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Arkansas WATERplan
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ARKANSAS WATER PLAN UPDATE
TASK NO. 6 - SOUTHWEST ARKANSAS WATER RESOURCES PLANNING REGION

AUGUST 11, 2014

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Prepared for

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TABLE OF CONTENTS

1.0 INTRODUCTION 1-1
2.0 GEOGRAPHY AND HISTORY 2-1
2.1 Geography 2-1
2.2 History 2-3
2.2.1 Cultural 2-3
2.2.2 Water Resources Development 2-5
3.0 PHYSICAL CHARACTERISTICS 3-1
3.1 Physiography 3-1
3.1.1 West Gulf Coastal Plain Province 3-1
3.1.2 Ouachita Mountain Province 3-3
3.2 Geologic Setting 3-4
3.2.1 Geology of the West Gulf Coastal Plain Province 3-4
3.2.2 Geology of the Ouachita Mountain Province 3-6
3.3 Ecoregions 3-7
3.4 Aquatic Biodiversity 3-11
3.5 Climate 3-11
3.5.1 Temperature 3-11
3.5.2 Precipitation 3-17
3.5.3 Evaporation 3-21
3.5.4 Drought 3-21
3.5.5 Climate Variability 3-23
3.6 Land Use 3-26
3.6.1 Forest 3-26
3.6.2 Agriculture 3-29
3.6.3 Wetlands 3-30
3.6.4 Public Land 3-32
3.7 Surface Water 3-32

TABLE OF CONTENTS (CONTINUED)

3.7.1 Rivers and Streams 3-33
3.7.2 Lakes and Impoundments 3-38
3.7.3 Wetlands 3-39
3.7.4 Surface Water Quality 3-39
3.8 Groundwater 3-40
3.8.1 Aquifers 3-40
3.8.2 Ground Water Quality 3-52
3.9 Groundwater-Surface Water Connections 3-56
4.0 SOCIO-ECONOMIC CHARACTERISTICS 4-1
4.1 Demographics 4-1
4.1.1 2010 Population 4-1
4.1.2 Changes from 1990 4-5
4.2 Income and Employment 4-6
4.2.1 Current Income and Employment Levels 4-6
4.2.2 Changes in Income and Employment from 1990 4-7
4.3 Economic Drivers 4-8
4.3.1 Current Regional Economic Drivers 4-8
4.3.2 Comparison to 1990 Regional Economy 4-16
4.4 Waste Generation and Disposal 4-19
4.4.1 Solid Waste 4-19
4.4.2 Hazardous Waste 4-20
4.4.3 Wastewater and Stormwater 4-21
5.0 WATER RESOURCES ISSUES 5-1
5.1 Flooding 5-1
5.2 Red River Waterborne Transportation 5-1
5.3 Water Supply 5-2
5.3.1 Monitoring 5-2
5.3.2 Red River Alluvial Aquifer 5-3

TABLE OF CONTENTS (CONTINUED)

5.3.3 Sparta Aquifer ..... **Error! Bookmark not defined.**
5.3.4 Cane River Aquifer 5-5
5.3.5 Carrizo Aquifer 5-5
5.3.6 Wilcox Aquifer 5-6
5.3.7 Nacatoch Aquifer 5-6
5.3.8 Ozan Aquifer 5-8
5.3.9 Tokio Aquifer 5-8
5.3.10 Trinity Aquifer 5-9
5.3.11 Critical Groundwater Areas 5-10
5.4 Water Quality Issues 5-12
5.4.1 Water Quality Monitoring 5-12
5.4.2 Non-attainment of Surface Water Quality Standards 5-18
5.4.3 Nutrient Surplus Area 5-24
5.4.4 Non-attainment of Drinking Water Quality Standards and Water Quality Guidelines by Groundwater 5-25
5.4.5 Fish Consumption Advisories 5-26
5.4.6 Nonpoint Source Pollution 5-27
5.4.7 Contaminants of Emerging Concern 5-27
5.5 Water Infrastructure 5-29
5.6 Loss of Aquatic Biodiversity 5-29
6.0 INSTITUTIONAL AND REGULATORY SETTING 6-1
6.1 Legal Framework 6-1
6.1.1 Federal Laws and Regulatory Programs 6-1
6.1.2 Federal Laws and Assistance Programs 6-10
6.1.3 State Laws and Regulatory Programs 6-16
6.1.4 State Financial Assistance Programs 6-29
6.1.5 Non-regulatory State Water Management Programs 6-33
6.1.6 Local Regulations 6-34

TABLE OF CONTENTS (CONTINUED)

6.1.7 Non-regulatory Regional Water Resources Management 6-34
6.1.8 Interstate Compacts 6-35
6.2 Institutional Framework 6-38
6.2.1 Federal Agencies 6-38
6.2.2 Arkansas Agencies 6-40
6.2.3 Federal-state Organizations 6-43
6.2.4 Regional and Local Entities 6-44
6.2.5 Nonprofit Organizations 6-45
6.2.6 Institutional Interactions in Water Resources Management 6-46
7.0 REFERENCES 7-1

LIST OF APPENDICES

APPENDIX A: 2008 303(d) List of Impaired Streams in the SAWRPR

LIST OF FIGURES

Figure 2.1. Map of the SAWRPR 2-2
Figure 2.2. Irrigated cropland in the SAWRPR 2-8

Figure 3.1. Physiographic regions within the SAWRPR 3-2
Figure 3.2. Surface geology of the SAWRPR 3-5
Figure 3.3. Ecoregions of the SAWRPR 3-8
Figure 3.4 Species of greatest conservation need found in the SAWRPR 3-12
Figure 3.5 Endemic species of the SAWRPR 3-13
Figure 3.6. Designated ecologically sensitive waterways within the SAWRPR 3-14

TABLE OF CONTENTS (CONTINUED)

Figure 3.7. Arkansas climate divisions 3-15

Figure 3.8. Average monthly maximum and minimum temperatures for the SAWRPR 3-16

Figure 3.9. Average annual maximum temperatures across the SAWRPR 3-18

Figure 3.10. Average annual precipitation in the SAWRPR 3-19

Figure 3.11. Average precipitation compared to average potential evapotranspiration in the SAWRPR 3-20

Figure 3.12. Historical values of the Palmer Drought Severity Index for climate division 7 3-22

Figure 3.13. Historical average temperatures for the SAWRPR 3-24

Figure 3.14. Historical annual precipitation totals for the SAWRPR 3-25

Figure 3.15. Summary of 2006 land use in the SAWRPR 3-27

Figure 3.16. Land use map of the SAWRPR 3-28

Figure 3.17. Average annual surface runoff in the SAWRPR, 1951-2011 3-34

Figure 3.18. Average monthly flows reported at USGS gauging stations on selected unregulated streams of the SAWRPR 3-35

Figure 3.19. Average monthly flows reported at USGS gauging station on Red River at Spring Bank, AR 3-36

Figure 3.20. Locations of the USGS gauging stations for data in Figure 3.15 3-37

Figure 3.21. Aquifers of the SAWRPR 3-42

Figure 4.1. 2010 county population in the SAWRPR 4-3

Figure 4.2. 2010 population centers in the SAWRPR 4-4

Figure 4.3. Value of sales and receipts in the SAWRPR 4-9

Figure 4.4. Employment by industrial sectors in the SAWRPR 4-10

Figure 4.5 Outstand resource waters within the SAWRPR 4-13

Figure 5.1. Location of critical groundwater area designated within the SAWRPR 5-11

Figure 5.2. Routine surface water quality monitoring sites in the SAWRPR 5-14

Figure 5.3. Routine groundwater quality monitoring wells in the SAWRPR 5-16

TABLE OF CONTENTS (CONTINUED)

Figure 5.4. Waterbodies in the SAWRPR classified as impaired due to low dissolved oxygen or nitrate in the 2008 303(d) list 5-19

Figure 5.5. Waterbodies in the SAWRPR classified as impaired due to siltation/turbidity in the 2008 303(d) list 5-20

Figure 5.6. Waterbodies in the SAWRPR classified as impaired due to minerals in the 2008 303(d) list 5-21

Figure 5.7. Waterbodies in the SAWRPR classified as impaired due to pathogens, temperature, metals, or pH in the 2008 303(d) list 5-22

Figure 5.8. Locations of active fish consumption advisories in the SAWRPR 5-28

Figure 5.9 Numbers of crayfish Species of Greatest Conservation Need (SGCN) in watersheds of the SAWRPR 5-30

Figure 5.10 Numbers of fish SGCN in watersheds of the SAWRPR 5-31

Figure 5.11 Numbers of mussel SGCN in the watersheds of the SAWRPR 5-32

Figure 5.12 Total numbers of crayfish, fish, and mussel SGCN in the watersheds of the SAWRPR 5-33

Figure 6.1. Status of flood hazard mapping in the SAWRPR 6-9

Figure 6.2. ADEQ water quality planning segments included in the SAWRPR 6-27

Figure 6.3. Red River Compact boundaries in the SAWRPR 6-36

LIST OF TABLES

Table 2.1. Counties in the SAWRPR 2-1

Table 2.3 History of wild/natural and scenic rives in the SAWRPR 2-9

Table 2.2 History of WMAs in the SAWRPR 2-10

Table 3.1. Characteristics of ecoregions within the SAWRPR 3-9

Table 3.2. Forest land comparison for the SAWRPR 3-26

Table 3.3. Agricultural land comparison for the SAWRPR 3-29

TABLE OF CONTENTS (CONTINUED)

Table 3.4. Acreage for major crops for counties along the Red River 3-31
Table 3.5. Public lands in the SAWRPR 3-32
Table 3.6. Summary of lakes and impoundments in the SAWRPR 3-38
Table 3.7. Information for significant publicly owned lakes in the SAWRPR 3-39
Table 3.8. Nomenclature, geologic age, and use for aquifers in the SAWRPR 3-41

Table 4.1. 2010 county populations in the SAWRPR..... 4-2
Table 4.2. Demographic summary for counties in the SAWRPR 4-5
Table 4.3. Additional demographic characteristics of counties in the SAWRPR..... 4-5
Table 4.4. Income and employment characteristics for counties in the SAWRPR 4-6
Table 4.5. Value of agricultural sales in the counties of the SAWRPR 4-11
Table 4.6. 2012 Tourism revenues..... 4-14
Table 4.8. Economic benefits from USACE reservoirs in the SAWRPR in 2010 4-15
Table 4.7. Economic contributions from wildlife recreation in Arkansas 4-15
Table 4.9. 2012 oil, gas, and brine production in counties of the SAWRPR..... 4-16
Table 4.10. Livestock inventories for the counties of the SAWRPR 4-18
Table 4.11 2012 solid waste generation and disposal information for RSWMDs in the SAWRPR 4-20
Table 4.12. Permitted hazardous waste generators in counties within the SAWRPR 4-21
Table 4.13. NPDES permitted discharges in the SAWRPR 4-22
Table 4.14. Numbers of NPDES wastewater permits reported for the SAWRPR in 1990 and 2013..... 4-22

Table 5.1. Summary of impaired waters in the SAWRPR..... 5-18
Table 5.2. TMDLs for waterbodies in SAWRPR 5-23
Table 5.3. Fish consumption advisories in the SAWRPR 5-26
Table 5.4. Federally designated threatened and endangered species occurring in aquatic and semi-aquatic habitats in SAWRPR..... 5-34
Table 5.5. State designated threatened and endangered plant species occurring in semi-aquatic habitats in the SAWRPR 5-35

TABLE OF CONTENTS (CONTINUED)

Table 5.7. Exotic aquatic plant species present in the SAWRPR 5-35

Table 5.6. Exotic aquatic animal species present in the SAWRPR 5-36

Table 6.1 Federal laws and regulatory programs that address SAWRPR water quality 6-2

Table 6.2 Federal laws and regulatory programs that address aspects of SAWRPR water resources other than water quality 6-5

Table 6.3. Mitigation banks within, and serving, the SAWRPR 6-7

Table 6.4 Federal laws and assistance programs that affect the EAWRPR water quality 6-11

Table 6.5 NRCS conservation programs summary for 2012 6-12

Table 6.6. Federal assistance programs for aspects of SAWRPR water resources other than water quality 6-14

Table 6.7. WRDA projects in the SAWRPR initiated after 1990 6-16

Table 6.8 State regulations related to water use in the SAWRPR 6-17

Table 6.9. State regulations that protect water quality within the SAWRPR 6-20

Table 6.10 State designated uses for surface waters in the SAWRPR 6-24

Table 6.11 Temperature and turbidity numeric criteria that apply in the SAWRPR 6-25

Table 6.12 Dissolved oxygen numeric water quality criteria that apply in the SAWRPR 6-25

Table 6.13 Numeric water quality criteria for minerals that apply in the SAWRPR 6-25

Table 6.14 State regulations relating to water management within the SAWRPR 6-28

Table 6.15 Federal assistance programs ministered by ANRC for public drinking water and wastewater systems within the SAWRPR 6-30

Table 6.16 State financial assistance programs for public drinking water and wastewater systems within the SAWRPR 6-30

Table 6.17 State incentive and assistance programs that protect water quality within the SAWRPR 6-31

Table 6.18 Summary of Red River Compact allocations that apply in the SAWRPR 6-37

Table 6.19 Federal agencies with water resources-related responsibilities in the SAWRPR 6-39

TABLE OF CONTENTS (CONTINUED)

Table 6.20 Arkansas agencies and entities with responsibilities in the SAWRPR related to water resources 6-41

Table 6.21 Some of the regional and local government entities involved in water resources management in the SAWRPR 6-44

Table 6.22 Nonprofit organizations involved in water resources management in the SAWRPR 6-45

Table 6.23 Examples of interactions of federal, state, and local entities in water resources management within the SAWRPR 6-46

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**	

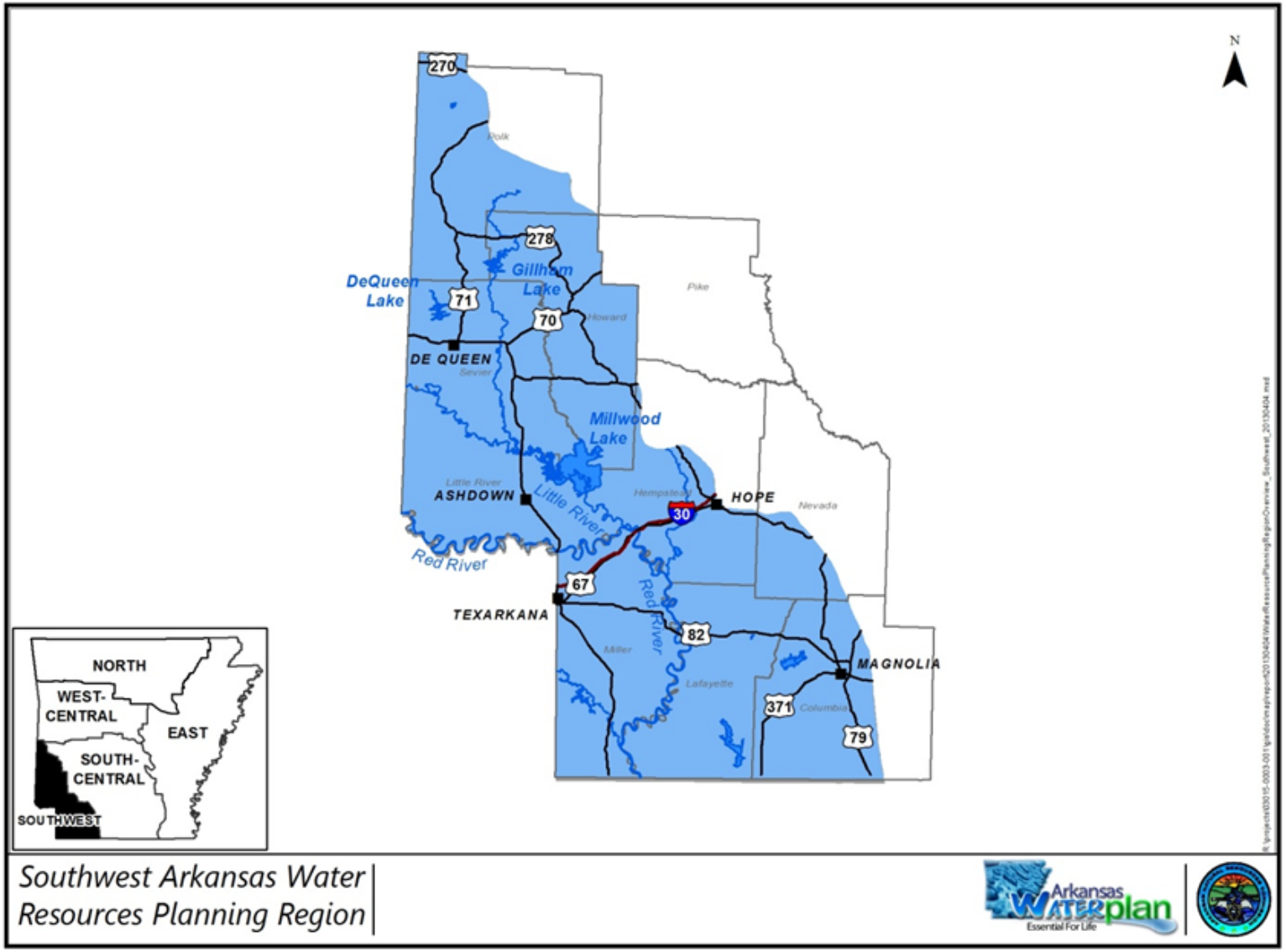

Figure 2.1. Map of the SAWRPR.

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).

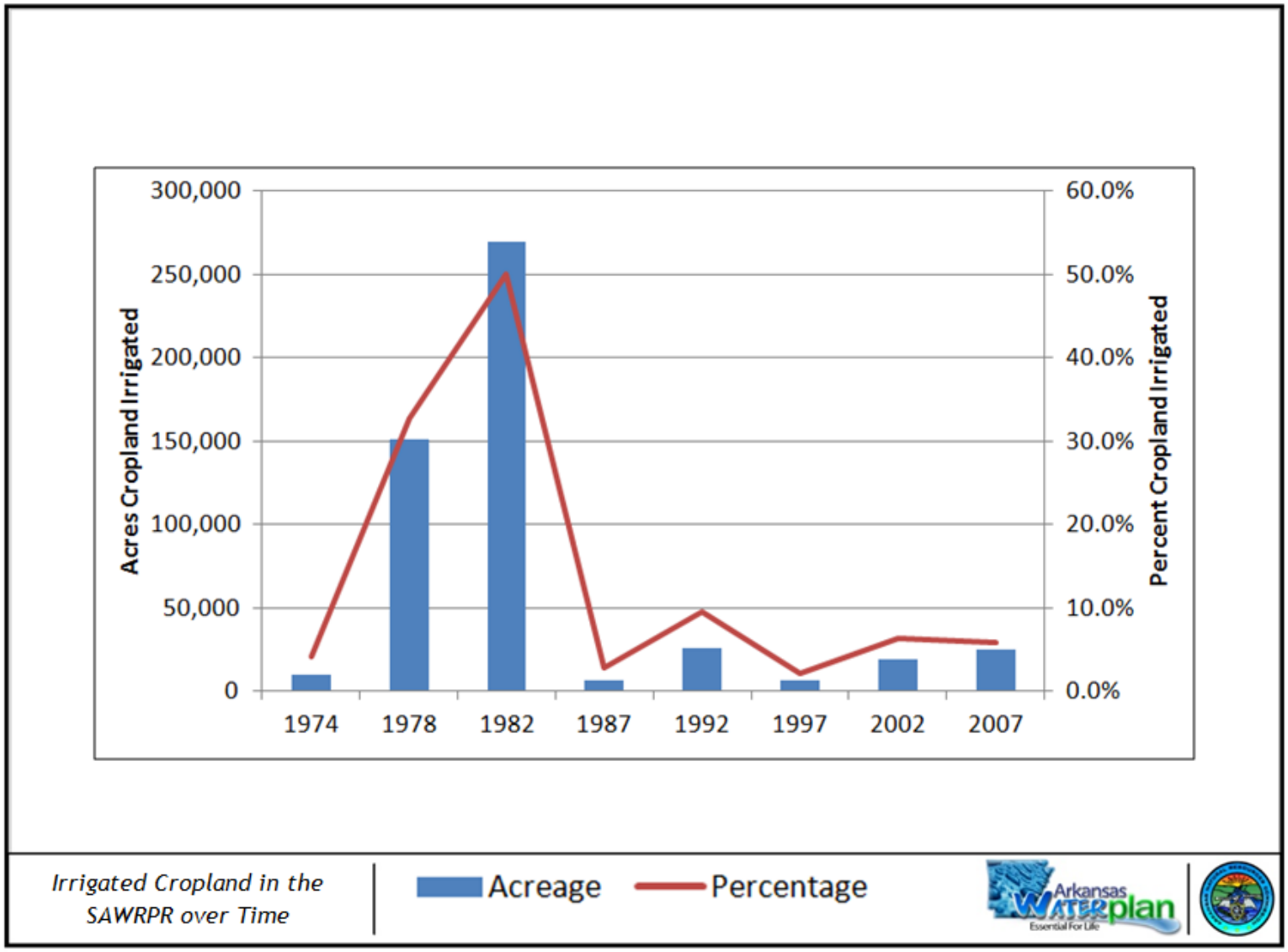

Figure 2.2. Irrigated cropland in the SAWRPR over time (USDA National Agricultural Statistics Service 2013).

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).

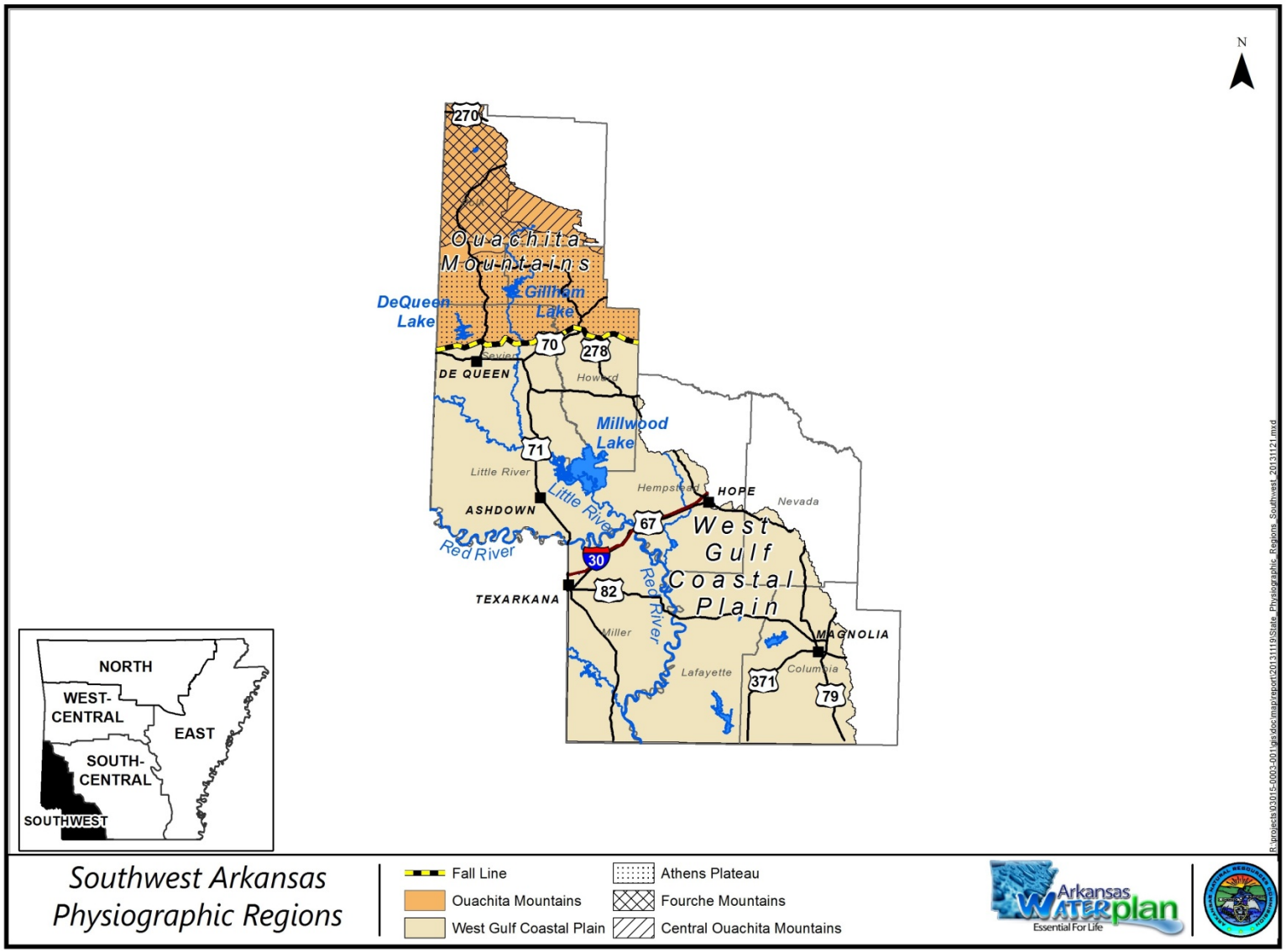

Figure 3.1. Physiographic regions within the SAWRPR.

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).

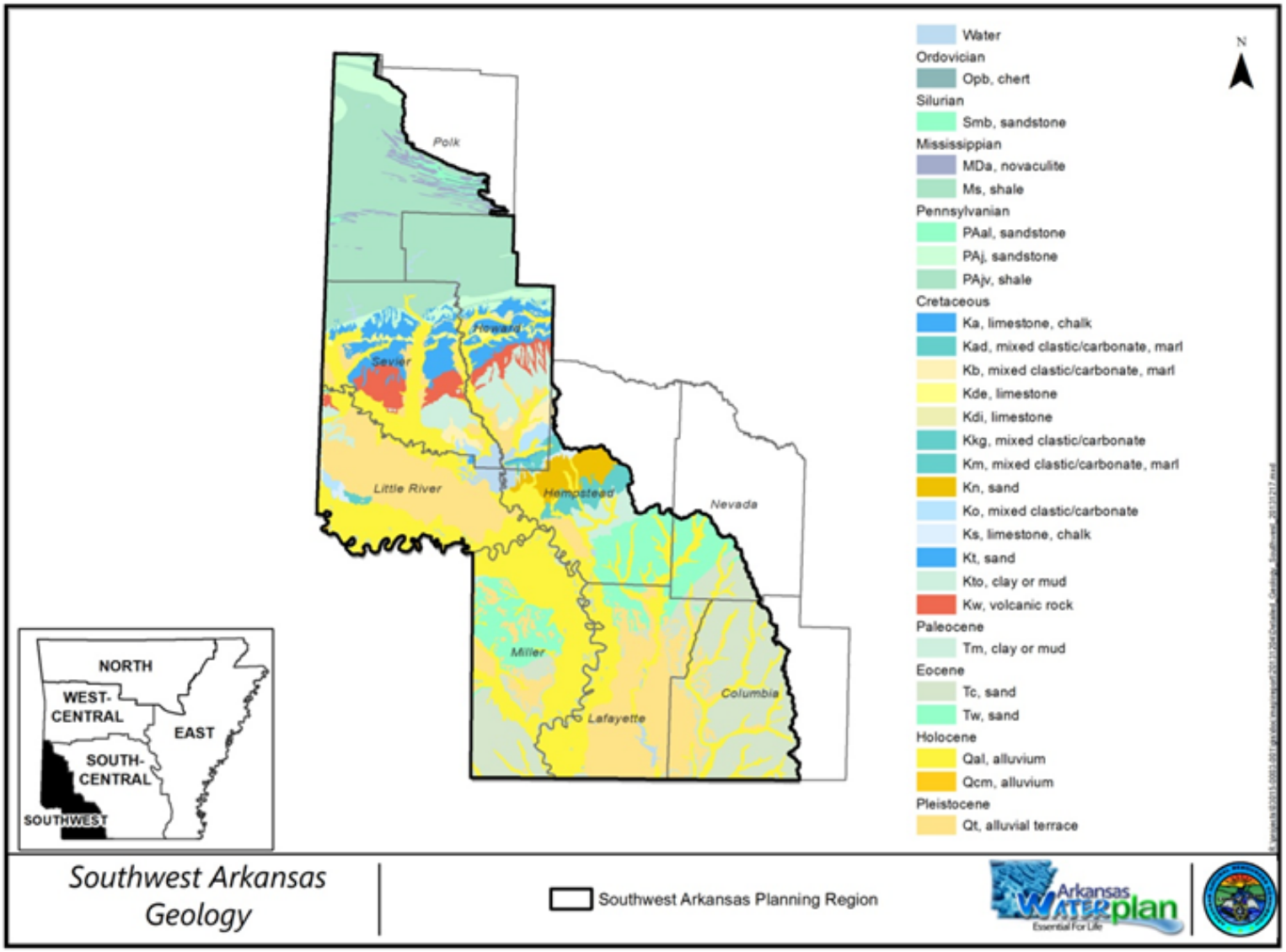

Figure 3.2. Surface geology of the SAWRPR (Haley et al 1993).

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

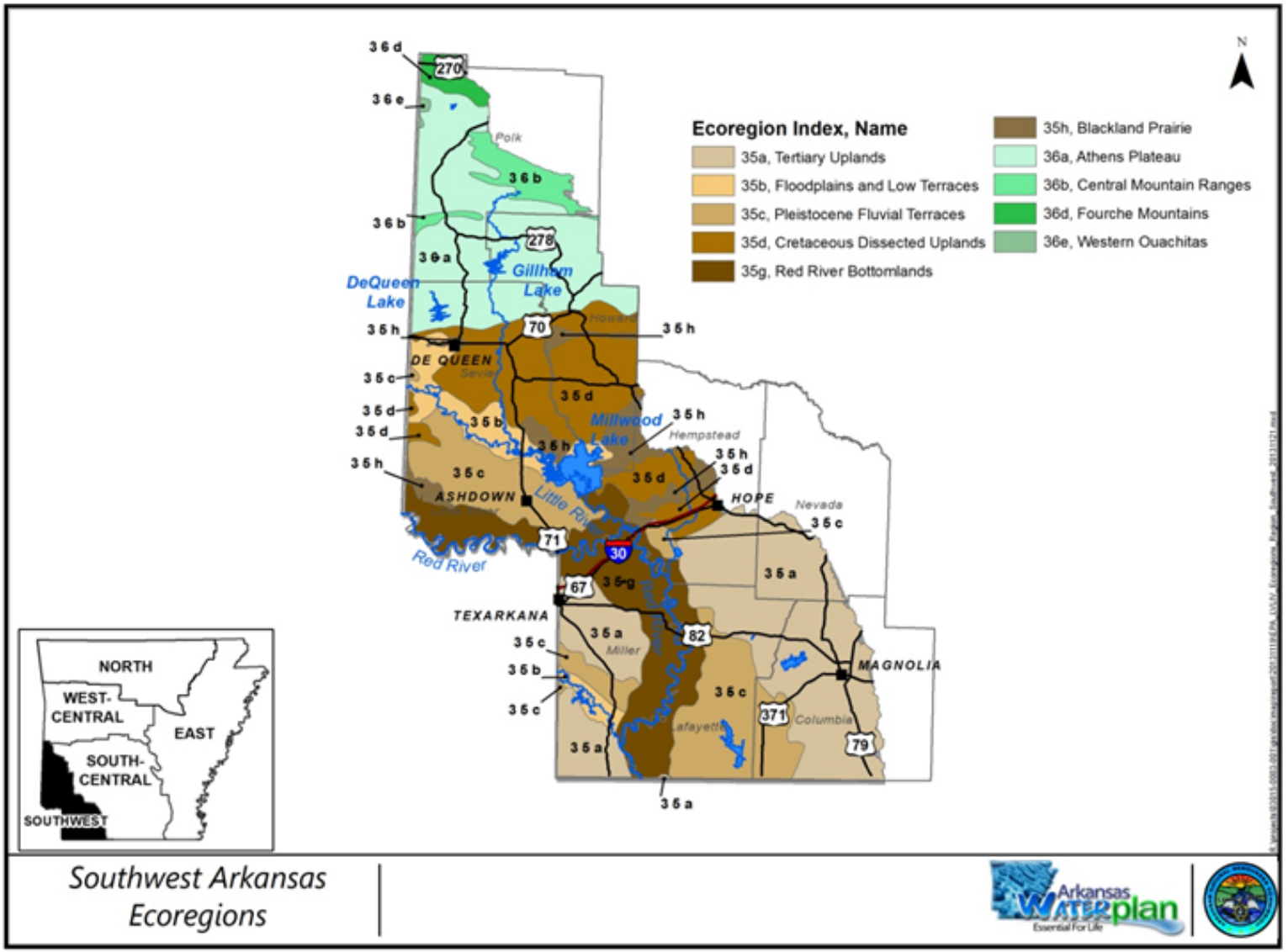

Figure 3.3. Ecoregions of the SAWRPR (Woods et al 2004).

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.

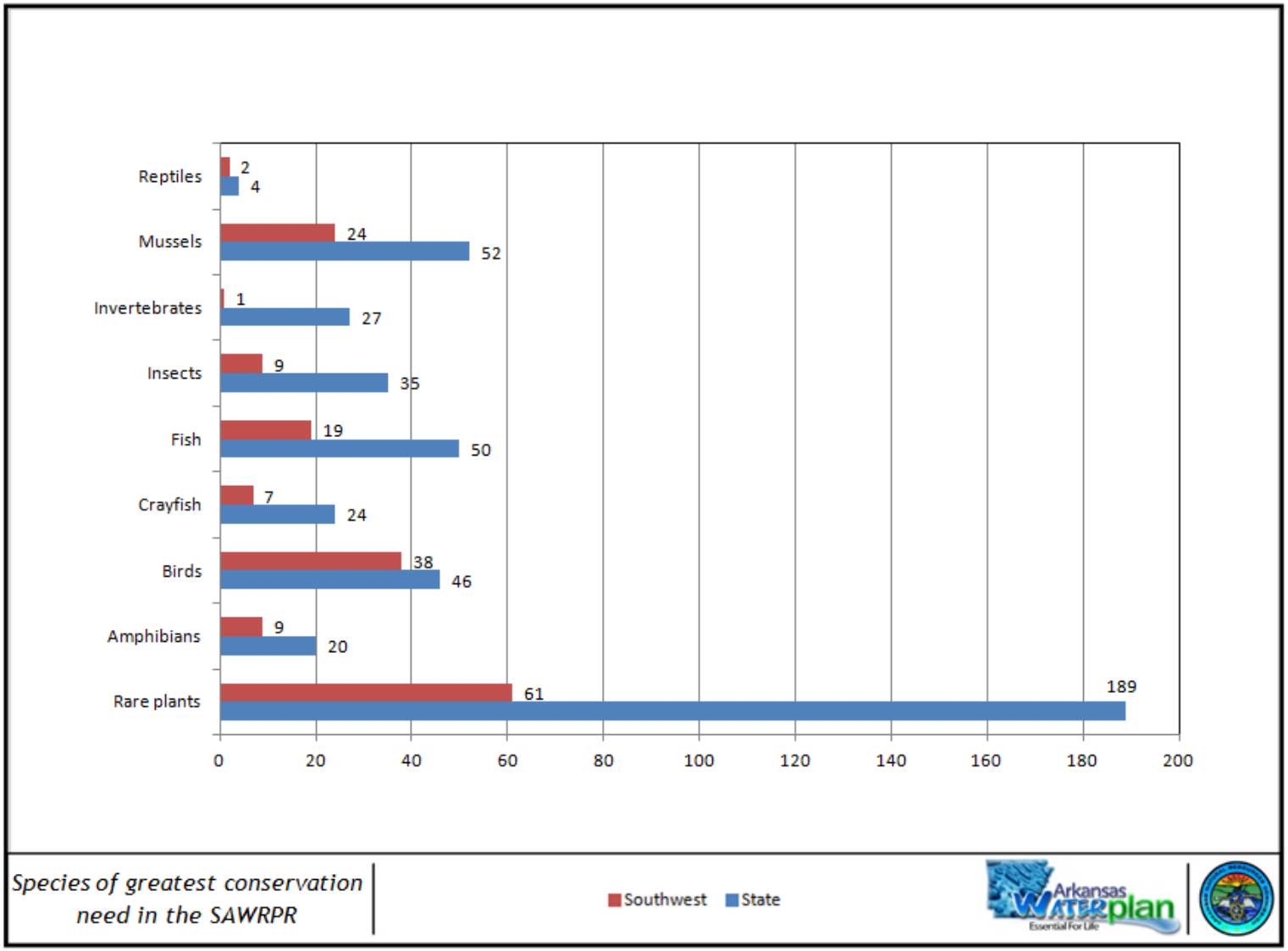

Figure 3.4. Species of greatest conservation need found in the SAWRPR (J. Anderson 2006, ANHC 2013).

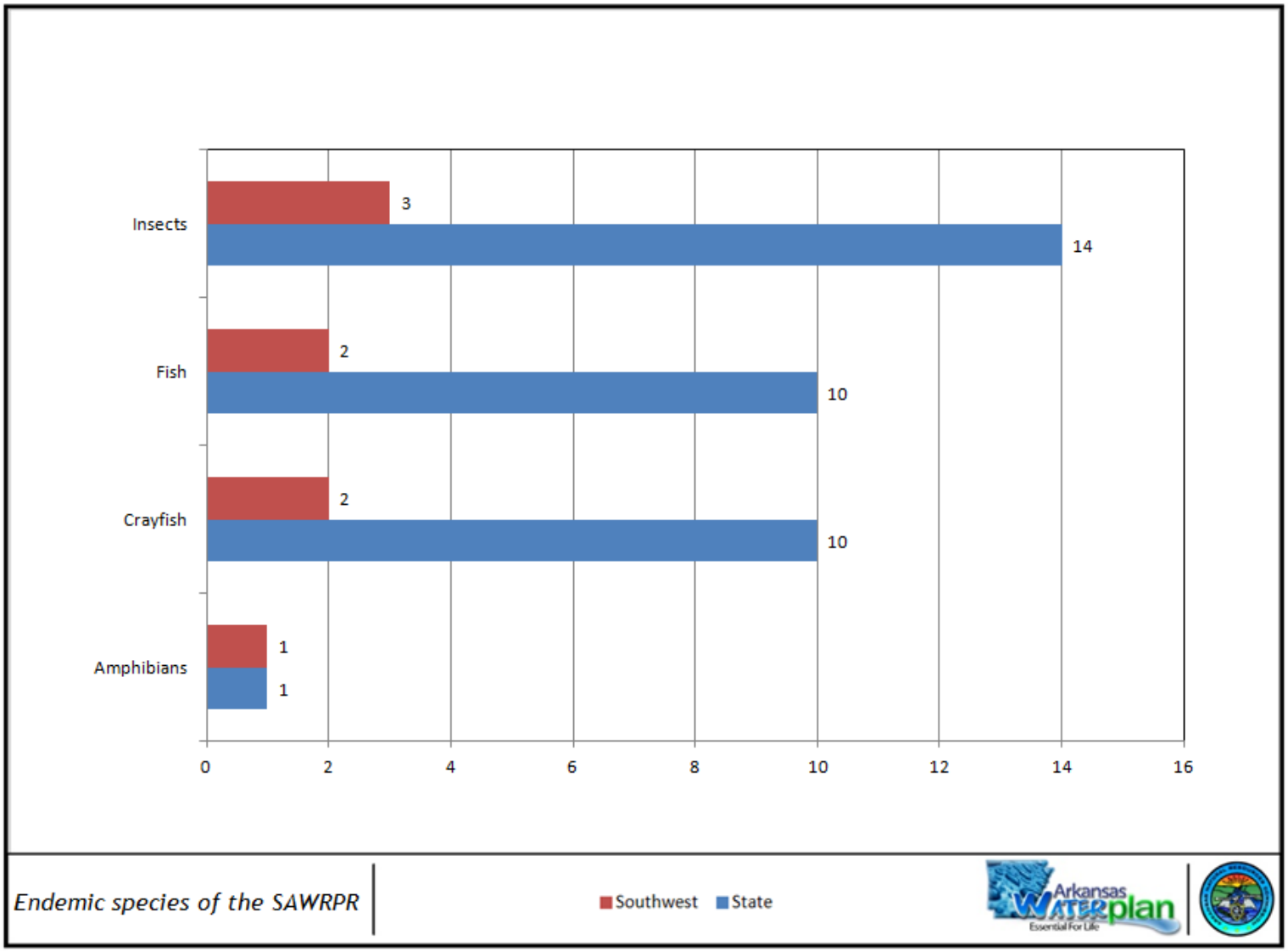

Figure 3.5. Endemic species of the SAWRPR (Anderson 2006).

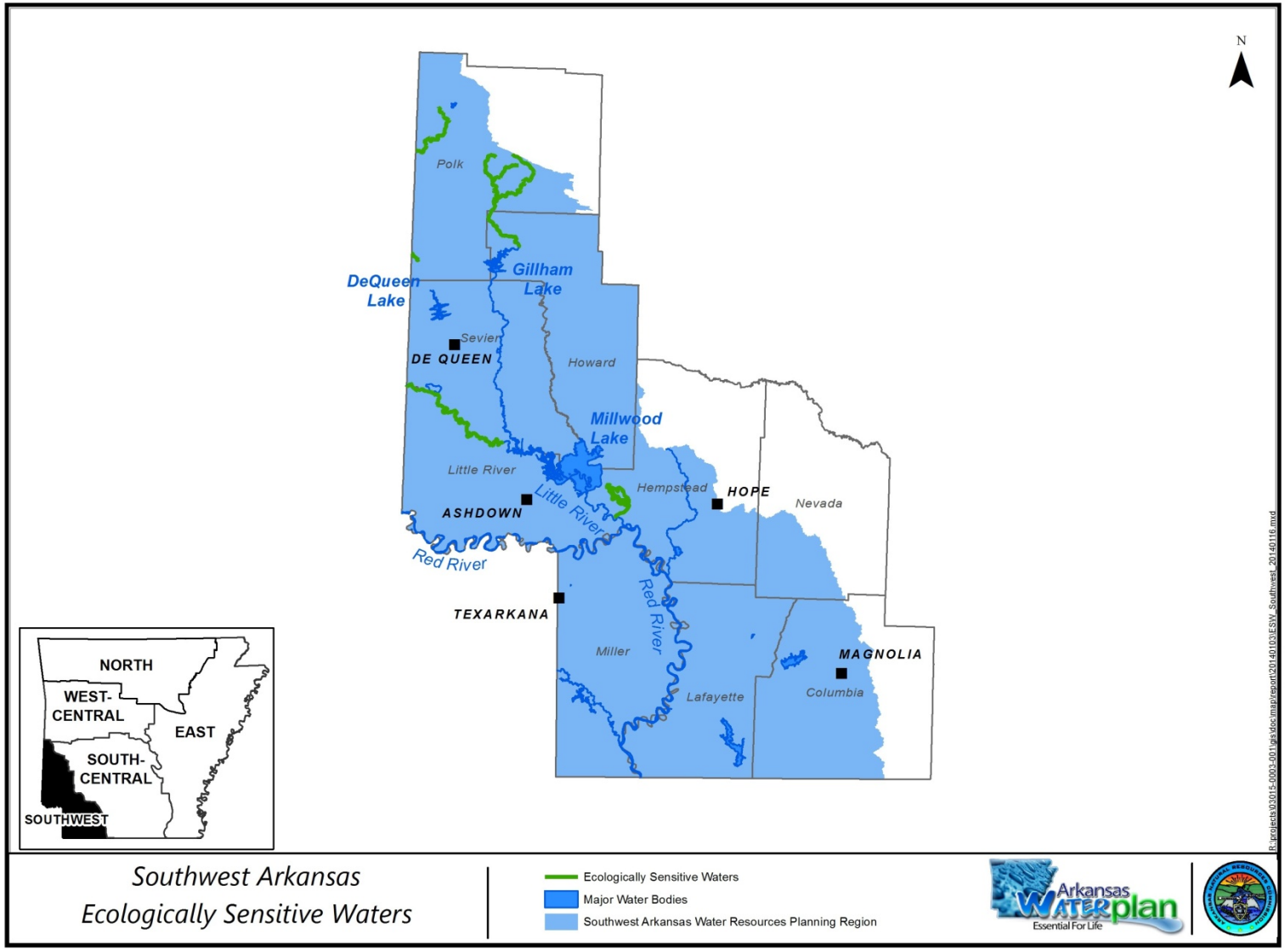

Figure 3.6. Designated ecologically sensitive waterways within the SAWRPR.

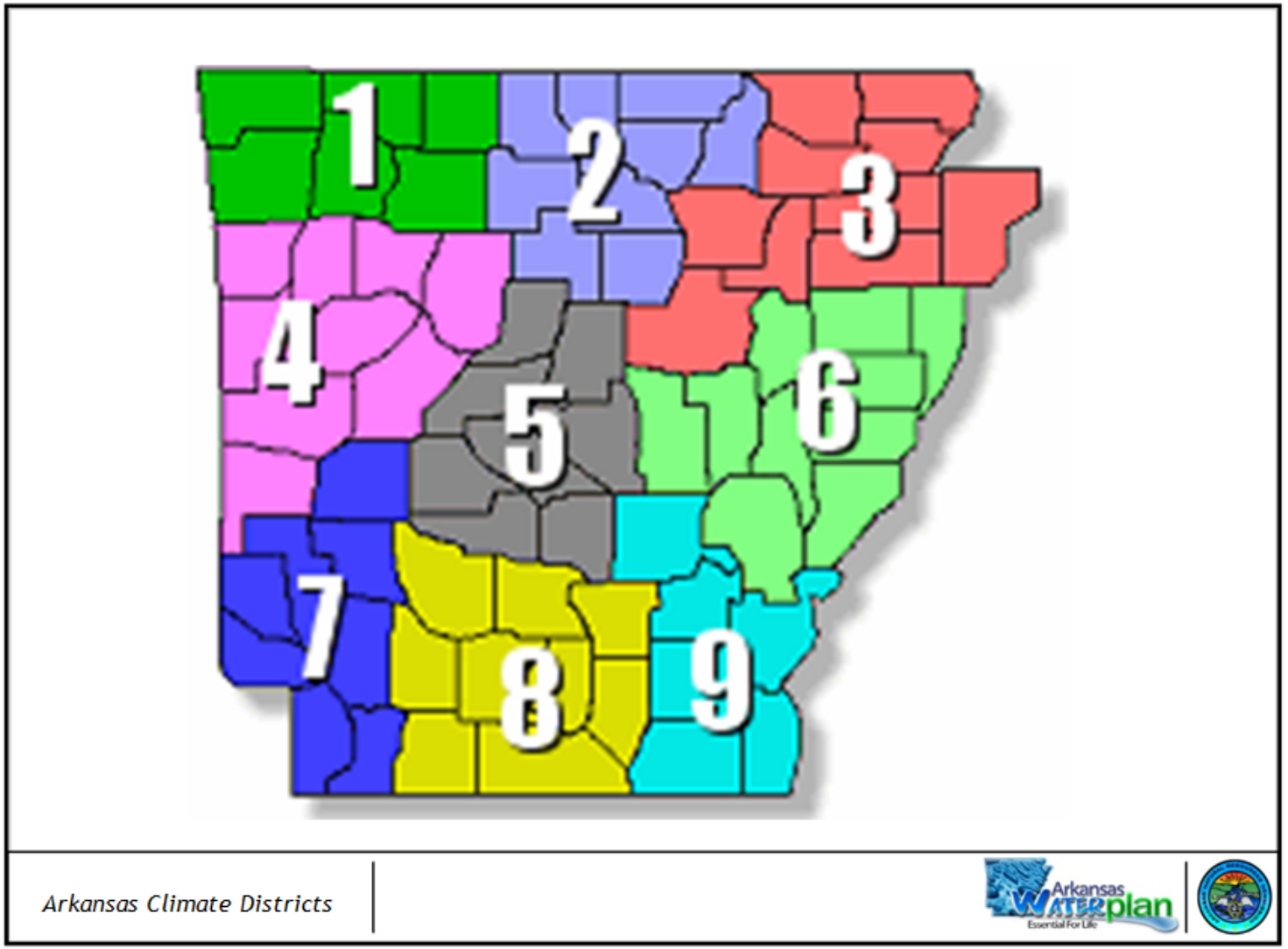

Figure 3.7. Arkansas climate divisions (Natinal Weather Service 2013).

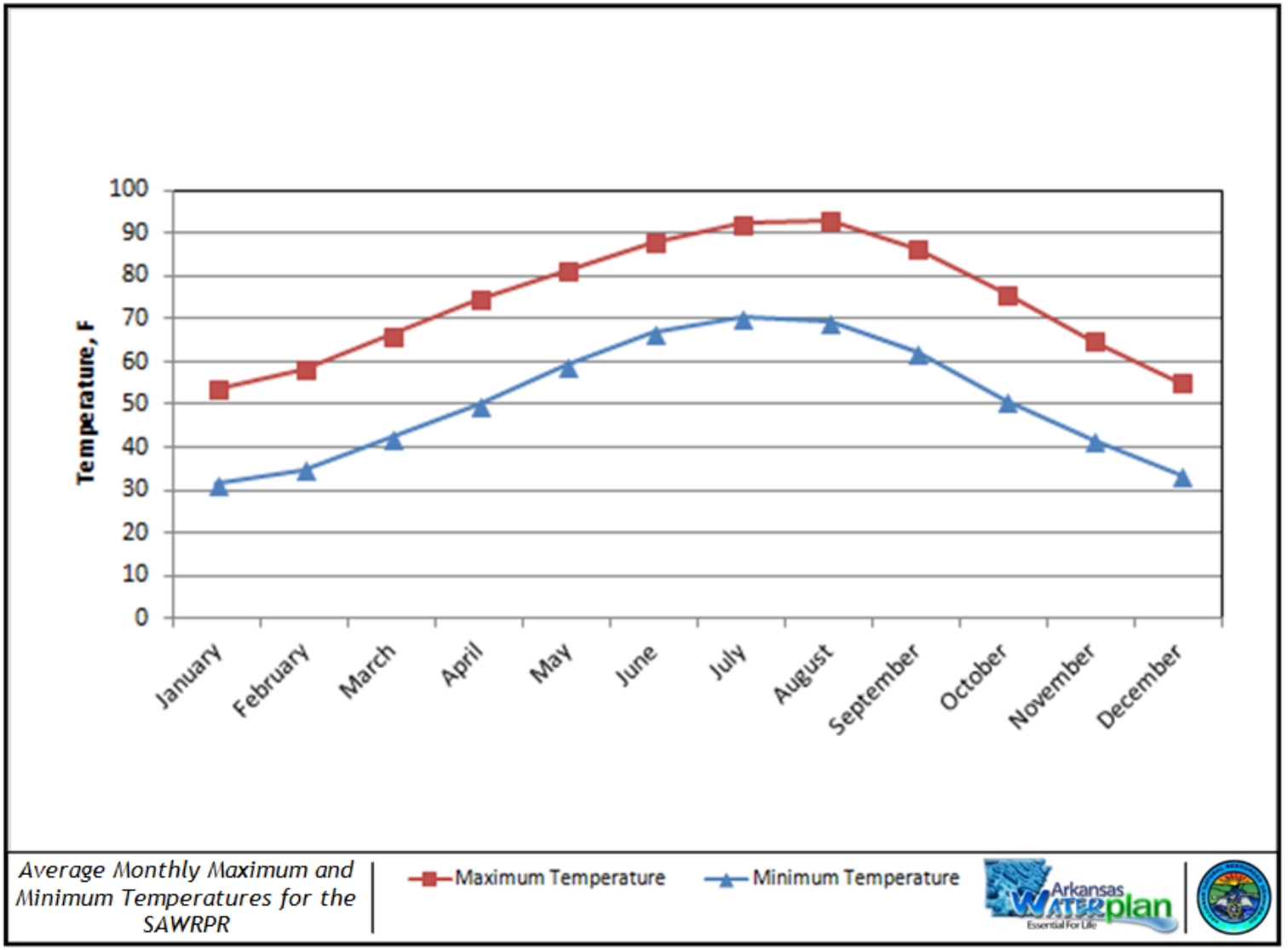

Figure 3.8. Average monthly maximum and minimum temperatures for the SAWRPR 1981 - 2010 (PRISM Climate Group 2004).

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).

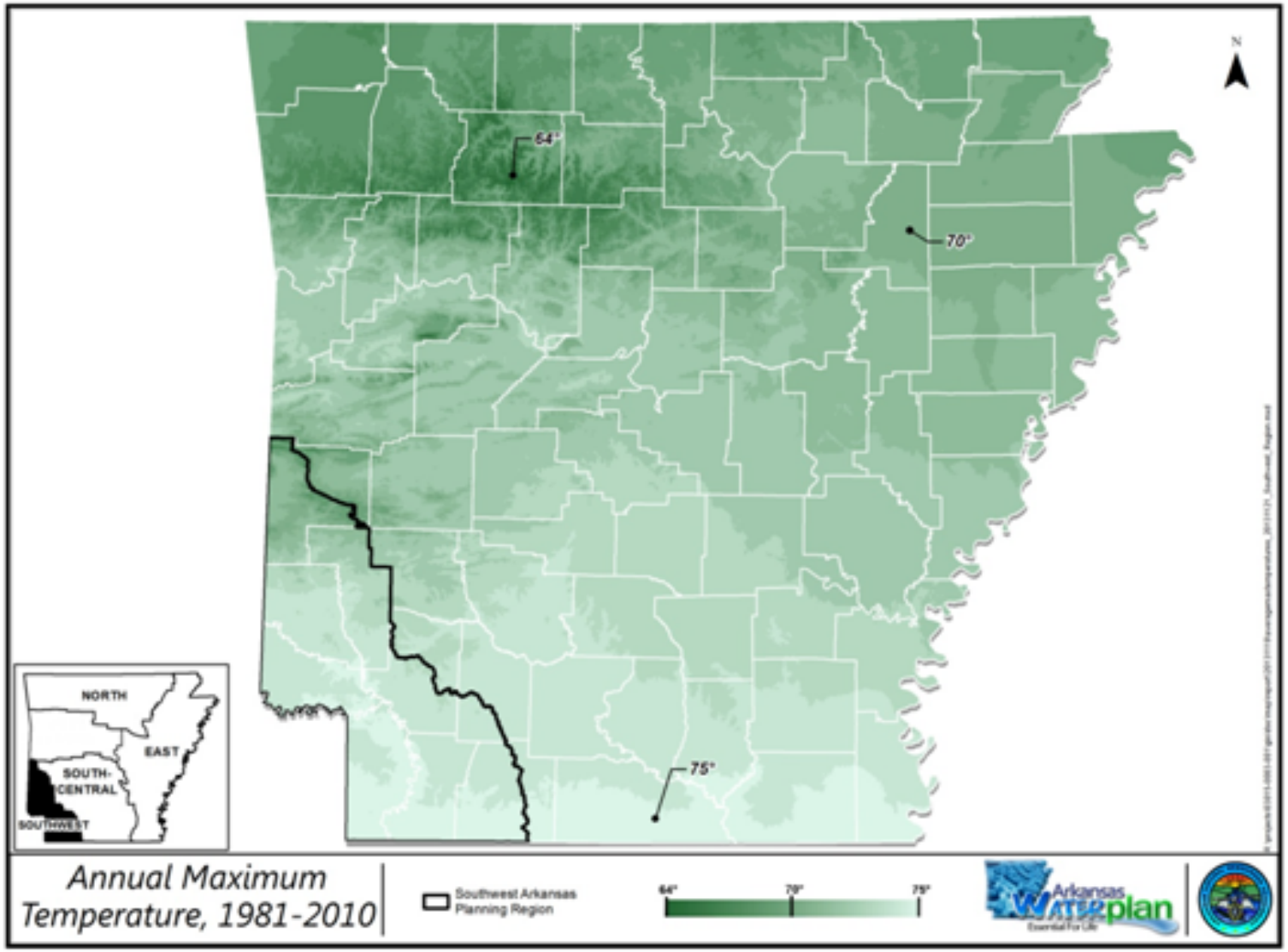

Figure 3.9. Average annual maximum temperatures (degrees F) across the SAWRPR., 1981 – 2010 (PRISM Climate Group 2004).

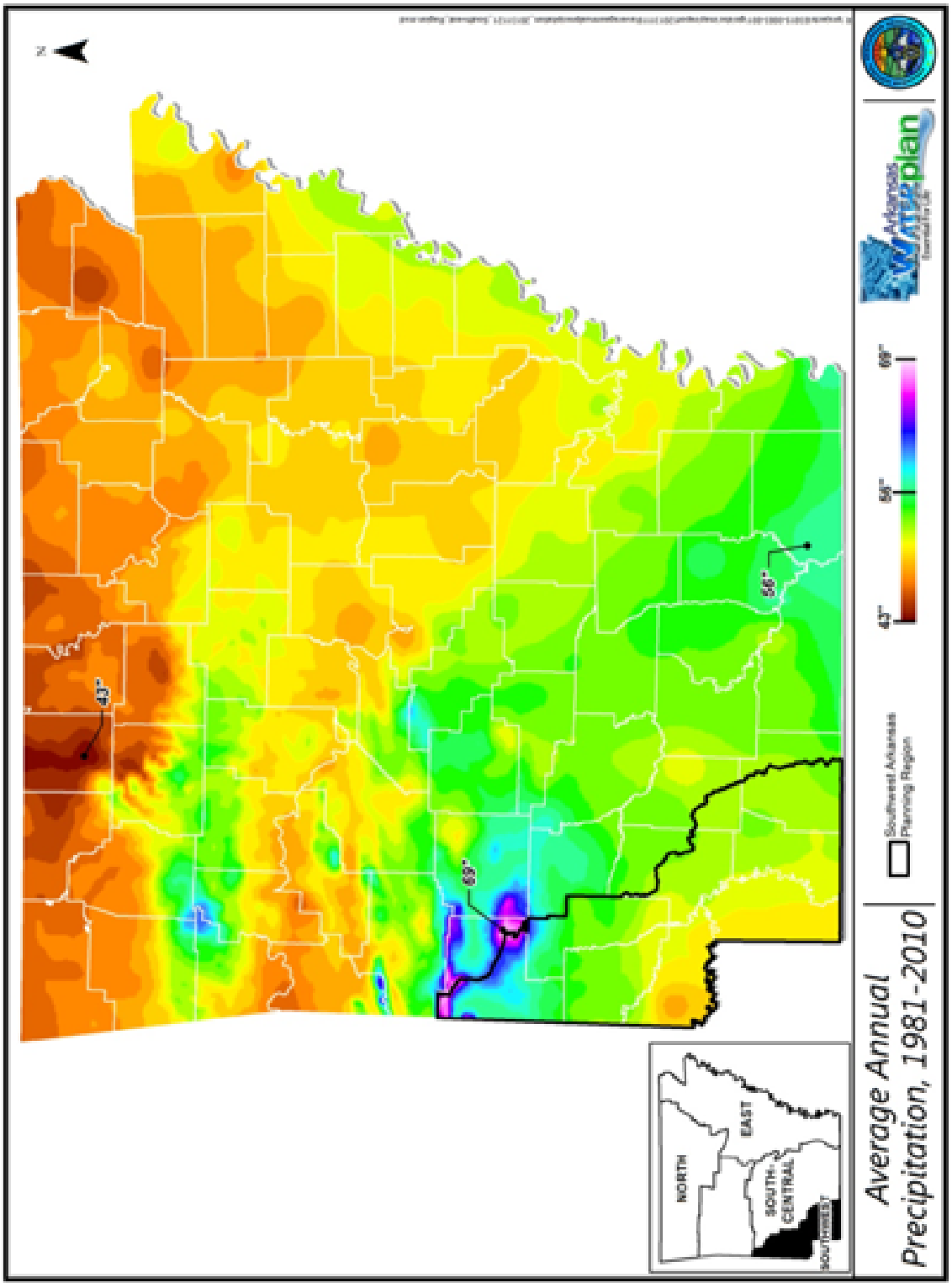

Figure 3.10. Average annual precipitation (inches) in the SAWRPR (PRISM Climate Group 2004).

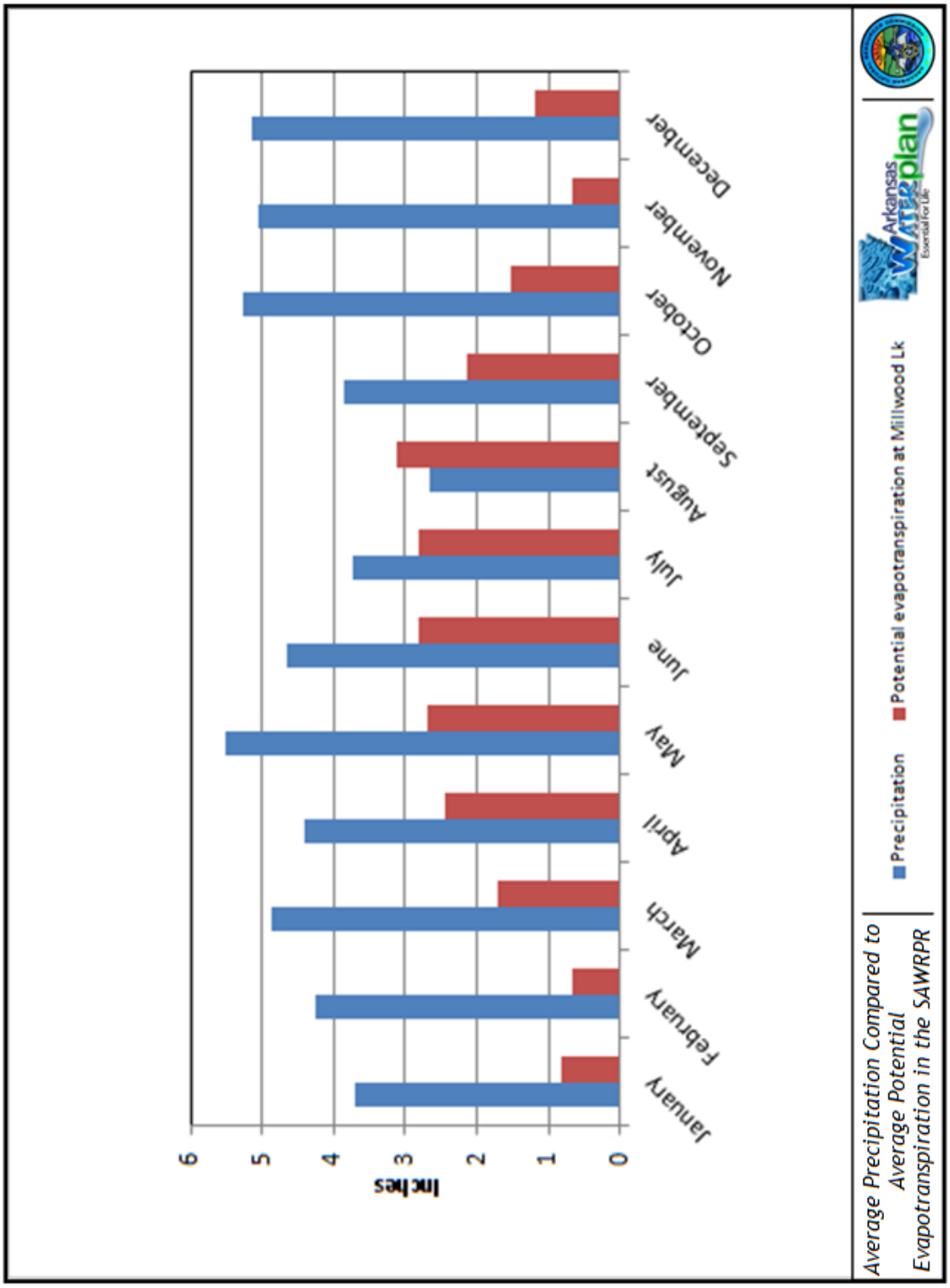

Figure 3.11. Average precipitation compared to average potential evapotranspiration in the SAWRPR (PRISM Climate Data Group 2004, NOAA NCDC 2013a).

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).

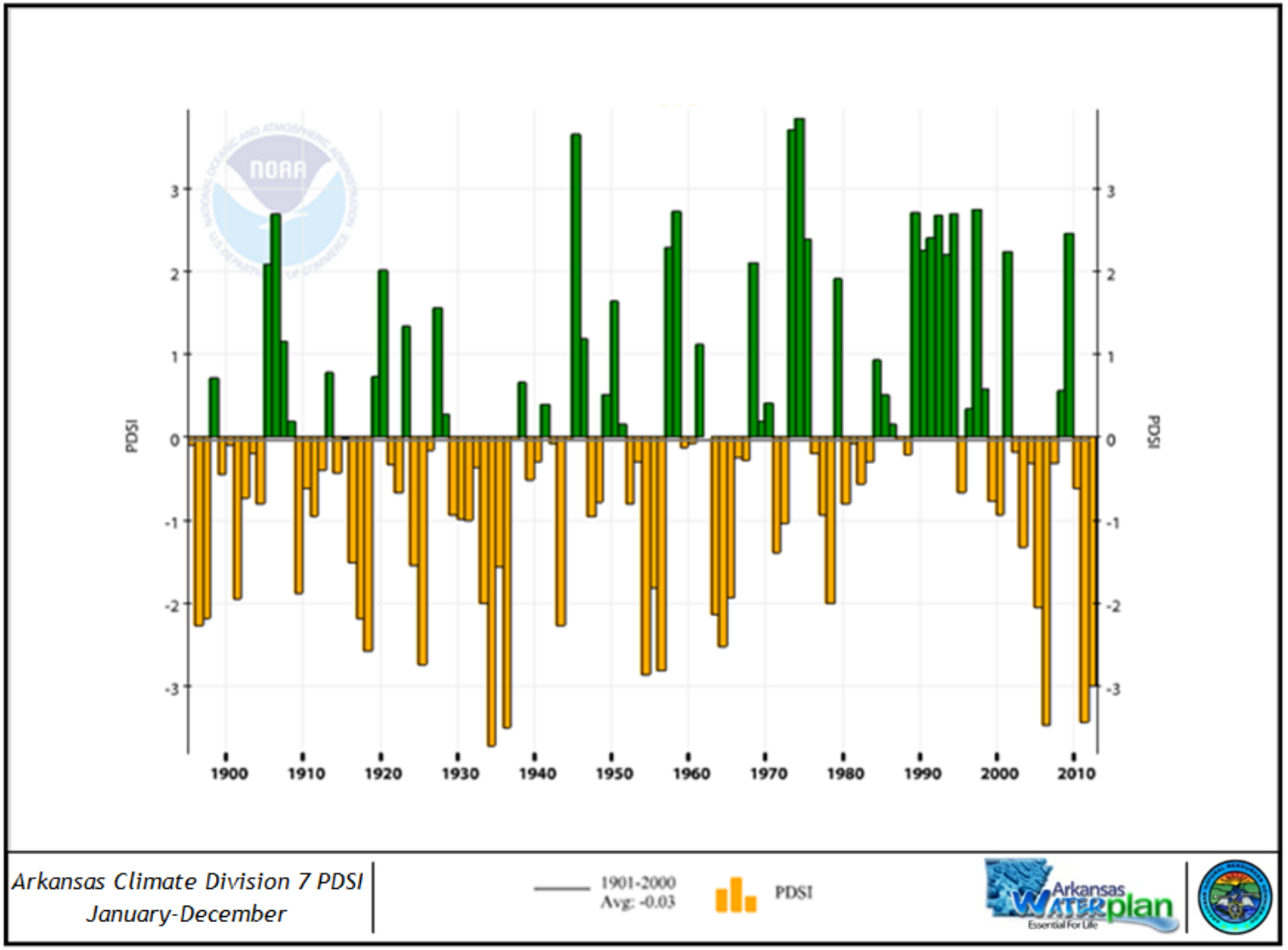

Figure 3.12. Historical values of the Palmer Drought Severity Index for climate division 7 (NOAA NCDC 2013b).

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.

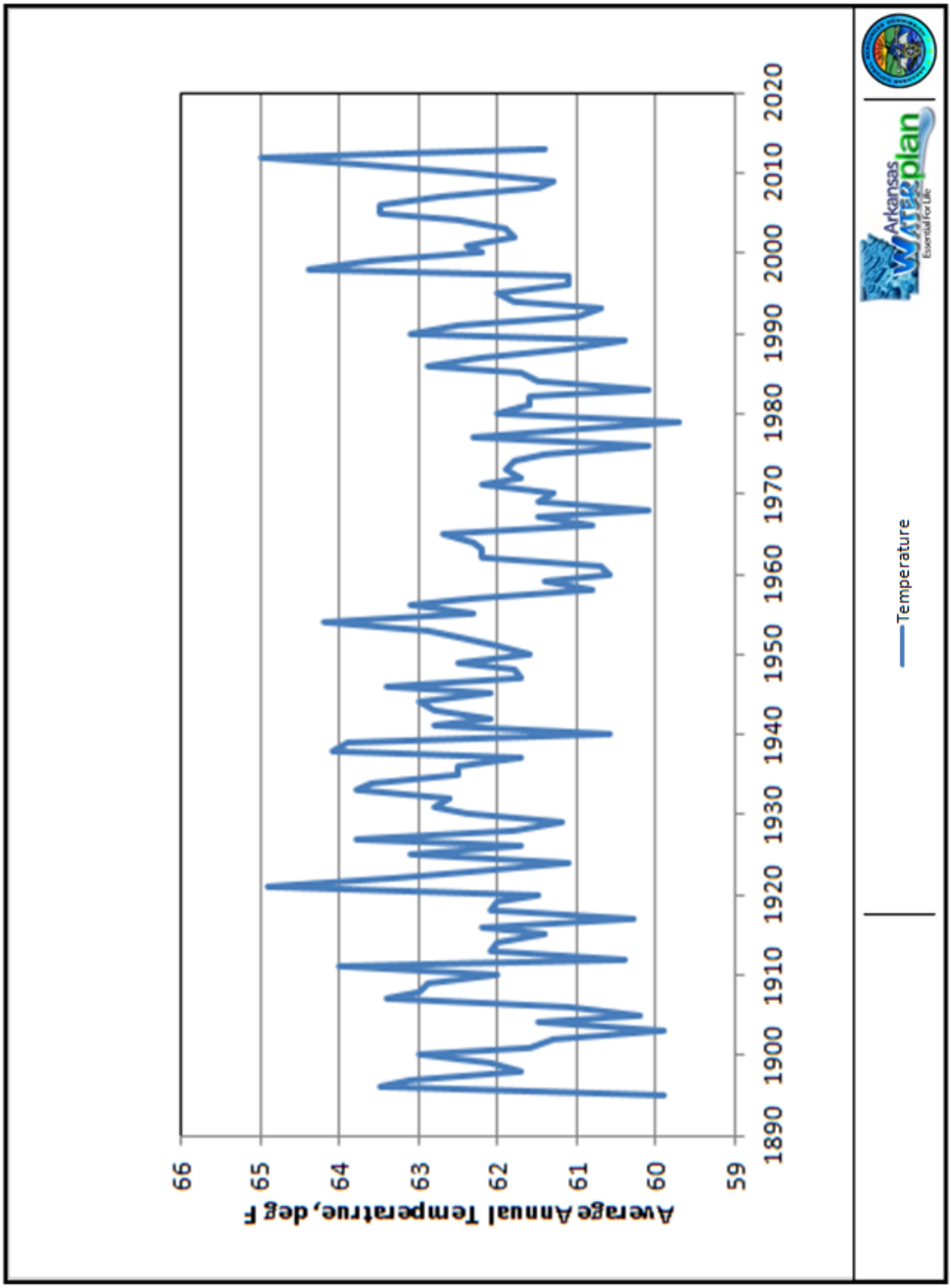

Figure 3.13. Historical average annual temperatures for the SAWRPR (NOAA NCDC 2013c).

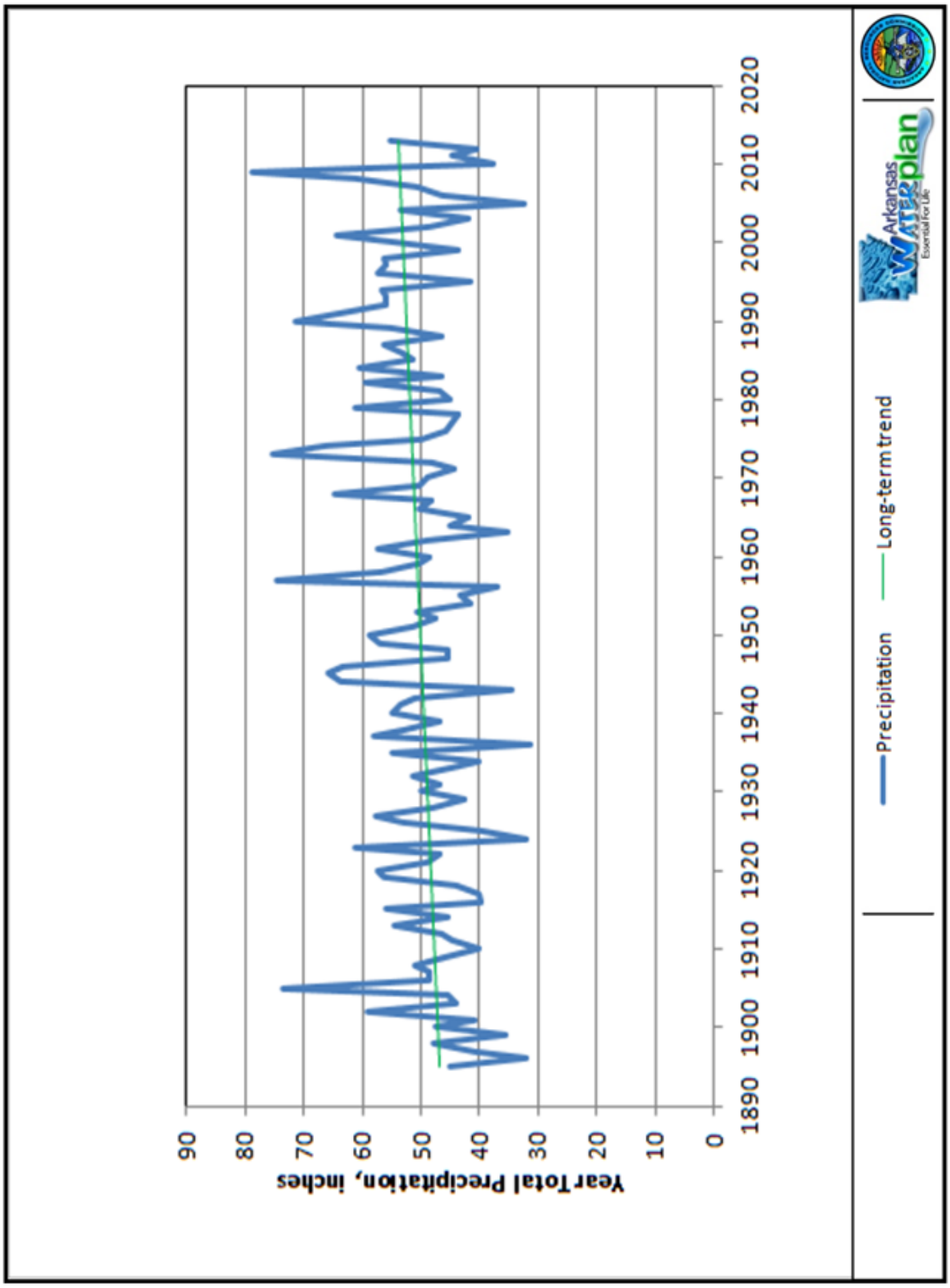

Figure 3.14. Historical annual precipitation totals for the SAWRPR (NOAA NCDC 2013c).

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)

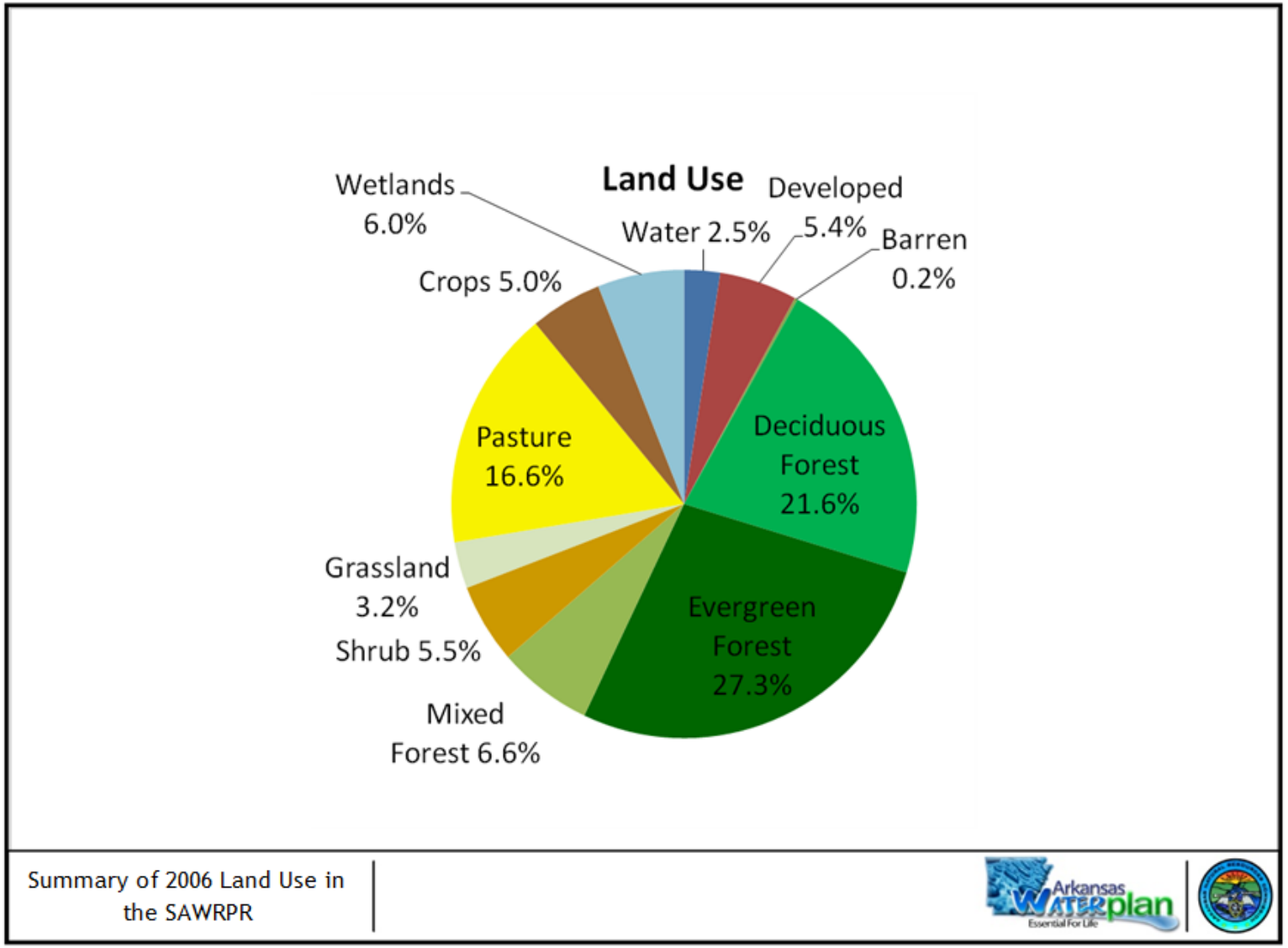

Figure 3.15. Summary of 2006 land use in the SAWRPR (Fry et al. 2011).

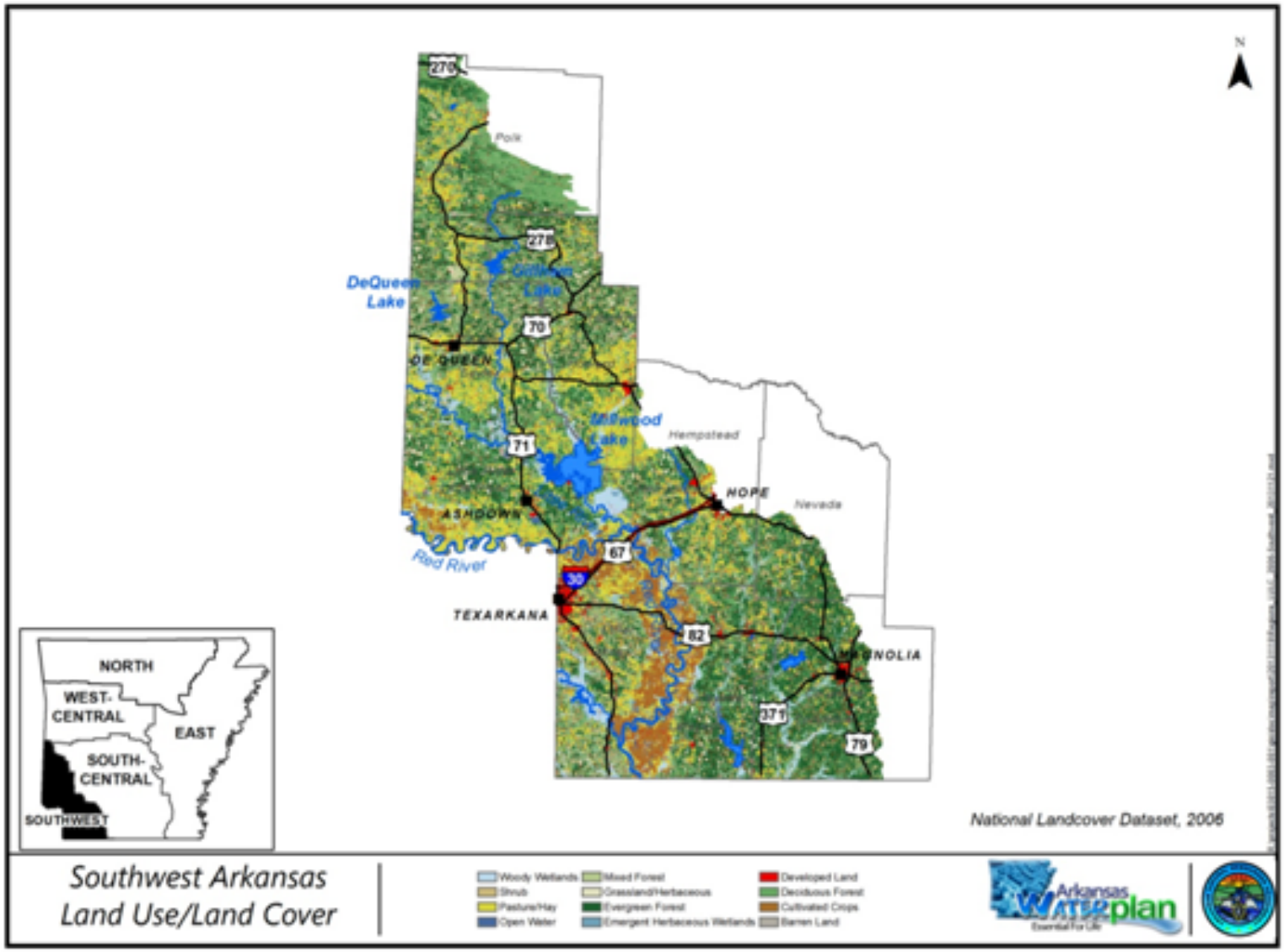

Figure 3.16. Land use map of the SAWRPR (Fry et al. 2011).

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).

	Cropland (acres)			Pasture		
County	**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).

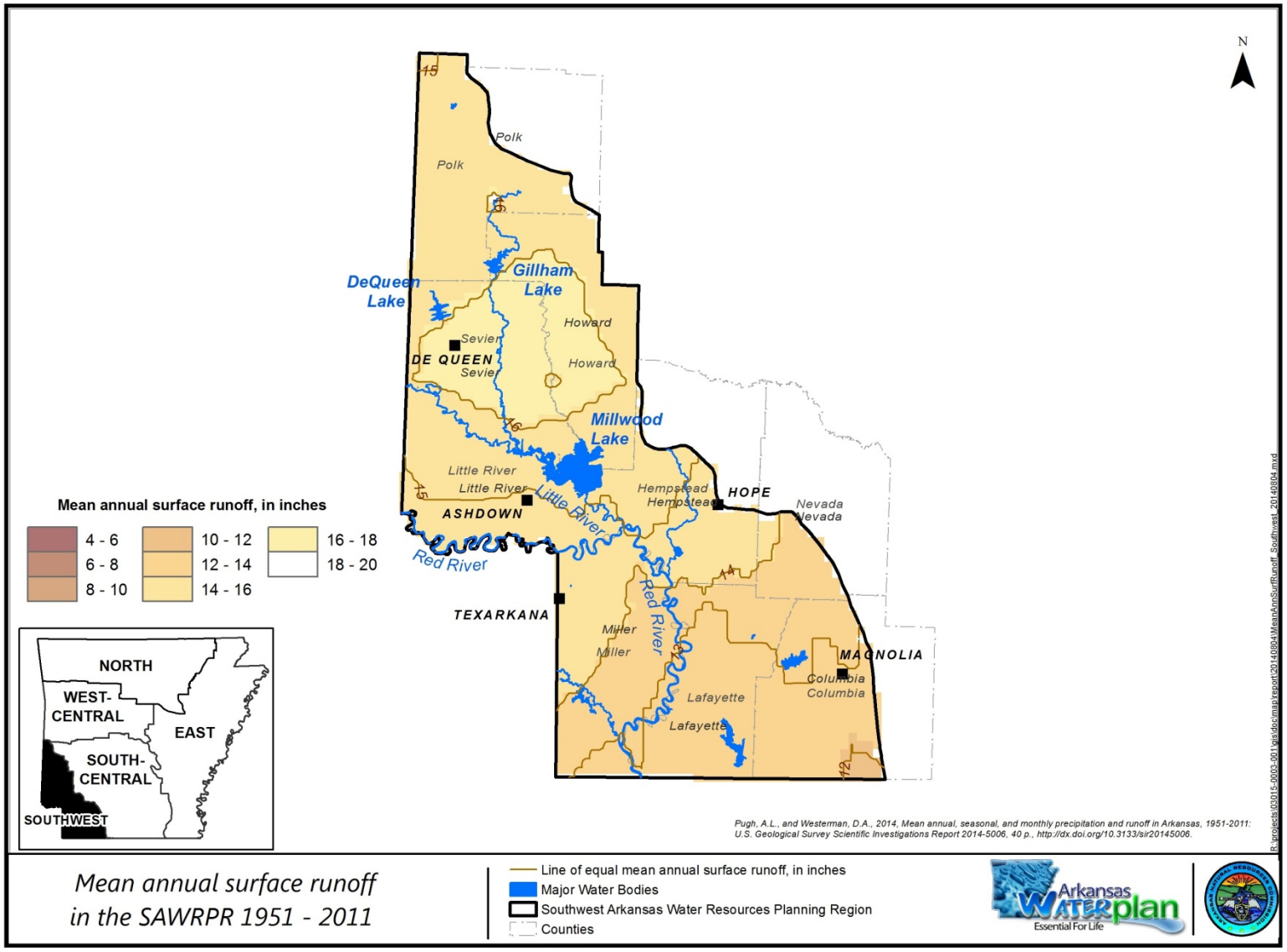

Figure 3.17 Average annual surface runoff in the SAWRPR, 1951 to 2011 (Pugh and Westerman 2014).

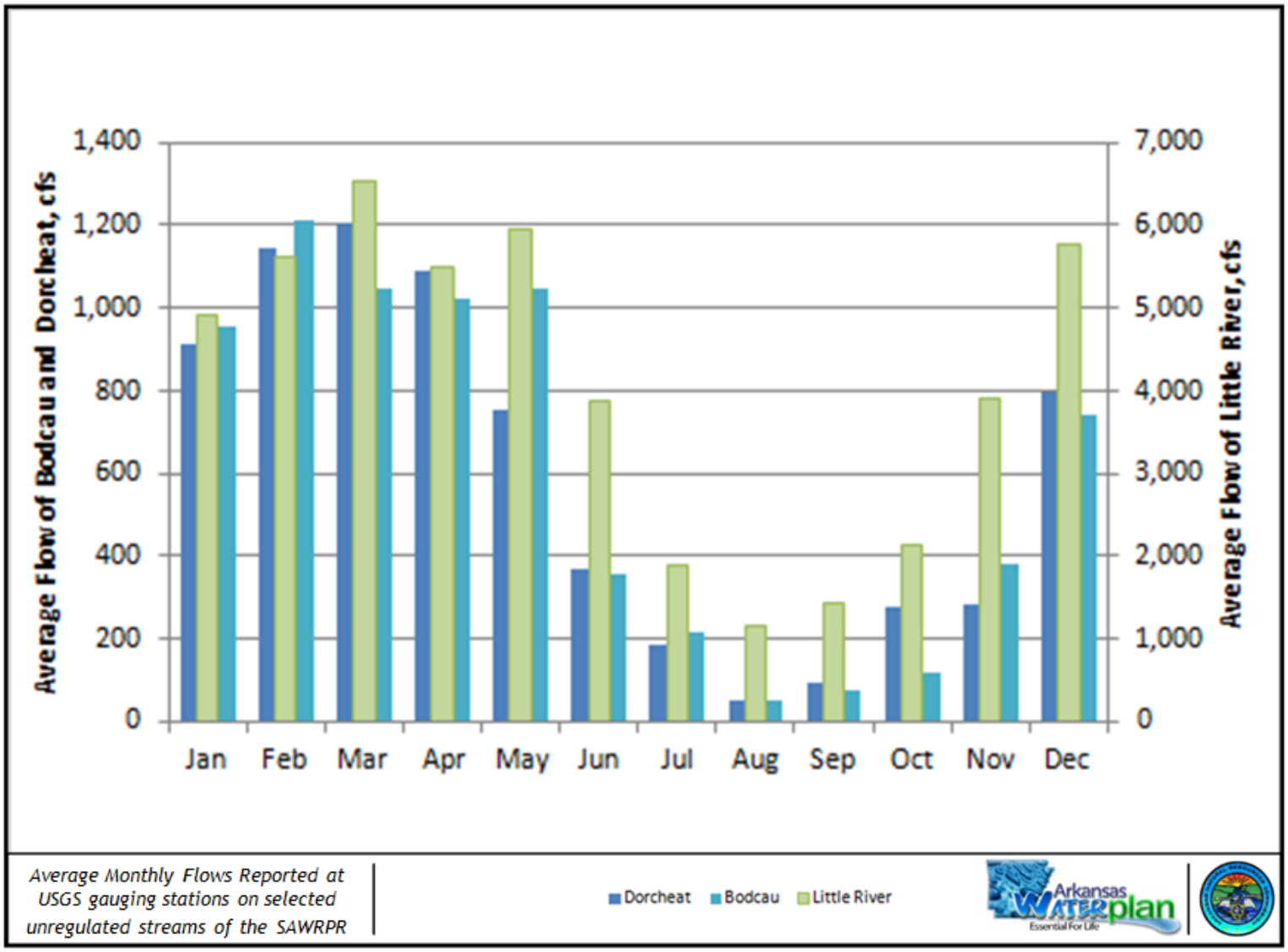

Figure 3.18. Average monthly flows reported at USGS gauging stations on selected unregulated streams of the SAWRPR.

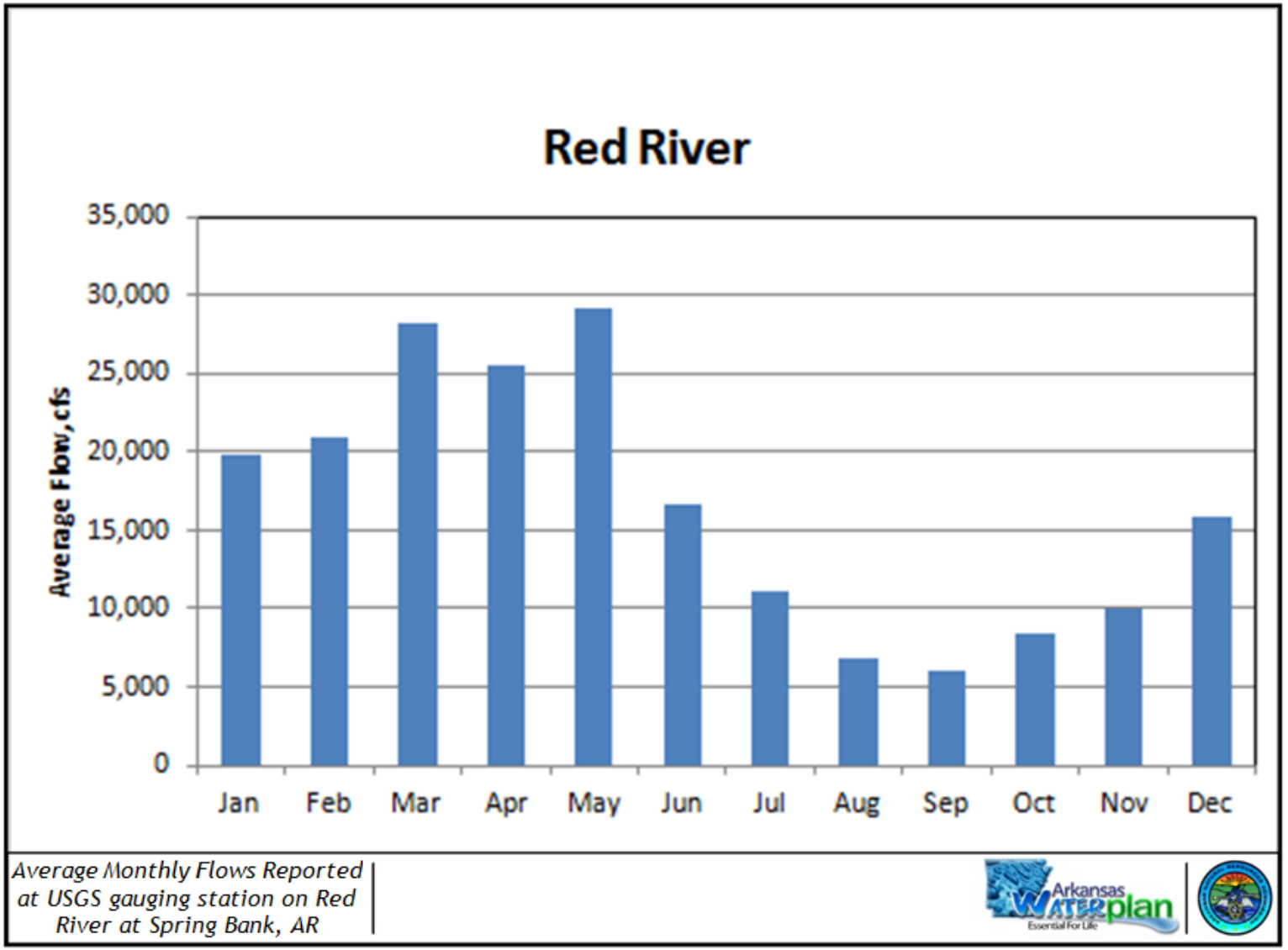

Figure 3.19. Average monthly flows reported at USGS gauging station on the Red River at Spring Bank, AR.

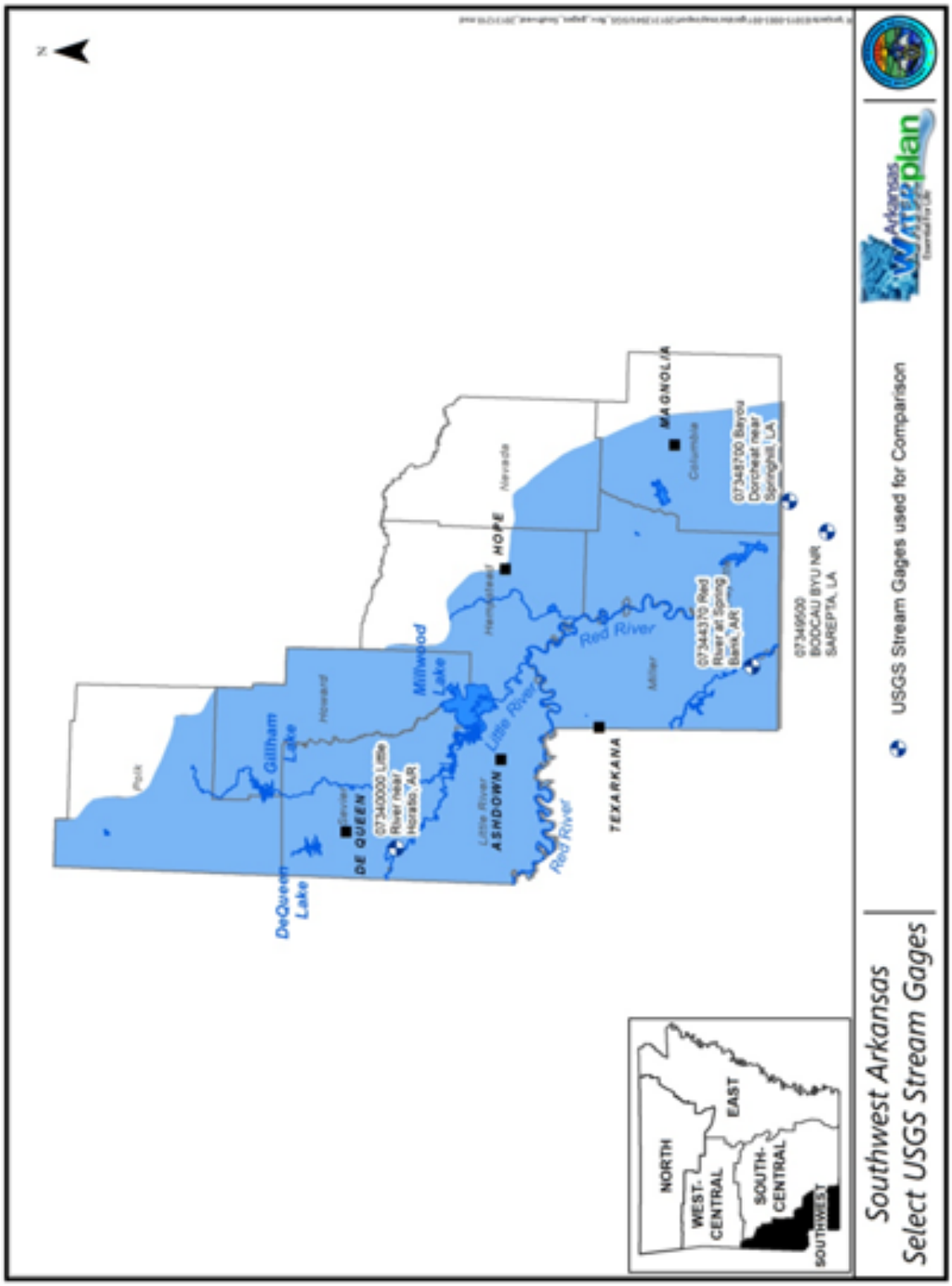

Figure 3.20. Locations of USGS gauging stations for data in Figure 3.15.

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

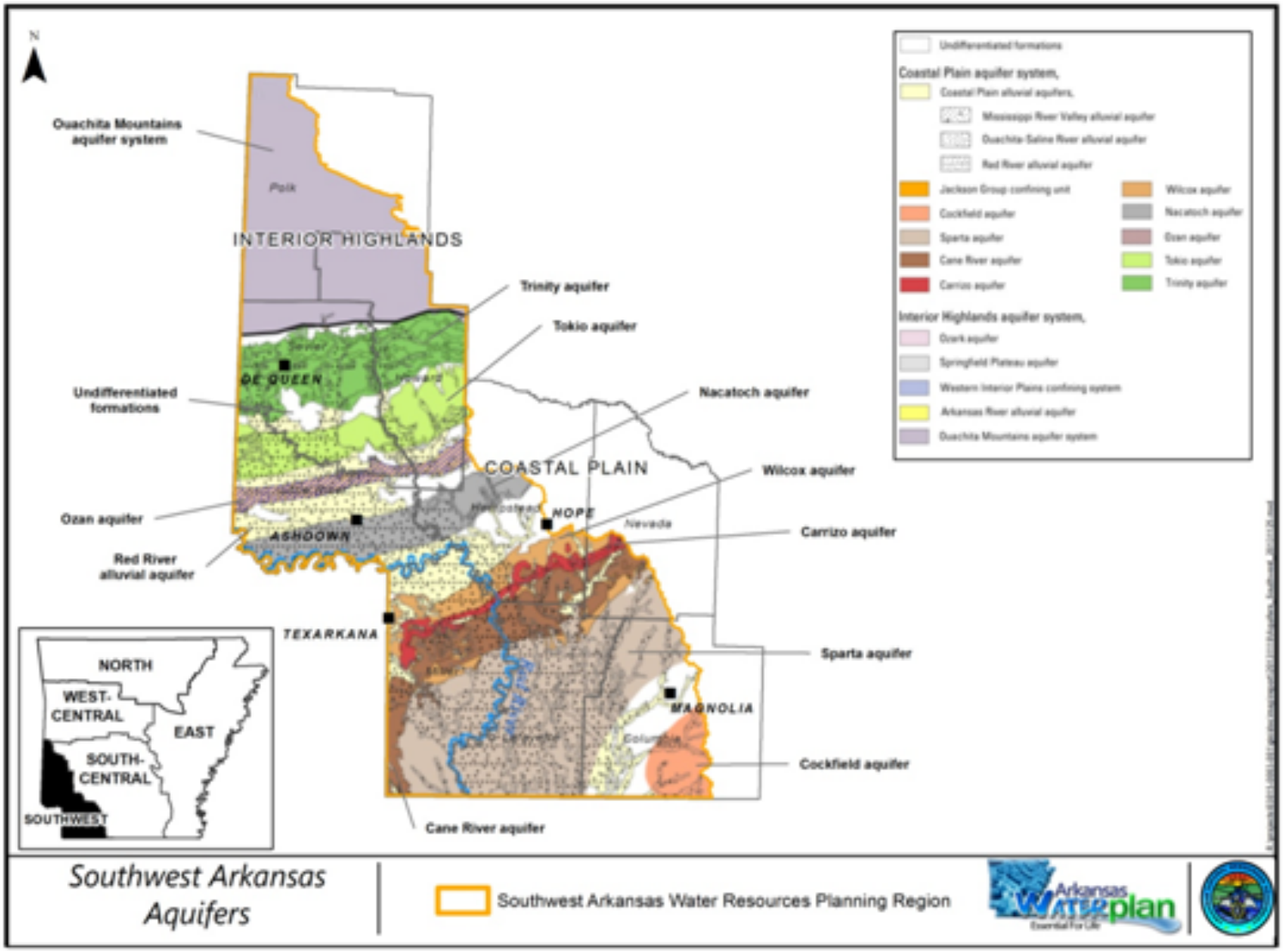

Figure 3.21. Aquifers of the SAWRPR (Kresse et al. 2013).

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.

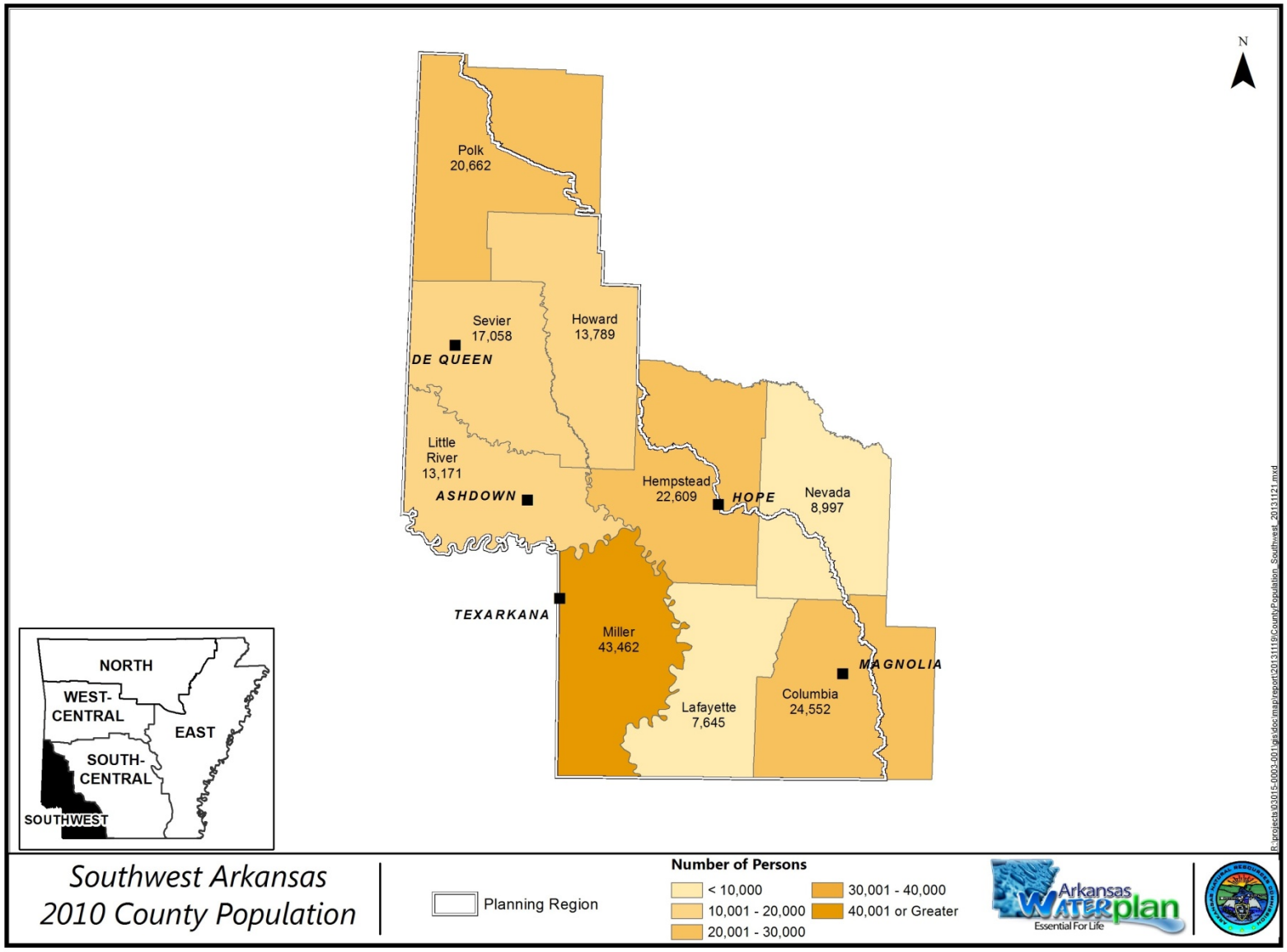

Figure 4.1. 2010 county population in the SAWRPR (US Census Bureau 2012a).

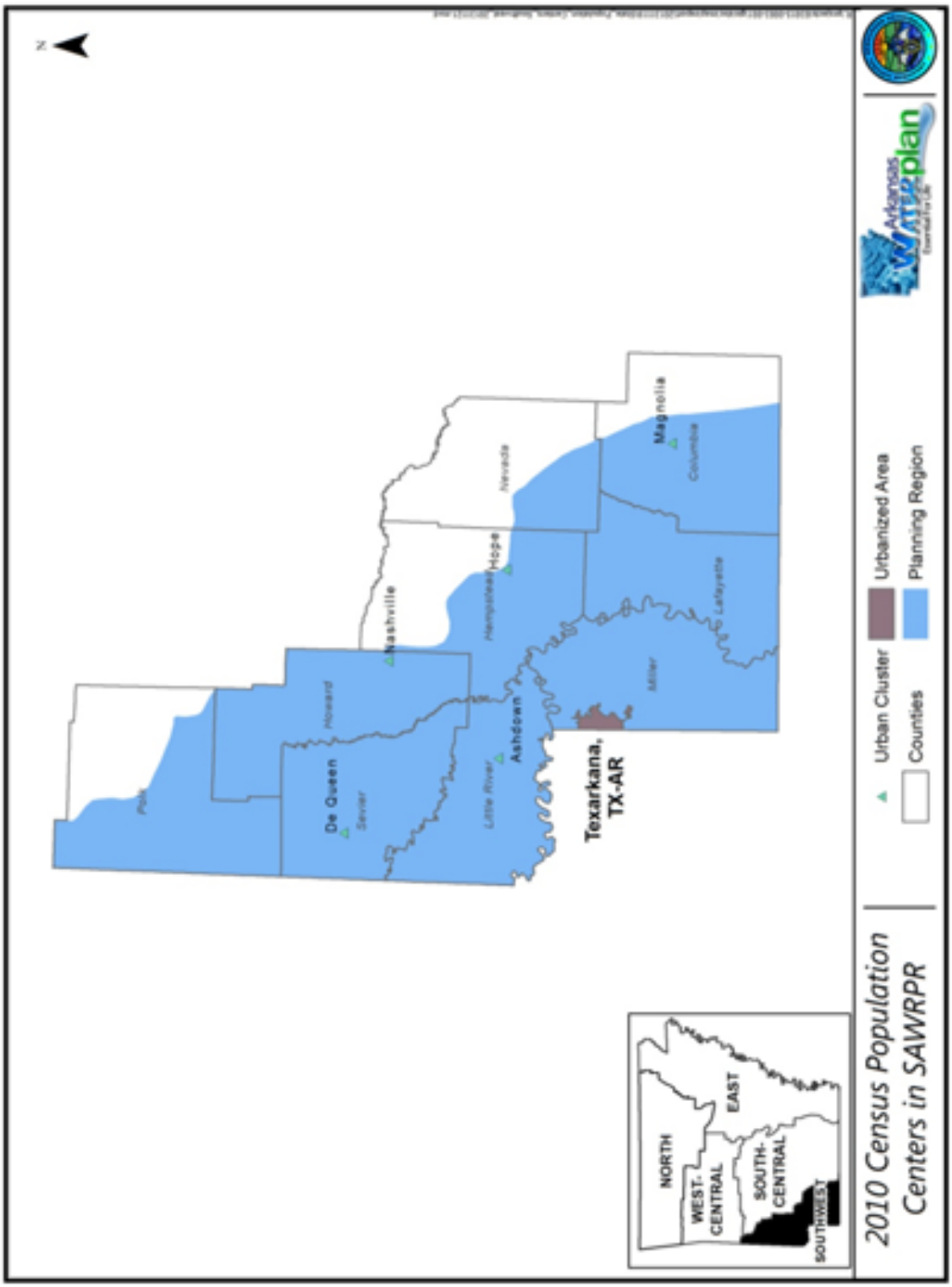

Figure 4.2. 2010 population centers in the SAWRPR (US Census Bureau 2012b).

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).

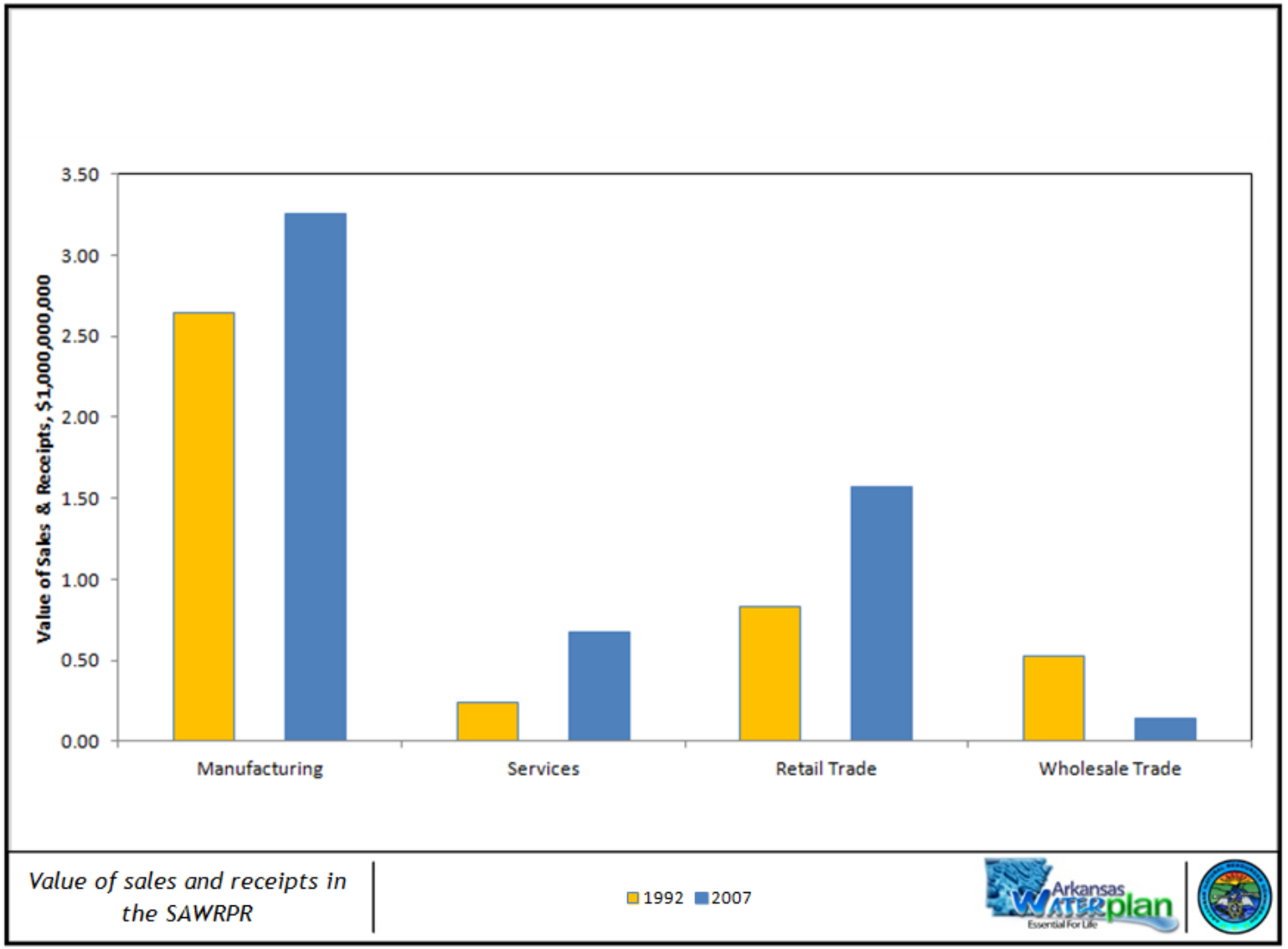

Figure 4.3. Value of sales and receipts in the SAWRPR (US Census Bureau 1993, 2011b).

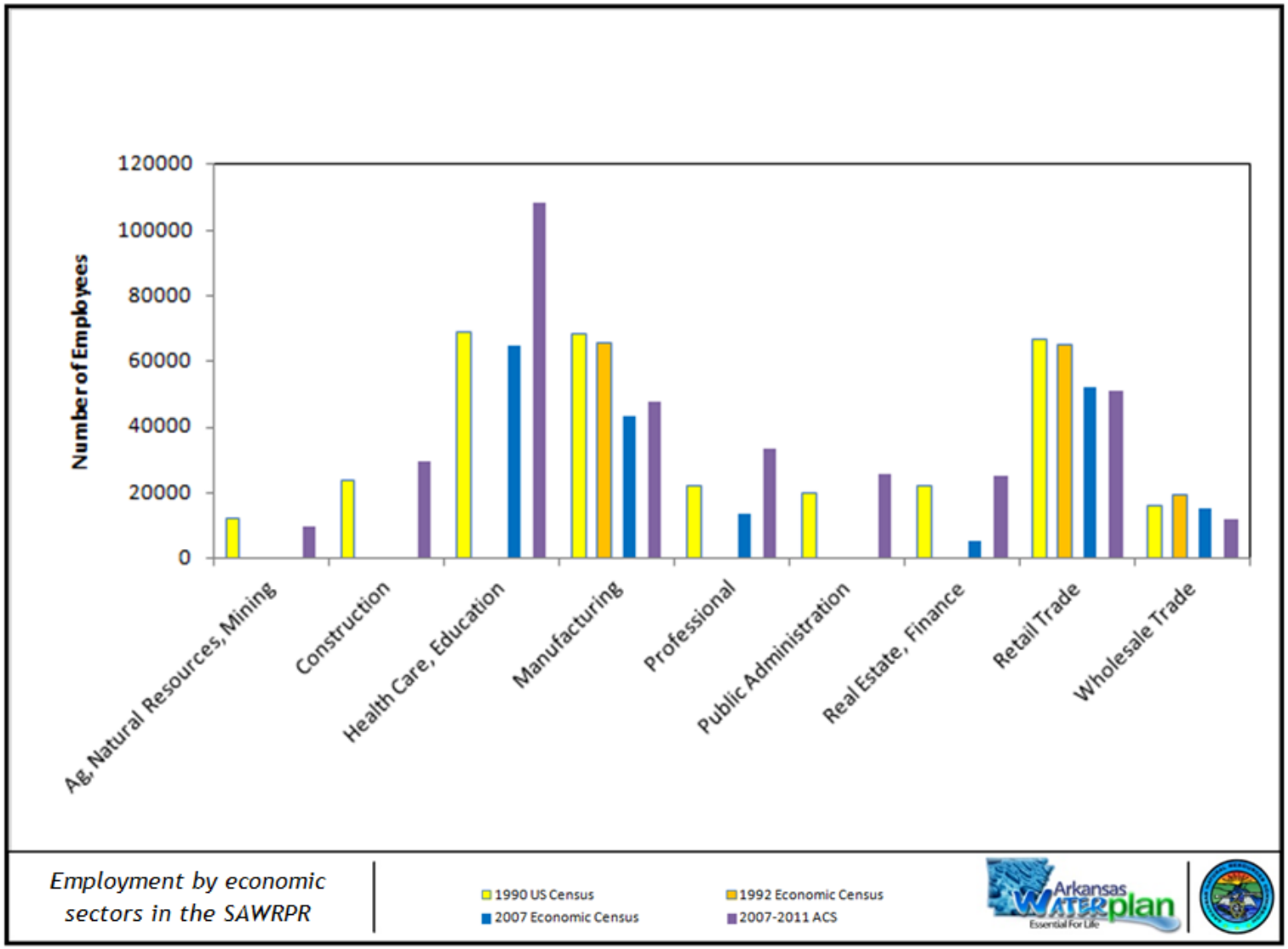

Figure 4.4. Employment by economic sectors in the SAWRPR (Census State Data Center 2013; US Census Bureau n.d.b 1993, 2011b).

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.).

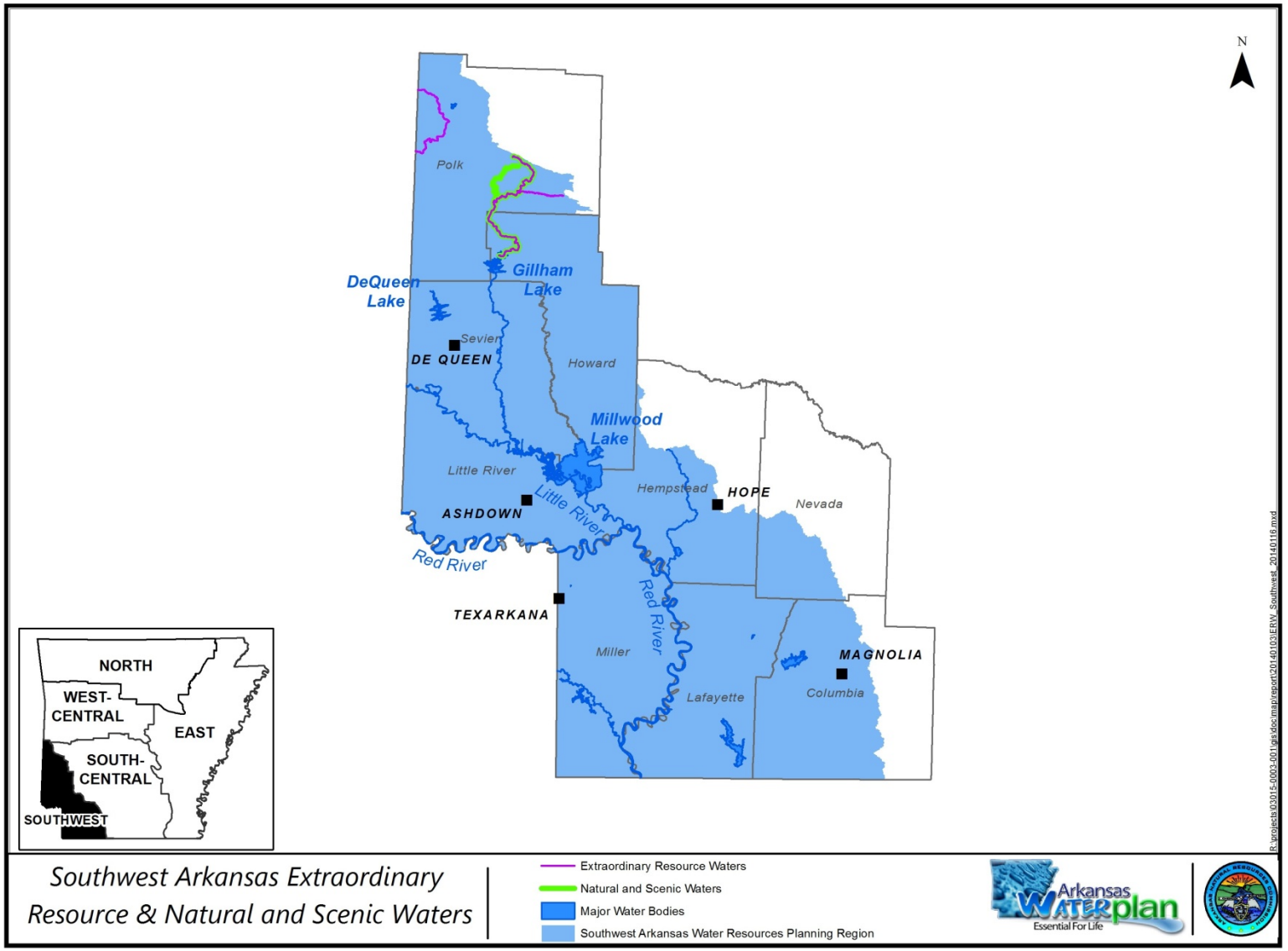

Figure 4.5. Outstanding resource waters within the SAWRPR.

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.

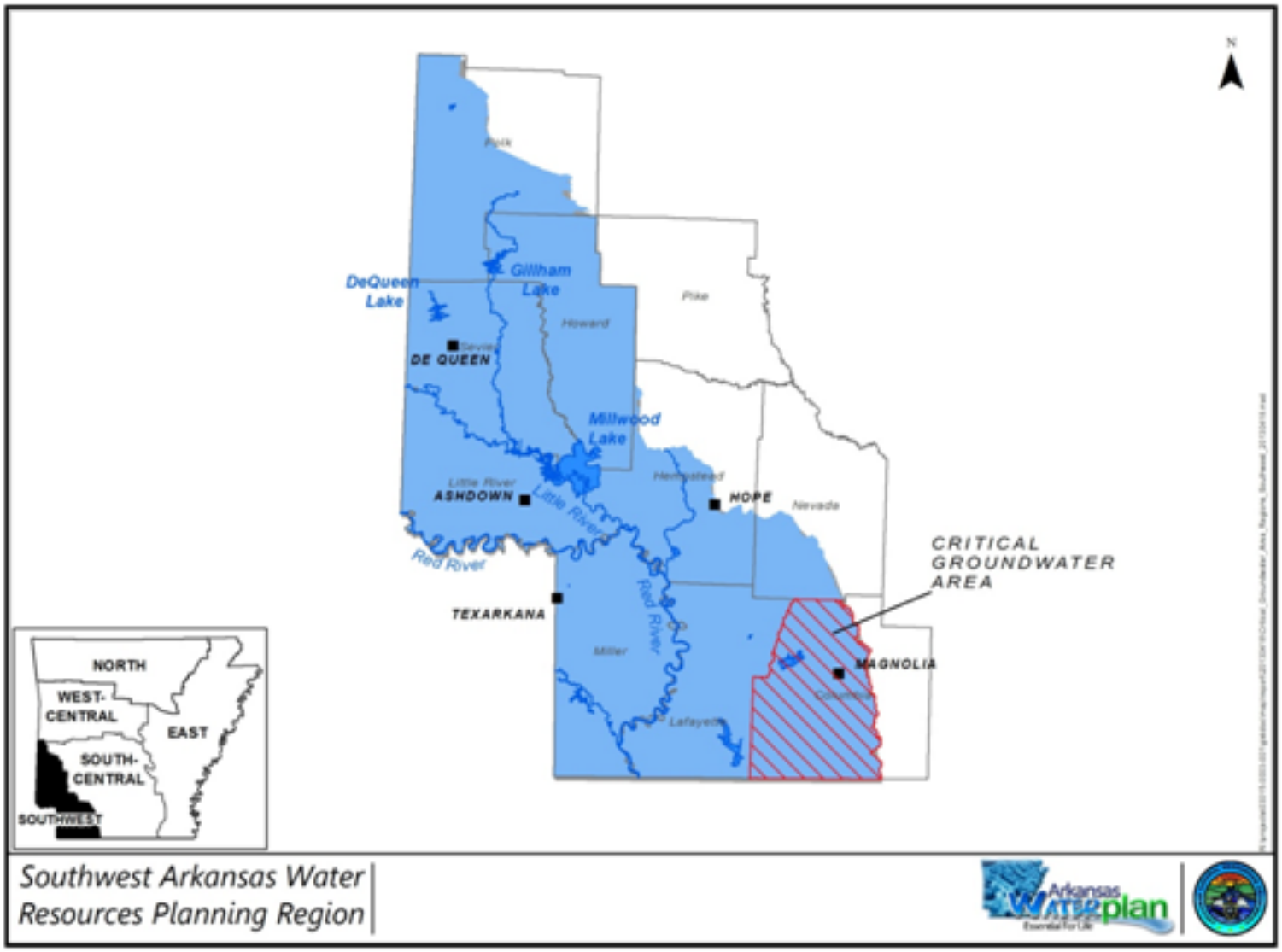

Figure 5.1. Location of critical groundwater area designated within the SAWRPR.

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).

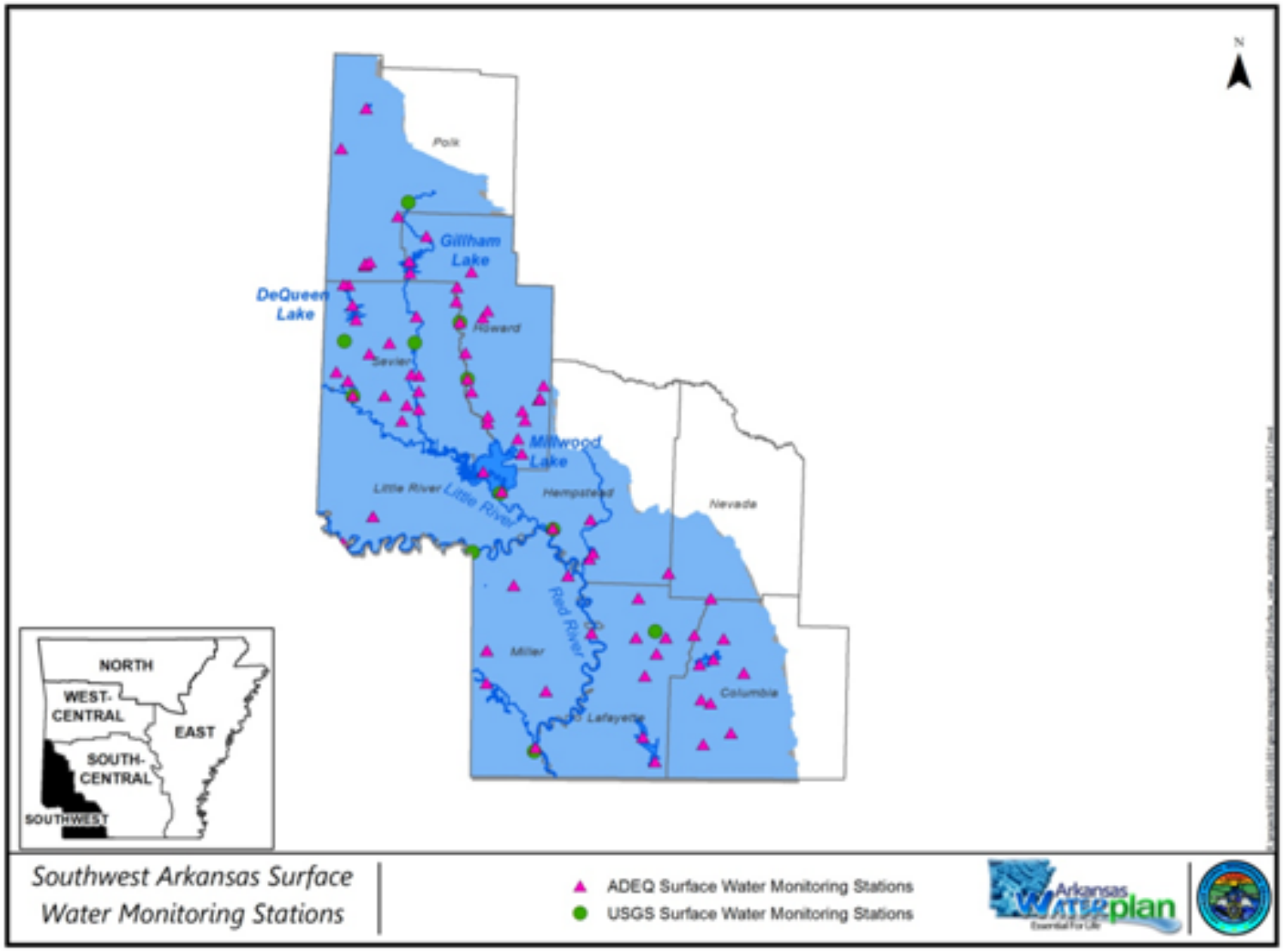

Figure 5.2. Routine surface water quality monitoring sites in the SAWRPR.

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.

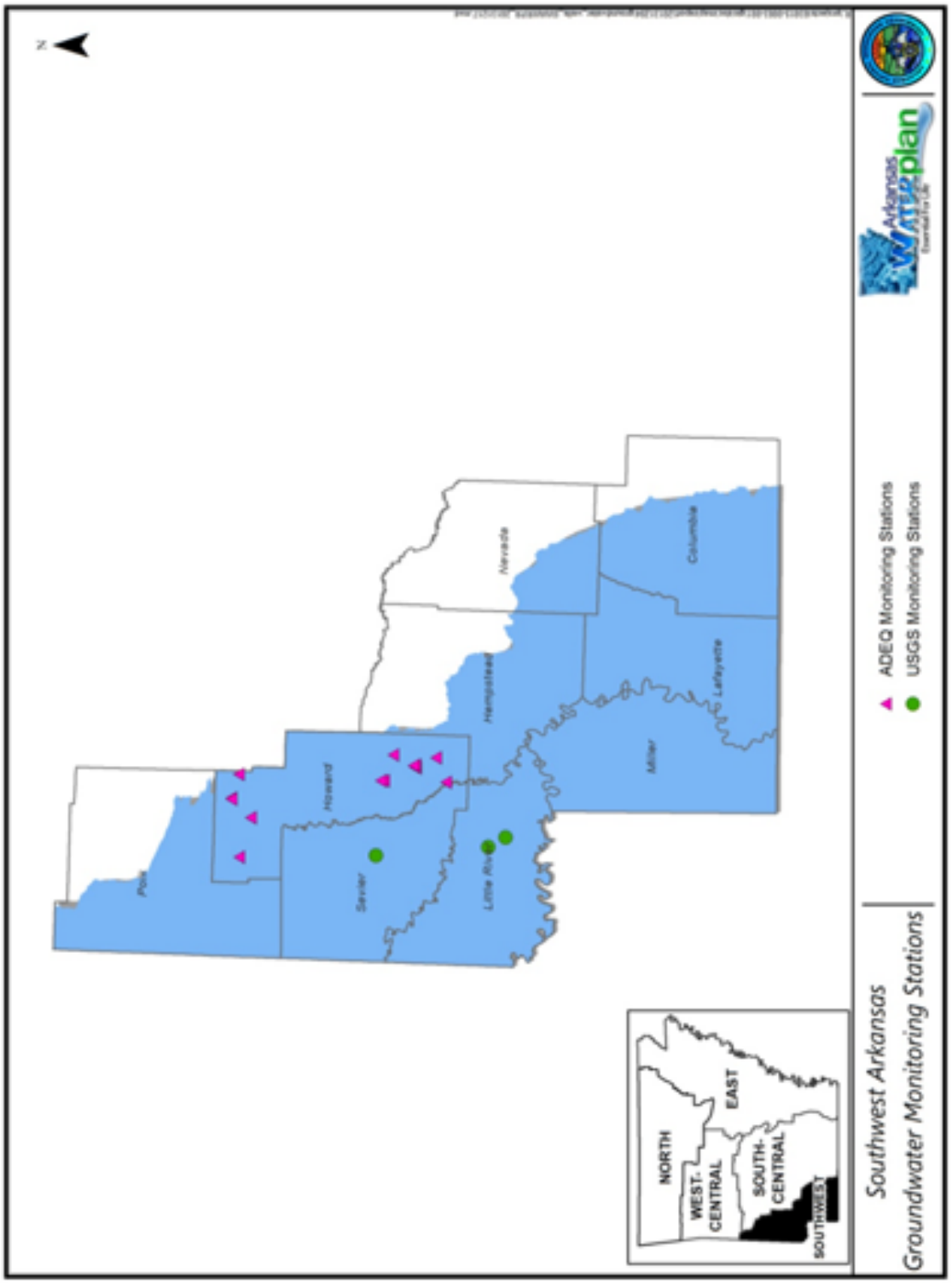

Figure 5.3. Routine groundwater quality monitoring in the SAWRPR.

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

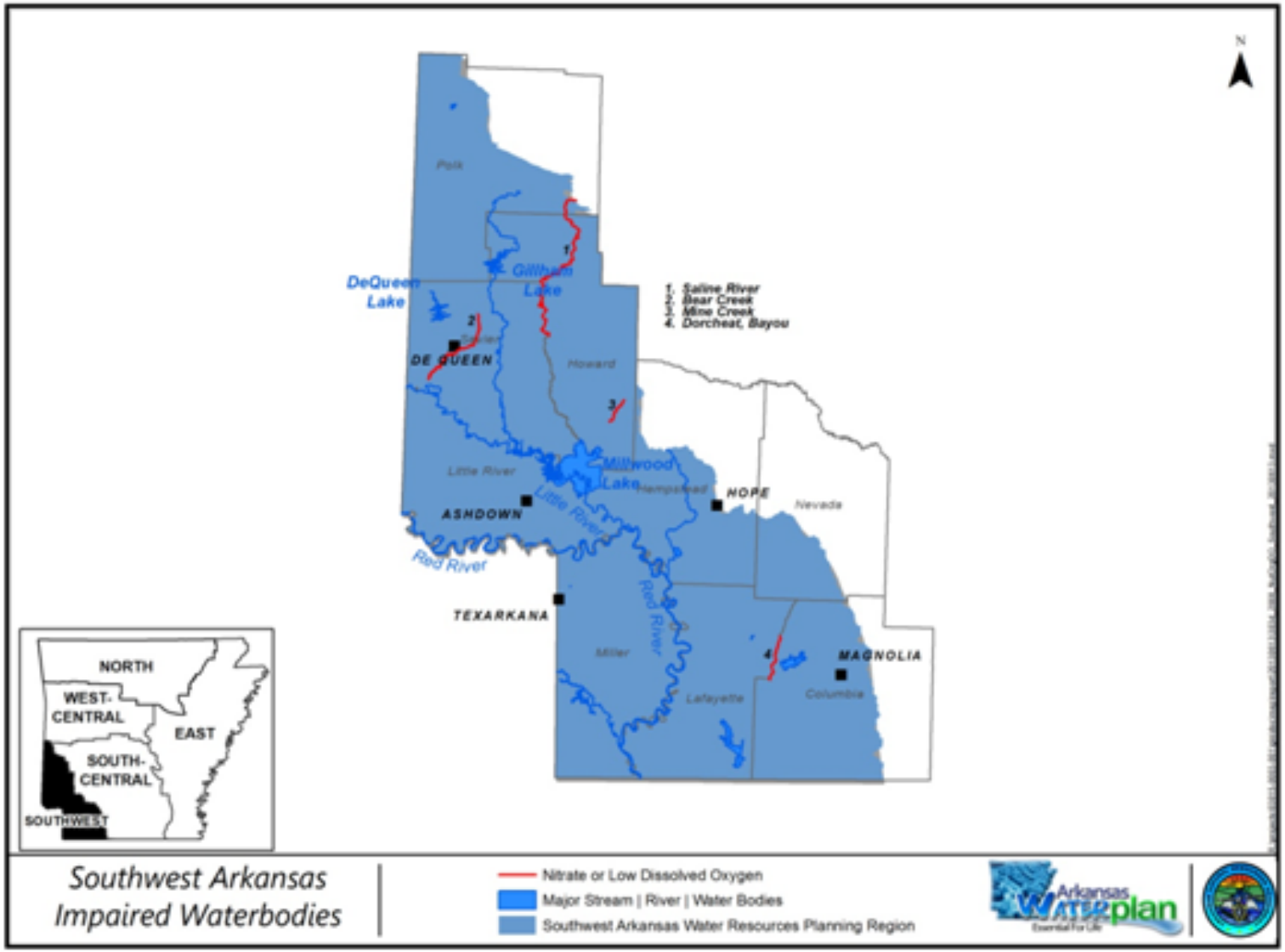

Figure 5.4. Waterbodies in the SAWRPR classified as impaired due to low dissolved oxygen or nitrate in the 2008 303(d) list (ADEQ 2008,2009).

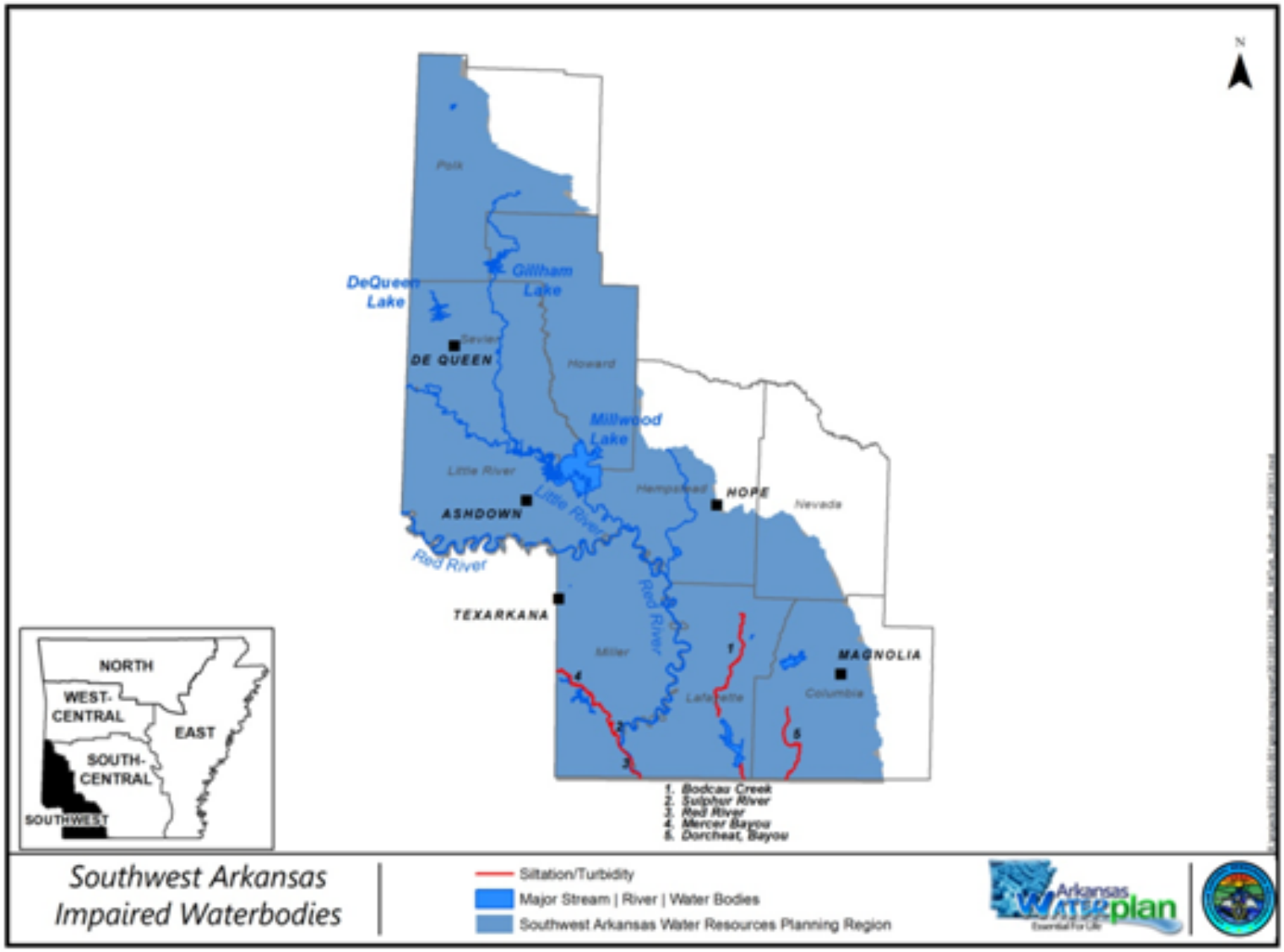

Figure 5.5. Waterbodies in the SAWRPR classified as impaired due to siltation/turbidity in the 2008 303(d) list (ADEQ 2008,2009).

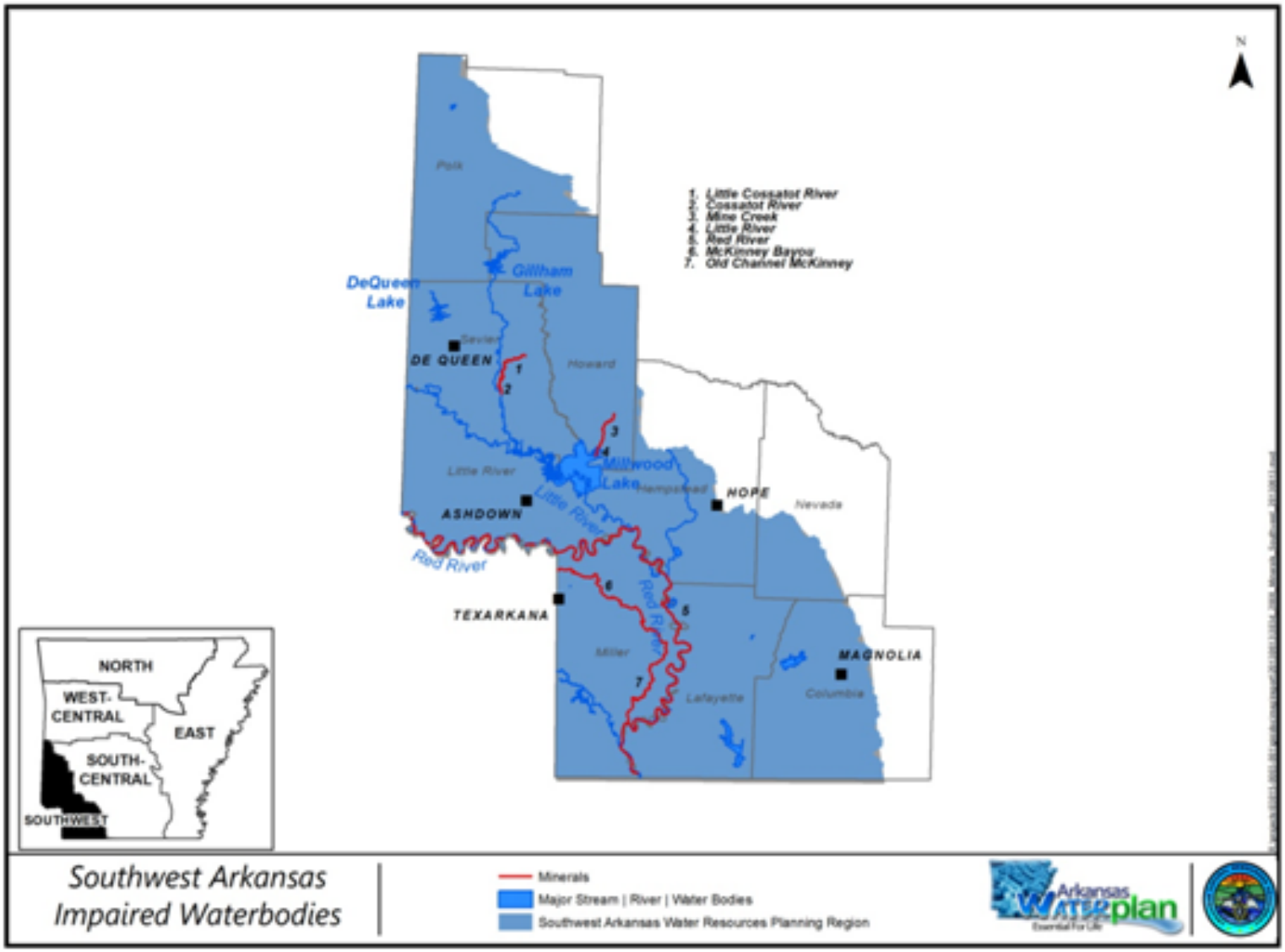

Figure 5.6. Waterbodies in the SAWRPR classified as impaired in the 2008 303(d) list due to minerals (ADEQ 2008,2009).

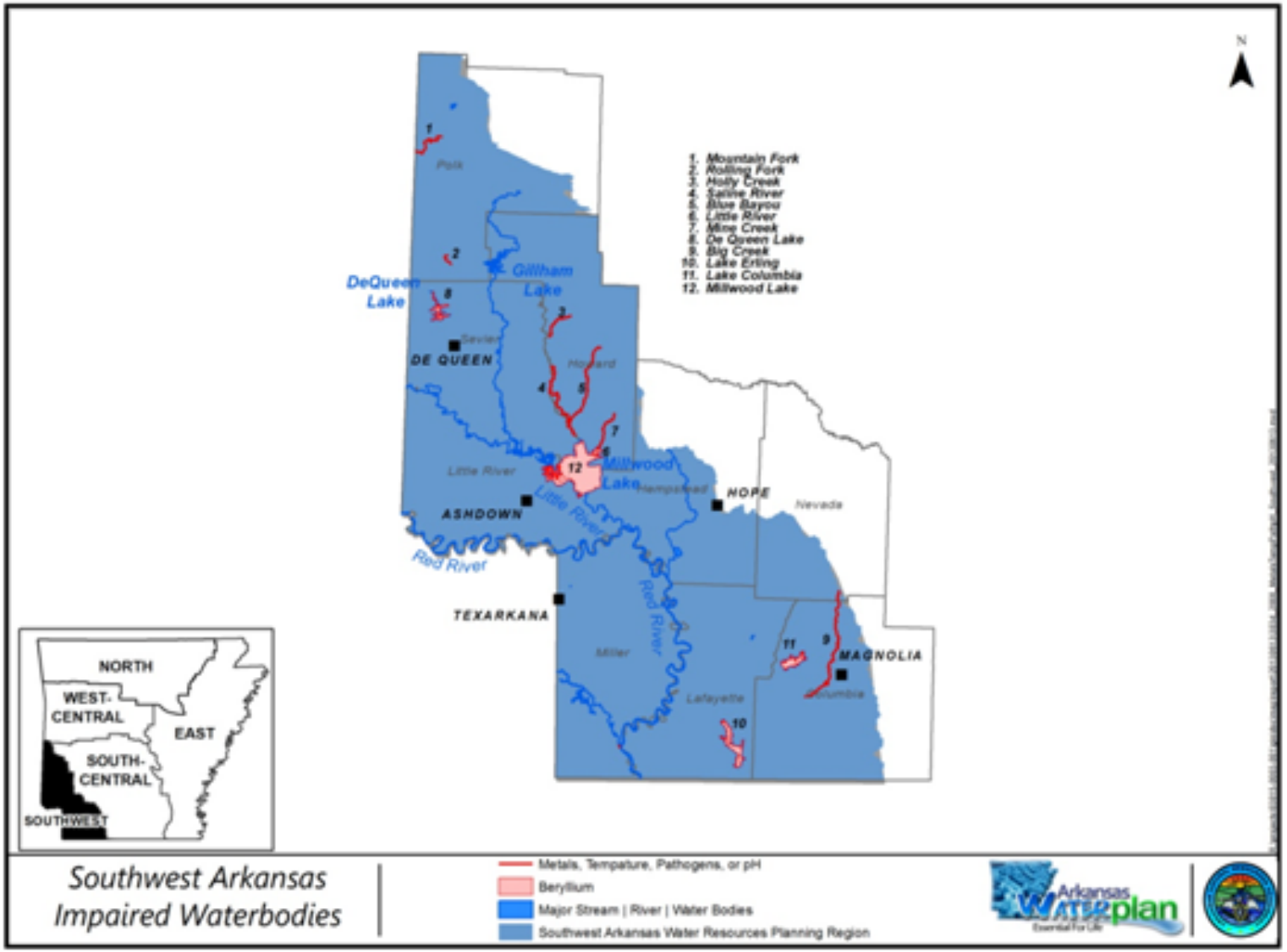

Figure 5.7. Waterbodies in the SAWRPR classified as impaired due to pathogens, temperature, metals, or pH in the 2008 303(d) list (ADEQ 2008,2009).

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.

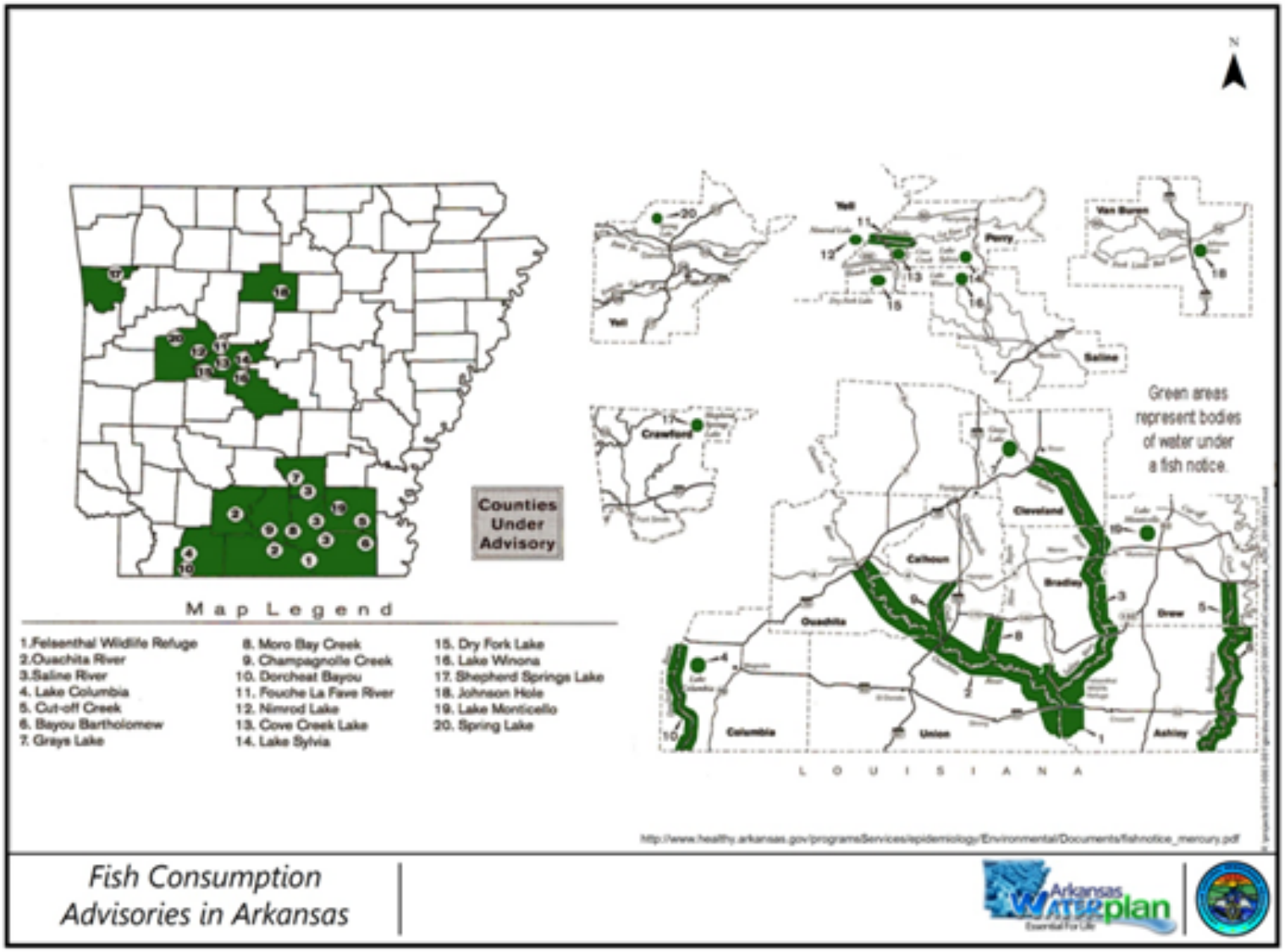

Figure 5.8. Locations of active fish consumption advisories in the SAWRPR (ADH, AGFC, ADEQ 2011).

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.

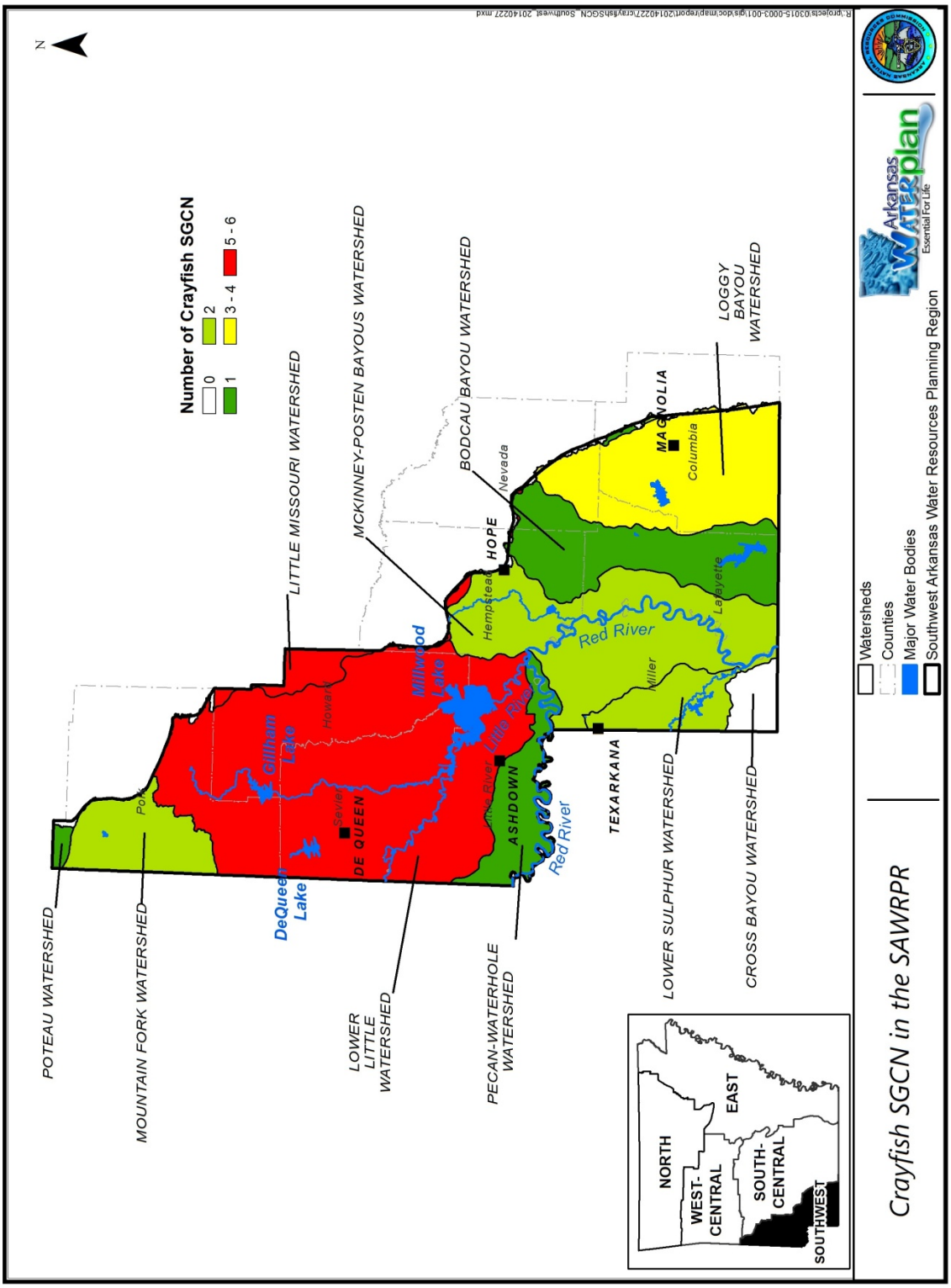

Figure 5.9. Numbers of crayfish Species of Greatest Conservation Need (SGCN) in watersheds of the SAWRPR.

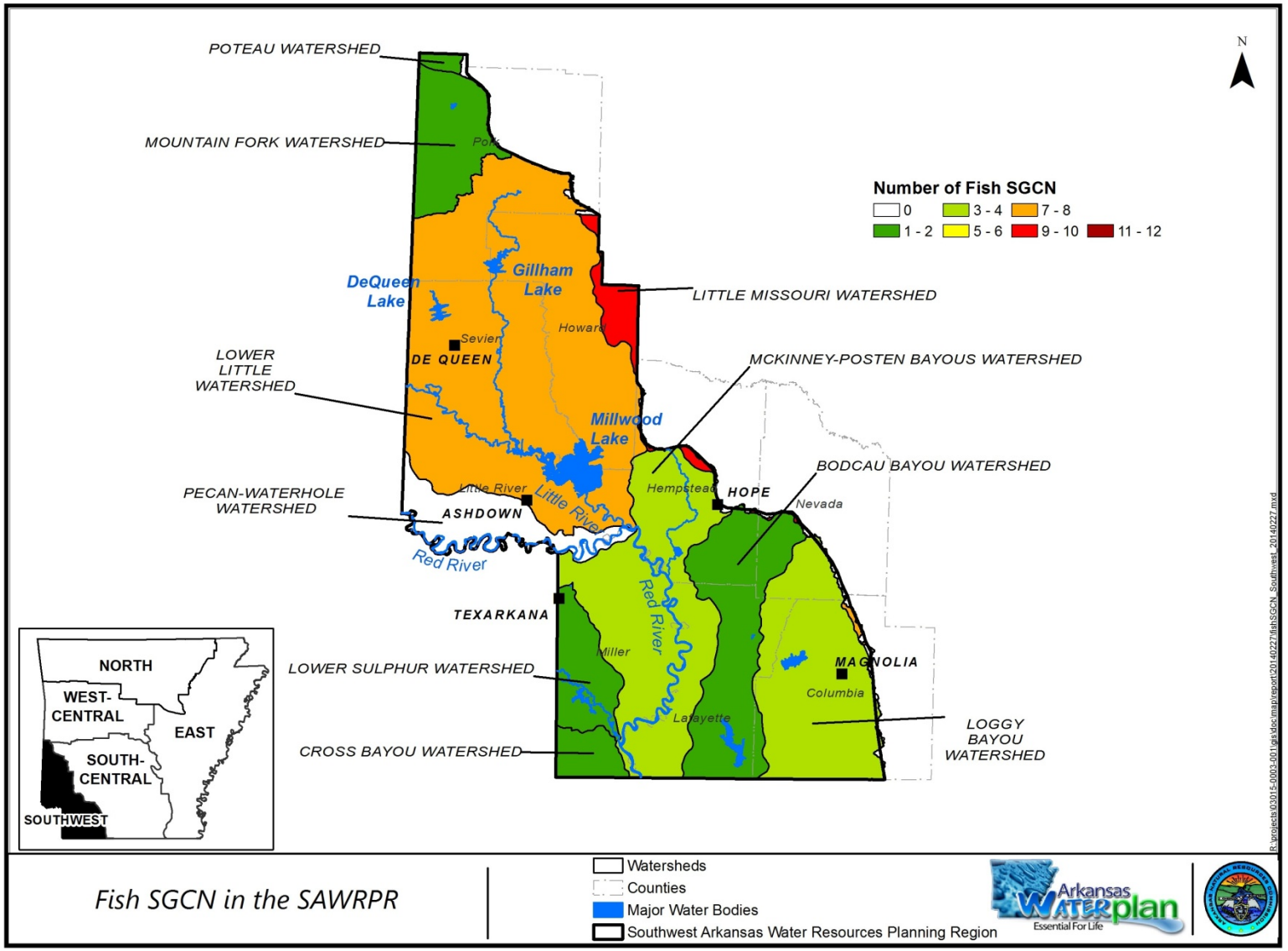

Figure 5.10 Numbers of fish SGCN in watersheds of the SAWRPR.

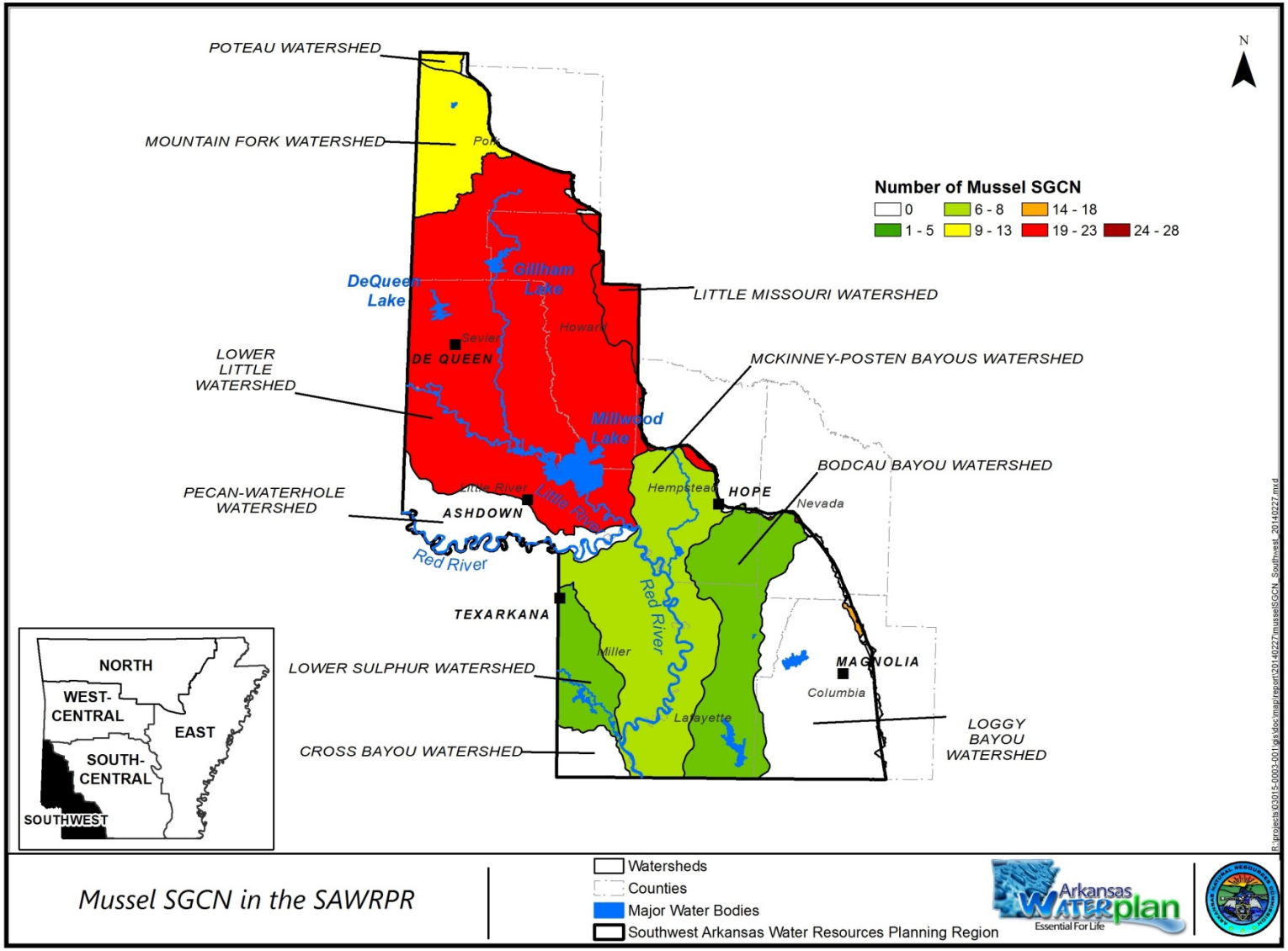

Figure 5.11. Numbers of mussel SGCN in the watersheds of the SAWRPR.

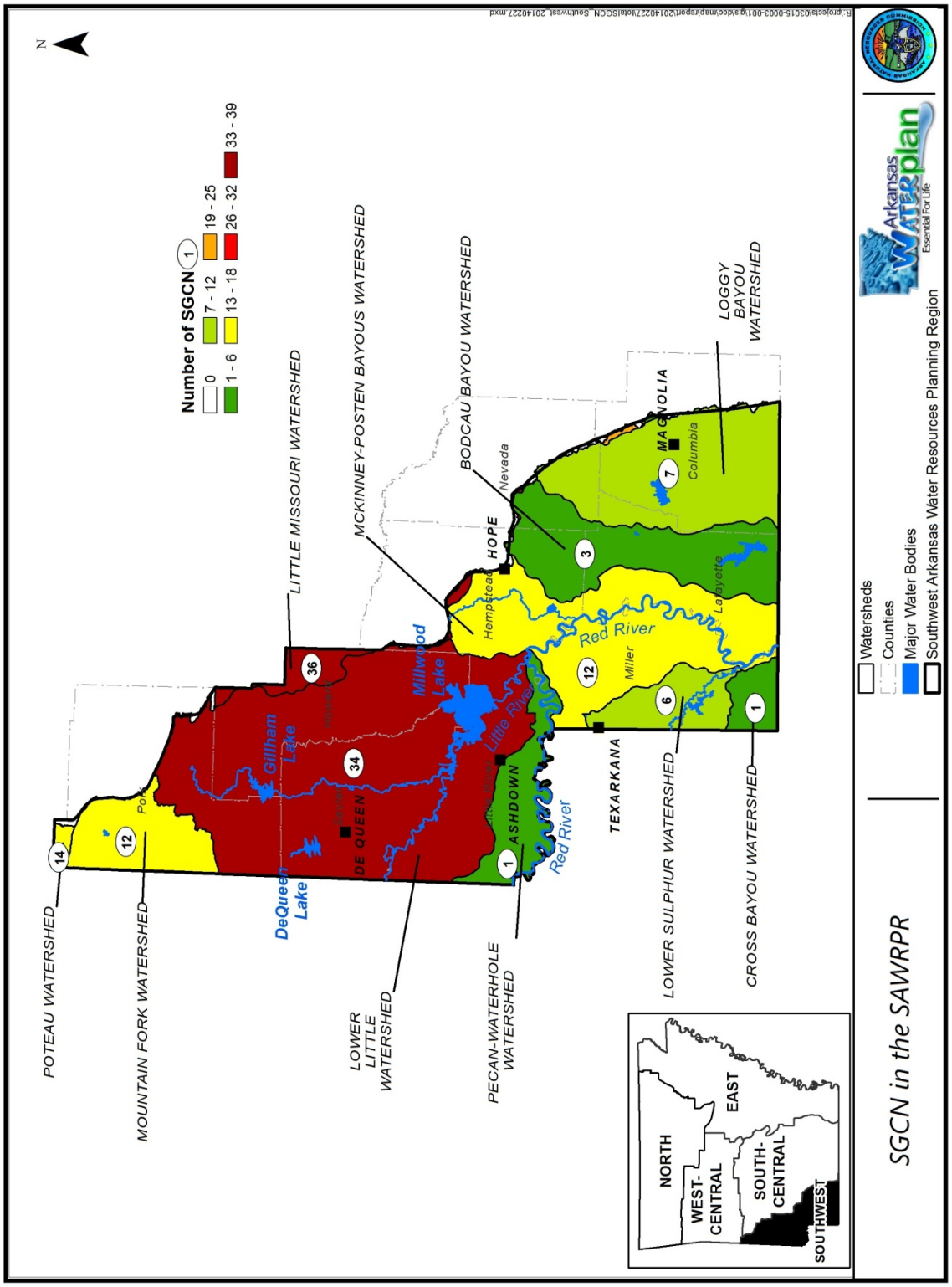

Figure 5.12. Total numbers of crayfish, fish, and mussel SGCN in the watersheds of the SAWRPR.

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	FEMA	Flood recovery, flood reduction
	Floodplain mapping program		
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.

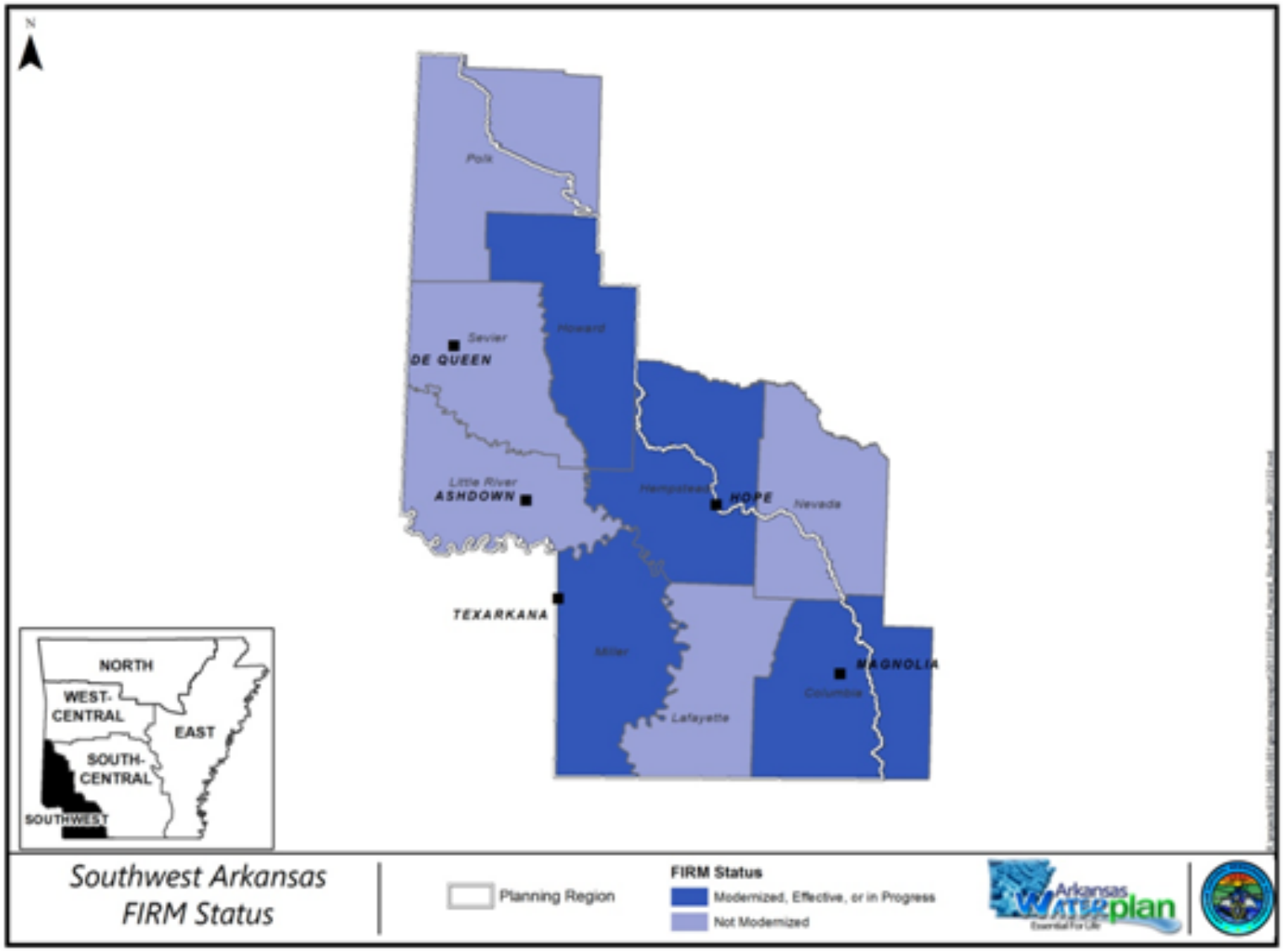

Figure 6.1. Status of flood hazard mapping in the SAWRPR.

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).

	CRP			EQIP			WHIP - drought		
County	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, acceptable materials for landfill disposal regional solid waste management districts	Arkansas Solid Waste Management Act (Arkansas Code § 8-6-201 et seq.),	Resource Conservation and Recovery Act,
	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.).

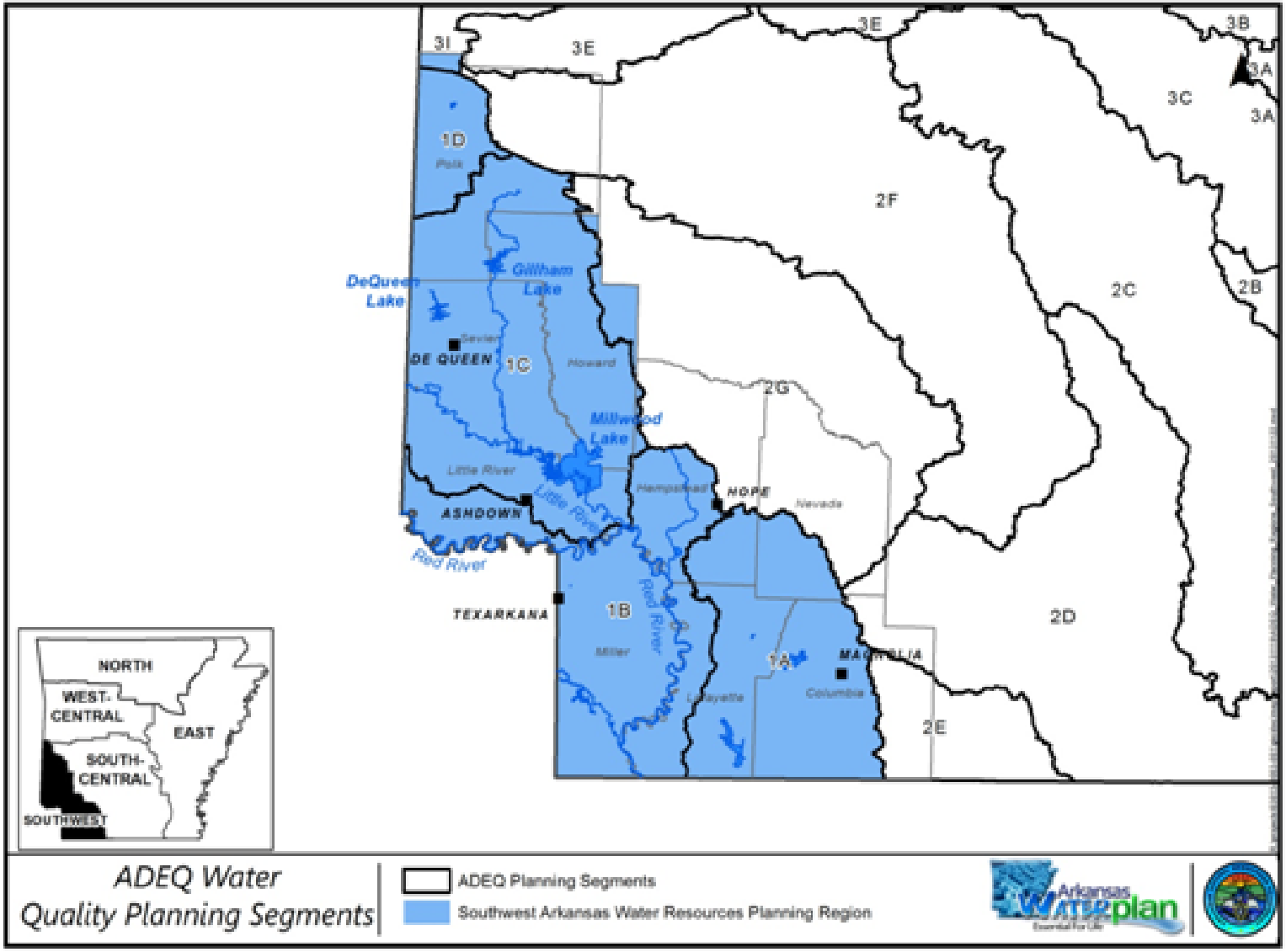

Figure 6.2. ADEQ water quality planning segments included in the SAWRPR.

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

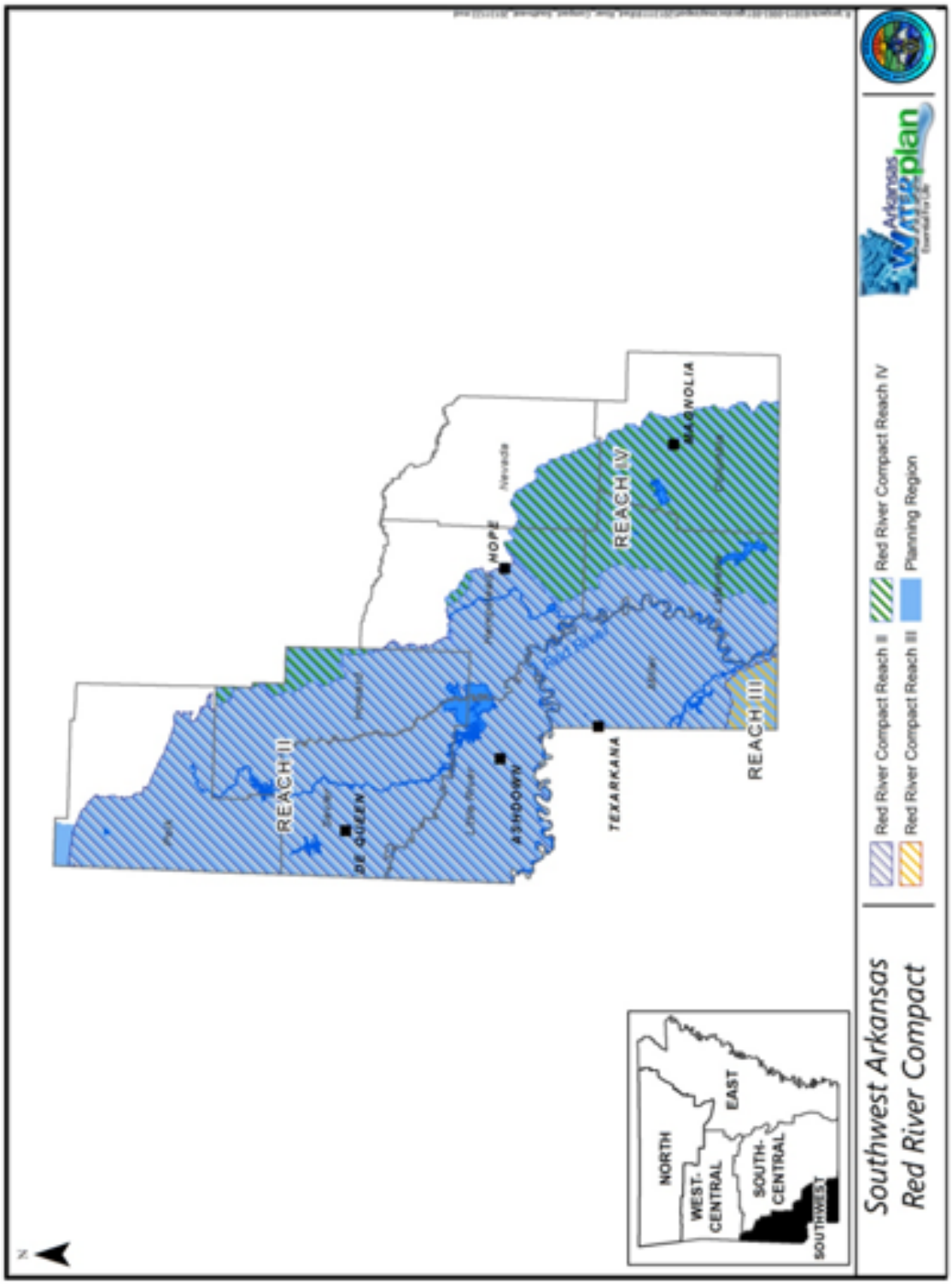

Figure 6.3. Red River Compact boundaries in the SAWRPR.

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

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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