land surface as noted from data gathered in the mid-1960s (Boswell et al. 1968).

5.3.11 Critical Groundwater Areas

The 1990 AWP update advocated sustainable, conjunctive use of groundwater and surface water resources in this region to meet water resources needs. A number of voluntary programs have been initiated to try to reduce the rate of groundwater depletion in areas where groundwater level declines are the greatest.

Historically, the Sparta aquifer in south Arkansas provided abundant water of high quality. However, demand for water, particularly in Columbia County, resulted in withdrawals that significantly exceeded recharge. As a result, water levels declined at rates greater than 1 foot per year through the 1980s and 1990s. Water levels at Magnolia had decreased since measurements were taken through the 1990s, and county water-level declines averaged 3.0 feet per year from 1969 to 1995 (Joseph 2000). A cone of depression in the Sparta aquifer had formed beneath Magnolia and was expanding to coalesce with the cone of depression in Union County. As water levels began to drop below the top of the formation, water users and managers alike began to question the ability of the aquifer to supply water of high quality for the long term and began to evaluate management approaches to protect the aquifer. In 1996, the Sparta aquifer was declared a Critical Groundwater Area by ANRC in five counties, including Columbia County (Figure 5.1). This action allowed counties within the designated area to establish local conservation boards with management, regulatory, and taxing authority to plan, guide, and implement management strategies targeting the achievement of sustainable use of the aquifer.

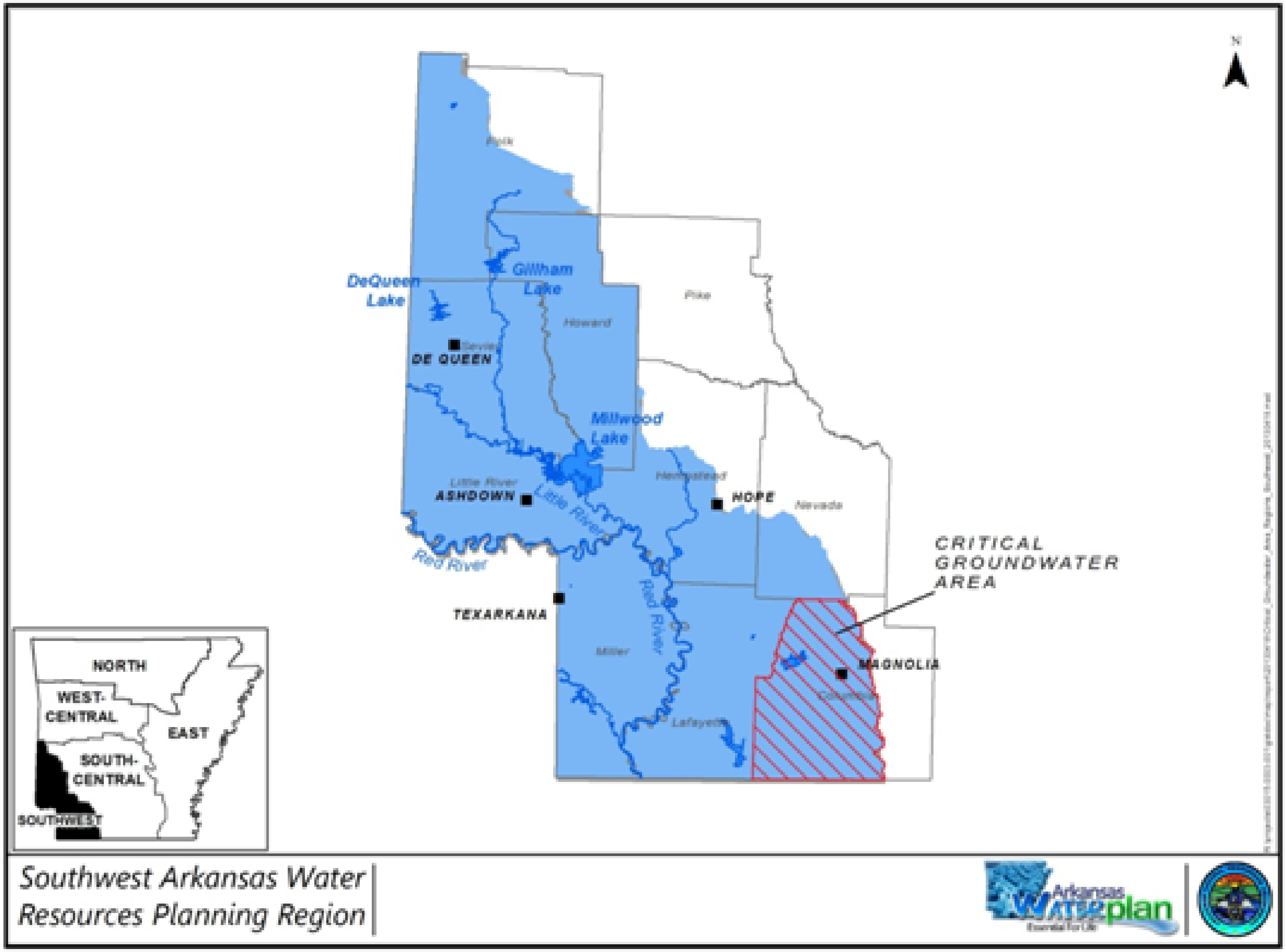

Figure 5.1. Location of critical groundwater area designated within the SAWRPR.

Construction of Lake Columbia and installation of a surface-water supply system in 1993 resulted in decreased withdrawals from the Sparta aquifer, and the cone of depression centered beneath Magnolia diminished considerably (Hays et al. 1998). However, recent increased industrial usage of the Sparta aquifer in Columbia County threatens further groundwater recovery. Water level data from 2009 revealed declines in the water surface after 2007, and deepening of the center of the cone of depression (Kresse et al. 2013).

5.4 Water Quality Issues

Federal law requires states to assess the water quality of the waters of the state (both surface water and groundwater) and prepare a comprehensive report documenting the water quality, which is to be submitted to EPA every two years. ADEQ is the agency in Arkansas responsible for enforcing the water quality standards and preparing the comprehensive report for submittal to EPA. This section discusses surface water and groundwater quality issues that have been identified in the state. These issues include non-attainment of surface water quality standards, non-attainment of drinking water standards and water quality guidelines in groundwater, fish consumption advisories, nonpoint source pollution of surface water and groundwater, and contaminants of emerging concern.

5.4.1 Water Quality Monitoring

To assess water quality, it is necessary to collect water quality data through monitoring programs. Monitoring of water quality in Arkansas occurs under a range of programs, including routine ambient, special project, and research-oriented monitoring. Multiple agencies are responsible for the various water quality monitoring programs, and numerous entities assist with monitoring activities. Surface water and groundwater monitoring programs in Arkansas are outlined below.

5.4.1.1 Surface Water

ADEQ monitors water quality of surface waters through several programs. The ambient water quality monitoring network includes 22 sites on rivers and streams in the SAWRPR that are sampled monthly for chemical analysis (Figure 5.2). The roving water quality monitoring network includes seven stream sites in the planning region. The roving sites statewide are divided into four regional groups. All of the roving sites in the SAWRPR are in the same regional group. The groups of roving sites are sampled for chemical and bacterial analysis on a rotating basis, bimonthly over a 2-year period, every 6 years. Bacterial analysis is also performed on samples from the ambient water quality monitoring network within the active region of the roving water quality monitoring network. In addition, ADEQ conducts water quality monitoring during “intensive surveys.” These surveys can involve water sampling for chemical and bacterial analysis, as well as biological sampling to evaluate water quality. Intensive surveys are conducted for a variety of purposes, including determination of total maximum daily loads (TMDLs), and to augment water quality information from the routine water quality monitoring networks for more accurate assessment of designated use support. ADEQ also routinely monitors water quality in 10 significant publicly owned lakes within the planning region (ADEQ 2008, ADEQ 2012a).

The monitoring and reporting requirements for surface water used for human consumption are authorized by both federal and state regulations. A summary of these requirements can be found in Chapter 5 of *Arkansas Public Water System Compliance Summary*, “Microbial Disinfection By-Products Rules” (ADH 2012). There are around 30 public water supply systems in the SAWRPR that use surface water (ADH n.d.). Depending on the treatment methods used and the number of customers served by the public water supply utilizing surface water, the monitoring requirements for the raw surface water, or source water, will vary and may include turbidity, *Escherichia coli* (*E. coli*), cryptosporidium, total organic carbon, and alkalinity.

The USGS also routinely monitors surface water quality data in the SAWRPR. Data from USGS monitoring stations may also be used in the biennial assessment. There are two active USGS water quality monitoring stations in the SAWRPR (Figure 5.2). Samples are collected at these stations monthly, bi-weekly, or quarterly (USGS 2013b).

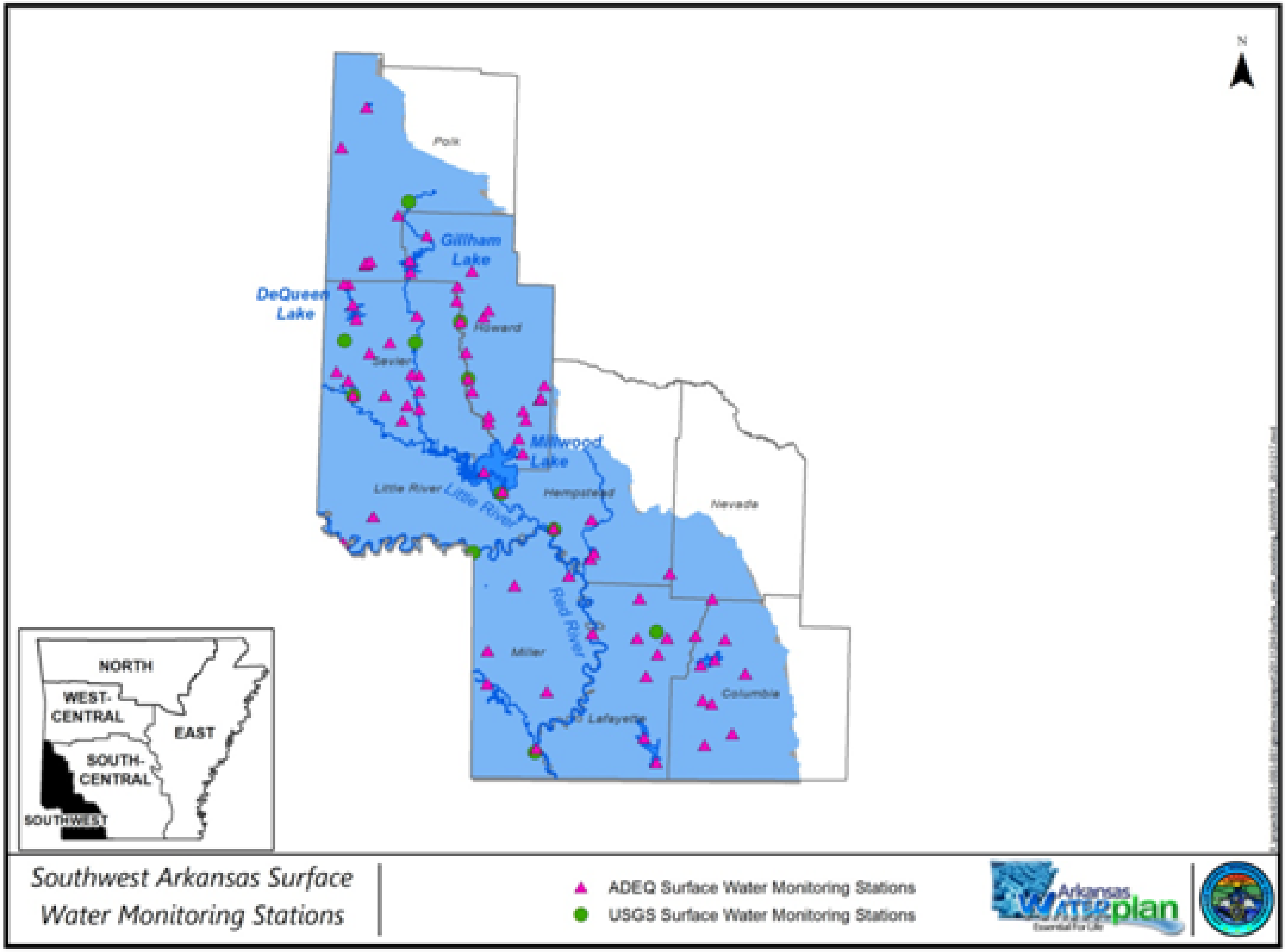

Figure 5.2. Routine surface water quality monitoring sites in the SAWRPR.

5.4.1.2 Groundwater

In the SAWRPR, groundwater quality monitoring is performed on many levels ranging from ambient to research-oriented and mandated monitoring. Multiple agencies are responsible for the various groundwater monitoring programs, and numerous entities assist with monitoring activities. Divisions of ADEQ administer mandated groundwater monitoring programs at various sites that are regulated by state and federal programs. The purpose of this monitoring is to evaluate potential and actual impacts to groundwater resulting from human activities and natural phenomenon (ADEQ 2008). For example, within the planning region are two active properties in the State's Brownfields program that are currently being evaluated; one site that is on the State Priority List that is monitored; one active site in the Elective Cleanup program; two Class I solid waste landfills; and a number of hazardous constituent sites and leaking underground storage tank sites that are being evaluated or monitored through other regulatory mechanisms. These sites may have contaminated groundwater with numerous organic chemicals exceeding safe drinking water standards, but the areal extent of the plume may be limited, with no off-site migration and no known groundwater users at risk.

ADEQ developed the Arkansas Ambient Ground Water Monitoring Program in 1986, which currently consists of 12 monitoring areas and approximately 250 wells and springs throughout the state (Kresse et al. 2013). Part of ADEQ's Athens Plateau Area is located within the planning region (Figure 5.3). Under this program, samples are collected from wells completed in the Ouachita Mountains aquifer and Cretaceous aquifers in the Athens Plateau (Pike and Howard Counties) to develop baseline conditions and monitor potential impacts of the agricultural industry on groundwater. Data are presented in various ADEQ publications available on their website and in the EPA's STORET database (ADEQ 2008).

The University of Arkansas (U of A) has conducted a significant amount of groundwater research that has resulted in scientific data and information necessary to understand, manage, and protect water resources within the state (Kresse et al. 2013). Hard-copy or digital reports, theses, dissertations, and journal articles are available at the U of A Mullin's Library, Arkansas Water Resources Center technical library, or through various online sources.

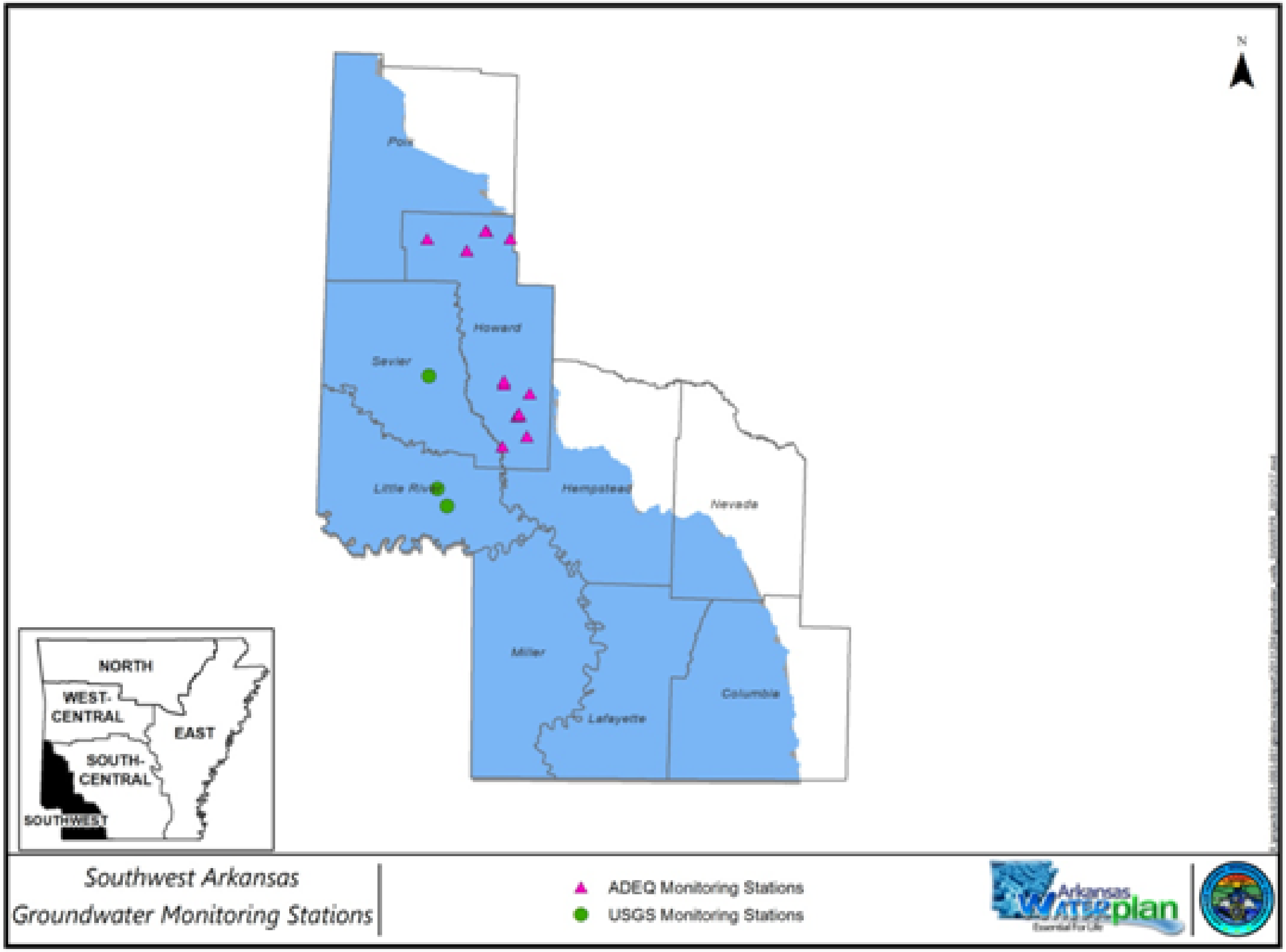

Figure 5.3. Routine groundwater quality monitoring in the SAWRPR.

The Arkansas Department of Health (ADH) is the primary agency for the federal Safe Drinking Water Act (SDWA) and is responsible for monitoring public water-supply wells. ADH maintains a statewide database that consists of 1300 wells (Kresse et al. 2013). Every three years, these wells are sampled for inorganic, organic (including pesticides, herbicides, synthetic organic compounds, and volatile organic compounds), and radiochemical contaminants. The Total Coliform Rule of the SDWA requires sampling on monthly basis, where the number of samples required is dependent upon the population size. Nitrate monitoring is performed on a yearly basis unless a sample greater than or equal to 50% of the maximum contaminant level (MCL) is detected and prompts the need for increased frequency. Additionally, the Disinfection Byproduct Rule of the SDWA requires monitoring of trihalomethanes and haloacetic acids (byproducts of chlorine and other disinfectants used to treat drinking water) on a quarterly or annual basis. While all of the programs above collect samples from treated drinking water, ADH also collects samples from untreated water sources (surface and groundwater) that include bacteria, particulates, algae, organics, pathogens, total organic carbon on a weekly or monthly basis as required by the SDWA (ADEQ 2008).

Several ambient groundwater quality monitoring programs exist that involve cooperative efforts among the USGS, ANRC, and ADEQ. Figure 5.3 shows the locations where ambient groundwater quality monitoring is performed in the SAWRPR. Groundwater quality monitoring activities are primarily funded by EPA grants under Sections 106 and Sections 319 of the Clean Water Act.

The USGS has 24 groundwater wells or springs monitored for water quality scattered throughout the state, with four of these sites located in the planning region (Sevier, Little River and Hempstead Counties) (Figure 5.3). Samples are collected on a five-year rotational basis and analyzed for a variety of constituents including nutrients, metals, organics, radioactivity, and selected primary and secondary drinking water standards constituents (Kresse et al. 2013). In addition, the USGS samples many other wells and springs for purposes of water quality and quantity investigations or as part of other monitoring programs, such as the National Water Information System. Data from these investigations and monitoring programs are presented in reports or available for download online at the Arkansas Water Science Center (http://ar.water.usgs.gov/) or similar USGS websites (ADEQ 2008, Kresse et al. 2013g).

5.4.2 Non-attainment of Surface Water Quality Standards

In 2008, 961 of the over 3,200 miles of streams and 45,070 of the 58,803 acres of lakes in the SAWRPR were assessed for water quality. Of the waterbodies assessed, 492 stream miles and 3,150 lake acres did not meet numeric water quality criteria or did not support all of their designated uses. Minerals (chloride, sulfate, and total dissolved solids [TDS]), metals (lead, zinc, copper, and mercury), and sediment/siltation were the primary causes of impaired water quality in the majority of the stream miles assessed (Table 5.1) (ADEQ 2008, 2009). Mercury and nutrients were the sources of impairment for lakes in the SAWRPR (Table 5.1). The sources of the pollutants causing impairment in streams and rivers within the planning region are most often unknown (ADEQ 2009). Figures 5.4 through 5.7 show locations of impaired waterbodies in the SAWRPR. A detailed listing of stream water quality impairments in the planning region identified in the 2008 303(d) list is included as Appendix A.

Table 5.1. Summary of impaired waters in the SAWRPR (ADEQ 2009).

Pollutant	Miles of impaired stream	Acres of impaired lakes
TDS	241.9	0
Sulfate	213.0	0
Chloride	149.2	0
Lead	97.7	0
Sediment/Siltation	87.0	0
pH	79.0	0
Nutrients	53.9	200
Mercury	50.6	2,950
Copper	42.5	0
Pathogens	40.1	0
Zinc	35.9	0
Temperature	33.8	0
Dissolved Oxygen	28.3	0

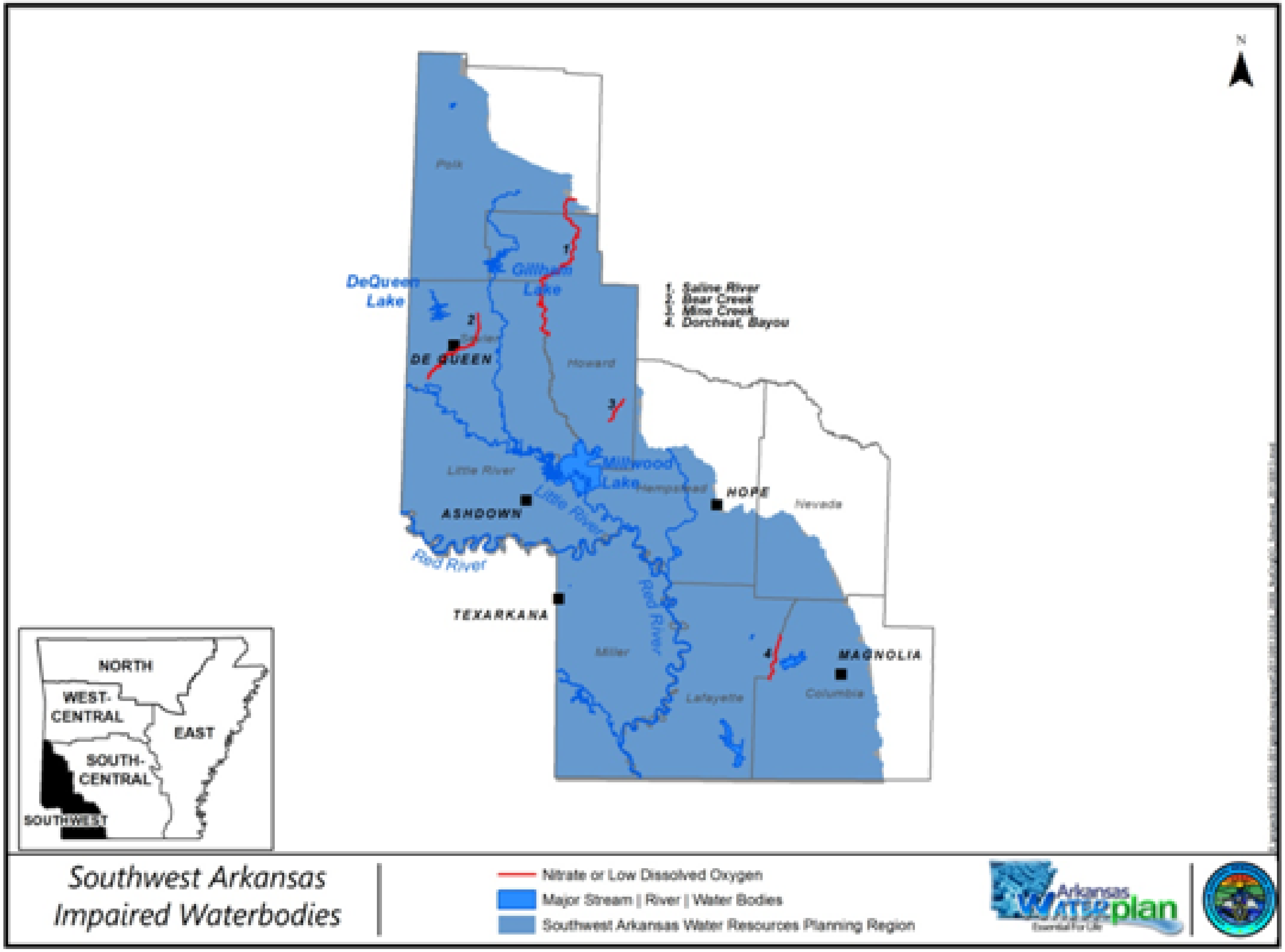

Figure 5.4. Waterbodies in the SAWRPR classified as impaired due to low dissolved oxygen or nitrate in the 2008 303(d) list (ADEQ 2008,2009).

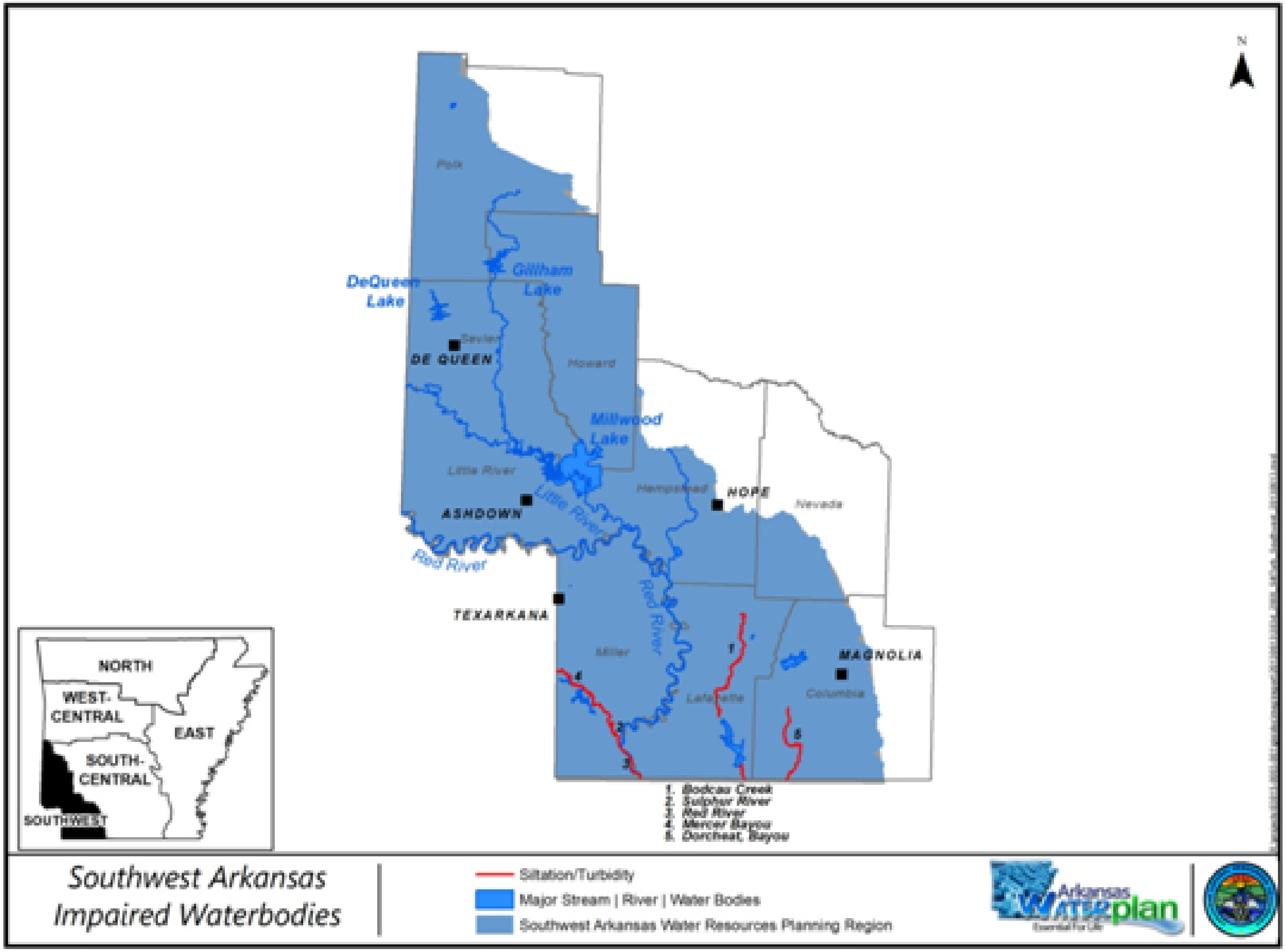

Figure 5.5. Waterbodies in the SAWRPR classified as impaired due to siltation/turbidity in the 2008 303(d) list (ADEQ 2008,2009).

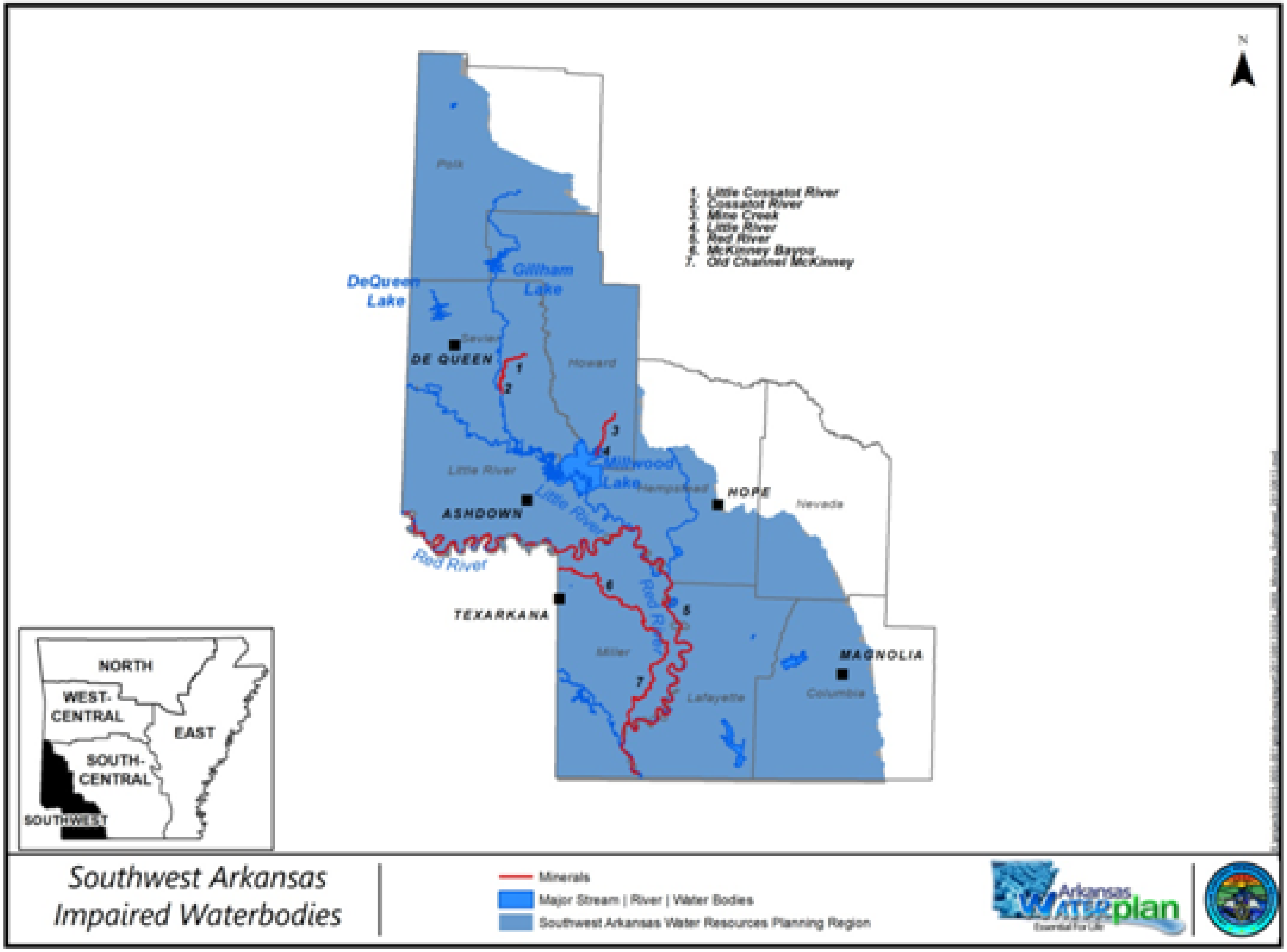

Figure 5.6. Waterbodies in the SAWRPR classified as impaired in the 2008 303(d) list due to minerals (ADEQ 2008,2009).

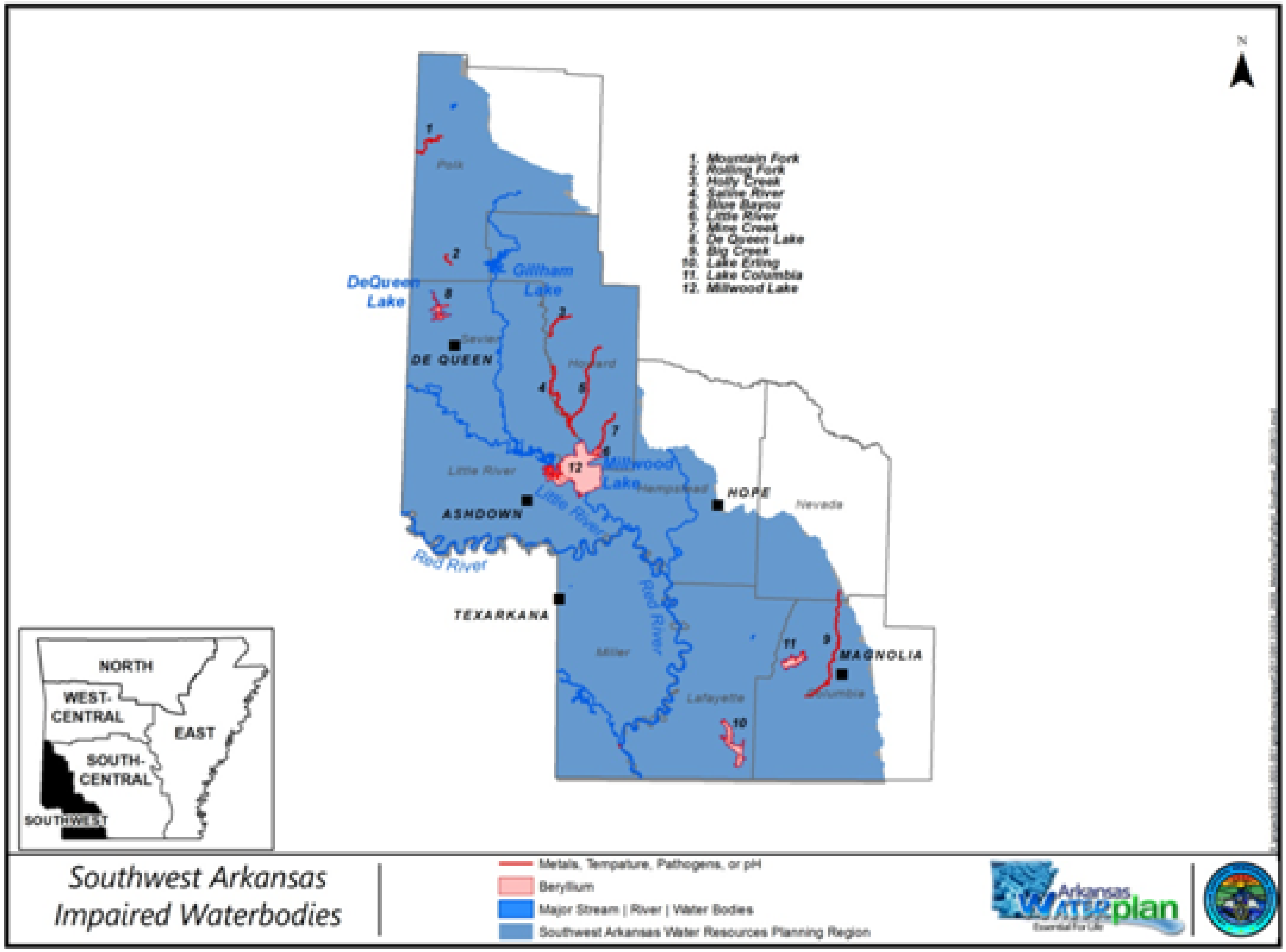

Figure 5.7. Waterbodies in the SAWRPR classified as impaired due to pathogens, temperature, metals, or pH in the 2008 303(d) list (ADEQ 2008,2009).

It should be noted that while a waterbody may be impaired due to sediment, there is no numeric water quality standard for sediment/siltation. Arkansas has a numeric water quality standard for turbidity but not total suspended solids (TSS); thus turbidity is the chemical parameter that is assessed to determine if sediment impairment exists. There is currently no other method that is consistently used by EPA or ADEQ to measure sediment or siltation in water.

In cases where exceedances of water quality criteria are preventing the attainment of a designated use, a TMDL must be developed. A TMDL is the maximum amount of a pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant, resulting in the waterbody being listed as impaired. A TMDL allows for the allocation of pollutant loads between point sources and nonpoint sources discharging to the waterbody, as well as a margin of safety.

TMDL reports have been prepared for a number of waterbodies in the SAWRPR addressing sediment/turbidity, minerals, metals, nutrients, and low dissolved oxygen (Table 5.2). A watershed restoration strategy has been developed for the Lower Little River and Upper Mountain Fork watersheds in Arkansas and Oklahoma to address water quality impairments that have been identified in these watersheds, and protect the good overall water quality of the region (Lower Little River Watershed Coalition 2004).

Table 5.2. TMDLs for waterbodies in SAWRPR (ADEQ 2012b).

Waterbody	Impaired Uses	Pollutants	Tmdl Status
Dorcheat Bayou	Agriculture & Industrial Water Supply	Sulfate	Final 2012
	Fish Consumption	Mercury	Final 2002
	Aquatic Life	Lead, pH	Final 2012
Days Creek	Drinking Water	Nitrate	Final 2005
Columbia Lake	Fish Consumption	Mercury	Final 2002
First Old River Lake	Aquatic Life	Nutrients	
Beech Creek	Not Reported	DO, Lead, Turbidity	Final 2012
Bodcau Creek	Aquatic Life	Copper, Lead, pH, Turbidity	Final 2012
Little Bodcau Creek	Not Reported	Lead	Final 2012
Big Creek	Aquatic Life	Lead, pH	Final 2012

Table 5.2. TMDLs for waterbodies in SAWRPR (continued).

Waterbody	Impaired Uses	Pollutants	Tmdl Status
Big Creek	Not Reported	Chloride, Sulfate, TDS	Final 2012
Horsehead Creek	Not Reported	Lead, pH	Final 2012
Holly Creek	Primary Contact Recreation	Pathogens	Final 2008
Mine Creek	Primary Contact Recreation	Pathogens	Final 2008
Red River	Agriculture & Industrial Water Supply	Chloride, Sulfate, TDS	Final 2012
	Aquatic Life	Siltation/Turbidity	Final 2012
Mckinney Bayou	Agriculture & Industrial Water Supply	Chloride, Sulfate, TDS	Final 2012
Sulphur River	Not Reported	Sulfate, TDS	Final 2012
	Aquatic Life	Temperature, Siltation/Turbidity	Final 2012
Rolling Fork	Aquatic Life	Nitrate, Total Phosphorus, Copper	Final 2005

5.4.3 Nutrient Surplus Area

Controversy over phosphorus concentrations in streams that cross the Arkansas-Oklahoma border, primarily the Illinois River, prompted actions in Arkansas to reduce nutrients in these streams. One of these actions was the declaration of eight watersheds in Arkansas as Nutrient Surplus Areas. One of these watersheds. Mountain Fork of the Little River, is in the SAWRPR (Figure 5.6). This designation requires that nutrient management practices be used in these areas to help to reduce nitrogen and phosphorus levels in the surface and ground water. Nutrient management training and planning is also required.

This watershed is designated as a Nutrient Surplus Area because the State of Oklahoma has designated the Mountain Fork downstream of the Arkansas border as a scenic river, and set phosphorus limits for scenic rivers at 0.037 mg/L (Oklahoma Statute § 82-1451 et seq., Oklahoma Water Resources Board 2013). The U.S. Supreme Court has ruled that a downstream state’s water quality requirements must be met at the state line.

5.4.4 Non-attainment of Drinking Water Quality Standards and Water Quality Guidelines by Groundwater

No groundwater quality standards have been set by state agencies in Arkansas; although there are state regulations to protect groundwater quality (see Section 6). However, groundwater used as a drinking water source is required to meet state and federal drinking water quality standards. Other groundwater users, such as farmers and industries, have developed guidelines that they use to determine if groundwater quality is suitable for their uses. Where shallower aquifers have been heavily pumped, saltwater intrusion has locally contaminated groundwater.

5.4.4.1 Red River Alluvial Aquifer

Water-quality issues in groundwater from the Red River alluvial aquifer have restricted domestic and industrial use of the Red River alluvial aquifer. In Miller County, the groundwater in the Red River alluvial aquifer has naturally high salinity, which restricts its usefulness.

Four wells completed in the Red River alluvial aquifer in western Little River County had nitrate concentrations greater than 10 mg/L, exceeding the drinking water MCL for nitrate (Kresse et al. 2013). These results are likely from shallow wells, which are more vulnerable to surface sources of nitrate (for example, septic systems).

5.4.4.2 Ozan Aquifer

The Ozan aquifer, as previously discussed, represents some of the least used and poorer quality water of any aquifer in the State. High chloride concentrations can occur in groundwater within the outcrop area of the Ozan aquifer, which is atypical of most Cretaceous and Tertiary aquifers of the West Gulf Coastal Plain.

5.4.4.3 Other West Gulf Coastal Plain Aquifers

Except for the Sparta aquifer, which contains high-quality water throughout its extent in the planning region, the remaining West Gulf Coastal Plain aquifers within the planning region contain groundwater that is typically of high quality in the outcrop areas but exhibit water quality changes along the flow path. Most wells in the planning region are completed in the outcrop areas because higher salinity occurs downdip from the outcrop area (Kresse et al. 2013). Sharp increases in the salinity of the Nacatoch and Tokio aquifers occur in Little River and Miller

Counties and Sevier County, respectively, limiting use at distances greater than approximately 5 to 20 miles downdip of the outcrop area. In the outcrop areas sulfate and/or chloride concentrations in these aquifers can exceed the Federal secondary drinking water standard of 250 mg/L (Kresse et al. 2013). Additionally, iron concentrations may be elevated in the outcrop areas and would require treatment for some uses.

5.4.4.4 Ouachita Mountains Aquifer

Groundwater in the Ouachita Mountains aquifer is primarily suitable for most domestic and farm uses; however, groundwater from some wells exhibits high hardness values and contains concentrations of iron, manganese, and chloride, in excess of concentrations recommended for some uses. The most common complaint by water users in regard to the groundwater for domestic use is that the groundwater can be hard and high in iron content (Albin 1965, Halberg et al. 1968, Cole and Morris 1986, Kresse and Hays 2009).

5.4.5 Fish Consumption Advisories

There are active fish consumption advisories due to mercury and polychlorinated biphenyls (PCBs) for several waterbodies in the SAWRPR. Details of these advisories are given in Table 5.3. The locations of these water bodies are shown on Figure 5.8.

Table 5.3. Fish consumption advisories in SAWRPR (ADH, AGFC, ADEQ 2011; ADEQ 2008).

Waterbody	**Affected extent**	**Pollutant of concern**	**Restrictions for high risk groups[1]**	**Restrictions for general public**
Tributary of big creek	2 miles	PCB	Closed to fishing	Closed to fishing
Columbia lake	Entire lake (2,950 acres)	Mercury	Should not eat pickerel, flathead catfish, gar, bowfin, or largemouth bass 16 inches or longer.	Should not eat pickerel, flathead catfish, gar, or bowfin. No more than 2 meals/month of largemouth bass 16 inches or longer.
Dorcheat bayou	50.6 miles	Mercury	Should not eat fish.	Should not eat largemouth bass 16 inches or longer. No more than 2 meals/month of any predator species.

[1] pregnant or breastfeeding women, women who plan to become pregnant, and children under 7 years of age.

5.4.6 Nonpoint Source Pollution

Nonpoint source pollution was identified as a water resources issue in the 1990 AWP (ASWCC 1990). Nonpoint source pollution still contributes significantly to surface water and groundwater quality issues in Arkansas; it is the most frequently cited source of pollutants causing non-attainment of surface water quality standards (ADEQ 2012a). Potential sources of nonpoint pollution in the SAWRPR include agriculture, silviculture, resource extraction, construction and maintenance of unpaved roads, and urban runoff (ANRC 2011b).

There are no hazardous waste remedial action sites in the SAWRPR that have been included on the National Priority List, i.e., Superfund sites. There is one site in the planning region that was identified as a state priority for hazardous waste cleanup due to contamination of surface water. Runoff from exposed piles of smelting waste at the abandoned Red River Aluminum facility near Stamps, Arkansas in Lafayette County, was determined to be affecting water quality in Bodcau Creek. A fish kill in the creek during 1996 was caused by contamination from this site. The primary contaminant of concern was chloride. The site was added to the state priority list in 2001. Final remediation consisted of disposing of the smelting waste in an onsite landfill. The remediation was completed in early 2013 (ADEQ 2013g).

5.4.7 Contaminants of Emerging Concern

There is growing interest, nationally and in Arkansas, in the occurrence of a group of chemicals called contaminants of emerging concern, which include pharmaceuticals, personal care products (e.g., soap and shampoo), natural and synthetic hormones, surfactants, pesticides, fire retardants, and plasticizers primarily in surface waters, but also starting to be measured in groundwater across the nation. The risks to human health and the environment from the majority of these chemicals are unknown, which is why they are referred to as “contaminants of emerging concern.” Contaminants of emerging concern have been detected in surface waters in Arkansas (Galloway et al. 2005). Detection, however, does not indicate there is an effect.

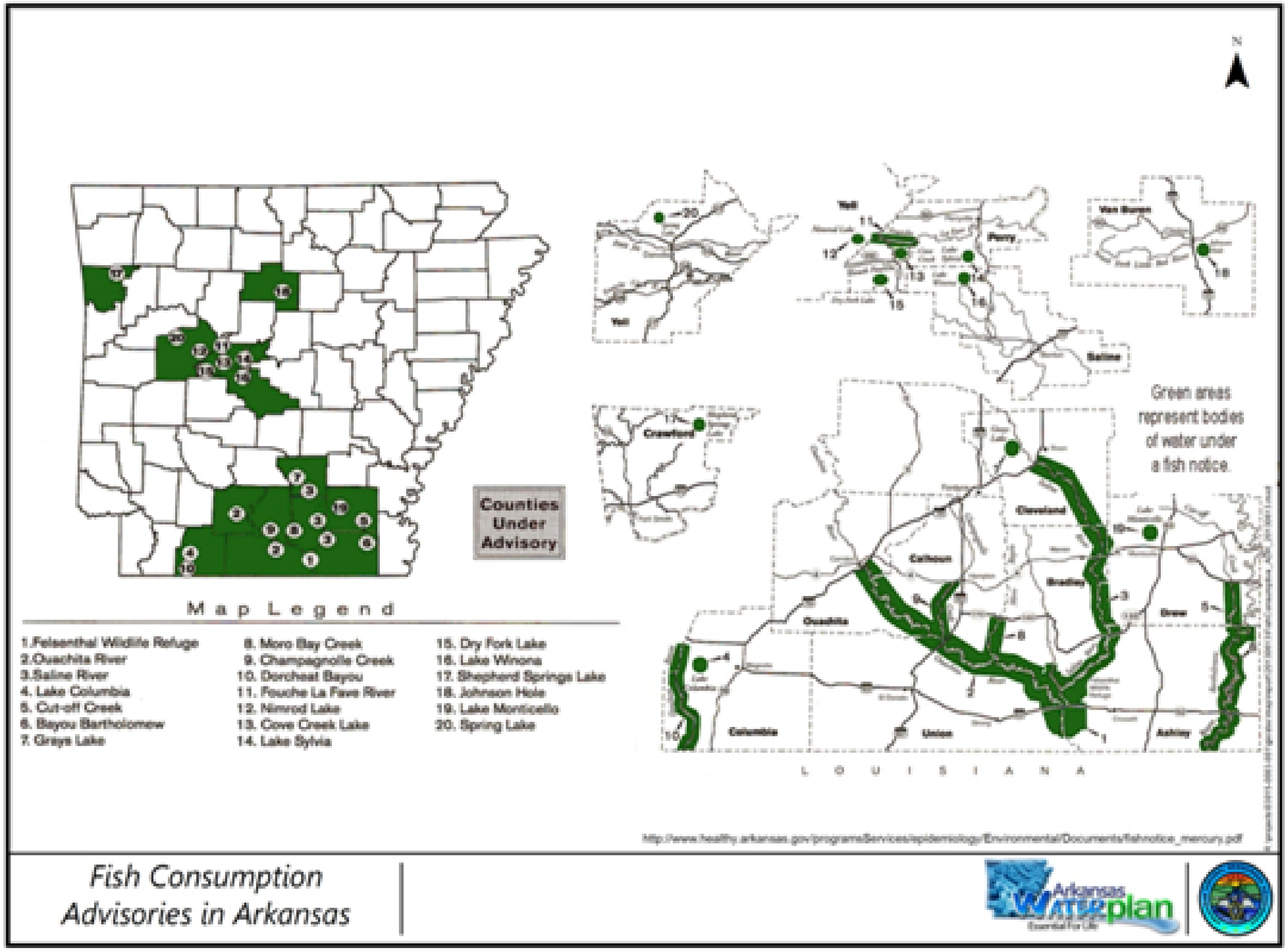

Figure 5.8. Locations of active fish consumption advisories in the SAWRPR (ADH, AGFC, ADEQ 2011).

5.5 Water Infrastructure

Communities throughout the state struggle to maintain drinking water and wastewater infrastructure, including treatment plants and distribution lines. A few communities in the SAWRPR are experiencing growth that is requiring expansion of water supply and wastewater capacity (see Section 4.1). In other areas within the planning region, maintaining aging infrastructure with limited financial resources is more likely an issue.

Another concern is the recent increased focus on nutrients in wastewater discharges. Historically, permitted point source discharges in Arkansas were not limited with regard to the amount of nutrients that can be in the wastewater they discharge. Current regulations require that all point source discharges in watersheds of waterbodies included on the Arkansas list of impaired waters due to phosphorus, be limited in the amount of phosphorus that can be present in their discharge. Point source discharges in Nutrient Surplus Areas can also be subject to phosphorus limitations under this regulation (Arkansas Regulations 2.509). There are several municipalities in the planning region have wastewater treatment plants that are currently required to monitor total phosphorus and nitrate levels in their wastewater discharge (ADEQ 2013c). Expensive upgrades to existing wastewater facilities may be required to meet discharge nutrient limits.

5.6 Loss of Aquatic Biodiversity

In a 2002 report, NatureServe ranked Arkansas 13th in the nation for the level of reportedly extinct species (NatureServe 2002). In 2005, 369 animal species of greatest conservation need were identified for Arkansas by a team of specialists (Anderson 2006). These species of greatest conservation need include over 60 species associated with aquatic and semi-aquatic habitats that occur in the SAWRPR (see Figure 3.4). Figures 5.9 through 5.12 show the numbers of aquatic species of greatest conservation need present in watersheds within the SAWRPR. The highest numbers of species of greatest conservation need are present in the Little River and its tributaries (Figure 5.12). The greater the number of aquatic species of greatest conservation need present in a watershed, the more important it is to protect and restore water resources and their aquatic habitats in the watershed. The condition of aquatic habitats depends on characteristics such as water levels, flow volumes, and seasonal variability in both.

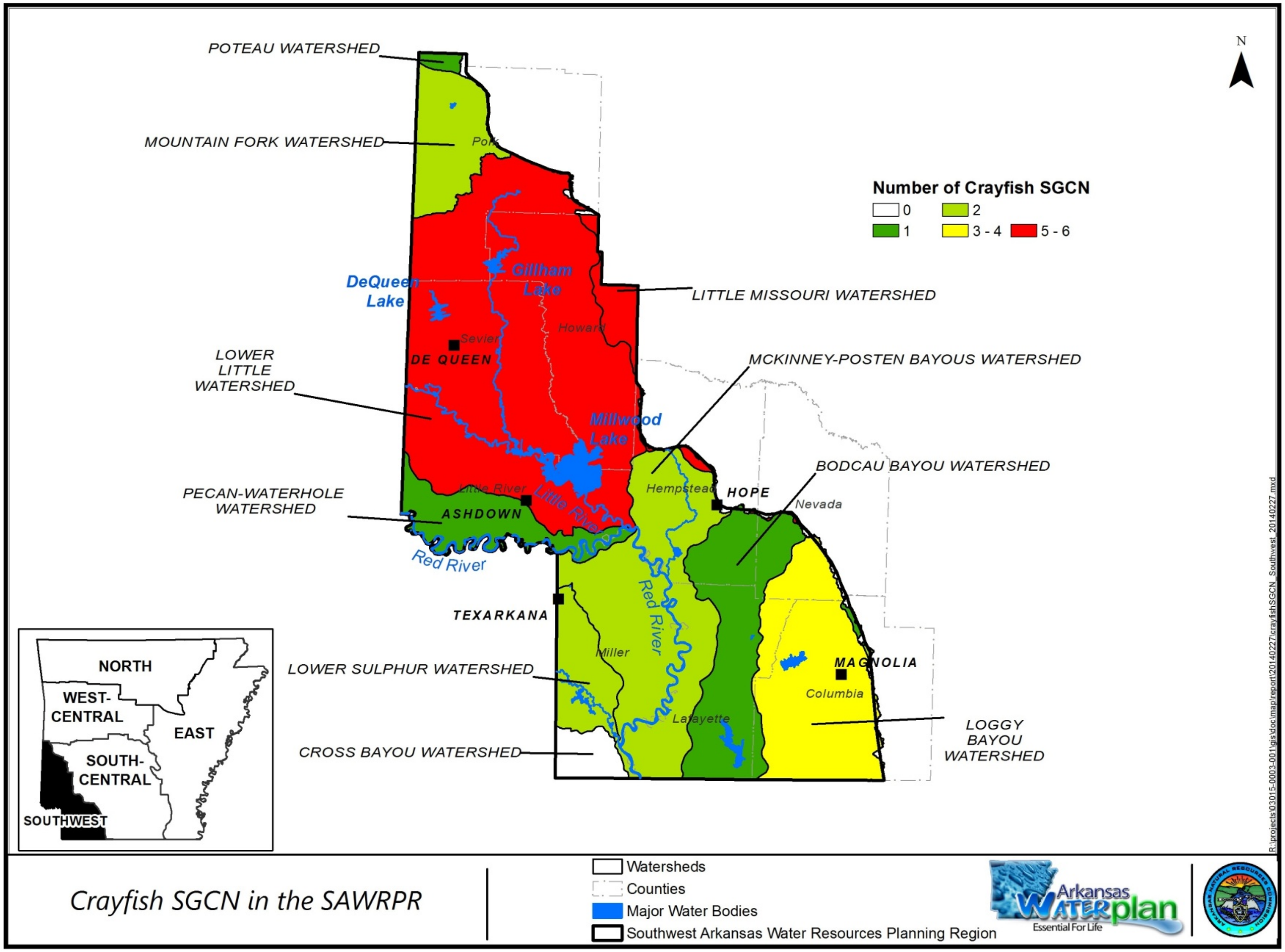

Figure 5.9. Numbers of crayfish Species of Greatest Conservation Need (SGCN) in watersheds of the SAWRPR.

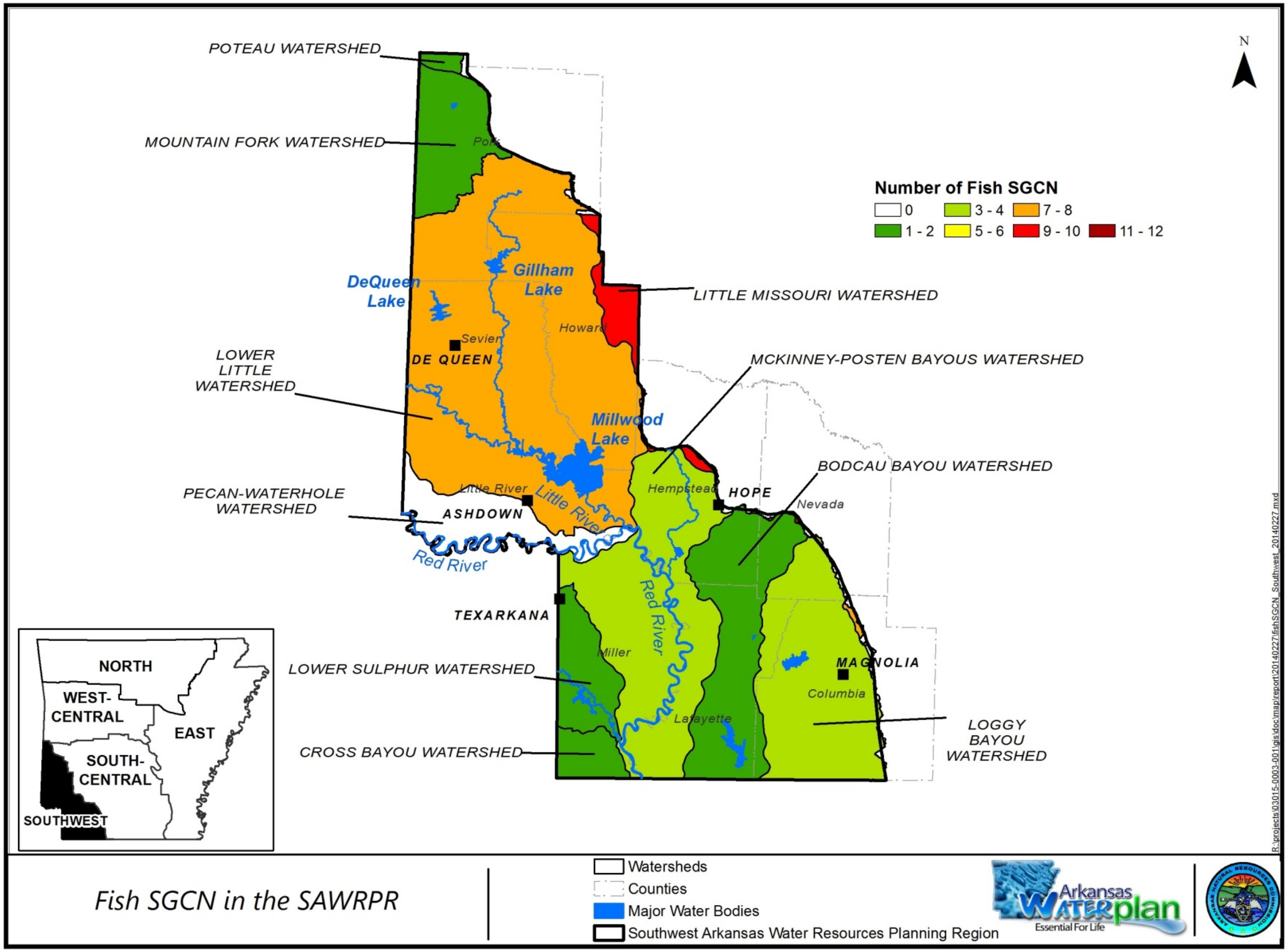

Figure 5.10 Numbers of fish SGCN in watersheds of the SAWRPR.

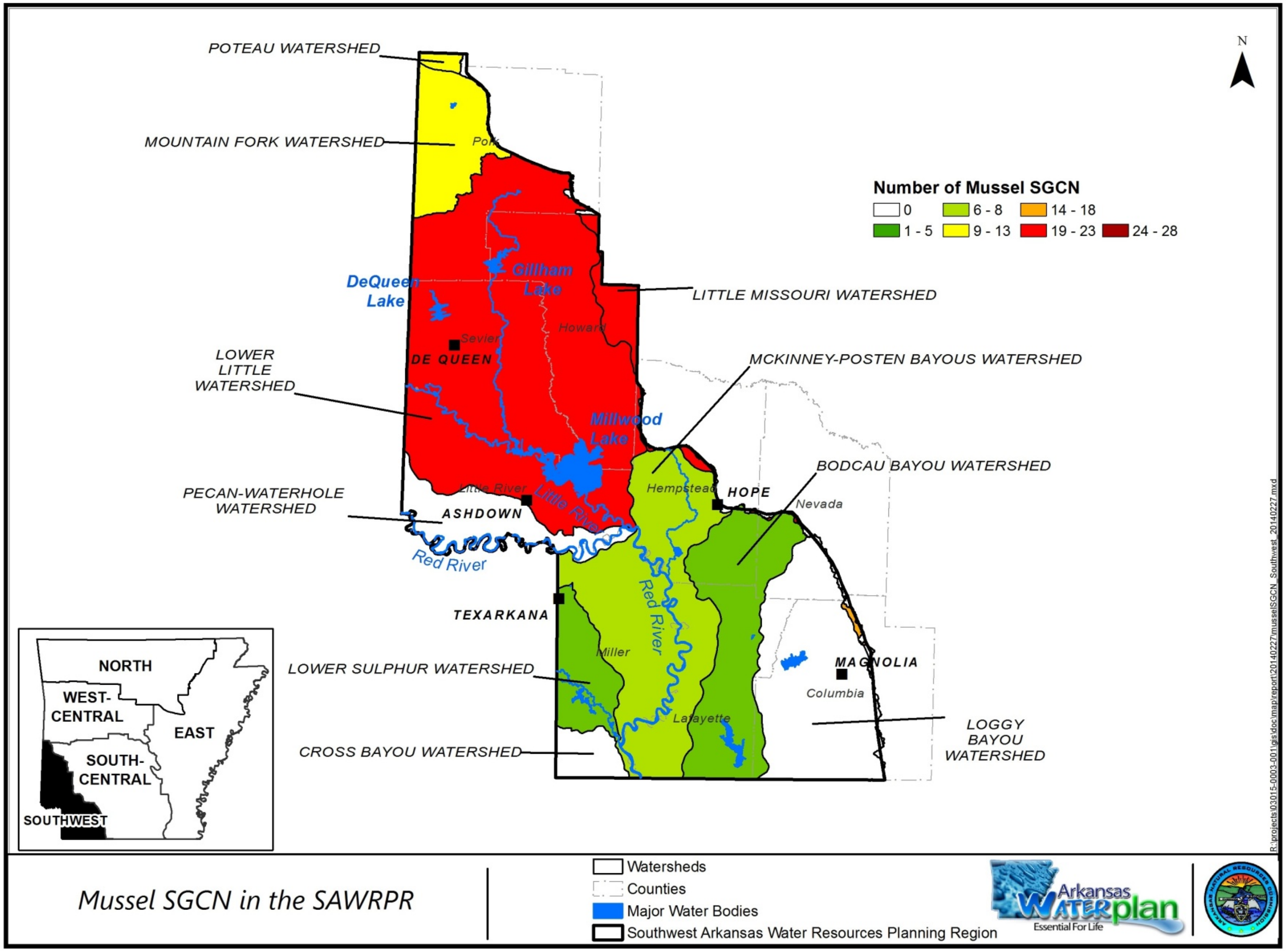

Figure 5.11. Numbers of mussel SGCN in the watersheds of the SAWRPR.

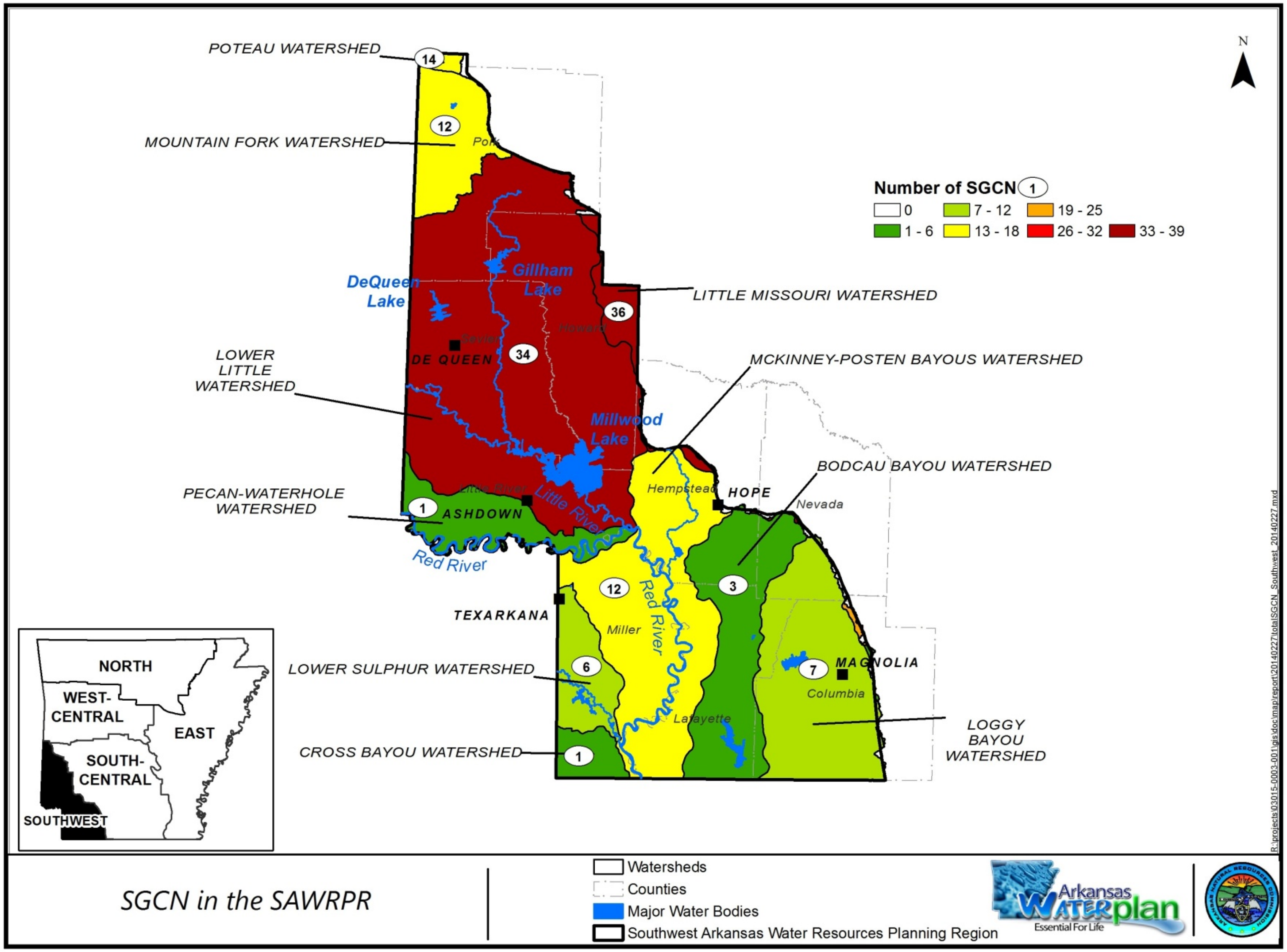

Figure 5.12. Total numbers of crayfish, fish, and mussel SGCN in the watersheds of the SAWRPR.

Seven aquatic and semi-aquatic species present in the planning region are on the federal list of threatened and endangered species (Table 5.4).

Table 5.4. Federally designated threatened and endangered species occurring in aquatic and semi-aquatic habitats in SAWRPR (ANHC 2013).

Common Name	Family	Species Name	Status	SAWRPR Habitat
Scaleshell	Mussel	Leptodea Leptodon	Endangered	Riffles Of Medium To Large Rivers
Ouachita Rock Pocketbook	Mussel	Arkansia Wheeleri	Endangered	Pools, Backwaters, And Side Channels Of Rivers And Large Creeks In The Ouachita Mountains
Leopard Darter	Fish	Percina Pantherina	Threatened	Clear, Small To Medium Upland Rivers With Gravel To Boulder Substrates In Pools
Pink Mucket	Mussel	Lampsilis Satura	Endangered	Large, Fast Rivers With Rocky Or Boulder Substrates
Arkansas Fatmucket	Mussel	Lampsilis Powellii	Threatened	Deep Pools With Sandy Substrates In Small To Medium Rivers
Interior Least Tern	Bird	Sterna Antillarum Athalassos	Endangered	Mud Flats, Ponds, Lakes
Harperella	Plant	Ptilimnium Modosum	Endangered	Rocky Substrates In Shallow Areas Of Clear, Fast Streams

In addition to the animals of greatest conservation need, the Arkansas Natural Heritage Commission has identified 61 species of rare aquatic and semi-aquatic plants that occur in the SAWRPR. Five semi-aquatic plant species present in the planning region are on the state threatened and endangered plant species list (Table 5.5). There is one semi-aquatic plant species present in the planning region that is designated as endangered by the federal government (Table 5.4). These plant species of concern are affected by water quality, water levels, flow rates, and/or changes in seasonal patterns of water levels or flow.

Table 5.5. State designated threatened and endangered plant species occurring in semi-aquatic habitats in the SAWRPR.

Common Name	Species Name	Status
Southern Tubercled Orchid	Platanthera Flava	Threatened
White-Top Sedge	Rhynchospora Colorata	Endangered
Panicled Indigo Bush	Amorpha Paniculata	Threatened
Red Bay	Persea Borbonia	Endangered
Few-Flower Beaksedge	Rhyncospora Rariflora	Threatened

In some cases, the presence of non-native aquatic species is believed to affect aquatic biodiversity. There are 17 non-native aquatic animal species known to occur in the SAWRPR (Table 5.6). Several of the non-native fish species present in the region are sportfish species that have been introduced purposely and are regularly stocked. The impact of many of the non-native species on native species is unknown. Some species, such as carp, are suspected to affect native species as a result of modifying aquatic habitats, e.g., removing vegetative cover and increasing turbidity. Other species, such as non-native sportfish and Asian clams, are suspected to affect native species by competing with them for food and/or habitat (USGS 2013c). There are also four species of non-native invasive aquatic plants known to occur in the planning region (Table 5.7).

Table 5.7. Non-native aquatic plant species present in the SAWRPR (University of Georgia Center for Invasive Species and Ecosystem Health 2013).

Species Common Name	Species Scientific Name	Origin	Counties	Dates Identified	Method Of Introduction	Impact
Alligator Weed	*Alternanthera philoxeroides*	South America	Little River	2010	Accidental	Habitat Modification
Hydrilla	*Hydrilla verticillata*	Asia	Howard, Little River, Sevier	2005	Accidental	Competition With Natives
Parrotfeather	*Myriophyllum aquaticum*	South America	Nevada, Polk	1988	Introduced	Competition With Natives
Watercress	*Nasturtium officinale*		Polk	1988		

Table 5.6. Exotic aquatic animal species present in the SAWRPR (USGS 2013).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of Introduction	Impact
Freshwater jellyfish	*Craspedacusta sowerbyi*	China	Tributary of High Creek, Hempstead County	2003	Accidental	Unknown
Grass Carp	*Ctenopharyngodon idella*	Asia	Millwood Lake Boggy Creek Bois d'Arc Creek Saline River Lake Erling Tributary to McKinney Bayou	1988	Stocked	Predation, food competition, habitat modification
Common Carp	*Cyprinus carpio*	Asia	Little River Lake Earling Red River Bois d'Arc Creek Millwood Lake	1988	Stocked	Habitat modification
Fathead Minnow	Pimephales promelas	US	Lake Earling Sulphur River Bois d'Arc Creek Millwood Lake	1988	accidental	Unknown
Brown Bullhead	*Ameiurus nebulosus*	US	Sulphur River Bois d'Arc Creek Millwood Lake Pecan-waterhole drainage Powell Creek	1988	Stocked	Predation of native species
Asian Clam	*Corbicula fluminea*	Asia	Sulphur River Maniece Bayou McKinney Bayou Red River	1975	Accidental	Biofouling, competition, habitat alteration
			Mountain Fork	2010		
Nutria	*Myocastor coypus*	South America	Lafayette Miller Little River Sevier Howard Hempstead Columbia Counties		Imported and escaped	Overgrazing of wetlands
Waterflea	*Daphnia lumholtzi*	Africa Australia Asia	Lake Earling Millwood Lake Beard Lake	1995	Accidental	Competition

Table 5.6. Exotic aquatic animal species present in the SAWRPR (continued).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of Introduction	Impact
Goldfish	*Carassius auratus*	Asia	Lake Earling	1988	Accidental	Competition, habitat modification
White Catfish	*Ameiurus catus*	US (East Coast)	Lake Earling	1988	Stocking	unknown
Inland Silverside	*Menidia beryllina*	US (East and Gulf Coasts, Red River)	Millwood Lake	1987	Stocked	Competition
Rock Bass	*Ambloplites rupestris*	US (eastern Mississippi River drainage)	Cossatot River Mountain Fork	1997	Stocked	Competition
Northern Pike	*Esox lucius*	US (North)	Millwood Lake	1988	Stocked	Predation of natives
Blue Catfish	*Ictalurus furcatus*	US (Red River)	Lake Columbia Little River	1997	Stocked	None
			Dierks Reservoir Gillham Reservoir Sugar Creek	1988		
Sunshine Bass	*Morone chrysops x M saxatilis*	None (hybrid)	DeQueen Lake	1992	Stocked	Hybridizing with natives
Striped Bass	*Morone saxatilis*	US (East and Gulf coasts)	Red River	1988	Stocked	Predation of natives
			Millwood Lake	1973		
			Little River	1997		
Saugeye	*Sander canadensis x vitreus*	None (hybrid)	Gillham Reservoir	1992	Stocked	Hybridization with native walleye

6.0 INSTITUTIONAL AND REGULATORY SETTING

This section provides a description of the regulatory and institutional framework for water resources management in SAWRPR. It includes general descriptions of federal and state laws, regulations, and programs that deal with water resources management in the region, as well as a listing of federal, state, and local governmental and nonprofit institutions that are involved in water resources management in the region. In addition, the interrelationships between regulations and institutions at the federal, state, and local levels in the SAWRPR are illustrated.

6.1 Legal Framework

The legal framework for management and use of water resources in Arkansas is based on court case law, laws enacted by the Arkansas General Assembly, and rules and regulations enacted by state agencies. Federal laws and regulations also influence the regulation of water resources in the state (ANRC 2011a). The discussion below identifies and summarizes the laws and regulations and associated programs that guide water management in SAWRPR, and summarizes changes that have occurred in this legal framework since the 1990 AWP update.

6.1.1 Federal Laws and Regulatory Programs

Federal policy recognizes that states have primary authority for regulation of water usage within their borders. Therefore, the federal laws, regulations, and associated programs that influence water resources management in the SAWRPR primarily relate to water quality. Federal legislation and programs also deal with other aspects of management of water resources in the region such as conservation and protection of waterbodies, flood control, and navigation.

6.1.1.1 Water Quality

The current federal laws and programs that guide management of water quality in the SAWRPR are summarized in Table 6.1. The Clean Water Act (CWA) of 1972 (most recently amended in 2002) and the SDWA of 1974 (most recently amended in 1996) are two important pieces of federal water quality legislation that authorize a number of federal water quality

Table 6.1. Federal laws and regulatory programs that address SAWRPR water quality.

Federal Law	Federal Water Quality Regulatory Programs	Responsible Federal Agency
Clean Water Act	Ambient nutrient water quality standards	EPA
	Biosolids regulations	
	Impaired waters	
	Nonpoint source pollution management	
	NPDES point source permitting	
	NPDES stormwater permitting	
	NPDES pesticide application permitting	
	NPDES confined animal feeding operations permitting	
	State ambient water quality standards	
	State biennial water quality assessment	
	Total maximum daily loads (TMDL)	
	Dredge and fill permitting	USACE
Safe Drinking Water Act	Source water protection	EPA
	Underground injection wells	
Underground storage tank regulations	Underground storage tank program	EPA
Resource Conservation and Recovery Act	Hazardous waste management	EPA
	Solid waste management	
	Subtitle D	
Comprehensive Environmental Response, Compensation, and Liability Act	Hazardous waste site clean up	EPA
Federal Insecticide, Fungicide, and Rodenticide Act	Endangered species protection program	EPA
	Labeling requirements	
	Registration	
Surface Mining Control and Reclamation Act	Mine reclamation	US Department of the Interior (USDI)
	Surface mining control	
Toxic Substances Control Act	PCB Program	EPA
Soil and Water Resources Conservation Act	Conservation Effects Assessment Program	USDA
Arkansas Wilderness Act	National forests	USFS
National Forest Management Act		
Weeks Act		
Oil Pollution Act	Oil spill response planning	EPA
Pollution Prevention Act	Pollution prevention planning	EPA
National Environmental Policy Act	Environmental impact analysis of Federal projects, with mitigation	EPA, Council on Environmental Quality

Note: Highlighted laws and programs were promulgated after the 1990 AWP update.

programs. Legislation related to forest conservation, such as the Cooperative Forestry Assistance Act, is included here because forests can protect and improve water quality. The EPA is responsible for administering the majority of these laws and programs; however, EPA has delegated some of this authority to state agencies such as ADEQ and the Arkansas Department of Health.

The CWA of 1972 established the NPDES program that regulates point source discharges through a permit program. The NPDES program is managed by EPA, but ADEQ has been delegated authority to issue NPDES permits. NPDES permits are based on a combination of technology-based and water quality based standards. Technology-based standards are developed by EPA for certain categories based on the performance of pollution control technologies available to the industry without regard for the receiving water body. Water quality based standards are developed after consideration of the designated uses of the receiving water body and the water quality criteria necessary to protect those uses. In 1987, Congress amended the CWA to include nonpoint sources of pollution such as stormwater runoff from industries, construction sites, and municipalities. NPDES permits for the SAWRPR are summarized in Section 4. The 1987 amendments also addressed management of biosolids (sewage sludge). The CWA also requires permits for dredge and fill activities in wetlands, lakes, streams, rivers, and other waters of the US. These permits are issued by the USACE.

The TMDL program was established by the CWA in 1972; however, TMDLs were rarely developed for waterbodies until the 1990s, after environmental groups began suing the EPA over the lack of TMDLs being performed (EPA 2008). The CWA requires that a TMDL study be conducted for waterbodies identified as having impaired water quality. The TMDL study is conducted to determine the maximum amount of a pollutant that a waterbody can receive and still meet ambient water quality standards. This maximum load is split between point sources and nonpoint sources. These loads are then compared to the estimated existing point source and nonpoint source loads to determine the amount of reduction required for the waterbody to meet its water quality standards. The first TMDLs for waterbodies in the SAWRPR were completed in 2001. Prior to this, beginning in the 1980s, ADEQ routinely performed Wasteload Allocation Studies as part of the NPDES permitting process to determine the amount of a pollutant that could be discharged to a waterbody. Since 2001, 20 TMDLs have been completed for waterbodies in the SAWRPR (see Section 5).

In 1998, EPA initiated a program to develop ambient water quality criteria for nutrients, i.e., nitrogen and phosphorus. At the time, nutrients were identified as a leading cause of water quality issues across the nation, including such high profile events as the hypoxic zone in the Gulf of Mexico and algal blooms along the national seacoast. In 2001, EPA published recommended criteria development plans (EPA 2013b).

The drinking water source water protection program was initiated as a result of the 1996 amendment to the SWDA. The purpose of this program is to prevent the need for increased treatment of drinking water (resulting in increased treatment costs and costs to customers) due to water quality degradation, by protecting the quality of the drinking water source. In the majority of cases, the cost of protecting drinking water sources from pollution is far lower than the cost of upgrading water treatment to remove increased pollution. There are approximately 75 public water utilities in the SAWRPR that are subject to SDWA regulations (ADH n.d.).

Subtitle D of the 1991 amendment of the Resource Conservation and Recovery Act (RCRA) introduced specifications for how landfills were to be constructed and managed to protect water quality. This led to sweeping changes in solid waste management across the country and in Arkansas (ADEQ 2011).

6.1.1.2 Water Resources Management

The federal regulations and programs that address non-water quality aspects of water resources management in the SAWRPR are summarized in Table 6.2. These include regulations and programs that address flood control, river navigation, wetlands tracking, or water-based recreation. Programs related to drinking water infrastructure are also included in Table 6.2 and discussed below. Some of the legislation and programs that address water quality also address other aspects of water resources management. For example, preservation of forest lands protects water quality and hydrology. As a result, there is some duplication in Tables 6.1 and 6.2. Federally appropriated water is not available for other uses. Federal water appropriations preempt other beneficial water uses, such as irrigation.

Table 6.2. Federal laws and regulatory programs that address aspects of SAWRPR water resources other than water quality.

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Clean Water Act	Wetland and stream mitigation	USACE	Physical protection of waterbodies, including wetlands
Safe Drinking Water Act	Consumer confidence reports	EPA	Protects/improves public water supply
	Finished water criteria	EPA	Protects human health
	Operator certification	EPA	Informs the public
Endangered Species Act	Freshwater species protection	USFWS	Mechanism for physical protection of waterbodies that are habitats for endangered species
	Waterfowl protection		
Soil and Water Resources Conservation Act	Census of Agriculture	USDA	Irrigation and agriculture
	Conservation Effects Assessment Program	USDA	Water resources protection/improvement
	Natural Resources Inventory	USDA	Characterize water resources
National Environmental Policy Act	Environmental Impact Statements and Mitigation	EPA, Council on Environmental Quality	Water resources protection/mitigation
Flood Control Act/Water Resources Development Act	Dam safety	USACE	Water storage, water supply, flood reduction, flow management, restoration of physical aquatic habitat
	Flood control reservoirs		
	Levees		
	Navigation systems		
Arkansas Wilderness Act	National forests	USFS	Well managed forestlands improve and protect water resources
National Forest Management Act			
Weeks Act			
Rivers and Harbors Act	Navigation	USACE	Federal navigation systems in Arkansas
	Section 10	USACE	Protects waterbodies, including wetlands
Migratory Bird Hunting and Conservation Stamp Act	Small wetland acquisition program	USFWS	Protects wetlands
Emergency Wetlands Resources Act	National Wetlands Inventory	USFWS	Track wetland resources
Dam Safety and Security Act	National Dam Safety Program	Federal Emergency Management Agency (FEMA)	Protection of lives and property

Table 6.2. Federal laws and regulatory programs that address aspects of SAWRPR water resources other than water quality (continued).

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Wild and Scenic Rivers Act	National Wild and Scenic Rivers	USFS	Preservation of water resources for recreation
Land and Water Conservation Fund Act	Funding for purchase of public lands	USDI	Preservation of water resources for recreation
National Flood Insurance Act	Floodplain insurance program Floodplain mapping program	FEMA	Flood recovery, flood reduction
National Parks Acts	National Parks	USDI National Park Service	Protection of water resources associated with national parks
Migratory Bird Conservation Act	Acquisition of lands for wildlife refuges	Migratory Bird Conservation Commission	Preservation of water resources for bird habitat
National Wildlife Refuge System Improvement Act	National Wildlife Refuges	USFWS	Preservation of water resources for habitat
National Flood Insurance Act	National Flood Insurance Program	FEMA	Insurance against flood losses
	Floodplain management	FEMA	Reduction of flood damage
	Flood hazard mapping	FEMA	Identification of flood hazard areas
None	Climate monitoring	NOAA	Tracking precipitation and evaporation – water availability
	Climate prediction	NOAA	Future water availability
	Drought status	NOAA	Enactment of water shortage specific management

Note: Highlighted programs were initiated after the 1990 AWP update.

An important federal program for mitigating impacts to wetlands and streams is part of the dredge and fill permitting program of the CWA (Section 404), overseen by the USACE. This mitigation program was initiated in 1990, when the EPA and the USACE signed a memorandum of agreement establishing a process for determining the need for mitigation of impacts to wetlands, streams, and other water resources under the CWA Dredge and Fill Permitting program. This program provides a means for dredge and fill permit applicants to compensate for unavoidable destruction of aquatic habitat by either restoring or creating similar habitat either on site or at another location (EPA 2013c). There are 3 sites within the SAWRPR that have been permitted as mitigation banks for CWA dredge and fill permitting (Table 6.3). The program is a mechanism for implementing the federal policy of no-net-loss of wetlands (EPA 2013c). Revised regulations governing this mitigation program were issued in 2008. As of October 2013, there were 1,283 wetland mitigation credits and 49,914 stream mitigation credits available in public mitigation banks in the SAWRPR (Table 6.3).

Table 6.3. Mitigation banks within, and serving, the SAWRPR (USACE 2013).

Name of site	Location	Year Established	Area, acres	Primary service area	Secondary service area	Sponsor	Credits
Meniece Bayou Stream Mitigation Bank	Lafayette County	2010	657.16	Lafayette, Miller, Hempstead Counties	Little River, Nevada, Columbia, Pulaski, Saline, Ouachita, Cleveland, Grant, Lincoln, Howard, Hot Springs, Jefferson, Bradley, Union, Ashley, Drew, Pike, Sevier, Calhoun, Clark, Dallas Counties	Whitehead Forestry Service, Inc.	1,072.2 wetland
Menice Bayou Phase II Stream	Lafayette County	2011	42.16	HUC 11,140,201	(same as above)	Whitehead Forestry Service, Inc.	25,986.22 stream
Days Creek Mitigation Bank	Miller County	2013	302.42	Parts of Miller County and Caddo Parish west of Red River		ANRC	210.7 bottomland hardwood 23,927.8 stream

The 1996 amendments to the SDWA directed EPA and the states to develop requirements for certification of water treatment system operators (EPA 2012d). These amendments also initiated a program that required public water suppliers that operate community water systems to provide annual reports to drinking water utility customers on the quality of their drinking water (EPA 2013d).

The Endangered Species Act provides for protection and recovery of imperiled terrestrial, freshwater, and marine plant and animal species (except pest insects) (USFWS 2013). The SAWRPR contains aquatic and semi-aquatic habitat important for a number of endangered species (See Tables 5.4 and 5.5).

Portions of the Cossatot River and its tributary, Brushy Creek, are included in the National Wild and Scenic Rivers system. The purpose of this program is to preserve free-flowing rivers with outstanding natural, cultural, or recreational characteristics. The designated portion of the Cossatot River extends from the confluence of Mine Creek in Polk County to 4.6 miles downstream of the state highway 4 bridge. The designated portion of Brushy Creek extends from approximately 4 miles upstream of the National Forest boundary to its confluence with the Cossatot River. These designated stream reaches are managed by the US Forest Service, USACE, and State of Arkansas (ANHC 2012, Interagency Wild and Scenic Rivers Council n.d.).

Under the National Flood Insurance Act, flood hazard maps have been completed for the entire SAWRPR, and approximately half of the region's mapping has been, or is in the process of being, modernized, within the last 8 years. The Counties of Lafayette, Little River, Nevada, Polk, and Sevier are not yet modernized. Modernized flood hazard maps typically include updated Special Flood Hazard Areas (SFHAs), and are created in a digital countywide format. Figure 6.1 provides an illustration of the status of the flood hazard maps for the Southwest Region. For the communities participating in the National Flood Insurance Program (NFIP), the flood hazard maps identify the regulatory SFHA whereby the community floodplain administrator applies the locally adopted and enforced floodplain management ordinance. Participation in the NFIP is voluntary; however, non-participation results in Federal flood insurance not being available to residents and restricts post-disaster financial assistance. All of the counties included in the Southwest Region, with the exception of one (Little River County), are participating in the NFIP as well as a large percentage of the communities.

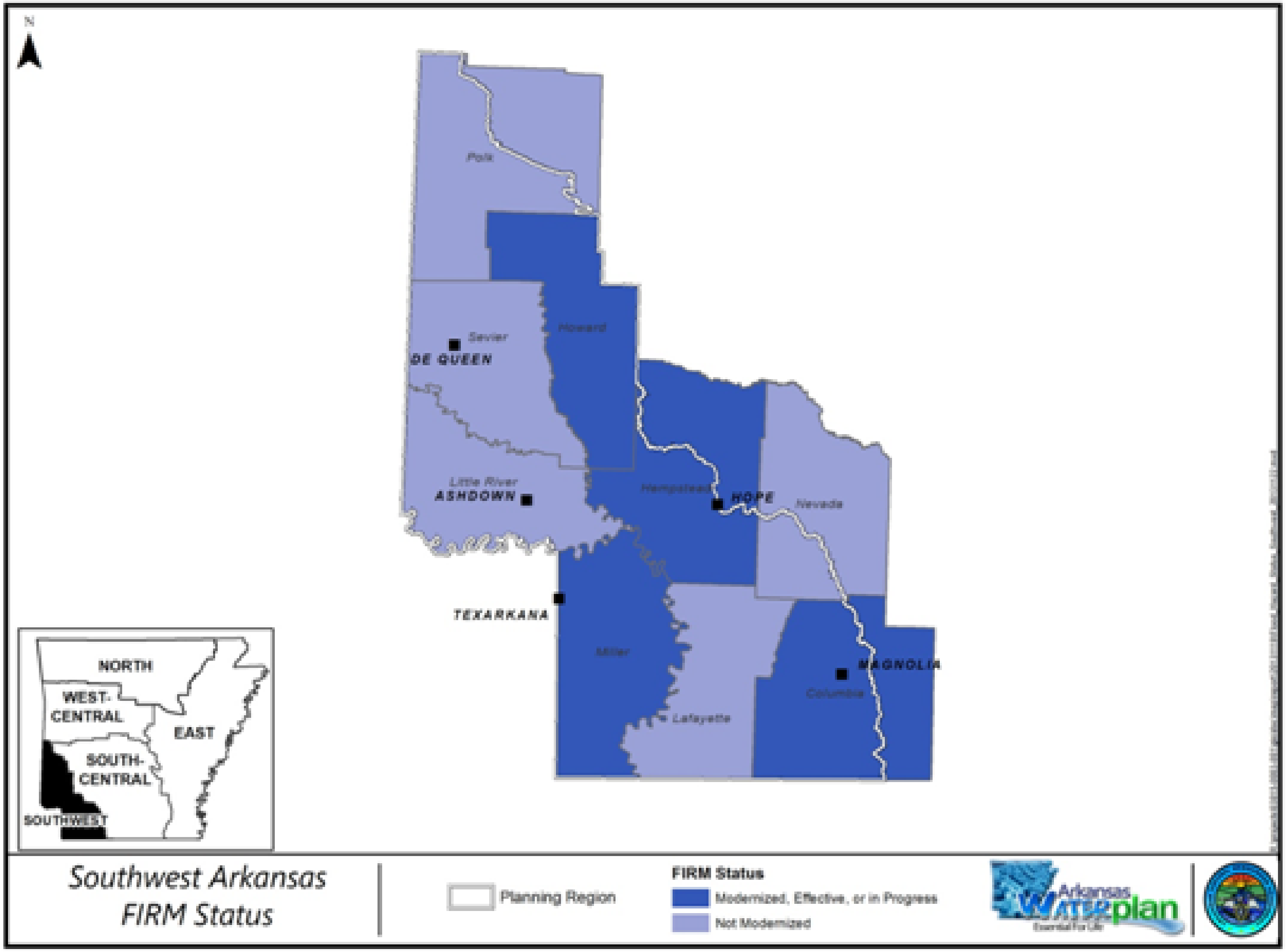

Figure 6.1. Status of flood hazard mapping in the SAWRPR.

Surface waters in the SAWRPR that are under some degree of federal management include the Rolling Fork (Dequeen Lake), Cossatot River (National Wild and Scenic River, Gilham Lake), Brushy Creek (National Wild and Scenic River), Saline River (Dierks Lake), and Little River (Millwood Lake). The reservoirs on these rivers are managed by the USACE. Portions of Brushy Creek and the Cossatot River that are designated as National Wild and Scenic River are managed by the USFS.

6.1.2 Federal Laws and Assistance Programs

Federal laws have also established a number of programs to provide technical and financial assistance for water resources management, that are available in the SAWRPR. Assistance programs for management of water quality and other aspects of water resources are discussed in the following sections.

6.1.2.1 Water Quality

Table 6.4 summarizes current federal assistance programs available in the SAWRPR and the associated federal laws. The majority of the federal assistance programs listed in Table 6.4 originated through the Farm Bill. The Farm Bill has been amended four times since 1990, most recently in 2013 (National Agricultural Law Center 2012). New conservation programs that are intended to assist farmers in protecting and restoring water quality have been added with each amendment (see Table 6.4). In 2012, over 16,800 acres in the counties of the SAWRPR were enrolled in Farm Bill programs that affect water quality, and over $2.5 million in funding provided to those counties by these Farm Bill programs (Table 6.5) (NRCS 2012).

Table 6.4. Federal laws and assistance programs that affect the SAWRPR water quality.

Federal Law	Federal Water Quality Funding Assistance Programs	Responsible Federal Agency
CWA	Clean water state revolving loan fund	EPA
	Nonpoint source pollution management grants	
	Water pollution control program grants	
Comprehensive Environmental Response, Compensation, and Liability Act	Hazardous waste site clean up	EPA
Cooperative Forestry Assistance Act	Forest Stewardship Program	USFS
	Forest Legacy Program	
	Urban and Community Forestry Program	
Housing and Community Development Act	Community Development Block Grants program	US Department Housing and Urban Development (HUD)
Farm Bill	Agricultural Water Enhancement Program	NRCS
	Conservation Reserve Program (CRP)	USDA Farm Services Agency
	Conservation Innovation Grants Program	NRCS
	Conservation Stewardship Program	
	Cooperative Conservation Partnership Initiative	
	Environmental Quality Incentives Program (EQIP)	
	Farm and Ranch Land Protection Program	
	Grassland Reserve Program	
	Grazing Lands Conservation Initiative	
	National Water Management Center	
	Organic Initiative	
	Wetlands Reserve Program	
	Wildlife Habitat Incentives Program (WHIP)	
American Recovery and Reinvestment Act	Clean Water State Revolving Fund, clean up of leaking underground storage tanks	Recovery Accountability and Transparency Board
Clean Vessel Act	Funding for pumpout stations and waste reception facilities for recreational boaters	USFWS
Consolidated Farm and Rural Development Act	Water and waste disposal systems for rural communities	USDA Rural Utilities Service
	Water and Waste Disposal Loans and Grants	
	Solid Waste Management Grants	
	Grant Program to Establish a Fund for Financing Water and Wastewater Projects	

Note: Highlighted laws and programs were promulgated after the 1990 AWP update.

6.5. NRCS conservation programs summary for 2012 (NRCS 2012).

County	CRP			EQIP			WHIP - drought		
	contracts	acres	$ obligated	contracts	acres	$ obligated	contracts	Acres	$ obligated
Columbia*	1	209.2	$671	12	901.8	$168,901	2	130	$21,076
Hempstead*	0	0	0	12	924.4	$222,331	0	0	0
Howard	0	0	0	26	1,530.4	$399,459	3	55	$22,785
Lafayette	3	2,688.3	$51,231	28	2,324.1	$467,489	0	0	0
Little River	0	0	0	7	25	$140,314	0	0	0
Miller	0	0	0	6	221.4	$79,657	0	0	0
Nevada*	0	0	0	4	204.4	$25,067	0	0	0
Polk*	0	0	0	38	5,374.2	$531,347	0	0	0
Sevier	0	0	0	24	2,255.9	$426,491	0	0	0
Totals		2,897.5	$51,902		13,761.6	$2,461,056		185	$43,861

* Part of this county is included in another planning region.

The CWA authorizes EPA to provide federal funding assistance to states and local entities through three funding programs. Through the Clean Water State Revolving Fund, federal funds are provided to ANRC to fund a low interest loan program for wastewater treatment, nonpoint source pollution control, and watershed management projects in the state. Grants for nonpoint source pollution control projects are authorized under Section 319 of the CWA. Finally, Section 106 of the CWA authorizes federal funding assistance to states and interstate agencies through grants for pollution control programs such as discharge permitting and water quality monitoring.

There are additional federal laws that authorize programs that provide assistance for community waste treatment and management to protect water quality. HUD grants for construction and upgrading of wastewater infrastructure were also authorized by the Housing and Community Development Act. Several programs to provide financial assistance for wastewater systems and solid waste programs in rural areas were authorized by the Consolidated Farm and Rural Development Act.

The American Recovery and Reinvestment Act was promulgated in 2009 to save and create jobs during the recession that began in 2008. This act initiated several programs that provide money to states for a range of activities, including improvements to wastewater treatment systems and clean up of leaking underground storage tanks and hazardous waste sites (EPA 2013e). Over $25 million of recovery money was awarded to the Arkansas State Clean Water Revolving Loan Fund, and $1.6 million was awarded to the ADEQ Leaking Underground Storage Tank Program. Recovery money was awarded to two leaking underground storage tank remediation projects in the planning region (EPA n.d.).

The Clean Vessel Act was promulgated in 1992. This act established a program to provide grants to states to pay for construction, maintenance, operation, or renovation of boat pumpout stations and waste reception facilities (US Congress 1992).

Forestry assistance programs are included in Table 6.4 because forest improvement can improve water quality.

6.1.2.2 Water Resources Management

The federal assistance programs that address non-water quality aspects of water resources management are summarized in Table 6.6. These include programs that address flood control, water conservation, water supply systems, fisheries, and aquatic habitat for wildlife. Some of the programs that provide assistance for addressing water quality, also address other aspects of water resources management. For example, HUD Community Development Block Grants can be used for drinking water utilities as well as wastewater treatment systems. As a result, there is some duplication in Tables 6.4 and 6.6.

Table 6.6. Federal assistance programs for aspects of SAWRPR water resources other than water quality.

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Safe Drinking Water Act	Drinking water state revolving fund	EPA	Protects human health
American Recovery and Reinvestment Act	Drinking Water State Revolving Fund	Recovery Accountability and Transparency Board	American Recovery and Reinvestment Act
Farm Bill	Agricultural Water Enhancement Program	NRCS	Water conservation
	Cooperative Conservation Partnership Initiative	NRCS	Water conservation
	Conservation Innovation Grants Program	NRCS	Water conservation
	Emergency Watershed Protection	NRCS	Flooding reduction, revocery
	Groundwater Decline Initiative	NRCS	Water Conservation
	National Water Management Center	NRCS	Waterbody protection/restoration
	On-farm Energy Initiative	NRCS	Water conservation
	Watershed protection and flood prevention	NRCS	Flooding management
	Wetlands Reserve Program	NRCS	Physical waterbody protection/restoration
	Wildlife Habitat Incentives Program	NRCS	Physical waterbody protection/restoration
Cooperative Forestry Assistance Act	Urban and Community Forestry Program	USFS	Trees in communities reduce stormwater runoff, improving hydrology
	Forest Stewardship Program	USFS	Well-managed forestlands improve and protect water resources
	Forest Legacy Program		
Flood Control Act/Water Resources Development Act	Habitat restoration	USACE	Water storage, water supply, flood reduction, flow management, restoration of physical aquatic habitat
	Irrigation projects		
Housing and Community Development Act	Community Development Block Grants program	HUD	Protects/improves public water supply

Table 6.6. Federal assistance programs for aspects of SAWRPR water resources other than water quality (continued).

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Sport Fish Restoration Act	Boating infrastructure grants	USFWS	Recreational boating and fishing
	Multistate conservation grants	USFWS	Aquatic habitat research and education
	Sport fish restoration grants	USFWS	Preservation of water resources for fish and wildlife habitat
Land and Water Conservation Fund Act	Matching grants for acquisition and development of public recreation areas and facilities	USDI National Park Service	Preservation of water resources for recreation
Pittman-Robertson Wildlife Restoration Act	Wildlife restoration grant programs	USFWS	Preservation of water resources for fish and wildlife habitat
Consolidated Farm and Rural Development Act	Water and waste disposal systems for rural communities	USDA Rural Utilities Service	Protects/improves public water supply
	Water and Waste Disposal Loans and Grants		
	Household Water Well System Grant Program		
	Grant Program to Establish a Fund for Financing Water and Wastewater Projects		
	Emergency Community Water Assistance Grants		

The 1996 amendment of the Safe Drinking Water Act established the Drinking Water State Revolving Fund to assist drinking water utilities in financing infrastructure improvements and pollution prevention activities. Using this fund, states can offer utilities low-cost loans and other types of assistance for funding improvements. Funds available through the American Recovery and Reinvestment Act were awarded to the Arkansas Drinking Water State Revolving Fund (EPA n.d.).

Farm Bill amendments and associated assistance programs, as well as the Conservation Effects Assessment Program, the assistance programs associated with the Consolidated Farm and

Rural Development Act, and the HUD Community Block Development Grant program were discussed in Section 6.1.2.1. Farm Bill programs address water conservation (e.g., Groundwater Decline Initiative), flood control (e.g., Watershed protection and Flood prevention), and conservation and restoration of aquatic habitat (e.g., Wetlands Reserve Program, Wildlife Habitat Incentives Program). In 2012, over 16,800 acres in the counties of the SAWRPR were enrolled in Farm Bill programs, and over $2.5 million was allocated to these counties (Table 6.5) (NRCS 2012). In 2003, NRCS initiated an irrigation project in Little River County intended to provide irrigation for 30,000 acres of cropland using water from the Red River (US Government 2004).

Several water resources projects have been authorized in Arkansas since 1990 under the Water Resources Development Act (WRDA). Projects located in the SAWRPR that have been authorized and funded through WRDA are described in Table 6.7.

Table 6.7. WRDA projects in SAWRPR initiated after 1990 (USACE Vicksburg District 2013).

Project Name	Location	Description	Authority	Status
Red River Navigation Feasibility	Miller, Lafayette, Little River, and Hempstead Counties	Investigation of alternatives for extending navigation on the Red River above Shreveport, into Arkansas	WRDA 2007	On-going
Red River Emergency Bank Protection	Lafayette County	Construction of Dickson revetment		On-going
Red River Below Dennison Dam	Hempstead County	Rehabilitation of Red River levees	WRDA 2007	On-going

6.1.3 State Laws and Regulatory Programs

Arkansas has primary authority for regulation of water usage within the state. Many of the state laws and agency regulations related to water quality implement federal laws. The federal government has delegated authority to the state for a number of the regulatory administrative activities of both the CWA and the SDWA.

6.1.3.1 Water Use Regulations

State water use law is based on a policy where riparian land owners, i.e., persons owning land that abuts a waterbody, have the right to reasonable use of the water within that waterbody. The reasonable use policy means that all landowners along a stream have the right to free and unrestricted use of the stream flow, provided that their use does not negatively affect the availability of water for other riparian users. Similarly, landowners have the right to reasonable use of groundwater under their property, as long as that use does not adversely affect the ability of other landowners to use the groundwater. In addition to water rights related to water withdrawals and consumptive use, Arkansas regulations address water rights related to public recreational uses of surface water such as boating and fishing (ANRC 2011a).

In Arkansas, at the state level, regulations and programs authorized by the General Assembly that are related to water use are generally administered by the ANRC. In addition, the Arkansas Water Well Construction Commission promulgates rules for construction of water supply wells, and the Arkansas Public Services Commission regulates private water utility fees. State incentive programs for water conservation, as well as funding for water resources development projects, have also been legislated. Table 6.8 summarizes selected Arkansas water use regulations that apply in the SAWRPR.

Table 6.8. State regulations related to water use in the SAWRPR.

State Water Use Regulations	Subjects Addressed by State Regulations	Related State Legislation
Title 3: Rules for the Utilization of Surface Water	Registration of surface water withdrawals	Arkansas Code §15-22-215
	Minimum streamflows, water available for allocation	Arkansas Code §15-22-222
	Surface water transfers	Arkansas Code §15-22-304
	Allocation during periods of water shortage	Arkansas Code §15-22-217
Title 4: Rules for the Protection and Management of Groundwater	Registration of groundwater withdrawals	Arkansas Code §15-22-302
	Groundwater protection program	Arkansas Groundwater Protection and Management Act (Arkansas Code §15-22-901 et seq.)

Note: Highlighted legislation was promulgated after the 1990 AWP update.

State law requires ANRC to "establish and enforce minimum stream flows for the protection of instream water needs" (Arkansas Code § 15-22-222). Minimum streamflow is defined by Arkansas Code §15-22-202(6) as "…the quantity of water required to meet the largest of [specified] instream flow needs as determined on a case-by-case basis." The needs to be met that are specified in the statute are interstate compacts, navigation, fish and wildlife, water quality, and aquifer recharge. This definition is used to set minimum streamflows by rulemaking under Arkansas Code §15-22-222. Where no minimum flow is set by rule, these factors are used to make a case-by-case determination of minimum flow.

The minimum streamflow, set by rule or determined on a case-by-case basis, represents the trigger point for a "shortage" requiring allocation of water use. Because of the critical low flow conditions which may exist at the minimum streamflow level, the 1990 AWP recommended taking steps to reduce water withdrawals before water levels drop to minimum streamflow levels. The ANRC may allocate water among uses during a shortage.

Prior to adoption of Act 593 of 2013, minimum streamflows were classified as a "reserved" use when allocating water during a shortage, along with drinking water use and federal water rights. The legislation removed this reserved status and demoted minimum streamflows to a position below agriculture and industry in the allocation hierarchy, and ahead of hydropower and recreation. The intent was to ensure that agricultural and industrial surface water use is not curtailed during a shortage in an effort to protect instream flow needs (interstate compacts, navigation, fish and wildlife, water quality, and aquifer recharge). This change, especially as it applies a state law limitation on federal interests in navigation, interstate compacts and water quality, including wastewater discharge permits for sewer systems and industries, has not been tested.

In 1985, the Arkansas General Assembly adopted a departure from traditional riparian law by allowing transfer of water for use on non-riparian land. Prior to determining how much water is available to transfer, ANRC must first calculate the amount of water that must remain in the stream. The amount of water that must remain in the stream must be enough to cover: (1) existing riparian water rights as of June 28, 1985; (2) water needs of federal water projects as they existed on June 28, 1985; (3) firm yield of all reservoirs in existence on June 28, 1985; (4)

maintenance of instream flows for fish and wildlife, water quality, aquifer recharge requirements, and navigation; and (5) future water needs of the basin of origin as projected in the AWP. The General Assembly limited the amount of excess surface water that may be permitted for non-riparian transfer to 25% of the average annual yield from the watershed after the greatest of the instream needs listed above is met.

Minimum streamflow is often mistakenly equated with fish and wildlife flow requirements. Fish and wildlife flows are one of the 5 elements of minimum streamflow, which also includes interstate compacts, navigation, water quality, and aquifer recharge. Two different methods are used to calculate fish and wildlife flows for different situations. For case-by-case determinations of minimum flow for use in characterizing shortage and allocating water during a shortage, fish and wildlife flow requirements are estimated using a modified Tennant Method (ASWCC 1988). To calculate fish and wildlife flow requirements when determining the amount of excess water available for transfer to nonriparian users, the "Arkansas Method" (Filipek, Keith and Giese 1987) is used.

In 1991, the Arkansas Ground Water Protection and Management Act (Arkansas Code §15-22-901 et seq.) was signed into law, providing ANRC with authority to designate critical groundwater areas. As of 2013, one critical groundwater area has been designated in the SAWRPR (Figure 5.1). ANRC publishes annual groundwater reports on the condition of the state's groundwater resources, including recommendations concerning aquifer safe yield and designation of critical groundwater areas (ANRC 2011).

Legislation passed in 2001 (Arkansas Code §15-22-915) requires the use of water meters on all non-domestic wells withdrawing water from sustaining aquifers, beginning in 2006. Designated sustaining aquifers in the SAWRPR include the Nacatoch, Wilcox, Sparta, and Cockfield aquifers (Figure 3.21).

6.1.3.2 Water Quality Regulations

Water quality regulations are promulgated by the General Assembly, APCEC, the State Board of Health, and ANRC. To protect surface water and groundwater quality, there are state regulations and laws that regulate discharge of wastewater, discharge of stormwater, underground storage tanks, underground injection of fluids, management of livestock, and disposal of solid waste. Table 6.9 identifies state regulations and laws, along with associated federal laws, that address water quality.

Table 6.9 illustrates that there are myriad state regulations, covering a range of activities, that address water quality. The most basic of these are the regulations that set criteria for the quality of state surface waters and groundwater. These regulations identify the uses that state waterbodies should support, and specify narrative and numeric criteria for water quality to ensure the identified uses can be supported. In Arkansas, numeric water quality criteria for dissolved oxygen, turbidity, temperature, and minerals are ecoregion-based (APCEC 2011). Arkansas is in the process of developing numeric criteria for nutrients in surface water to meet federal requirements (ADEQ 2012c). State numeric water quality criteria for groundwater are in development

Table 6.9. State regulations that protect water quality within the SAWRPR.

Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Regulation 1: Prevention of Pollution by Salt Water and Other Oil Field Wastes Produced by Wells in All Fields or Pools[1]	Environmental protection during oil drilling	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 2: Water Quality Standards for Surface Waters of the State of Arkansas[1]	Water quality standards (designated uses and numeric criteria)	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 3: Licensing of Wastewater Treatment Operators[1]	Licensing program for wastewater treatment operators	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 4: Disposal Permits for Real Estate Subdivisions in Proximity to Lakes and Streams[1]	State wastewater permit	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 5: Liquid Animal Waste Systems[1]	State wastewater permit	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 6: Regulations for State Administration of the NPDES Program[1]	Federal wastewater permits (NPDES)	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act

Table 6.9. State regulations that protect water quality within the SAWRPR (continued).

Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Regulation 12: Storage Tank Regulations[1]	Petroleum storage tank trust fund	Petroleum Storage Tank Trust Fund Act (Arkansas Code § 8-7-901 et seq.)	Clean Water Act, Underground Storage Tank Regulations, including Energy Policy Act of 2005
Regulation 15: Open-Cut Mining and Land Reclamation Code[1]	Environmental protection during non-coal mining activities	Arkansas Open Cut Land Reclamation Act (Arkansas Code §15-57-301 et seq.) Arkansas Quarry Operation, Reclamation, and Safe Closure Act (Arkansas Code §15-57-401 et seq.)	None
	Restoration of non-coal mining sites		
Regulation 17: Underground Injection Control Code[1]	Underground injection of wastewater	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Safe Drinking Water Act
Regulation 20: Surface Coal Mining and Reclamation Code[1]	Environmental protection during coal mining activities	Arkansas Surface Coal Mining and Reclamation Act (Arkansas Code § 15-58-101 et seq.)	Surface Mining Control and Reclamation Act
	Restoration of coal mining sites		
Regulation 22: Solid Waste Management[1]	Landfill construction specifications,	Arkansas Solid Waste Management Act (Arkansas Code § 8-6-201 et seq.),	Resource Conservation and Recovery Act,
	acceptable materials for landfill disposal		
	regional solid waste management districts		
	Pollution prevention	Arkansas Pollution Prevention Act (Arkansas Code § 8-10-201 et seq.)	Pollution Prevention Act

Table 6.9. State regulations that protect water quality within the SAWRPR (continued).

Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Regulation 23: Hazardous Waste Management[1]	Hazardous waste management,	Arkansas Hazardous Waste Act (Arkansas Code § 8-7-201 et seq.), Arkansas Hazardous Materials Transportation Act (Arkansas Code § 27-2-101 et seq.)	Resource Conservation and Recovery Act
	pollution prevention	Arkansas Pollution Prevention Act (Arkansas Code § 8-10-201 et seq.)	Pollution Prevention Act
Regulation 27: Licensing of Landfill Operators and Illegal Dumps Control Officers[1]	Licensing of landfill operators	Arkansas Code § 8-6-901 et seq.	Resource Conservation and Recovery Act
	licensing of illegal dumps control officers	Illegal Dump Eradication and Corrective Action Program Act (Arkansas Code § 8-6-501 et seq.)	
Regulation 29: Brownfields Redevelopment[1]	Clean-up and redevelopment of contaminated sites	Arkansas Hazardous Waste Act (Arkansas Code § 8-7-201 et seq.), Remedial Action Trust Fund Act, Arkansas Voluntary Clean-up Act (Arkansas Code § 8-7-1101 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Regulation 32: Environmental Professional Certification[1]	Certification program for professionals involved in clean-up of contaminated sites	Phase I Environmental Site Assessment Consultant Act (Arkansas Code § 8-7-1301 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Regulation 34: State water permit regulation[1]	Regulation of systems with the potential to pollute water resources that are not otherwise regulated	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Rules and regulations pertaining to general sanitation[3]	Groundwater pollution	Arkansas Sewage Disposal Systems Act (Arkansas Code § 14-236-101 et seq.)	Clean Water Act
	surface water pollution		
	sewage treatment		
Rules and regulations pertaining to public water systems[3]	Safety of drinking water supplied by public water systems	Arkansas Code § 20-7-101 et seq.	Safe Drinking Water Act
Rules and regulations pertaining to semi-public water systems[3]	Safety of drinking water supplied by semi-public water systems	Arkansas Code § 20-7-101 et seq.	Safe Drinking Water Act

Table 6.9. State regulations that protect water quality within the SAWRPR (continued).

Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Rules and regulations pertaining to water operator licensing[3]	Licensing for drinking water treatment systems	Arkansas Code § 17-51-101 et seq.	Safe Drinking Water Act
Rules and regulations pertaining to onsite wastewater systems, designated representative, and installers[3]	Permitting of onsite wastewater treatment systems (septic systems),	Arkansas Sewage Disposal Systems Act (Arkansas Code § 14-236-101 et seq.)	Clean Water Act
	Licensing of designated representatives for onsite wastewater treatment systems		
	Licensing of installers of onsite wastewater treatment systems		
Rules and regulations pertaining to mobile home and recreational vehicle parks[3]	Water supply	Arkansas Code § 20-7-101 et seq.	Clean Water Act, Safe Drinking Water Act, Resource Conservation and Recovery Act
	wastewater disposal		
	solid waste management		
Arkansas regulations on pesticide classification[4]	Pesticide classification	Arkansas Pesticide Control Act (Arkansas Code § 2-16-401 et seq.), Arkansas Pesticide Use and Application Act (Arkansas Code § 20-20-201 et seq.)	Federal Insecticide, Fungicide, and Rodenticide Act
Arkansas regulations on pesticide applicator licensing[4]	Licensing of pesticide applicators	Arkansas Pesticide Use and Application Act (Arkansas Code § 20-20-201 et seq.)	Federal Insecticide, Fungicide, and Rodenticide Act
Arkansas Water Well Construction Commission Rules and Regulations[2]	Specifications for construction of water wells to provide safe drinking water	Water Well Construction Act (Arkansas Code § 17-50-101 et seq.)	Safe Drinking Water Act
Rules and regulations pertaining to outdoor bathing places[3]	Swim beach water quality	Arkansas Code § 20-7-101 et seq.	Clean Water Act
Marine sanitation[3]	Marine sanitation	Arkansas Code § 27-101-401 et seq.	Clean Vessel Act

Note: Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update.
1 Responsible state agency is ADEQ
2 Responsible state agency is ANRC
3 Responsible state agency is Arkansas Department of Health
4 Responsible state agency is Arkansas State Plant Boar.

A summary of the designated uses assigned to surface waterbodies in the SAWRPR under Regulation 2 is provided in Table 6.10. Ouachita Mountain and Gulf Coastal Plains ecoregion numeric surface water quality criteria apply in the SAWRPR. Ouachita Mountain water quality criteria apply to surface waters in Polk County, and northern Sevier and Howard Counties. Numeric surface water quality criteria for the water bodies in the planning region are listed in Tables 6.11 through 6.13. Figure 6.2 shows the ADEQ Water Quality Planning Segments that are located in the planning region.

Table 6.10. State designated uses for surface waters in the SAWRPR (APCEC 2011).

Designated use	Waterbodies
Extraordinary resource waters	Cossatot river upstream of Gilham reservoir, Caney Creek, Mountain Fork Fiver
Natural and scenic waterway	Cossatot River upstream of Gilham reservoir, Brushy Creek
Ecologically sensitive waterbodies	Mountain Fork River, Cossatot River upstream of Gilham reservoir, Robinson Creek, Little River upstream of Millwood reservoir, Grassy Lake and Yellow Creek downstream of Millwood reservoir
Primary contact recreation	All streams with watersheds greater than 10 sqare miles, except Lick Creek and All lakes and reservoirs,
Secondary contact recreation	All waters
Domestic, industrial, and agricultural water supply	All waters except: • no domestic water supply use on Rolling Fork River from Unnamed Tributary A near Grannis to Dequeen reservoir, • no domestic water supply use on Rolling Fork River Tributaries A and A1, • no domestic water supply use on Red River from Oklahoma to Little River, • no domestic water supply use on Mine Creek from Highway 27 to Millwood reservoir, and • no domestic or industrial water supply use on Caney Creek nor Bois d’Ark Creek downstream of Caney Creek
Fishery	All lakes and reservoirs
Seasonal fishery	All streams with watersheds smaller than 10 square miles
Perennial fishery	All streams with watersheds of 10 square miles or larger, All streams where discharge is 1 cfs or more

Table 6.11. Temperature and turbidity numeric criteria that apply in the SAWRPR.

Water body	Temperature (Fahrenheit)	Turbidity – base flow (NTU)	Turbidity – all flows (NTU)
Ouachita mountain ecoregion streams	86.0	10	18
Gulf coastal plains ecoregion typical streams	86.0	21	32
Lakes and reservoirs	89.6	25	45
Red river	89.6	50	150
Unnamed tributary of Lake June	95.0	21	32

Table 6.12. Dissolved oxygen numeric water quality criteria that apply in the SAWRPR.

Water body	DO primary (mg/L)	DO critical (mg/L)
Ouachita mountain ecoregion streams with watershed < 10 square miles	6	2
Ouachita mountain ecoregion streams with watershed 10 square miles or greater	6	6
Gulf coastal plains ecoregion streams with watershed < 10 square miles	5	2
Gulf coastal plains ecoregion streams with watershed 10 to 500 square miles	5	3
Gulf coastal plains ecoregion streams with watershed > 500 square miles	5	5
Lakes and reservoirs	5	N/A
Lick creek	5	2

Table 6.13. Numeric water quality criteria for minerals that apply in the SAWRPR.

Water body	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
Ouachita Mountains ecoregion values	15	19.9	141.9
Gulf Coastal Plains ecoregion values	18.6	41.2	137.8
Cossatot River	10	15	70
Days Ccreek	250	250	500
Gulf Coastal Plains ecoregion reference streams	18.7	41.3	138
Little River Rolling Fork upstream of unnamed tributary A	20	20	100
Mckinney Bayou	180	60	480
Mine Creek from highway 27 to Millwood Lake	90	65	700
Mountain Fork	20	20	110
Ouachita Mountain ecoregion reference streams	15	20	142
Red River from Little River to Louisiana	250	200	500
Red River from Oklahoma to Little River	250	200	850
Rolling Fork from unnamed tributary A to Dequeen Lake	130	70	670
Saline River	20	10	90

Table 6.13. Numeric water quality criteria for minerals that apply in the SAWRPR (continued).

Water body	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
Sulphur River	120	100	500
Unnamed tributaries of Rolling Fork A and A1	135	70	700
Bayou Dorcheat	100	16*	250
Albemarle unnamed tributary to Horsehead Creek	137*	ER (41.2)	383*
Horsehead Creek from Albemarle unnamed tributary to mouth	85*	ER (41.2)	260*
Cypress Creek Bodcau Creek	250	70	500
Crooked Creek	250	10	500
Dismukes Creek	26*	ER (41.2)	157*
Big Creek from Dismukes Creek to Bayou Dorcheat	20*	ER (41.2)	200*
Bois d'Arc Creek from Caney Creek to Red River Caney Creek	113*	283*	420*
Poston Bayou	120	40	500
Kelley Bayou	90	40	500

* developed using background flow of 4 cfs
ER – ecoregion criterion

The state source water and wellhead protection programs address protection of the quality of surface waters and aquifers used as public drinking water supplies. There are 75 active public water supply utilities in the SAWRPR. Over 45 of these utilities use groundwater from their own wells, and are subject to the state wellhead protection program. About 10 of these utilities use surface water and are subject to the state source water protection program. The remainder of the water utilities in the planning region purchase groundwater and/or surface water to supply to their customers (ADH n.d.).

6.1.3.3 Floodplain Management Regulations

Arkansas Code provides that it is the policy of the state to encourage and support actions to prevent and lessen flood hazards and losses. The state has the authority to adopt measures that will discourage development in flood-prone land, assist in reducing damage caused by floods, and improve long-range land management in flood-prone areas (Arkansas Code §14-268-101 et seq.).

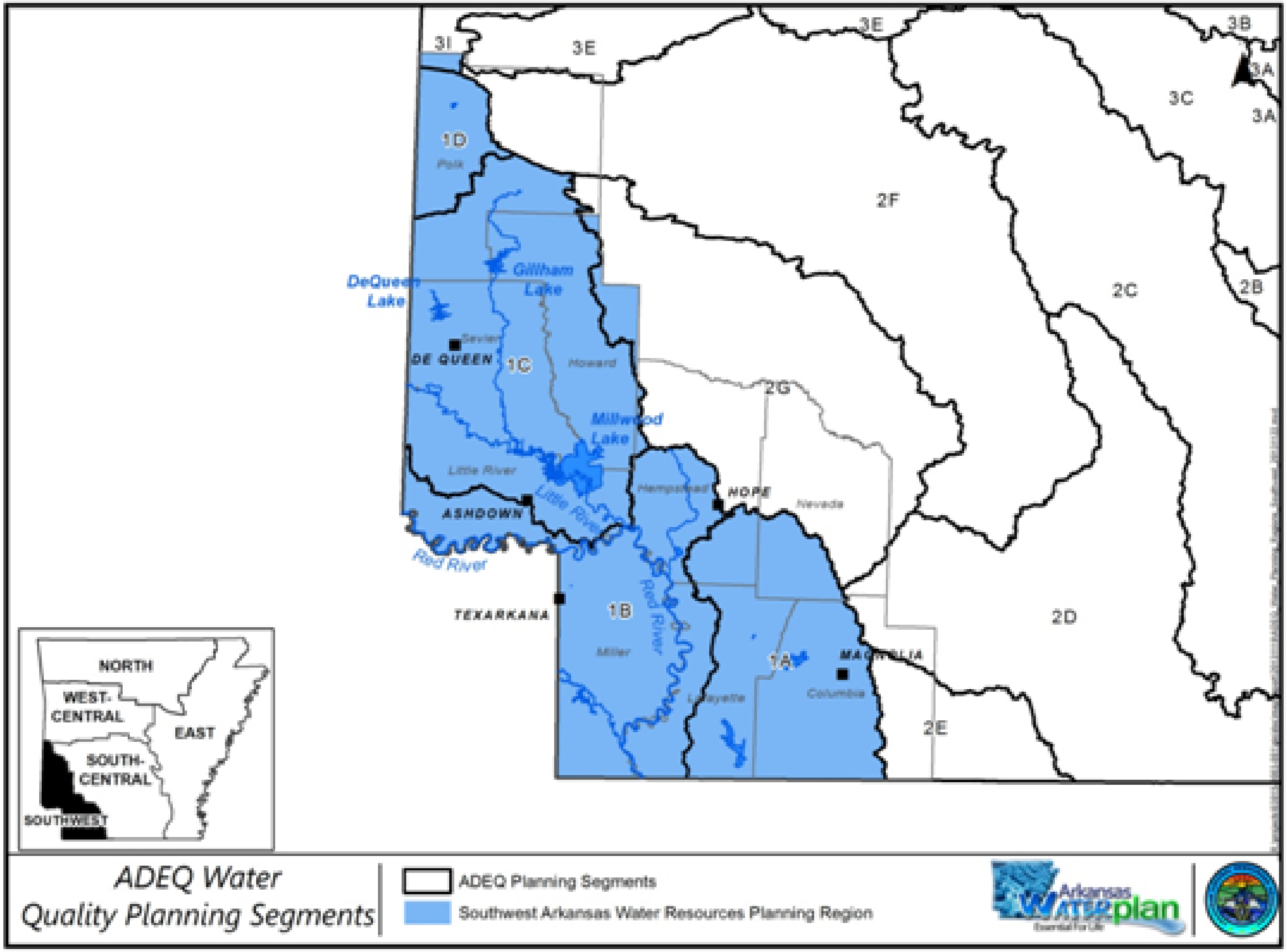

Figure 6.2. ADEQ water quality planning segments included in the SAWRPR.

Arkansas statute also requires each county, city, or town that is participating in the National Flood Insurance Program to designate a "person to serve as the floodplain administrator to administer and implement the ordinance and any local codes and regulations relating the management of flood-prone areas" (Arkansas Code §14-268-106(a)). The designated floodplain administrator must also be accredited by ANRC under the commission's authority regarding flood control (Title 18: Rules governing the floodplain administrator accreditation program). Continuing education for the floodplain administrator is an especially important component of the state's accreditation program (Arkansas Code §14-268-106, §15-24-102, and §15-24-109).

6.1.3.4 Water Management Regulations

Other state regulations and programs address additional aspects of water resources and their management. Table 6.14 summarizes these regulations, and the associated state and federal legislation.

Table 6.14 State regulations relating to water management within the SAWRPR.

State Water Resources Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Title 6 – Water plan compliance review procedures[1]	AWP	Arkansas Code § 15-22-503 and 504	None
Title 7 – Rules governing design and operation of dams[1]	Dam safety	Arkansas Code § 15-22-201 et seq.	Water Resources Development Act/Dam Safety and Security Act
Title 12 – Rules governing the Arkansas wetland mitigation bank program[1]	Wetland mitigation bank	Arkansas Wetlands Mitigation Bank Act (Arkansas Code § 15-22-1001 et seq.)	Rivers and Harbors Act, Clean Water Act
Rules and regulations of the Arkansas Natural Heritage Commission	Arkansas Natural and Scenic Rivers System	Arkansas Natural and Scenic Rivers System Act (Arkansas Code § 15-23-301 et seq.)	Wild and Scenic Rivers Act
Arkansas Wildlife Resources Regulations[3]	Allowance for fish passage at dams.	Arkansas Code § 15-44-110	
	Screens required on surface water intakes to protect fish	Arkansas Code § 15-44-111	

1 Responsible state agency is ANRC
Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update

The Arkansas Wetland Mitigation Banking Program (Arkansas Code §15-22-1002), authorized in 1995, is a state-sponsored initiative that promotes, in cooperation with federal, state, nonprofit, and other interested entities, the restoration, creation, enhancement, and conservation of aquatic resources, including wetlands, streams, and deep-water aquatic habitat. This legislation authorizes ANRC to operate wetland and stream mitigation banks and to sell mitigation "credits" to private, nonprofit, and public entities required to provide mitigation for dredge and fill activities under the CWA. The "credits" represent the accrual or attainment of aquatic resource function at the mitigation bank site which results from restoration, creation, enhancement, or conservation efforts. The state wetland mitigation bank provides a cost-effective alternative for mitigating impacts. The USACE regulates both public and private mitigation banking and is responsible for approving the number of "credits" available within any individual bank. When an individual or entity is required to provide compensatory mitigation for unavoidable loss of function, the USACE can approve the purchase of "credits" from the state mitigation bank to satisfy all regulatory mitigation requirements. The Days Creek Mitigation Bank in Miller County is a state mitigation bank (Table 6.3).

6.1.4 State Financial Assistance Programs

Arkansas has several programs that provide financial incentives and assistance for water resources management. The federal government has also delegated authority to the state to administer several federal assistance programs authorized by the CWA, the SDWA, the Housing and Community Development Act, and the Comprehensive Environmental Response, Compensation, and Liability Act.

6.1.4.1 Financial Assistance for Public Water and Wastewater Projects

ANRC is responsible for managing and distributing monies from several federal assistance programs intended to assist communities in constructing and maintaining drinking water and wastewater treatment systems (Table 6.15). There are also state-funded programs that provide financial assistance for drinking water and wastewater systems (Table 6.16). These programs are also administered by ANRC. Programs shown in both Tables 6.15 and 6.16 use both federal and state funding sources.

Table 6.15. Federal assistance programs ministered by ANRC for public drinking water and wastewater systems within the SAWRPR .

Federal Program	Federal funding source	State Program
Community Development Block Grant Program	HUD	Arkansas Community and Economic Development Program
Drinking water state revolving loan fund program	EPA	Water resources cost share revolving fund program
		Construction assistance revolving loan fund
Clean water state revolving loan fund program	EPA	Water resources cost share revolving fund program
		Construction assistance revolving loan fund

Table 6.16. State financial assistance programs for public drinking water and wastewater systems within the SAWRPR (administered by ANRC).

State Water Use Regulations	**State Assistance Programs**	**Related State Legislation**
Title 5: Administrative rules and regulations for financial assistance	Water resources development general obligation bond fund	Arkansas Water Resources Cost Share Finance Act (Arkansas Code § 15-22-801 et seq.),
	Water development fund program	
	Water resources cost share revolving fund program	
	Water, sewer, and solid waste management systems program	
	Water, waste disposal, and pollution abatement facilities general obligation loan bond program	Arkansas Water, Waste Disposal, and Pollution Abatement Facilities Financing Act (Arkansas Code § 15-20-1301 et seq.)
Title 15: Rules governing loans from the safe drinking water revolving loan fund	Safe drinking water revolving loan program	Arkansas Code § 15-22-1101 et seq.
	Construction assistance revolving	Arkansas Code § 15-5-901 et seq

State Water Use Regulations	State Assistance Programs	Related State Legislation
	loan fund	
Title 16: Rules governing the Arkansas clean water revolving loan fund program	clean water revolving loan fund program	Arkansas Code § 15-5-901 et seq.
	construction assistance revolving loan fund	
Title 23: Rules governing water and wastewater project funding through the Arkansas community and economic development program	Funding for construction or improvement of community treatment facilities for drinking water and wastewater treatment	Arkansas Code § 15-5-901 et seq.

6.1.4.2 State Incentive and Assistance Programs for Promoting Water Quality and water Resource Management

ADEQ and ANRC administer a number of incentive and assistance programs related to water resources management (Table 6.17). These include programs to assist with clean-up of hazardous waste contamination, reduction of nonpoint source pollution, and management of solid wastes to protect water quality. In addition, there are state programs to encourage water conservation and preservation of wetlands. All but one of the programs listed in Table 6.17 are funded by state sources. The state nonpoint source pollution management grant program is federally funded under the authority of the Clean Water Act Section 319.

Table 6.17. State incentive and assistance programs that protect water quality within the SAWRPR.

State Regulation	State Assistance Programs	Related State Legislation	Related Federal Legislation
Regulation 11: Solid Waste Disposal Fees, Landfill Post-Closure Trust Fund, and Recycling Grants Programs[1]	Recycling Fund	Solid Waste Management Recycling Fund Act (Arkansas Code §8-6-601 et seq.)	Resource Conservation and Recovery Act
Regulation 12: Storage Tank Regulations[1]	Petroleum storage tank trust fund	Petroleum Storage Tank Trust Fund Act (Arkansas Code § 8-7-901 et seq.)	Clean Water Act, Underground Storage Tank Regulations, including Energy Policy Act of 2005

Table 6.17. State incentive and assistance programs that protect water quality within the SAWRPR (continued).

State Regulation	State Assistance Programs	Related State Legislation	Related Federal Legislation
Regulation 29: Brownfields Redevelopment[1]	Clean-up funding	Arkansas Hazardous Waste Management Act (Arkansas Code § 8-7-201 et seq.), Remedial Action Trust Fund Act (Arkansas Code § 8-7-501 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Regulation 30: Remedial Action Trust Fund, Site Priority List[1]	Clean-up funding, prioritization of contaminated sites for clean-up	Remedial Action Trust Fund Act (Arkansas Code § 8-7-501 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Title 5: Administrative rules and regulations for financial assistance[2]	Sewer and solid waste management systems program waste disposal and pollution abatement facilities general obligation bond program	Arkansas Code § 14-230-101 et seq., § 15-22-601 et seq., § 15-22-701 et seq.	None
Title 10: Rules governing the Arkansas water resource agricultural cost-share program[2]	Arkansas water resources agricultural cost-share program	Arkansas Code § 15-22-913 through 914, § 15-22-507	Farm Bill
Title 13: Rules governing the tax credit program for the creation and restoration of private wetland and riparian zones[2]	Wetlands and Riparian Zone Tax Credit Program	Arkansas Private Wetland Riparian Zone Creation and Restoration Incentive Act (Arkansas Code § 26-51-1501 et seq.)	Clean Water Act
Title 14: Rules for implementing the Water Resources Conservation and Development Incentives Act[2]	Groundwater conservation tax incentives	Water Resource Conservation and Development Incentives Act (Arkansas Code § 26-51-1001 et seq.)	None
Title 16: Rules governing the Arkansas clean water revolving loan fund program[2]	Funding for construction of community wastewater treatment facilities	Arkansas Code §15-5-901 et seq.	Clean Water Act

Table 6.17. State incentive and assistance programs that protect water quality within the SAWRPR (continued).

State Regulation	State Assistance Programs	Related State Legislation	Related Federal Legislation
Title 23: Rules governing water and wastewater project funding through the Arkansas community and economic development program[2]	Funding for construction or improvement of community treatment facilities for wastewater	None	Housing and Community Development Act
None	Nonpoint source pollution grant program[2]	None	Clean Water Act (Section 319)

Note: Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update.
1 Responsible state agency is ADEQ
2 Responsible state agency is ANRC

6.1.5 Non-regulatory State Water Management Programs

There are state agency programs for natural resources protection and management that apply to water resources. These include planning, guidance, and incentive programs. These programs do not necessarily have regulations associated with them. However, they guide the activities of state agencies related to water resources. The AWP is one such program. Others are described below.

6.1.5.1 Arkansas Wildlife Action Plan

A state wildlife action plan was prepared by the AGFC, and approved by USFWS in 2007. This plan prioritizes activities to protect species of concern and their habitats throughout the state. This plan addresses amphibians, birds, fish, crayfish, insects, mammals, mussels, and reptiles. There are at least 80 species of greatest conservation need identified for Arkansas in this plan that are found in the SAWRPR. The most highly recommended conservation activity for this planning region is habitat restoration and improvement (Anderson 2006).

6.1.5.2 Arkansas Forestry Best Management Practices

The Arkansas Forestry Commission has prepared a booklet of approved guidelines for conducting forest management practices in a way that minimizes water quality impacts.

Implementation of these best management practices is voluntary. These management practices are applicable to commercial and private timber operations on public or private land.

6.1.5.3 Arkansas State Wetland Strategy

A state wetland strategy was ed in 1995 by a team of Arkansas agencies. This strategy consisted of 10 elements that addressed conservation and restoration of wetlands, and improving understanding of wetlands, both by the scientific and natural resources community and by the public. Implementation of this strategy resulted in legislation that created the Arkansas Mitigation Banking Program, and the Arkansas Riparian Zone and Wetland Creation Tax Credit Program.

6.1.5.4 Arkansas Nonpoint Source Management Plan

ANRC regularly prepares a state nonpoint source pollution management plan. The purpose of this plan to provide a guide and focus for public agencies, nonprofit organizations, interest groups, and other stakeholders to work together to "develop, coordinate, and implement programs to reduce, manage or abate" nonpoint source pollution. The plan is updated every five years. The current plan was updated in 2011.

6.1.6 Local Regulations

There are also local regulations that influence management of water resources. These can include zoning laws; regulations promulgated by municipalities, counties, water and wastewater utilities; and regulations promulgated by irrigation, drainage, water, and sewer districts.

6.1.7 Non-regulatory Regional Water Resources Management

Several agencies and organizations have developed management or restoration programs for areas within the SAWRPR. The purpose of some of these programs is to implement a state or federal regulation or policy, such as ambient water quality standards, no net loss of wetlands, or conservation of wildlife. These programs constitute a framework that provides opportunities for leveraging resources (personnel and funding) to accomplish water resources management goals.

6.1.7.1 Nine-element Watershed Plans

Watershed plans are required by the CWA to guide activities for reducing pollution in waterbodies for which TMDLs have been developed. EPA has prepared guidance describing the nine elements that should be included in watershed plans to achieve TMDLs calculated for impaired waterbodies. A nine-element watershed plan must be completed and approved by EPA before restoration projects in the watershed can receive funding from the CWA Nonpoint Source Program (Section 319 funding). A nine-element watershed restoration action strategy for the Little River and Mountain Fork River was finalized in 2004. This strategy addresses nutrients, turbidity and pathogens. (Arkansas Water 2013, Lower Little River Watershed Coalition 2004).

6.1.7.2 Nonprofit Organizations

There are several nonprofit organizations that have active programs that involve water resources within the SAWRPR. These include The Nature Conservancy and Ducks Unlimited. The Nature Conservancy manages a blackland prairie nature preserve in Hempstead County (The Nature Conservancy 2013b).Ducks Unlimited has participated in a number of wetland habitat conservation and restoration projects on private lands and in WMAs within the SAWRPR (Ducks Unlimited n.d.).

6.1.8 Interstate Compacts

Arkansas is part of the Red River Compact, an interstate compact agreement among the states of Arkansas, Oklahoma, Texas, and Louisiana. One purpose of the compact is to promote the equitable apportionment and development of the water in the river basin among the participating states. According to Article II, Section 2.01 of the Red River Compact, each member state may use the water allocated to it by the compact in any manner deemed beneficial by that state. Each state may freely administer water rights and uses in accordance with the laws of that state, but such uses shall be subject to availability of water in accordance with the apportionments made by the compact.

There are five defined reaches in the Red River Basin covered by the compact (Figure 6.3). Bodcau Creek and Dorcheat Bayou in the SAWRPR are included in Reach IV of

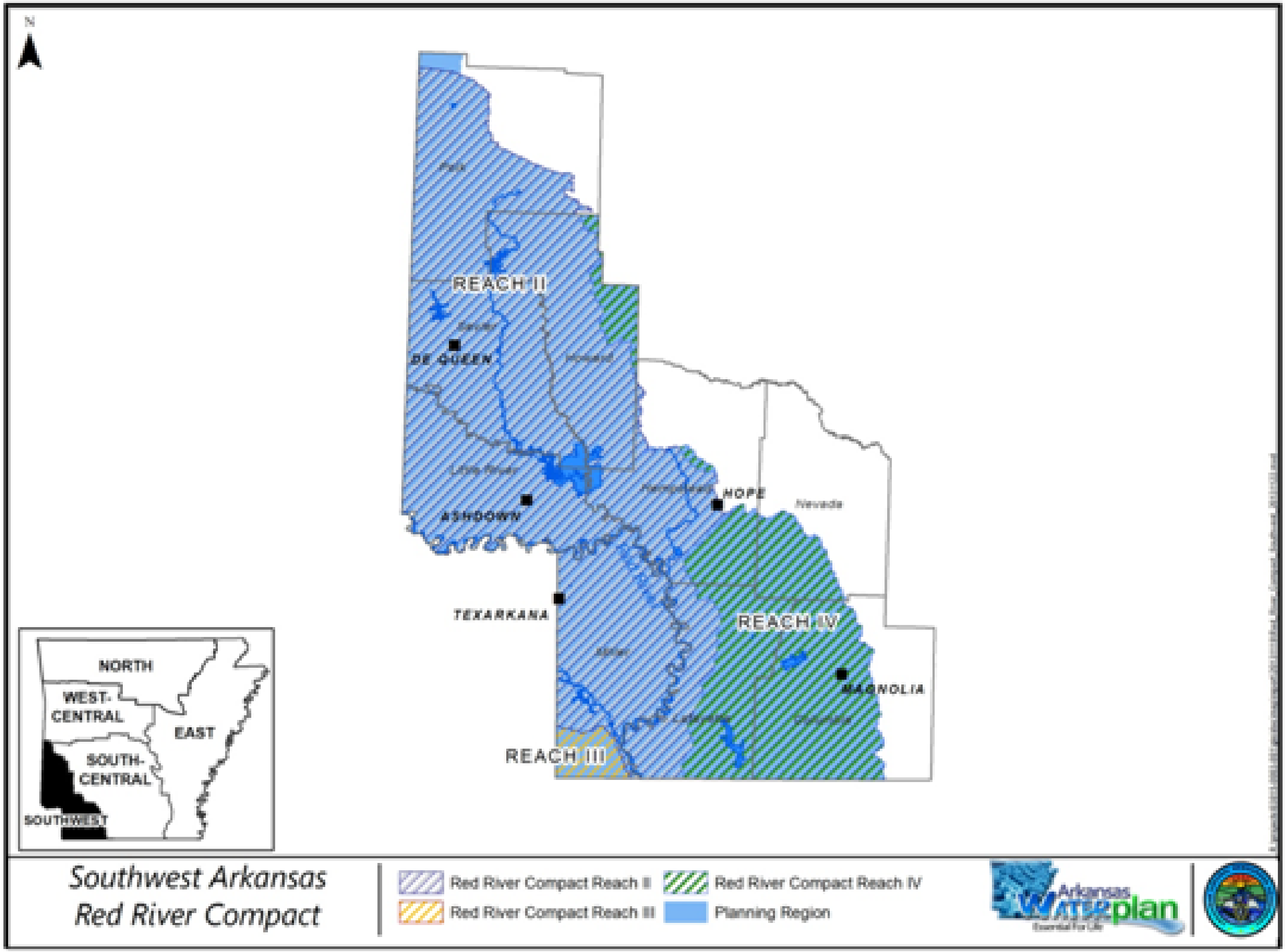

Figure 6.3. Red River Compact boundaries in the SAWRPR.

the Red River. Sulphur River and McKinney Bayou are included in Reach III of the Red River. The remaining rivers and streams in the SAWRPR are included in Reach II of the Red River. Table 6.18 summarizes flow allocations set in the compact for rivers and streams in the SAWRPR (Red River Compact Commission 1978).

Table 6.18. Summary of Red River Compact allocations that apply in the SAWRPR (Red River Compact Commission 1978).

Reach	Subbasin	Stream	Allocation	
II	3	Little River and its tributaries above Millwood Dam	Oklahoma shall allow 40% of the flow originating below Pine Creek (Little River), Lukfata (Glover Creek), and Broken Bow (Mountain Fork) reservoirs to flow into Arkansas	
II	5	Red River between Dennison Dam and Louisiana State line	When flow at Louisiana state line is at least 3,000 cfs:	Each state is allowed up to 25% of flow over 3,000 cfs at the Louisiana state line
			When flow at Louisiana state line is between 1,000 cfs and 3,000 cfs	Arkansas, Texas, and Oklahoma shall allow 40% of the flow entering subbasin 5 and 40% of the runoff originating in subbasin 5 to flow into Louisiana
			When flow at Louisiana state line is less than 1,000 cfs	Arkansas, Oklahoma, and Texas shall allow flow equivalent to weekly runoff originating in subbasin 5 and all undesignated flow entering subbasin 5 to flow into Louisiana
			When flow at Index, Arkansas is less than 526 cfs	Oklahoma and Texas shall allow 40% of the weekly runoff originating in their states to flow into Arkansas
III	1	Streams of the Cypress Creek – Twelve Mile Bayou Watershed that cross the Texas-Arkansas border downstream of any dam sites	Arkansas is entitle to 40% of the runoff originating in this subbasin	
III	2	Streams of the Cypress Creek – Twelve Mile Bayou watershed that cross the Louisiana-Arkansas border	Arkansas is apportioned 60% of the runoff originating in this subbasin	

Table 6.18. Summary of Red River Compact allocations that apply in the SAWRPR (continued).

Reach	Subbasin	Stream	Allocation
IV	2	Tributaries of the Red River originating in Arkansas and crossing the Louisiana-Arkansas border before joining the Red River, and downstream of any dam sites	Arkansas is apportioned 60% of the runoff originating in this subbasin

6.2 Institutional Framework

Governmental responsibility for water resources management in the SAWRPR is split among many agencies on three levels (federal, state, and local). As a result, management of water resources in the SAWRPR can require coordination among a number of government entities. In addition, there are nonprofits and universities that participate in water resources management in the planning region.

6.2.1 Federal Agencies

There are 14 federal agencies involved in water resources management in the SAWRPR. These federal agencies are listed in Table 6.19, along with their respective activities in this planning region.

Table 6.19. Federal agencies with water resources-related responsibilities in the SAWRPR.

Federal Agency	Responsibility in Arkansas

EPA	• Oversees state agencies in implementation of management and funding programs under
	  o Clean Water Act,
	  o Safe Drinking Water Act,
	  o RCRA,
	  o Superfund,
	  o Federal Insecticide, Fungicide, and Rodenticide Act, and
	  o Surface Mining Control and Reclamation Act
	• Conducts TMDL studies and other water quality studies in the planning region
	• Implements programs under the Toxic Substances Control Act

FEMA	Prepares flood hazard maps for the state and encourages State and local governments to guide development decisions away from defined flood hazard risk areas through participation in the National Flood Insurance Program
HUD	Provides funding for water and wastewater infrastructure improvements
NOAA	Participates in monitoring precipitation and climate in the state

NRCS National Water Management Center	• Located in Little Rock
	• Serves as a water resources information exchange
	• Provides support and training related to
	  o environmental compliance,
	  o hydrology and hydraulics,
	  o stream geomorphology and restoration,
	  o water quality and quantity,
	  o watershed and dam rehabilitation, and
	  o technology outreach

USACE	• Manages federal water supply and flood control projects in the planning region • Implements sections of the Clean Water Act related to impacts to navigable waters and wetlands • Constructs flood control, irrigation, and water supply projects authorized by the Water Resources Development Act • Oversees dam safety for federal dams
USDA	• Conducts the Census of Agriculture • Conducts the Natural Resources Inventory • Manages Conservation Effects Assessment Projects (regional)
USDA Farm Services Agency	Implements the Conservation Reserve Program for erosion control and habitat restoration in the planning region
USFS	• Manages the Ouachita National Forest and associated surface waters • Forest management incentive programs • Participates in forest inventory • Manages Urban and Community Forestry Program

Table 6.19. Federal agencies with water resources-related responsibilities in the SAWRPR (continued).

Federal Agency	Responsibility in Arkansas
NRCS	• Implements over 20 Farm Bill erosion control and habitat restoration funding and technical assistance programs in the planning region • Appraises the status and trends of soil, water, and related resources on non-federal land in the state and assesses their capability to meet present and future demands
USDA Rural Development	• Implements USDA rural utilities financial assistance programs
USDI National Park Service	• Manages one national historic site and associated water resources within the planning region • Provides funds for land and water conservation projects
USFWS	• Implements the Endangered Species Act and programs to o Promote management of ecosystems, o Promote conservation of migratory birds, o Promote preservation of wildlife habitat, o Promote restoration of fisheries, o Combat invasive species, and o Promote international wildlife conservation • Manages the Pond Creek National Wildlife Refuge in the planning region • Implements the Partners For Wildlife Program for restoration of wetlands, streams, and riparian areas • Conducts the National Wetland Inventory • Oversees state wildlife planning through the State Wildlife Grant Program
USGS	• Flow and stage monitoring of rivers and streams • Groundwater level monitoring • Water quality monitoring • Groundwater modeling • Water quality modeling • Water data storage and management

6.2.2 Arkansas Agencies

There are over 20 Arkansas agencies involved in water resources management in the SAWRPR. These state agencies are listed in Table 6.20, along with a description of their water resources management responsibilities within the planning region.

Table 6.20. Arkansas agencies and entities with responsibilities in the SAWRPR related to water resources.

Arkansas State Entity	Responsibility
ADEQ	• Implements state water quality policy and the Clean Water Act NPDES program • Develops and enforces water quality standards • Investigates citizen complaints regarding water pollution • Oversees solid waste management • Operates the hazardous waste management program • Manages contaminated site clean-up and redevelopment programs • Develops and enforces mining and mine site reclamation regulations • Manages the storage tank regulation program • Permits no-discharge facilities and underground injection operations • Water quality monitoring and assessment
ANRC	• Regulates, permits, and tracks water use and dam construction • Monitors climate (State Climatologist) • Administers federal water resources funding programs • Prepares water resources and nonpoint source pollution management plans • Develops and maintains mitigation banking and restoration incentive programs for aquatic resources • Supports conservation districts • Promotes public health and safety and minimize flood losses through o training, o education, o technical assistance in floodplain management, and o accrediting floodplain administrators
ADH	• Regulates public water supply systems • Implements the Safe Drinking Water Act source water protection programs • Issues fish consumption advisories • Implements state health rules and regulations that apply to water resources • Regulates septic tanks and licenses septic tank cleaners • outdoor bathing and swimming • Implements state marine sanitation program
Arkansas Department of Parks and Tourism	• Manages the 5 state parks and associated water resources in the planning region • Prepares comprehensive outdoor recreation plan • Manages outdoor recreation grant program

Table 6.20. Arkansas agencies and entities with responsibilities in the SAWRPR related to water resources (continued).

Arkansas State Entity	Responsibility

Arkansas Forestry Commission	• Provides guidelines for protection of water resources in forestry operations
	• Monitors use of forestry BMPs
	• Participates in forest inventory
	• Implements forest management incentive programs
	• Implements Urban and Community Forestry program
	• Designates and manages state forests for a variety of purposes, including
	    o watershed protection
	    o erosion and flood control

AGFC	• Manages protection, conservation and preservation of fish and wildlife in the planning region through
	    o habitat management,
	    o wildlife management areas,
	    o fish stocking,
	    o hunting and fishing regulations, and
	    o education and outreach programs
	• Prepares state Wildlife Action Plan
	• Implements conservation grant programs
	• Manages public waters in the planning region

Arkansas Geological Survey	• Participates in research of, and provides information and education about, state water resources • Mapping • Water well construction records
Arkansas Livestock and Poultry Commission	Regulates disposal of livestock carcasses
Arkansas Multi-agency Wetland Planning Team	Developed the State Wetland Strategy and is the lead for developing state numeric nutrient criteria for wetlands
ANHC	• Surveys and conducts research on natural communities in the state • Acquires natural areas for preservation • Manages nine natural areas in the planning region

Arkansas Oil and Gas Commission	• Provides technical assistance related to protection of water resources from wastes associated with production of brine
	• Issues permits for drilling and operation of
	    o brine production wells
	    o injection and disposal wells

APCEC	Environmental policy-making body for the state
Arkansas Public Service Commission	Regulates rates and services of private water utilities, as well as utilities water crossings
Arkansas State Board of Health	Promulgates health rules and regulations for the state
AHTD	• Hazardous waste transportation permits • Stormwater management • Develops and implements construction BMPs

Table 6.20. Arkansas agencies and entities with responsibilities in the SAWRPR related to water resources (continued).

Arkansas State Entity	Responsibility

Arkansas State Plant Board	Implements
	• Insecticide, Fungicide, and Rodenticide Act programs,
	    o pesticide registration
	    o user and applicator training
	    o dealer licensing
	• state pesticide management plan for groundwater protection,
	• groundwater quality monitoring, and
	• climate/weather monitoring

Arkansas Water Well Construction Commission	• Regulates development of groundwater for water supply through licensing water well contractors and registering drillers and pump installers • Regulates specifications for construction of water wells • Maintains water well construction records
Arkansas Waterways Commission	Studies and promotes navigable waterways for transportation and economic development
U of A Cooperative Extension Service	Provides technical assistance to Arkansans related to water conservation, and protection and restoration of water quality
U of A Water Resources Center	Participates in research related to water resources, and in water resources management projects

6.2.3 Federal-state Organizations

There are at least three federal-state organizations involved in water resources management in the SAWRPR:

- Red River Compact Commission,
- Arkansas Conservation Partnership, and
- Arkansas Watershed Advisory Group.

The Red River Compact Commission administers the Red River Compact, which applies to all of the surface waters in the planning region (see Section 6.1.8). The commission is made up of one representative from the water agency of each of the member states (ANRC in

Arkansas), a resident from each state chosen by the governor, and a federal representative appointed by the US president (Oklahoma Water Resources Board n.d.).

The Arkansas Conservation Partnership supports locally-led natural resources conservation through coordination of education, financial, and technical assistance to landowners. Water resources and implementation of Farm Bill programs are two of the six natural resource issues that are the focus of the partnership. Members of the partnership include federal agencies, as well as ANRC, the NRCS, Arkansas Association of Conservation Districts, U of A Cooperative Extension, U of A at Pine Bluff, and Arkansas Forestry Commission. This partnership was formed in 1992 (ANRC 2012, Cooperative Conservation America n.d.).

The Arkansas Watershed Advisory Group (AWAG) provides technical assistance to form local watershed groups, hosts an annual water quality conference, and facilitates quarterly discussions of voluntary water quality management approaches. AWAG is a consortium of federal and state agencies with private citizens (ANRC 2011b).

6.2.4 Regional and Local Entities

There are numerous regional and local entities in the SAWRPR that are involved in activities related to water resources management. Examples of the types of local and regional entities present in this planning region are shown in Table 6.21, along with descriptions of their activities related to water resources management.

Table 6.21. Some of the regional and local government entities involved in water resources management in the SAWRPR.

Regional or Local Entity	Water Resources Involvement
Local Conservation Districts	Work with state and federal agencies to implement measures for the control of erosion and flooding, and conservation of soil and water resources
County Government	Responsible for unincorporated areas, sometimes including floodplain management and zoning
Arkansas Red River Commission	Work with federal and state agencies in planning and implementing improvements to the Red River
Irrigation Districts (e.g., Walnut Bayou Irrigation District)	Created by circuit court order to distribute water resources

Table 6.21. Some of the regional and local government entities involved in water resources management in the SAWRPR (continued).

Regional or Local Entity	Water Resources Involvement
Levee Districts	Provide for the construction and maintenance of levees along the Red River for flood protection
Red River Compact Commission	Administers the Red River Compact
Southwest and Western Arkansas Planning and Development Districts	• Water supply and wastewater infrastructure improvements • Assist Regional Solid Waste Management Districts
Regional Solid Waste Management Districts	Manage collection, disposal, and recycling of solid waste
Southwest Arkansas Water District	Public nonprofit organizations for distribution of water from Millwood Lake
Universities	Water resources and management research, education, and outreach
Water districts and associations	• Water supply planning and management • Supply water and wastewater services
Lower Little River Watershed Coalition	Development and implementation of watershed restoration action strategy

6.2.5 Nonprofit Organizations

There are several nonprofit organization that conduct activities in the SAWRPR that are related to water resources management. These organizations are listed in Table 6.22 with a description of their water resources related activities in the planning region.

Table 6.22. Nonprofit organizations involved in water resources management in the SAWRPR.

Name	Water Resources Involvement
The Nature Conservancy	Columbus Prairie Preserve
Audubon Arkansas	Three Important Bird Areas in the planning region: Blackland Prairie, Millwood Lake, and Little River Bottoms
Ducks Unlimited	Conservation and restoration of aquatic habitat for waterfowl
Stream teams	Water quality monitoring, stream bank rehab, restoration of fish habitat
Little River Watershed Coalition	Water resources planning, Sponsor for water quality and quantity projects
Arkansas Wildlife Federation	Conservation of aquatic habitat for fish and wildlife
Arkansas Farm Bureau	Advocate for agriculture
Arkansas Environmental Federation	Advocate for “practical common-sense [environmental] laws and regulations based on sound science…and waste minimization and pollution prevention.”

Table 6.22. Nonprofit organizations involved in water resources management in the SAWRPR (continued).

Name	Water Resources Involvement
Arkansas Water Works and Water Environment Association	Support of water and wastewater utilities
Arkansas Rural Water Association	Support of rural water and wastewater utilities

6.2.6 Institutional Interactions in Water Resources Management

As noted at the beginning of this section, water resources management in the SAWRPR involves numerous entities at multiple scales. Examples of the interactions among federal, state, and local entities that occur in water resources management in the SAWRPR are presented in Table 6.23.

Table 6.23. Examples of interactions of federal, state, and local entities in water resources management within the SAWRPR.

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
Water use registration	USGS (houses registration database)	ANRC (program lead)	Water utilities, irrigation districts (water withdrawers)
Dam safety	USACE Little Rock District (federal dams) FEMA (oversight)	ANRC (program lead), AGFC (dam builder), Arkansas Department of Parks and Tourism (dam builder)	Water utilities, municipalities, counties (dam builders)
State climate monitoring	NOAA National Weather Service, NOAA NCDC, USGS (precipitation monitoring), USACE (climate monitoring)	ANRC (State Climatologist), Arkansas State Plant Board (monitoring)	Community Collaborative Rain, Hail & Snow Network
Safe Drinking Water Act funding	EPA (funding)	ANRC (program lead)	Water utilities, municipalities/ communities, water districts
Red River compact	NRCS, USGS, USACE	ANRC (state representative)	Red River Compact Commission
Water Resources Conservation Tax Incentives	NRCS	ANRC (program lead), U of A Cooperative Extension Service	Conservation districts

Table 6.23. Examples of interactions of federal, state, and local entities in water resources management within the SAWRPR (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
Conservation district grants program	None	ANRC (program lead)	Conservation districts
Nutrient surplus areas	NRCS	ANRC (program lead)	Conservation districts (planning)
Nutrient management applicator certification	None	ANRC (certification), U of A Cooperative Extension Service (training)	None
Nutrient management planner certification	None	ANRC (certification), U of A Cooperative Extension Service (training)	None
Community development block water and wastewater grants	HUD (funding)	ANRC (program lead), Arkansas Economic Development Commission	Water utilities, wastewater utilities, water districts, sewer districts
Consolidated Farm and Rural Development Act funding	USDA Rural Utilities Service (funding)	None	Municipalities, Rural water , wastewater, and solid waste utilities
Floodplain management and flood control	FEMA (insurance), USACE Little Rock District (flood control project)	ANRC (administrator certification)	Levee districts, counties, municipalities
Nonpoint source pollution management	EPA (funding), NRCS (conservation programs), USFS (BMPs), The Nature Conservancy (projects), USDA Farm Services Agency (conservation program)	ANRC (program lead), Universities, Arkansas Water Resources Center, Audubon Arkansas, U of A Cooperative Extension Service, Arkansas Farm Bureau, ADEQ (TMDLs)	Watershed organizations, Conservative districts, water districts, stream teams, nonprofit organizations
Clean Water Act funding program (including nonpoint source and clean water revolving loan fund)	EPA (funding)	ANRC (program lead)	Watershed organizations, sewer districts, municipalities, nonprofit organizations
Groundwater protection and management – critical groundwater areas	USGS, USACE (water projects)	ANRC (program lead), Water Well Construction Commission	Counties
Wetland and riparian zone tax credit program	None	ANRC (program lead)	Watershed organizations
Wetland and stream mitigation	USACE (lead)	ANRC (state mitigation bank), AHTD, AGFC, ADEQ, ANHC	Whitehead Forestry Services Inc., Ducks Unlimited, local conservation districts

Table 6.23. Examples of interactions of federal, state, and local entities in water resources management within the SAWRPR (continued).

State Water Resources Responsibility/Program	Involves: Federal Entities	State Entities	Regional or Local Entities
Non-riparian water use permitting	None	ANRC (program lead)	Water utilities
Arkansas Recovery Act water and wastewater funding	Recovery Accountability and Transparency Board	ANRC (program lead)	Water utilities, wastewater utilities, water districts, sewer districts
State water utility funding	None	ANRC (program lead)	Water utilities, water districts
State wastewater utility funding	None	ANRC (program lead)	Wastewater utilities, sewer districts
NPDES discharge permits	EPA (oversight, guidance)	ADEQ (program lead)	Dischargers
Underground injection control	EPA	ADEQ (program lead), Arkansas Oil and Gas Commission (program lead)	Dischargers
Wastewater pretreatment program	EPA	ADEQ (program lead)	Dischargers
Water quality standards	EPA	APCEC (regulations), ADEQ (implementation, enforcement), ANRC (groundwater standards), Multi-Agency Wetland Planning Team (nutrients in wetlands)	Local governments, regulated entities, interest groups
Water quality assessment	EPA (oversight, guidance), USGS (data), USACE (data)	ADEQ (implementation)	Interest groups
TMDLs	EPA (oversight, guidance), USGS (data), USACE (data)	ADEQ (program lead)	Interest groups, nonprofit organizations
Storage tank regulation	EPA	ADEQ (program lead)	None
Solid waste management	EPA (oversight)	ADEQ (program lead)	Regional solid waste management districts
Landfill post-closure trust fund	None	ADEQ (program lead)	Regional solid waste management districts
Hazardous waste management	EPA (oversight)	ADEQ (program lead), AHTD (transport)	Interest groups
Remedial action trust fund	None	ADEQ	Interest groups
Brownfields	EPA (oversight)	ADEQ	municipalities
Superfund	EPA (oversight)	ADEQ	Interest groups
Mining reclamation	USDI	ADEQ	Interest groups

Table 6.23. Examples of interactions of federal, state, and local entities in water resources management within the SAWRPR (continued).

State Water Resources Responsibility/Program	Involves: Federal Entities	State Entities	Regional or Local Entities
Water quality monitoring	EPA (oversight, studies), USGS (monitoring, studies), USACE (monitoring, studies)	ADEQ, ANRC, U of A Water Resources Center (studies), AGFC (stream teams), Arkansas State Plant Board (groundwater monitoring)	Stream teams (monitoring), water utilities (monitoring)
Fish tissue sampling	None	ADEQ (program lead), ADH (consumption advisories), AGFC (sampling)	None
Stormwater management	EPA	ADEQ, U of A Cooperative Extension Service	Counties, municipalities
Spill prevention	EPA	ADEQ	None
Finished drinking water criteria	EPA	ADH	Water utilities, water districts
Source Water Protection	EPA	ADH, Arkansas Water Well Construction Commission	Water utilities (planning)
Consumer Information	EPA	ADH	Water utilities
Regulation of drinking water utilities	EPA	ADH, Arkansas Public Service Commission	Water utilities
Pesticide registration, labeling and classification	EPA	Arkansas State Plant Board	Pesticide distributors and users
Community Forestry	USFS	Arkansas Forestry Commission, Arkansas Urban Forestry Council	Municipalities
Forest stewardship	USFS, USDA Farm Services Agency, NRCS	Arkansas Forestry Commission, AGFC, ANRC, Arkansas Historic Preservation Program, U of A Cooperative Extension Service, ANHC	Landowners
Forest Legacy	USFS (funding), Land Trust Alliance	Arkansas Forestry Commission	Landowners
State parks	USACE, National Park Service (funding)	Arkansas Department of Parks and Tourism	Volunteers, users
Stream teams	None	AGFC	Stream teams
Wildlife management areas, Wildlife refuges	USFWS	AGFC	Volunteers, users, nonprofit organizations
Fishing and boating programs	USACE, USFWS	AGFC, Arkansas Department of Parks and Tourism	Fishers and boaters

Table 6.23. Examples of interactions of federal, state, and local entities in water resources management within the SAWRPR (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
Pollution prevention program	EPA	ADEQ	Industries
Red River navigation	USACE Little Rock District	Arkansas Waterways Commission	Red River Valley Association, Arkansas Red River Commission
Walnut Bayou Irrigation project	NRCS	ANRC	Walnut Bayou Irrigation District, Red River Compact Commission
Natural/Wild and Scenic Rivers (Cossatot River)	USFS, USACE Little Rock District	ANHC, Arkansas Department of Parks and Tourism	Volunteers, users

7.0 REFERENCES

ADEM. 2010. *All Hazard Mitigation Plan, State of Arkansas.* Little Rock: Arkansas Department of Emergency Management.

ADEQ. 2008. *2008 Integrated Water Quality Monitoring and Assessment Report.* Little Rock: ADEQ.

ADEQ. 2009. *Approved Arkansas 2008 Section 303(d) List.* Little Rock, AR: Arkansas Department of Environmental Quality, Water Division.

ADEQ. 2011. *Timeline of Historical Events of Arkansas Solid Waste Management, 1971 - 2011.* Little Rock: Arkansas Department of Environmental Quality.

ADEQ. 2012a. *2012 Integrated Water Quality Monitoring and Assessment Report.* Little Rock: Arkansas Department of Environmental Quality.

ADEQ. 2012b. *Arkansas TMDLs.* http://www.adeq.state.ar.us/water/tmdls/default.asp#Display (accessed April 12, 2013).

ADEQ. 2012c. *State of Arkansas Nutrient Criteria Development Plan.* Little Rock: Arkansas Department of Environmental Quality.

ADEQ. 2013a. *Solid Waste Illegal Dumps Data Files.* http://www.adeq.state.ar.us/solwaste/branch_enforcement/illegal_dumps.asp (accessed May 13, 2013).

ADEQ. 2013b. *Arkansas Hazardous Waste Generators Facility Summary.* http://www.adeq.state.ar.us/hazwaste/rcra2/facil_sum.aspx (accessed May 2013).

ADEQ. 2013c. *ADEQ Facility and Permit Summary.* http://www.adeq.state.ar.us/home/pdssql/pds.asp (accessed March 13, 2013).

ADEQ. 2013d. *NPDES Industrial Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/industrial/npdes_industrial_permit_tracking.asp (accessed July 10, 2013).

ADEQ. 2013e. *NPDES Construction Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/construction/npdes_constructionstormwater_permit_tracking.asp (accessed July 2, 2013).

ADEQ. 2013f. *NPDES MS4 Small Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/ms4/npdes_ms4_stormwater_permit_tracking.asp (accessed July 2, 2013).

ADEQ. 2013g. *Arkansas's Remedial Action Trust Fund.* http://www.adeq.state.ar.us/hazwaste/branch_tech/ratf.aspx#spl (accessed October 2013).

ADH. 2011. "Arkansas Marine Sanitation Program." *Marine Sanitation.* http://www.healthy.arkansas.gov/programsServices/environmentalHealth/MarineSanitation/Pages/MarineSanitation.aspx (accessed July 26, 2013).

ADH. 2012. "Arkansas Public Water System Compliance Summary." *Arkansas Department of Health, Environmental Health, Engineering, Reports and Forms.* http://www.healthy.arkansas.gov/programsServices/environmentalHealth/Engineering/Documents/Reports/Compliance/ComplianceSummary.pdf (accessed July 30, 2013).

ADH. n.d. *Drinking Water Information for Arkansans.* http://www.healthy.arkansas.gov/eng/autoupdates/pwslist0.htm (accessed March 20, 2013).

ADPCE. 1990. *Arkansas Water Quality Inventory Report 1990.* Little Rock: Arkansas Department of Pollution Control and Ecology.

Advameg, Inc. n.d. *Arkansas Economy.* http://www.city-data.com/states/Arkansas-Economy.html (accessed June 1, 2013).

AGFC. 2009. "Wildlife Management Area Boundary (polygon), Arkansas." *Geocommons.* http://geocommons.com/overlays/18197 (accessed April 25, 2013).

AGFC. 2011. *Wildlife Management Areas.* http://www.agfc.com/hunting/pages/wmalist.aspx (accessed March 22, 2013).

AGFC. 2013a. *General Fishing Regulations.* http://www.agfc.com/fishing/pages/fishingregulations.aspx (accessed September 18, 2013).

AGFC. 2013b. *The Great Outdoors, A $1.8 Billion Business in Arkansas.* brochure, Little Rock: Arkansas Game and Fish Commission.

AHTD. 2006. "Public Land Boundary (polygon)." *GeoStor.* http://www.geostor.arkansas.gov/G6/Home.html?q=public+land+boundary (accessed April 25, 2013).

Akridge, Scott. 2011. "Southwest Trail." *Encyclopedia of Arkansas History and Culture.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2305 (accessed July 16, 2013).

Albin, D.R. 1964. *Geology and Ground-water Resources of Bradley, Calhoun, and Ouachita Counties, Arkansas.* Water Supply Paper 1779-G, Little Rock: USGS.

Albin, D.R. 1965. *Water-resources Reconnaissance of the Ouachita Mountains, AR.* Water Supply Paper 1809-J, Little Rock: USGS.

Anderson, J.E. (ed.). 2006. *Arkansas Wildlife Action Plan.* Little Rock: Arkansas Game and Fish Commission.

ANHC. 2012. "River Designations." *The Encyclopedia of Arkansas History and Culture.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2623 (accessed October 2013).

ANHC. 2013. *Rare Species Search Engine: Find Arkansas Endangered Species.* http://www.naturalheritage.com/research-data/rarespecies-search.aspx (accessed July 2013).

ANRC. 1996. "The designation of the Sparta aquifer within Bradley, Calhoun, Columbia, Ouachita, and Union Counties as a Critical Ground Water Area." http://www.anrc.arkansas.gov/Rules%20and%20Regulations/orders/1995-1_designation_of_sparta_as%20cgwap.pdf (accessed May 31, 2013).

ANRC. 2005. *2006 - 2010 NPS Management Program Update.* Little Rock: ANRC.

ANRC. 2011a. *Water Law in Arkansas.* Little Rock: Arkansas Natural Resources Commission.

ANRC. 2011b. *2011 - 2016 Nonpoint Source Management Plan.* Little Rock, AR: ANRC.

ANRC. 2012. "Interagency Coordination Teams." *Arkansaswater.org.* http://arkansaswater.org/index.php?option=com_content&task=view&id=241 (accessed July 2013).

APCEC. 2011. *Regulation No. 2, Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas.* Little Rock: Arkansas Pollution Control and Ecology Commission.

Arkansas Department of Parks and Tourism. 2001. *Millwood State Park and Vicinity Bird Checklist.* pamphlet, Little Rock: Arkansas Department of Parks and Tourism.

Arkansas Department of Parks and Tourism. 2012. "2012 Annual Report." *Arkansas Tourism Official Site.* http://www.arkansas.com/!userfiles/editor/docs/apt-annual-report-financials-2012.pdf (accessed June 2013).

Arkansas Department of Parks and Tourism. 2013. *Arkansas Heritage Trail, Trail of Tears.* http://www.arkansasheritagetrails.com/tears/ (accessed April 30, 2013).

Arkansas Farm Bureau. 2012. *Arkansas Agricultural Profile.* Little Rock: Farm Bureau.

Arkansas Geological Survey. 2012. *Mineral Commodity Search/Map.* http://www.geology.ar.gov/minerals/mining_map.htm (accessed November 2013).

Arkansas Geological Survey. 2013. *Annual Report of Production 2012.* Little Rock: Arkansas Geological Survey.

Arkansas Water. 2013. *ArkansasWater.org.* http://arkansaswater.org/index.php?option=com_content&view=article&id=29&Itemid=2 (accessed June 25, 2013).

Arkansas Waterways Commission. 2013. "Exhibit M, Arkansas Waterways Commission Legislative Summary." *Arkansas Legislature.* http://www.arkleg.state.ar.us/assembly/2013/Meeting%20Attachments/440/I10444/Exhibit%20M%20-%20AR%20Waterways%20Cmsn.pdf (accessed May 16, 2013).

Arnold, Morris S. 1991. *Colonial Arkansas, 1686-1807: A Social and Cultural History.* Little Rock: University of Arkansas Press.

Arthur, J.K., and R.E. Taylor. 1990. *Definition of the Geohyrologic Framework and Preliminary Simulation of the Ground-water Flow in the Mississippi Embayment Aquifer System, Gulf Coastal Plain, United States.* Water Resources Investigation Report 86-4364, USGS.

Association of Arkansas Counties. 2013. *Association of Arkansas Counties.* http://www.arcounties.org/ (accessed October 16, 2013).

ASWCC. 1987a. *Arkansas State Water Plan, Upper Ouachita Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

ASWCC. 1987b. *Arkansas State Water Plan Lower Ouachita Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

ASWCC. 1988. *Arkansas State Water Plan Eastern Arkansas Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

ASWCC. 1990. *Arkansas Water Plan Executive Summary.* Little Rock: Arkansas Soil and Water Conservation Commission.

ASWCC. 1991. *Arkansas State Water Plan, Lakes of Arkansas.* Little Rock: Arkansas Soil and Water Conservation Commission.

Audubon Arkansas. n.d. *Audubon Arkansas IBA Site Descriptions.* http://ar.audubon.org/iba-site-descriptions (accessed April 2, 2013).

Baker, R.C., Hewitt, F. A., and Billingsley, G.A. 1948. Ground-water resources of the El Dorado Area, Union County, Arkansas: University of Arkansas Bulletin v. 42, no. 12, 39p.

Balogh, George W. 2013. "Timber Industry." *The Encyclopedia of Arkansas History and Culture*. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2143 (accessed July 23, 2013).

Bolton, S. Charles. 2012. "Louisiana Purchase through Early Statehood, 1803 through 1860." http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Boswell, E.H., E.M. Cushing, and E.L., Jeffery, H.G. Hosman. 1968. *Quaternary Aquifers in the MIssissippi Embayment.* Professional Paper 448-E, USGS.

Boswell, E.H., G.K. Moore, L.M. MacCary, H.G. Jeffery, and others. 1965. *Water Resources of the Mississippi Embayment; Cretaceous Aquifers in the Mississippi Embayment, with Discussions on Quality of the Water.* Professional Paper 448-C, Little Rock: USGS.

Boswell, E.H., and R.L. Hosman. 1964. *General Geology of the Mississippi Embayment.* Professional Paper 448-B, Little Rock: USGS.

Brandeis, Consuelo, Tony G. Johnson, Michael Howell, and James W. Bentley. 2011. *Arkansas' Timber Industry - An Assessment of Timber Product Output and Use, 2009.* Resource Bulletin SRS-183, Asheville: USDA Forest Service Southern Research Station.

Bridges, Kenneth. 2011. "Encyclopedia of Arkansas History and Culture." *Oil Industry*.. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=383 (accessed June 21, 2013).

Buckner, Ed. 2011. "Climate and Weather." *Encyclopedia of Arkansas History and Culture.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=4579 (accessed March 15, 2013).

Census State Data Center. 2013. *1990 Arkansas Census Data.* http://www.aiea.ualr.edu/arkansas-census-data.html?id=150:1990-arkansas-census-data&catid=1 (accessed May 31, 2013).

Clark, Brian R., and Rheannon M. Hart. 2009. *The Mississippi Embayment Regional Aquifer Study (MERAS): Documentation of a Groundwater-Flow Model Constructed to Assess Water Availability in the Mississippi Embayment. Scientific Investigations Report 2009-5172.* Reston, VA: US Geological Survey.

Clark, B.R., R.M. Hart, and J.J. Gurdak. 2011.*Groundwater availability of the Mississippi embayment.* Professional Paper 1785, US Geological Survey.

Clark, Patterson, and Laris Karklis. 2012. "USDA Upgrades Plant Hardiness Zone Map." *Washington Post.* http://www.washingtonpost.com/wp-srv/special/local/planthardinesszones/index.html (accessed March 2013).

Cole, E.F., and E.E. Morris. 1986. *Quality of Water Resources of the Ouachita National Forest, AR.* Water Resources Investigations Report 86-4166, Little Rock: USGS.

Cooperative Conservation America. n.d. *Cooperative Conservation Case Study, Arkansas Conservation Partnership.* http://www.cooperativeconservation.org/viewproject.asp?pid=103 (accessed July 29, 2013).

Cottingham, Jan. 2011. *Largest Forest Products Companies*. http://arkbiz.s3amazonaws.com/legacy/news/print_editions/ab_forest_products_companies_list_11.pdf (accessed October 2013).

Cottingham, Jan. 2012. *Arkansas' Bromine Industry Sees Rebound*. Arkansas Business.

DeBlack, Thomas A. 2012. *Civil War through Reconstruction, 1861 through 1874.* http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Department of Arkansas Heritage. 2013. *Discover Arkansas History, Regions - Gulf Coastal Plain.* http://www.arkansasheritage.com/discover/natural_environments/regions/coastalplain.aspx (accessed March 12, 2013).

Dollof, J.H., R.A. Rozendal, E.N. Siratovich, F.M. Jr. Swain, and J. Woncik. 1967. "Subsurface Upper Cretaceous stratigraphy of southwestern Arkansas." *Gulf Coast Association of Geological Survey Transactions 17*: 76-104.

Ducks Unlimited. n.d. *Conservation, Mississippi Alluvial Valley.* http://www.ducks.org/conservation/where-we-work/mississippi-alluvial-valley (accessed April 26, 2013).

Early, Anne M. 2011. "Pre-European Exploration, Prehistory through 1540.". http://www.encyclopediaofarkansas.net/ (accessed February 13, 2013).

EPA. 2008. *Handbook for Developing Watershed TMDLs.* Washington, DC: US Environmental Protection Agency.

EPA. 2009. *2009 edition of the drinking water standards and health advisories.* EPA 822-R-09-011, Washington D.C.: EPA Office of Water.

EPA. 2012a. *Landfills.* http://www.epa.gov/osw/nonhaz/municipal/landfill.htm (accessed June 3, 2013).

EPA. 2012b. *Large Quantity Generators.* http://www.epa.gov/osw/hazard/generation/lqg.htm (accessed July 9, 2013).

EPA. 2012c. *Small Quantity Generators.* http://www.epa.gov/osw/hazard/generation/sqg/index.htm (accessed July 9, 2013).

EPA. 2012d. *Operator Certification.* http://water.epa.gov/infrastructure/drinkingwater/pws/dwoperatorcert/basicinformation.cfm (accessed June 11, 2013).

EPA. 2013a *Western Ecology Division.* www.epa.gov/wed/pages/ecoregions.htm (accessed June 2013).

EPA. 2013b. *Nutrient Policy Data, What EPA is Doing.* http://www2.epa.gov/nutrient-policy-data/what-epa-doing (accessed July 12, 2013).

EPA. 2013c. *Compensatory Mitigation.* http://water.epa.gov/lawsregs/guidance/wetlands/wetlandsmitigation_index.cfm (accessed June 17, 2013).

EPA. 2013d. *Water: Consumer Confidence Report Rule Basic Information.* http://water.epa.gov/lawsregs/rulesregs/sdwa/ccr/basicinformation.cfm (accessed June 2013).

EPA. 2013e. "EPA Information Related to the American Recovery and Reinvestment Act of 2009." *EPA.* http://www.epa.gov/recovery/basic.html (accessed April 1, 2014).

EPA. n.d. *EPA Recovery Mapper.* http://epamap17.epa.gov/arra/# (accessed April 2014).

Fancher, G.H., and Mackay, D.K. 1946. Secondary Recovery Of Petroleum In Arkansas: A Report to the 56th General Assembly of the State of Arkansas under the auspices of the Arkansas Oil and Gas Commission, p. 245-250.

FEMA. 2009. *Miller County FIS.* Washington DC: FEMA.

Filipek, Steve, William E. Keith, and John Giese. 1987. "The Status of the Instream Flow Issue in Arkansas." *Proceedings Arkansas Academy of Science Vol. 41*, 1987: 43-48.

Foti, Thomas. 2008. *The Natural Divisions of Arkansas.* Little Rock: Arkansas Natural Heritage Commission.

Foti, Thomas. 2011. "Encyclopedia of Arkansas History and Culture, Ouachita Mountains." http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=442 (accessed March 12, 2013).

Fry, J., et al. 2011. "Completion of the 2006 national land cover database for the conterminous United States." *PE&RS, Vol.77(9)*: 858-864.

Galloway, JM, BE Haggard, MT Meyers, and WR Green. 2005. *Occurence of Pharmaceuticals and Other Organic Wastewater Constituents in Selected Streams in Northern Arkansas, Scientific Investigations Report 2005-5140.* Reston, Va: USGS.

GCGW. 2008. *Arkansas Governor's Commission on Globla Warning Final Report.* Little Rock: Arkansas Governor's Commission on Global Warming.

Gray, J. 1993. *Arkansas Forest History.* http://arkforests.org/foresthistory.html (accessed June 3, 2013).

Green, Brooks. 1986. "Irrigation expansion in Arkansas: A preliminary investigation." *Arkansas Historical Quarterly*: 261-268.

Halberg, H.N., C.T. Bryant, and M.S. Hines. 1968. *Water Resources of Grant and Hot Spring Counties, AR.* Water Supply Paper 1857, Little Rock: USGS.

Halberg, H.N., and Stephens, J.W. 1966. Use of water in Arkansas, 1965: State of Arkansas Geological Commission Water Resources Summary Number 5, 12 p.

Hale, H. 1926. City Water Supplies of Arkansas: University of Arkansas Engineering Experiment Station Bulletin No. 2, 100 p.

Hale, H., Baker, R.C., Walling, I.W., Parrish, D.M., Billingsley, G.A. 1947. Public Water Supplies of Arkansas: University of Arkansas Bulletin, Research Series No. 11, 104 p.

Haley, B.R., and Arkansas Geologic Commission Staff. 1993. *Geologic Map of Arkansas.* Little Rock: Arkansas Geological Survey.

Hart, Rheannon M., Brian R. Clark, and Susan E. Bolyard. 2008. *Digital Surfaces and Thicknesses of Selected Hydrogeologic Units within the Mississippi Embayment Regional Aquifer Study (MERAS). Scientific Investigations Report 2008-5098.* Reston, VA: US Geological Survey.

Hays, P.D., J.K. Lovelace, and T.B. Reed. 1998. *Simulated response to pumping stress in the Sparta aquifer of southeastern Arkansas and north-central Louisiana, 1998-2027.* Water-Resources Investigations Report 98-4121, USGS.

Hill, Julie. 2010. "Bromine." *Encyclopedia of Arkansas History and Culture*. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=4514 (accessed November 2013).

Hosman, R.L., A.T. Long, T.W. Lambert, H.G. Jeffery, and others. 1968. *Tertiary Aquifers in the Mississippi Embayment with Discussions of Quality of the Water by H.G. Jeffery.* Professional Paper 448-D, Little Rock: USGS.

Hosman, R.L., and J.S. Weiss. 1991. *Geohydric Units of the Mississippi Embayment and Texas Coastal Uplands Aquifer Systems, South-central United States.* Professional Paper 1416-B, Little Rock: USGS.

Interagency Wild and Scenic Rivers Council. n.d. *National Wild and Scenic Rivers Program Arkansas*. http://www.rivers.gov/arkansas.php (accessed October 2013).

Joseph, R.L. 1998. *Potentiometric Surfaces of Aquifers in the Cockfield Formation in Southeastern Arkansas and the Wilcox Group in Southern and Northeastern Arkansas, October 1966-July 1997.* Water Resources Investigation Report 98-4084, Little Rock: USGS.

Joseph, R.L. 2000. *Status of Water Levels and Selected Water-quality Conditions in the Sparta and Memphis Aquifers in Eastern and South-central Arkansas, 1999.* Scientific Investigations Report 200-4009, Little Rock: USGS.

Key, Joseph Patrick. 2012. "European Exploration and Settlement, 1951 through 1802." http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Kresse, T. M. et al. 2013. "Aquifers of Arkansas: protection, management, and hydrologic and geochemical characteristics of Arkansas' groundwater resources." *USGS In Review* (USGS)

Kresse, Timothy M., and Phillip D. Hays. 2009. *Geochemistry, Comparative Analysis, and Physical and Chemical Characteristics of the Thermal Waters East of Hot Springs National Park, Arkansas, 2006-09.* Scientific Investigations Report 2009-5263, Little Rock: 2009.

Lancaster, Guy. 2011. "Red River." *Encyclopedia of Arkansas History and Culture.*. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2650 (accessed July 16, 2013).

Lancaster, Guy. 2013. "Millwood Dam and Lake." *Encyclopedia of Arkansas History and Culture*. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=6036 (accessed July 16, 2013).

Lochmann, Steve. 2013. "Fish." *Encyclopedia of Arkansas History and Culture.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2097 (accessed September 18, 2013).

Lower Little River Watershed Coalition. 2004. *Lower Little River Watershed Restoration Action Strategy.* Ashdown: Lower Little River Watershed Coalition.

Ludwig, A.H. 1972. *Water Resources of Hempstead, Lafayette, Little River, Miller, and Nevada Counties, Arkansas.* Water Supply Paper 1998, USGS.

Ludwig, A.H. 1992. *Flow Duration and Low-flow Characteristics of Selected Arkansas Streams.* Water Resources Investigations Report 92-4026, Little Rock: US Geological Survey.

Mayfield, Walter. 2001. "Arkansas Mineral Resources (map)." Little Rock: Arkansas Geological Commission.

McLemore, Ken. 2013. "Commission Seeks to Stay Alive." *Hope Star*.

Moneyhon, Carl H. "Post-Reconstruction through the Gilded Age, 1875 through 1900." *The Encyclopedia of Arkansas History and Culture.* May 14, 2013. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=402 (accessed July 23, 2013).

Morrow, Lynn. n.d. "A "Duck and Goose Shambles": Sportsmen and market hunters at Big Lake, Arkansas." *Big Muddy.* http://www6.semo.edu/universitypress/bigmuddy/NF/A_Duck_and_Goose_Shambles.htm (accessed September 16, 2013).

National Agricultural Law Center. 2012. *United States Farm Bills.* http://www.nationalaglawcenter.org/farmbills/ (accessed June 11, 2013).

National Weather Service . 2013. "Climate Data." *National Weather Service Weather Forecast Office Little Rock AR.* http://www.srh.noaa.gov/lzk/?n=wxcntl3.htm (accessed June 12, 2013).

NatureServe. 2002. *States of the Union: Ranking America's Biodiversity.* Arlington: The Nature Conservancy.

NOAA. 2012. "The Palmer Drought Severity Index." *NOAA's Drought Information Center.* http://www.drought.noaa.gov/palmer.html (accessed June 12, 2013).

NOAA NCDC. 2013a. *Climate Data Online: Text and Map Search.* http://www.ncdc.noaa.gov/cdo-web/#t=secondTabLink (accessed May 2013).

NOAA NCDC. 2013b. *Historical Palmer Drought Indices.* http://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers.php (accessed May 15, 2013).

NOAA NCDC. 2013c. *Plot Time Series.* http://www.ncdc.noaa.gov/temp-and-precip/time-series/index.php (accessed June 2013).

NOAA NCDC. n.d. "Climate of Arkansas." *National Climatic Data Center.* http://hurricane.ncdc.noaa.gov/climatenormals/clim60/states/Clim_AR_01.pdf (accessed May 15, 2013).

North American Migration Flyways. http://www.birdnature.com/flyways.html (accessed October 2013).

NRCS. 2006. *Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin.* USDA Handbook 296, USDA.

NRCS. 2009. *Corps of Engineers - Vicksburg District, 159th Committee Meeting.* http://www.ar.nrcs.usda.gov/technical/coe_vicksburg_report_159th.html (accessed May 15, 2013).

NRCS. 2011. *Active Irrigation Projects.* http://www.ar.nrcs.usda.gov/programs/watersheds_irrigation_active.html (accessed June 18, 2013).

NRCS. 2012. "Arkansas Annual Report 2012." *NRCS Arkansas.* http://www.ar.nrcs.usda.gov/news/annual_report_2012.html (accessed July 15, 2013).

NRCS. 2013. *Arkansas NRCS Conservation Programs.* http://www.nrcs.usda.gov/wps/portal/nrcs/main/ar/programs/ (accessed September 17, 2013).

Oklahoma Water Resources Board. n.d. *Red River Compact Commission.* http://www.owrb.ok.gov/rrccommission/graphics/reach_2_5.jpg (accessed June 14, 2013).

Onellion, F.E., and J.H. Criner. 1955. *Ground-water Resources of Chicot County, Arkansas.* Water Resources Circular 3, Arkansas Geology and Conservation Commission.

Payne, N.J. 1975. *Geohydric Significance of Lithofacies of the Carrizo Sand of Arkansas, Louisiana, and Texas and the Meridian Sand of Mississippi.* USGS Professional Paper 569-D, USGS.

Payne, N.J. 1972. *Hydrology Significant of Lithofacies of the Cane River Formation or Equivalen of Arkansas, Louisiana, Mississippi, and Texas.* USGS Professional Paper 569-C, USGS.

Petersen, J.C., M.E. Broom, and W.V. Bush. 1985. *Geohydrologic Units of the Gulf Coastal Plain in Arkansas.* Water Resources Investitation Report 85-4116, USGS.

Plebuch, R.O., and M.S. and Hines. 1969. *Water Resources of Clark, Cleveland, and Dallas Counties, Arkansas.* Water-Supply Paper 1879-A, USGS.

PRISM Climate Group. 2004. Corvallis: Oregon State University.

Pugh, A.L., D.A. Westerman. 2014. *Mean Annual, Seasonal, and Monthly Precipitation and Runoff in Arkansas, 1951-2011.* US Geological Survey Scientific Investigations Report 2014-5006. Reston, VA: USGS.

Red River Compact Commission. 1978. "Red River Compact." Red River Compact Commission.

Red River Valley Association.2013. "FY 2014 Appropriations." *Red River Valley Association.* http://www.rrva.org/05082013/FY%202014%20Budget.pdf (accessed May 24, 2013).

Renken, Robert A. 1998. "Arkansas, Louisiana, Mississippi HA 730-F." In *Groundwater Atlas of the United States, HA 730,* by US Geological Survey. Reston, VA: US Geological Survey.

Robinson, Elton. 2009. "Groundwater running out?" *Delta Farm Press*.

Robison, Henry W., and Thomas M. Buchanan. 1988. *Fishes of Arkansas.* Fayetteville: University of Arkansas Press.

Schrader, T.P. 1998 *Status of Water Levels in Aquifers in the Nacatoch Sand and Tokio Formation of Southwestern Arkansas, 1996.* Water Resources Investigation Report 98-4130, Little Rock: USGS.

Schrader, T.P. 1999. *Status of Water Levels in Aquifers in the Nacatoch Sand of Southwestern and Northeastern Arkansas and the Tokio Formation of Southwestern Arkansas, 1999*. U.S. Geological Survey Water-Resources Investigations Report 99-4208-A. Little Rock: USGS.

Schrader, T. P. 2007. *Status of Water Levels in Aquifers in the Nacatoch Sand of Southwestern and Northeastern Arkansas and the Tokio Formation of Southwestern Arkansas, February 2005*. U.S. Geological Survey Scientific Investigations Report. 2007-5024. Little Rock: USGS.

Schrader, T.P., and J.M. Blackstock. 2010. *Water Levels in Aquifers in the Nacatoch Sand of Southwestern and Northeastern Arkansas and the Tokio Formation of Southwestern Arkansas, Spring 2008.* Scientific Investigations Report 2010-5238, Little Rock: USGS.

Schrader, T.P. and K.D. Rodgers. 2013. *Water levels in aquifers in the Nacatoch Sand of southwestern and northeastern Arkansas and the Tokio Formation of southwestern Arkansas-March 2011*. U.S. Geological Survey Scientific Investigations Report 2013-5130. Little Rock: USGS.

Schrader, T.P. and R. M. Scheiderer. 2004. *Status of water levels in aquifers in the Nacatoch Sand of southwestern and northeastern Arkansas and the Tokio Formation of southwestern Arkansas, 2002*. U.S. Geological Survey Water-Resources Investigations Report 2003-4284. Little Rock: USGS.

Scott, H. Don, James A. Ferguson, Linda Hanson, Todd Fugitt, and Earl Smith. 1998. *Agricultural Water Management in the Mississippi Delta Region of Arkansas. Research Bulletin 959.* Fayetteville: University of Arkansas.

Southwest Arkansas Planning and Development District. 2013. *Needs Assessment.* Magnolia: Southwest Arkansas Solid Waste Management District.

Spurgeon, John. 2010. "Freeman and Custis Red River Expedition." *The Encyclopedia of Arkansas History and Culture*. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=3541 (accessed November 22, 2013).

Stewart-Abernathy, Leslie. 2011. "Cherokee." http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Stone, C.G., and W.V. Bush. 1984. *General Geology and Mineral Resources of the Caddo River Watershed.* Information Circular 29, Little Rock: Arkansas Geological Commission.

Stroud, Hubert B. 2011. *The Encyclopeida of Arkansas History and Culture, West Gulf Coastal Plain*. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=443 (accessed March 20, 2013).

Tait, DB, RC Backer, and GA Billingsley. 1953. *The Ground-Water Resources of Columbia County, Arkansas - A Reconnaissance.* USGS Circular 241, USGS.

Terracon. 2013. *2013 Needs Assessment, Upper Southwest Regional Solid Waste Management District, Nashville, AR.* Nashville: Southwest Regional Solid Waste Management District.

Terry, J.E., C.T. Bryant, A.H. Ludwig, and J.E. Reed. 1986. *Water-Resources Appraisal of the South-Arkansas Lignite Area.* Information Circular 28-D, Little Rock: Arkansas Geological Commission.

Teske, Steven. 2011a. "Washington (Hempstead County)." *Encyclopedia of Arkansas History and Culture*. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=5606 (accessed July 16, 2013).

Teske, Steven. 2011b. "Nashville (Howard County)." *The Encyclopedia of Arkansas History and Culture.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=899 (accessed July 23, 2013).

Teske, Steven. 2013. "Dierks (Howard County)." *The Encyclopedia of Arkansas History and Culture*. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=897 (accessed July 23, 2013).

The Nature Conservancy. 2013a. *Arkansas Places We Protect.* http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/arkansas/placesweprotect/index.htm (accessed March 22, 2013).

The Nature Conservancy. 2013b. *Arkansas Blacklands Program.* http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/arkansas/placesweprotect/blacklands-program.xml (accessed September 12, 2013).

Trusley, Martha P. 2011 "Ashdown (Little River County)." *The Encyclopedia of Arkansas History and Culture.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=921 (accessed July 23, 2013).

U of A Divison of Agriculture. 2012. *Economic Contribution of Arkansas Agriculture.* Little Rock: University of Arkansas Division of Agriculture.

U of A Sam Walton College of Business. 2009. *Describing the Economic Impact of the Oil and Gas Industry in Arkansas.* Fayetteville: Univeristy of Arkansas.

University of Georgia Center for Invasive Species and Ecosystem Health. 2013. *Early Detection and Distribution Mapping System - Status of Invasive Plants in Arkansas.* http://www.eddmaps.org/tools/statereport.cfm?id=us_ar (accessed October 28, 2013).

US Census Bureau. 1956. *United States Census of Agriculture: 1954 Vol. 1, Counties and State Economic Areas, Part 23.* Washington, DC: US Government Printing Office.

US Census Bureau. 1989. *1987 Census of Agriculture Volume 1 Geographic Area Series Part 4 Arkansas State and County Data.* Washington, DC: US Government Printing Office.

US Census Bureau. 1993. "1992 Economic Census Area Profile, Arkansas." *Economic Census*. http://www.census.gov/epcd/www/92profiles/AR_92PRF.TXT (accessed May 29, 2013).

US Census Bureau. 2011a. "Urban Area Criteria for the 2010 Census." *Federal Register, 76 (164)*: 53033-53043.

US Census Bureau. 2011b. "EC0700A1-All Sectors, Geographic Area Series, Economy-Wide Key Statistics, 2007 Economic Census." *American Fact Finder.* http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_00A1&ProdType=table (accessed March 26, 2013).

US Census Bureau. 2012. *Arkansas 2010: Population and Housing Unit Counts.* Washington, DC: US Department of Commerce.

US Census Bureau. n.d.a. "DP05 ACS Demographic and Housing Estimates 2007-2011 American Community Survey 5-year Estimates." *American FactFinder.*

http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_11_5YR_DP05&prodType=table (accessed March 2013).

US Census Bureau. n.d.b. *DP03 - Selected Economic Characteristics, 2007-2011 American Community Survey 5-year Estimates.* http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_11_5YR_DP03 (accessed March 18, 2013).

US Congress. 1992. "Clean Vessel Act of 1992." *Digest of Federal Laws of Interest to the U.S. Fish and Wildlife Service.* http://www.fws.gov/laws/lawsdigest/clenves.html (accessed July 12, 2013).

US Government. 2004. "Walnut Bayou Irrigation Project in the Red River Watershed." *Federal Register Volume 69, Number 107*: 31343-31344.

USACE. 2011. *Value to the Nation State Level Report - Arkansas.* http://www.corpsresults.us/recreation/fastfacts/stateReport.cfml?State=12 (accessed October 2013).

USACE. 2013. *RIBITS (Regulatory In-lieu Fee and Bank Information Tracking System).* https://rsgisias.crrel.usace.army.mil/ribits/f?p=107:158:607386398458358::NO:RP:P27_BUTTON_KEY:1 (accessed October 22, 2013).

USACE Little Rock District. 2013. *Recreation.* http://www.swl.usace.army.mil/Missions/Recreation.aspx (accessed July 16, 2013).

USACE Vicksburg District. 2013. *Arkansas Project Status.* Vicksburg: USACE.

USDA National Agricultural Statistics Service. 2009. *2007 Census of Agriculture Arkansas State and County Data Volume 1 Geographic Area Series Part 4.* Washington DC: USDA.

USDA National Agricultural Statistics Service. 2013. *Publications.* http://www.agcensus.usda.gov/Publications/index.php (accessed November 25, 2013).

USDA Soil Conservation Service. 1987a. *Arkansas State Water Plan, Red River Basin Above Fulton.* Little Rock: Arkansas Soil and Water Conservation Commission.

USDA Soil Conservation Service. 1987b. *Arkansas State Water Plan, Red River Basin Below Fulton.* Little Rock: Arkansas Soil and Water Conservation Commission.

USFS. 2013. *Forest Inventory Data Online (FIDO).* http://apps.fs.fed.us/fia/fido/index.html (accessed September 13, 2013).

USFWS. 2013. *Endangered Species Act: Overview.* http://www.fws.gov/endangered/laws-policies/index.html (accessed March 13, 2013).

USFWS. n.d. "Pond Creek National Wildlife Refuge." US Fish and Wildlife Service.

USFWS, US Census Bureau. 1993. *1991 National Survey of Fishing, Hunting, and Wildlife-associated Recreation, Arkansas.* Washington, DC: US Government Printing Office.

USFWS, US Census Bureau. 2013. *2011 National Survey of Hunting, Fishing, and Wildlife-associated Recreation - Arkansas.* Washington, DC: US Fish and Wildlife Service.

USGS. 2013a. *2009 Minerals Yearbook Arkansas [Advanced Release]*. Reston: US Geological Survey.

USGS. 2013b. *USGS Water Quality Data for Arkansas.* http://waterdata.usgs.gov/ar/nwis/qw (accessed July 25, 2013).

USGS. 2013c. *NAS - Nonindigenous Aquatic Species Database Search.* http://nas.er.usgs.gov/queries/ (accessed October 2013).

USGS. n.d. *Arkansas Online Reports.* http://ar.water.usgs.gov/data-bin/publications (accessed December 2013).

Veatch, A.C. 1906. *Geology and Underground Water Resources of Northern Louisiana and Southern Arkansas.* Professional Paper 46, Little Rock: USGS.

Woods, Alan J, et al. 2004. *Ecoregions of Arkansas (color poster with map, descriptive text, summary tables, and photographs).* Reston, VA: US Geological Survey.

Zachary, D.L., K.F. Steele, L.J. Wood, and D.H. Johnston. 1986. *Stratigraphy and Hydrology of Upper Cretaceous and Tertiary Strata, Columbia and Union Counties, Arkansas.* Fayetteville: University of Arkansas.

APPENDIX A

2008 303(d) List of Impaired Waterbodies in the SAWRPR

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
1A – Dorcheat Bayou and Bodcau Bayou	197.5	197.5	Fish consumption	50.6	mercury	50.6	unknown
			Aquatic life	109.2	DO	11.7	Unknown
					Copper	28.4	Unknown
					Lead	74.2	Unknown, industrial point source
					pH	79	Unknown
					Sediment/siltation	48.7	Erosion
					Zinc	28.4	Unknown
			Agriculture & industrial water supply	20.3	Sulfate & TDS	20.3	Unknown
			Total	109.2			
1B – Red River, Sulphur River, and McKinney Bayou	389.6	340.1	Aquatic life	38.3	Sediment/siltation	38.3	Unknown, erosion
					Temperature	22.8	Unknown
			Drinking water supply	11	Nitrate	11	Municipal WWTP
			Agriculture & industrial water supply	209.4	Chloride	149.2	Unknown
					Sulfate	178.7	Unknown
					TDS	209.4	Unknown
			Total	243.2			
1C – Little River & tributaries	401.3	376.6	Aquatic life	88.6	Copper	14.1	Industrial point source
					DO	16.6	Unknown
					Sulfate	1.3	Industrial point source
					Zinc	7.5	Industrial point source
					Lead	23.5	Unknown

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
					Nitrate	12.8	Industrial point source
					Total phosphorus	12.8	Industrial point source
					TDS	12.2	unknown
			Primary contact	40.1	Pathogens	40.1	Unknown
			Drinking water supply	17.3	Nitrate	17.3	Municipal WWTP
			Agriculture & industrial water supply	12.7	Sulfate	12.7	Unknown
			Total	128.7			
1D – Mountain Fork & tributaries	60.9	47.3	Aquatic life	11	Temperature	11	Unknown