TMDLS FOR SEGMENTS LISTED FOR MERCURY IN FISH TISSUE FOR SELECTED ARKANSAS WATERSHEDS

December 10, 2002

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Prepared for

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EXECUTIVE SUMMARY

The Arkansas 1998 Section 303(d) List included stream reaches that were impaired due to excessive concentrations of mercury in fish. This TMDL study addresses 5 of the listed stream reaches. In addition, 8 lakes in Arkansas and 1 additional river reach are under fish consumption advisories as a result of high mercury concentrations in fish. These waterbodies are also addressed in this TMDL study. While there have been no known violations of the numeric mercury water quality standard and fishable designated use for these waterbodies, they are not meeting the narrative water quality standard and designated uses of fishable waterbodies.

The waterbodies included in this TMDL study are located predominantly in central and northern Arkansas, although there are a couple in the southwest corner of the state. Waterbodies that were close together and had similar watershed characteristics were grouped together because of similar causative factors such as atmospheric and geologic contributions. As a result, TMDLs were completed for 5 watersheds that included the waterbodies of interest for this study.

Arkansas has a numeric mercury water quality standard of 0.012 µg/L. There have been no known violations of this numeric mercury water quality standard in any of the waterbodies included in this TMDL study, but clean sampling procedures and ultra-trace level analyses have not been used. There are fish consumption advisories in all of these waterbodies because of mercury contamination of fish. The mercury Action Level for fish consumption advisories in Arkansas is 1 mg/kg. The safe target level for all fish species used in this TMDL study is 0.8 mg/kg. This incorporates a 20% margin of safety (MOS) for the Action Level.

The TMDLs were developed using a two step approach. The first step was to estimate the mercury loads to the watersheds from NPDES point sources, local emission sources, atmospheric deposition from non-local emission sources, watershed nonpoint sources, and watershed natural background sources. In the second step, average largemouth bass fish tissue mercury concentrations measured in the watersheds were used to estimate the reduction in fish tissue mercury needed to achieve the safe target level. A linear relationship was assumed between mercury levels in fish and mercury loading to the watersheds. The reduction in fish tissue mercury to achieve the target safe level was then used to determine the reduction needed in the mercury load to the watersheds.

The predominant sources of mercury loading to the watersheds were watershed nonpoint sources, watershed natural background, and non-local source atmospheric deposition. NPDES point sources accounted for less than 1% of the watershed mercury loads. Half of the watersheds did not have NPDES point sources of mercury. Watershed reduction factors for mercury loads ranged from 1.02 to 2.58. Even with these reductions, the character of mercury bioaccumulation makes it likely to be a long time before reductions in fish mercury levels are seen as a result of reduced loads to the watersheds.

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1.0 INTRODUCTION

The Arkansas 1998 Section 303(d) List included waterbodies impaired due to excessive concentrations of mercury in fish. Stream reaches listed for mercury in the Ouachita River basin in Arkansas were addressed in a separate TMDL study (FTN 2002). The current TMDL study addresses the remaining stream reaches listed for mercury in Arkansas. This TMDL study also addresses waterbodies where fish consumption advisories have been issued by the State of Arkansas. Table 1.1 identifies the stream reaches and lakes included in this TMDL study.

Figure 1.1 identifies the hydrologic unit category (HUC) watersheds that contain the waterbodies included in the current TMDL study (Note: all figures are located at the end of each section). Table 1.2 lists the HUCs that contain the waterbodies that are included in this TMDL study. The Loggy Bayou HUC, which includes Bayou Dorcheat and Columbia Lake, extends into Louisiana. The Louisiana Bayou Dorcheat stream reaches (subsegments) have been delisted for mercury (Louisiana 1999 Court Ordered Modified 303(d) List). Therefore, only the portion of Bayou Dorcheat upstream of the Arkansas-Louisiana state line is included in this TMDL study.

These segments are of critical concern because of litigation over the 303(d) process in Arkansas, and the pervasiveness of mercury contamination. While there have been no known violations of the numeric water quality standards and fishable designated use for these waterbodies, these segments are not meeting the narrative water quality standard and designated uses of fishable waterbodies. Therefore, development of a TMDL is required. This TMDL is being conducted under EPA Contract #68-C-99-249, Work Assignment #1-85.

Table 1.1. River segments and lakes on 303(d) List or where fish consumption advisories have been issued.

Waterbody Name	Segment / Reach	On 303(d) List	Fish Consumption Advisory	Priority
Bayou Dorcheat	11140203-020	Yes	Yes	Low
	11140203-022	Yes	Yes	Low
	11140203-024	Yes	Yes	Low
	11140203-026	Yes	Yes	Low
Fourche La Fave River	11110206-002	Yes	Yes	Low
South Fork Little Red River	11010014-036	No	Yes	—
Columbia Lake	—	No	Yes	—
Cove Creek Lake	—	No	Yes	—
Dry Fork Lake	—	No	Yes	—
Nimrod Lake	—	No	Yes	—
Johnson Hole	—	No	Yes	—
Shepherd Springs Lake	—	No	Yes	—
Spring Lake	—	No	Yes	—
Lake Sylvia	—	No	Yes	—
Lake Winona	—	No	Yes	—

Table 1.2. HUC number, name, and associated segments or waterbodies included in this TMDL.

Hydrologic Unit Category	HUC Name	Segments or Waterbodies in TMDL
11110206	Fourche La Fave	Fourche La Fave River, Lake Nimrod, Dry Fork Lake, Cove Creek Lake
11140203	Loggy Bayou	Bayou Dorcheat, Lake Columbia
11010014	Little Red	South Fork Little Red River, Johnson Hole
11110201	Frog-Mulberry	Shepherd Springs Lake
11110207	Lower Arkansas-Maumelle	Spring Lake, Lake Sylvia
08040203	Upper Saline	Lake Winona

Hydrologic unit categories that contain segments or waterbodies included in this

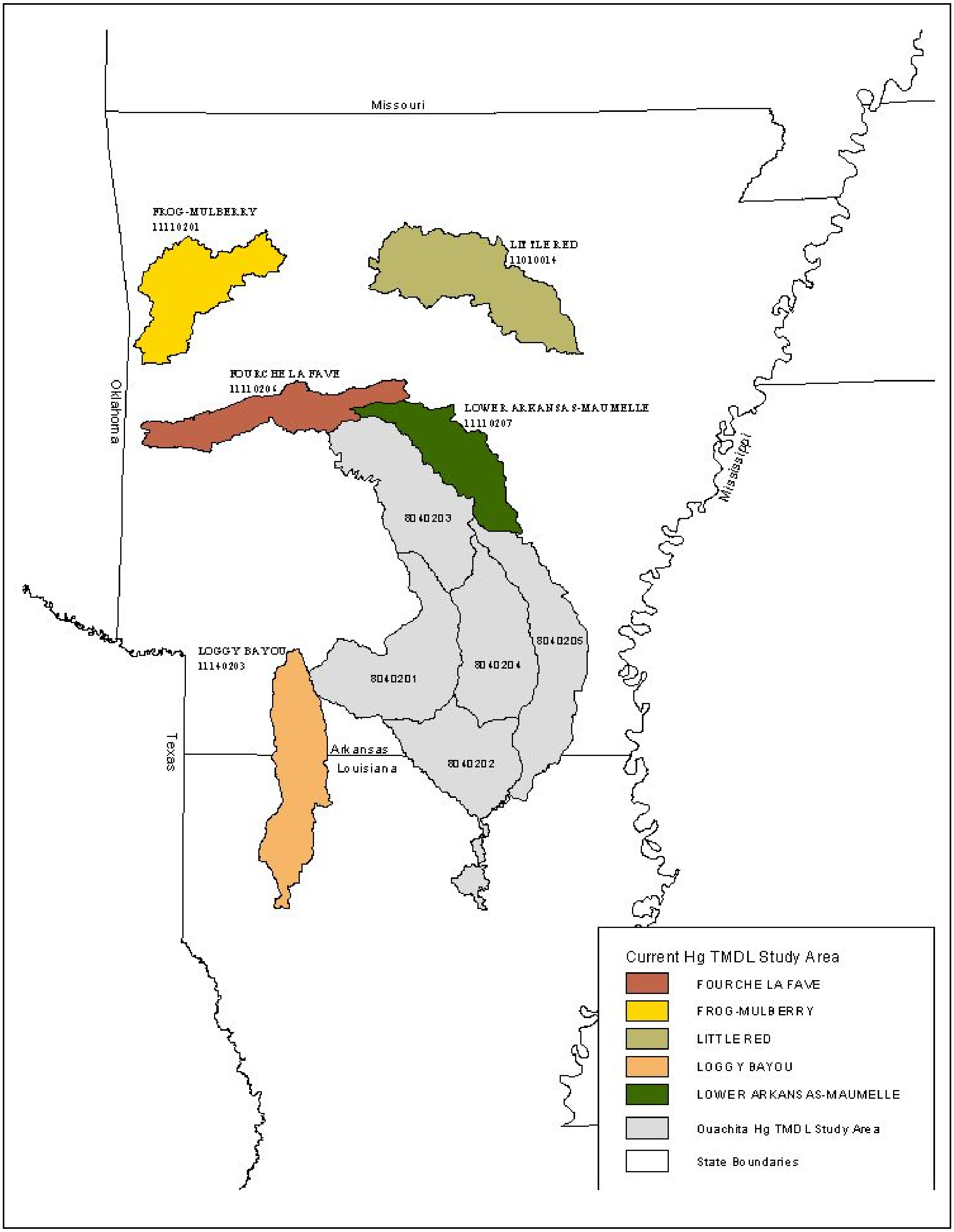


Figure 1.1.

TMDL.

2.0 DESCRIPTION OF WATERBODIES

The TMDL development is based on a watershed approach because of similar causative factors, such as atmospheric and geologic contributions. This TMDL complements and is consistent with the previous mercury TMDL developed for the Ouachita River (FTN 2002). The remaining waters in Arkansas listed for mercury in fish on the 303(d) List, or where fish consumption advisories have been issued by the state, have been grouped into six watersheds. A TMDL has been developed for each of the watersheds. The characteristics of the watersheds are described below.

2.1 Fourche La Fave Watershed

The Fourche La Fave watershed has been defined to include Fourche La Fave River and its tributaries located within the HUC 11110206 (Figure 2.1). This watershed includes listed portions of Fourche La Fave River, as well as Dry Fork Lake, Lake Nimrod, and Cove Creek Lake. The headwaters of the Fourche La Fave River begin in the southern portion of Scott County, Arkansas in the Ouachita Mountains. The Fourche La Fave River runs from west to east through Scott County, Yell County, and Perry County before emptying into the Arkansas River at the eastern edge of Perry County. The watershed drainage area covers approximately 715,690 acres (2,893 km^2) of land located within both the Ouachita Mountains and the Arkansas River Valley. The waters within the Fourche La Fave River watershed have been designated by ADEQ as suitable for the propagation of fish/wildlife, primary and secondary contact recreation and public, industrial and agricultural water supplies.

2.1.1 Topography

The following description of the topography of the watershed was taken from county soil surveys (USDA 1982, 1988, 1998). The watershed is in the Ouachita Mountains and Arkansas River Valley. The topography of this area can be described as level to very steep, with the main topographic divisions consisting of uplands, mountains, ridges, terraces, and flood plains, with slope ranges from 1% to 40%.

2.1.2 Soils

Soil characteristics for the watershed were taken from the county soil surveys (USDA 1982, 1988, 1998). Most of the soils in the watershed are classified as moderately well drained to well drained gravelly, cobbly, stony, very stony, and loamy soils on uplands and mountains. Soil associations that are most common in the watershed include Carnasaw-Sherless-Clebit and Carnasaw-Pirum-Clebit. Other soil associations that are somewhat common include Guthrie-Barling, Avilla-Kenn-Ceda, Spadra-Barling-Pickwick, Leadvale-Cane-Taft, Leadvale-Guthrie, Perry-Moreland, Muskogee-Wrightsville-McKamie, Leadvale-Endsaw-Taft, Spadra-Neff-Cupco, Kenn-Avilla-Ceda, and Octavia-Caston-Carnasaw.

2.1.3 Land Use

Land use in the watershed is predominantly forest land and some agricultural land (Figure 2.2). Areas and approximate percentages of each land use in the watershed are listed in Table 2.1. Most of the lowlands have been cleared, and on most farms drainage has been improved for more reliable crop production. Soybeans are the main crop grown on the bottom lands, but rice, wheat, and sorghums are also grown. Much of the farm income is from livestock, mainly beef cattle, poultry, and hogs. Portions of the forest land are owned by large timber companies and some areas are federally administered land within the Ouachita National Forest.

2.1.4 Description of Hydrology

USGS daily stream flow data were retrieved for the gage in the Fourche La Fave River near Gravelly, Arkansas. Basic information and summary statistics for the gage are summarized in Table 2.2.

Table 2.1. Acreage and percent of land use categories in the Fourche La Fave River watershed.

Land Use	Acres (km^2)	Percent
Forest	601,260 (2,430)	84.0
Agricultural	106,200 (430)	14.8
Wetland	780 (3)	0.1
Water	5,800 (23)	0.8
Urban	1,610 (7)	0.2
Other	30 (0.1)	0.004
TOTAL	715,690 (2,893)	100

Table 2.2. Information for stream flow gage station, Fourche La Fave River.

Gage name	Fourche La Fave River near Gravelly, AR
USGS gage number	07261500
Descriptive location	Latitude 34°52’21” Longitude 93°39’24” Located in Yell County near left bank on downstream side of bridge on State Highway 28
Drainage area	410 mi^2
Period of record	October 1987 to September 2000
Mean flow	604 ft^3/sec
Minimum flow	0.0 ft^3/sec
Maximum flow	44,800 ft^3/sec
Flow that is exceeded: 80% of the time 50% of the time 20% of the time	 10 ft^3/sec 159 ft^3/sec 681 ft^3/sec

Average annual precipitation for the watershed is approximately 52 inches (Hydrosphere 2000). Mean monthly precipitation totals for the watershed are shown in Figure 2.3. The mean monthly precipitation values are highest for December and lowest for August. Precipitation data for 1997 through 1999 from three stations within HUC 11110206 were used to calculate the annual and monthly mean precipitation for the watershed (Appendix A).

2.1.5 Point Sources

Information on NPDES point source discharges in the watershed was obtained by searching the PCS on the EPA website. The PCS search identified 3 facilities with NPDES permits within the watershed, which were municipal wastewater treatment systems that discharge within the Fourche La Fave River watershed. A listing of NPDES permitted facilities is included in Appendix B.

Information on local air emission sources in the airshed (airshed defined to include counties within 100 km of the watershed boundary) was obtained by searching the EPA Office of Air Quality Planning and Standards National Toxics Inventory (NTI) emission database on the EPA website. The NTI emission inventory includes point sources, area sources, and mobile sources. Data from the NTI website was downloaded using the maxiumum achievable control technology (MACT) report format. The MACT report includes the number of point sources and 1996 total hazardous air pollutant (HAP) emissions for each MACT source category included in the NTI by county. The database search for the airshed resulted in 217 air emission sources in 10 MACT source categories. The MACT source categories are based on standards for emission limitations developed under section 112(d) of the Clean Air Act (National Emissions Standards for Hazardous Air Pollutants). The limitations are based on the best demonstrated control technology or practices in similar sources to be applied to major sources emitting one or more of the listed toxic pollutants. A listing of the air emission sources is included in Appendix C.

2.2 Bayou Dorcheat Watershed

The Bayou Dorcheat watershed has been defined to include Bayou Dorcheat and its tributaries located within the HUC 11140203 north of the Arkansas-Louisiana state line (Figure 2.4). It includes listed portions of Bayou Dorcheat, as well as Lake Columbia. The headwaters of Bayou Dorcheat begin in southern Nevada County and northern Columbia County, Arkansas in the Gulf Coastal Plain ecoregion. Bayou Dorcheat runs from north to south through Columbia County, Arkansas and continues into Webster Parish, Louisiana before emptying into Lake Bistineau south of Minden, Louisiana. The watershed drainage area covers approximately 324,106 acres (1,312 km^2) of land located within the Gulf Coastal Plain ecoregion. The waters within the Bayou Dorcheat watershed have been designated by ADEQ as suitable for the propagation of fish/wildlife, primary and secondary contact recreation and public, industrial and agricultural water supplies.

2.2.1 Topography

The following description of the topography of the watershed was taken from county soil surveys (USDA 1985). The watershed is in the Gulf Coastal Plain ecoregion. The topography of this area can be described as level to moderately sloping, with the main topographic divisions consisting of upland flats, flood plains, low terraces, hilltops, and side slopes, with slope ranges from 0% to 12%.

2.2.2 Soils

Soil characteristics for the watershed were taken from the county soil surveys (USDA 1985). Most of the soils in the watershed are classified as poorly drained to moderately well drained loamy soils on upland flats, flood plains, low terraces, hilltops, and side slopes. Soil associations that are most common in the watershed include Bowie-Sacul, Harleston-Bowie, Guyton, and Felker-Adaton. Other soil associations that are somewhat common include Wrightsville-Louin, Sacul-Smithdale, and Smithdale.

2.2.3 Land Use

Land use in the watershed is predominantly forest land and agricultural land (Figure 2.5). Areas and approximate percentages of each land use in the watershed are listed in Table 2.3. The timber industry is an important part of the economy. A large acreage is managed for the production of pulpwood, poles, and saw logs. Most of the remaining land is used for pasture and forage crops. Livestock production and poultry production are also economically important in the area.

Table 2.3. Acreage and percent of land use categories in the Bayou Dorcheat watershed.

Land Use	Acres (km^2)	Percent
Forest	222,048 (899)	68.8
Agricultural	62,946 (255)	19.5
Wetland	32,986 (133)	10.2
Water	120(0.49)	0.04
Urban	4,667 (18.9)	1.4
Other	150 (0.61)	0.05
TOTAL	324,106 (1,312)	100

2.2.4 Description of Hydrology

USGS daily stream flow data were retrieved for the gage in the Bayou Dorcheat near Springhill, Louisiana. Basic information and summary statistics for the gage are summarized in Table 2.4.

Table 2.4. Information for stream flow gage station, Bayou Dorcheat.

Gage Name	Bayou Dorcheat near Springhill, LA
USGS gage number	07348700
Descriptive location	Latitude 32°59’40” Longitude 93°23’47” Located in Webster Parish near Springhill, LA
Drainage area	605 mi^2
Period of record	October 1957 to September 1998
Mean flow	617 ft^3/sec
Minimum flow	0.0 ft^3/sec
Maximum flow	35,000 ft^3/sec
Flow that is exceeded: 80% of the time 50% of the time 20% of the time	 10 ft^3/sec 134 ft^3/sec 900 ft^3/sec

Average annual precipitation for the watershed is approximately 61 inches (Hydrosphere 2000). Mean monthly precipitation totals for the watershed are shown in Figure 2.6. The mean monthly precipitation values are highest for January and lowest for July. Precipitation data for 1997 through 1999 from three stations within HUC 11140203 were used to calculate the annual and monthly mean precipitation for the watershed (Appendix A).

2.2.5 Point Sources

Information on NPDES point source discharges in the watershed was obtained by searching the PCS on the EPA website. The PCS search identified 10 facilities with NPDES permits within the watershed. Of these 10 permitted facilities, 4 were municipal wastewater treatment systems that discharge into the Bayou Dorcheat watershed. The remaining 6 NPDES permitted facilities were for commercial/industrial sources and did not have a permit limit for mercury. A listing of NPDES permitted facilities is included in Appendix B.

Information on local air emission sources in the airshed (airshed defined to include counties within 100 km of the watershed boundary) was obtained by searching the EPA Office of Air Quality Planning and Standards National Toxics Inventory (NTI) emission database on the EPA website. The NTI emission inventory includes point sources, area sources, and mobile sources. Data from the NTI website was downloaded using the maxiumum achievable control technology (MACT) report format. The MACT report includes the number of point sources and total 1996 hazardous air pollutant (HAP) emissions for each MACT source category included in the NTI by county. The database search for the airshed resulted in 185 air emission sources in 12 MACT source categories. The MACT source categories are based on standards for emission limitations developed under section 112(d) of the Clean Air Act (National Emissions Standards for Hazardous Air Pollutants). The limitations are based on the best demonstrated control technology or practices in similar sources to be applied to major sources emitting one or more of the listed toxic pollutants. A listing of the air emission sources is included in Appendix C.

2.3 South Fork Little Red Watershed

The South Fork Little Red watershed has been defined to include the South Fork Little Red River and its tributaries located within the HUC 11010014 (Figure 2.7). It includes listed portions of the South Fork Little Red River, as well as Johnson Hole. The headwaters of the South Fork Little Red River begin in the western portion of Van Buren County, Arkansas in the Boston Mountains. The South Fork Little Red River runs from west to east through Van Buren County, Arkansas before emptying into Greers Ferry Lake near Clinton, Arkansas. The watershed drainage area covers approximately 177,212 acres (717 km^2) of land located within the Boston Mountains. The waters within the South Fork Little Red River watershed have been designated by ADEQ as suitable for the propagation of fish/wildlife, primary and secondary contact recreation and public, industrial and agricultural water supplies.

2.3.1 Topography

The following description of the topography of the watershed was taken from county soil surveys (USDA 1986). The watershed is in the Boston Mountains. The topography of this area can be described as broad, gently sloping to rolling mountaintops and steep to very steep mountainsides. The mountaintops are generally capped with hard sandstone, and the mountainsides are typically interbedded sandstone, siltstone, and shale. Slope ranges from 1% to 60%.

2.3.2 Soils

Soil characteristics for the watershed were taken from the county soil surveys (USDA 1986). Most of the soils in the watershed are classified as well drained loamy, gravelly, and stony soils that formed in residual and colluvial material derived from shale or interbedded sandstone, siltstone, and shale. Soil associations that are most common in the watershed include Enders-Steprock-Nella, Steprock-Mountainburg-Rock Outcrop, Linker-Steprock, and Kenn-Ceda-Spadra.

2.3.3 Land Use

Land use in the watershed is predominantly forest land and agricultural land (Figure 2.8). Areas and approximate percentages of each land use in the watershed are listed in Table 2.5. Dairy herds, beef cattle, hogs, and poultry provide most of the farm income in the area of ridges, upland flats, and valleys. Some farms have small acreage of orchards, vegetables, strawberries, or a combination of these. On the bottom lands, soybeans are the main crop, but grain sorghum and winter small grains are also grown.

Table 2.5. Acreage and percent of land use categories in the South Fork Little Red watershed.

Land Use	Acres (km^2)	Percent
Forest	153,910 (622)	86.9
Agricultural	21,572 (87)	12.2
Wetland	—	—
Water	279 (1.1)	0.2
Urban	1,451 (5.9)	0.8
Other	—	—
TOTAL	177, 212 (717)	100

2.3.4 Description of Hydrology

USGS daily stream flow data were retrieved for the gage in the South Fork Little Red River at Clinton, Arkansas. Basic information and summary statistics for the gage are summarized in Table 2.6.

Average annual precipitation for the watershed is approximately 48 inches (Hydrosphere 2000). Mean monthly precipitation totals for the watershed are shown in Figure 2.9. The mean monthly precipitation values are highest for March and lowest for August. Precipitation data for 1997 through 1999 from three stations within HUC 11010014 were used to calculate the annual and monthly mean precipitation for the watershed (Appendix A).

Table 2.6. Information for stream flow gage station, South Fork Little Red River.

Gage Name	South Fork Little Red River at Clinton, AR
USGS gage number	07075300
Descriptive location	Latitude 35°35'29" Longitude 92°27'20" Located in Van Buren County near right bank on upstream side of bridge on US Highway 65 at Clinton
Drainage area	148 mi^2
Period of record	March 1939 to December 1961
Mean flow	579 ft^3/sec
Minimum flow	0.0 ft^3/sec
Maximum flow	29,400 ft^3/sec
Flow that is exceeded: 80% of the time 50% of the time 20% of the time	 15 ft^3/sec 170 ft^3/sec 735 ft^3/sec

2.3.5 Point Sources

Information on NPDES point source discharges in the watershed was obtained by searching the PCS on the EPA website. The PCS search identified 24 facilities with NPDES permits within the watershed. Of these 24 permitted facilities, 2 were municipal wastewater treatment systems that discharge within the South Fork Little Red watershed. The remaining 22 NPDES permitted facilities were for commercial/industrial sources and did not have a permit limit for mercury. A listing of NPDES permitted facilities is included in Appendix B.

Information on local air emission sources in the airshed (airshed defined to include counties within 100 km of the watershed boundary) was obtained by searching the EPA Office of Air Quality Planning and Standards National Toxics Inventory (NTI) emission database on the EPA website. The NTI emission inventory includes point sources, area sources, and mobile sources. Data from the NTI website was downloaded using the maxiumum achievable control technology (MACT) report format. The MACT report includes the number of point sources and total 1996 hazardous air pollutant (HAP) emissions for each MACT source category included in the NTI by county. The database search for the airshed resulted in 132 air emission sources in 8 MACT source categories. The MACT source categories are based on standards for emission limitations developed under section 112(d) of the Clean Air Act (National Emissions Standards for Hazardous Air Pollutants). The limitations are based on the best demonstrated control technology or practices in similar sources to be applied to major sources emitting one or more of the listed toxic pollutants. A listing of the air emission sources is included in Appendix C.

2.4 Shepherd Springs Lake Watershed

The Shepherd Springs Lake watershed has been defined to include Shepherd Springs Lake and its tributaries located within the HUC 11110201 (Figure 2.10). Shepherd Springs Lake and its tributaries are located in the northeastern portion of Crawford County, Arkansas. The watershed drainage area covers approximately 44,908 acres (182 km^2) of land located within the Boston Mountains. Shepherd Springs Lake has been designated by ADEQ as suitable for the propagation of fish/wildlife, primary and secondary contact recreation and public, industrial and agricultural water supplies.

2.4.1 Topography

The following description of the topography of the watershed was taken from county soil surveys (USDA 1979). The Shepherd Springs Lake watershed is in the Boston Mountains. The topography of this area can be described as steep, stony mountains. These mountains are capped by sandstone, and their sides interbedded sandstone and shale. Slope ranges from 3 to 50% and elevation ranges from about 500 to 2,380 feet.

2.4.2 Soils

Soil characteristics for the watershed were taken from the county soil survey (USDA 1979). Most of the soils in the Shepherd Springs Lake watershed are classified as well drained, gently sloping to very steep, deep, loamy and stony soils on hills and mountains. The main soil association that is common in the watershed is the Nella-Enders. Nella soils are on toeslopes and benches, and Enders soils are on hillsides and mountainsides.

2.4.3 Land Use

Land use in the watershed is predominantly forest land (Figure 2.11). Areas and approximate percentages of each land use in the watershed are listed in Table 2.7.

Table 2.7. Acreage and percent of land use categories in the Shepherd Springs Lake watershed.

Land Use	Acres (km^2)	Percent
Forest	40,533 (164)	90.3
Agricultural	3,936 (16)	8.8
Wetland	---	---
Water	270 (1.1)	0.6
Urban	169 (0.7)	0.3
Other	---	
TOTAL	44,908 (182)	100

The soils in most of this area are too steep for intensive farming use. They are used mainly for the production of wood crops and for native pasture. Some of the less sloping soils are suitable for improved pasture, and the soils in some of the narrow valleys are suitable for truck crops.

2.4.4 Description of Hydrology

Average annual precipitation for the watershed is approximately 53 inches (Hydrosphere 2000). Mean monthly precipitation totals for the watershed are shown in Figure 2.12. The mean monthly precipitation values are highest for March and lowest for August. Precipitation data for 1997 through 1999 from three stations within HUC 11110201 were used to calculate the annual and monthly mean precipitation for the watershed (Appendix A). USGS daily stream flow data were not available for this watershed.

2.4.5 Point Sources

Information on NPDES point source discharges in the watershed was obtained by searching the PCS on the EPA website. Based on information from the PCS search, there were no facilities identified with NPDES permits within the watershed.

Information on local air emission sources in the airshed (airshed defined to include counties within 100 km of the watershed boundary) was obtained by searching the EPA Office of Air Quality Planning and Standards National Toxics Inventory (NTI) emission database on the EPA website. The NTI emission inventory includes point sources, area sources, and mobile sources. Data from the NTI website was downloaded using the maxiumum achievable control technology (MACT) report format. The MACT report includes the number of point sources and total 1996 hazardous air pollutant (HAP) emissions for each MACT source category included in the NTI by county. The database search for the airshed resulted in 119 air emission sources in 8 MACT source categories. The MACT source categories are based on standards for emission limitations developed under section 112(d) of the Clean Air Act (National Emissions Standards for Hazardous Air Pollutants). The limitations are based on the best demonstrated control technology or practices in similar sources to be applied to major sources emitting one or more of the listed toxic pollutants. A listing of the air emission sources is included in Appendix C.

2.5 Spring Lake Watershed

For this TMDL, the Spring Lake watershed has been defined to include Spring Lake and its tributaries located within the HUC 11110207 (Figure 2.13). Spring Lake and its tributaries are located in the southeastern portion of Saline County, Arkansas. The watershed drainage area covers approximately 23,555 acres (95 km^2) of land located within the Gulf Coastal Plain ecoregion. Spring Lake has been designated by ADEQ as suitable for the propagation of fish/wildlife, primary and secondary contact recreation and public, industrial and agricultural water supplies.

2.5.1 Topography

The following description of the topography of the watershed was taken from county soil surveys (USDA 1979). The Spring Lake watershed is in the Gulf Coastal Plain ecoregion. The topography of this area can be described as level to moderately sloping uplands, with slope ranges from 3% to 8%.

2.5.2 Soils

Soil characteristics for the watershed were taken from the county soil survey (USDA 1979). Most of the soils in the watershed are classified as poorly drained to well drained loamy soils. Soil associations that are common in the watershed include Smithdale-Savannah-Amy and Tiak-Savannah.

2.5.3 Land Use

Land use in the watershed is predominantly forest land (Figure 2.14). Areas and approximate percentages of each land use in the watershed are listed in Table 2.8. Some areas are suitable for improved pasture and cultivated crops. Excess water is a moderate to very severe hazard on the level tracts. Erosion is a moderate to very severe hazard in the more sloping areas.

Table 2.8. Acreage and percent of land use categories in the Spring Lake watershed.

Land Use	Acres (km^2)	Percent
Forest	2,429 (9.8)	88.1
Agricultural	16 (0.1)	0.6
Wetland	0 (0)	0.0
Water	158 (0.6)	5.8
Urban	69 (0.3)	2.5
Other	63 (0.2)	2.3
TOTAL	2,735 (11.1)	100

2.5.4 Description of Hydrology

Average annual precipitation for the watershed is approximately 47 inches (Hydrosphere 2000). Mean monthly precipitation totals for the watershed are shown in Figure 2.15. The mean monthly precipitation values are highest for March and lowest for July. Precipitation data for 1997 through 1999 from three stations within HUC 11110207 were used to calculate the annual and monthly mean precipitation for the watershed (Appendix A). USGS daily stream flow data were not available for this watershed.

2.5.5 Point Sources

Information on NPDES point source discharges in the watershed was obtained by searching the PCS on the EPA website. Based on information from the PCS search, there were no facilities identified with NPDES permits within the watershed.

Information on local air emission sources in the airshed (airshed defined to include counties within 100 km of the watershed boundary) was obtained by searching the EPA Office of Air Quality Planning and Standards National Toxics Inventory (NTI) emission database on the EPA website. The NTI emission inventory includes point sources, area sources, and mobile sources. Data from the NTI website was downloaded using the maxiumum achievable control technology (MACT) report format. The MACT report includes the number of point sources and total 1996 hazardous air pollutant (HAP) emissions for each MACT source category included in the NTI by county. The database search for the airshed resulted in 113 air emission sources in 9 MACT source categories. The MACT source categories are based on standards for emission limitations developed under section 112(d) of the Clean Air Act (National Emissions Standards for Hazardous Air Pollutants). The limitations are based on the best demonstrated control technology or practices in similar sources to be applied to major sources emitting one or more of the listed toxic pollutants. A listing of the air emission sources is included in Appendix C.

2.6 Lake Winona and Lake Sylvia Watershed

For this TMDL, the Lake Winona and Lake Sylvia watersheds have been combined because of their close proximity and similar land uses. The Lake Winona watershed has been defined to include Lake Winona and its tributaries located within the HUC 08040203 (Figure 2.16). Lake Winona and its tributaries are located in the northern portion of Saline County, Arkansas. The watershed drainage area covers approximately 28,810 acres (117 km^2) of land located within the Ouachita Mountains. The Lake Sylvia watershed has been defined to include Lake Sylvia and its tributaries located within the HUC 11110207 (Figure 2.19). Lake Sylvia and its tributaries are located within the southeastern portion of Perry County, Arkansas. The watershed drainage area covers approximately 5,510 acres (22 km^2) of land located within the Ouachita Mountains. These lakes have been designated by ADEQ as suitable for the propagation of fish/wildlife, primary and secondary contact recreation and public, industrial and agricultural water supplies.

2.6.1 Topography

The following description of the topography of the watersheds was taken from county soil surveys (USDA 1979). The Lake Winona and Lake Sylvia watersheds are in the Ouachita Mountains. The topography of this area can be described as gently sloping to very steep ridges, crests, and side slopes, with slope ranges from 1% to 60%.

2.6.2 Soils

Soil characteristics for the watersheds were taken from county soil surveys (USDA 1979). Most of the soils in the watersheds are classified as poorly drained to well drained loam, gravelly loam, stony soil, and soils developed from sandstone and shale. Soil associations that are common in the watershed include Carnasaw-Townley-Pirum, Carnasaw-Pirum-Clebit, and Leadvale-Guthrie.

2.6.3 Land Use

Land use in the watersheds is predominantly forest land (Figure 2.17). Areas and approximate percentages of each land use in the watersheds are listed in Table 2.9. Most areas are mainly used for timber production. Steep slopes, available water capacity, depth to bedrock, stony or gravelly surface layer, and the severe hazard of erosion are the main limitations for plants.

Table 2.9. Acreage and percent of land use categories in the Lake Winona and Lake Sylvia watersheds.

Land Use	Acres (km^2)	Percent
Forest	33,048 (134)	96.3
Agricultural	---	---
Wetland	---	---
Water	1,272 (5.1)	3.7
Urban	---	---
Other	---	---
TOTAL	34,320 (139)	100

2.6.4 Description of Hydrology

Average annual precipitation for the watersheds is approximately 50 inches (Hydrosphere 2000). Mean monthly precipitation totals for the watersheds are shown in Figure 2.18. The mean monthly precipitation values are highest for March and lowest for August. Precipitation data for 1997 through 1999 from three stations within HUC 11110207 and three stations within HUC 08040203 were used to calculate the annual and monthly mean precipitation for the watershed (Appendix A). USGS daily stream flow data were not available for this watershed.

2.6.5 Point Sources

Information on NPDES point source discharges in the watersheds was obtained by searching the PCS on the EPA website. Based on information from the PCS search, there were no facilities identified with NPDES permits within the watersheds.

Information on local air emission sources in the airshed (airshed defined to include counties within 100 km of the watershed boundary) was obtained by searching the EPA Office of Air Quality Planning and Standards National Toxics Inventory (NTI) emission database on the EPA website. The NTI emission inventory includes point sources, area sources, and mobile sources. Data from the NTI website was downloaded using the maxiumum achievable control technology (MACT) report format. The MACT report includes the number of point sources and total 1996 hazardous air pollutant (HAP) emissions for each MACT source category included in the NTI by county. The database search for the airshed resulted in 128 air emission sources in 9 MACT source categories. The MACT source categories are based on standards for emission limitations developed under section 112(d) of the Clean Air Act (National Emissions Standards for Hazardous Air Pollutants). The limitations are based on the best demonstrated control technology or practices in similar sources to be applied to major sources emitting one or more of the listed toxic pollutants. A listing of the air emission sources is included in Appendix C.

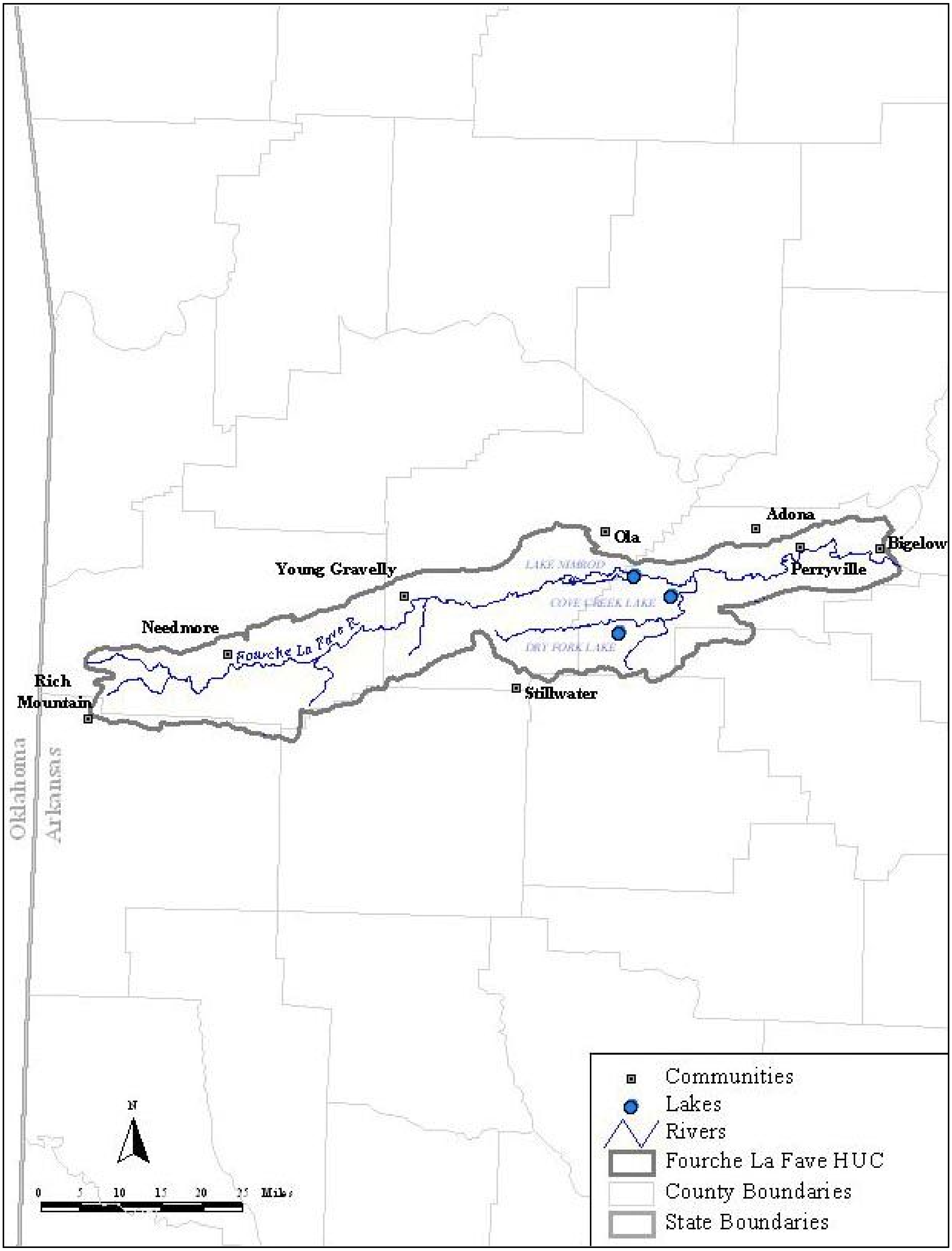


Figure 2.1. Fourche La Fave HUC 11110206.

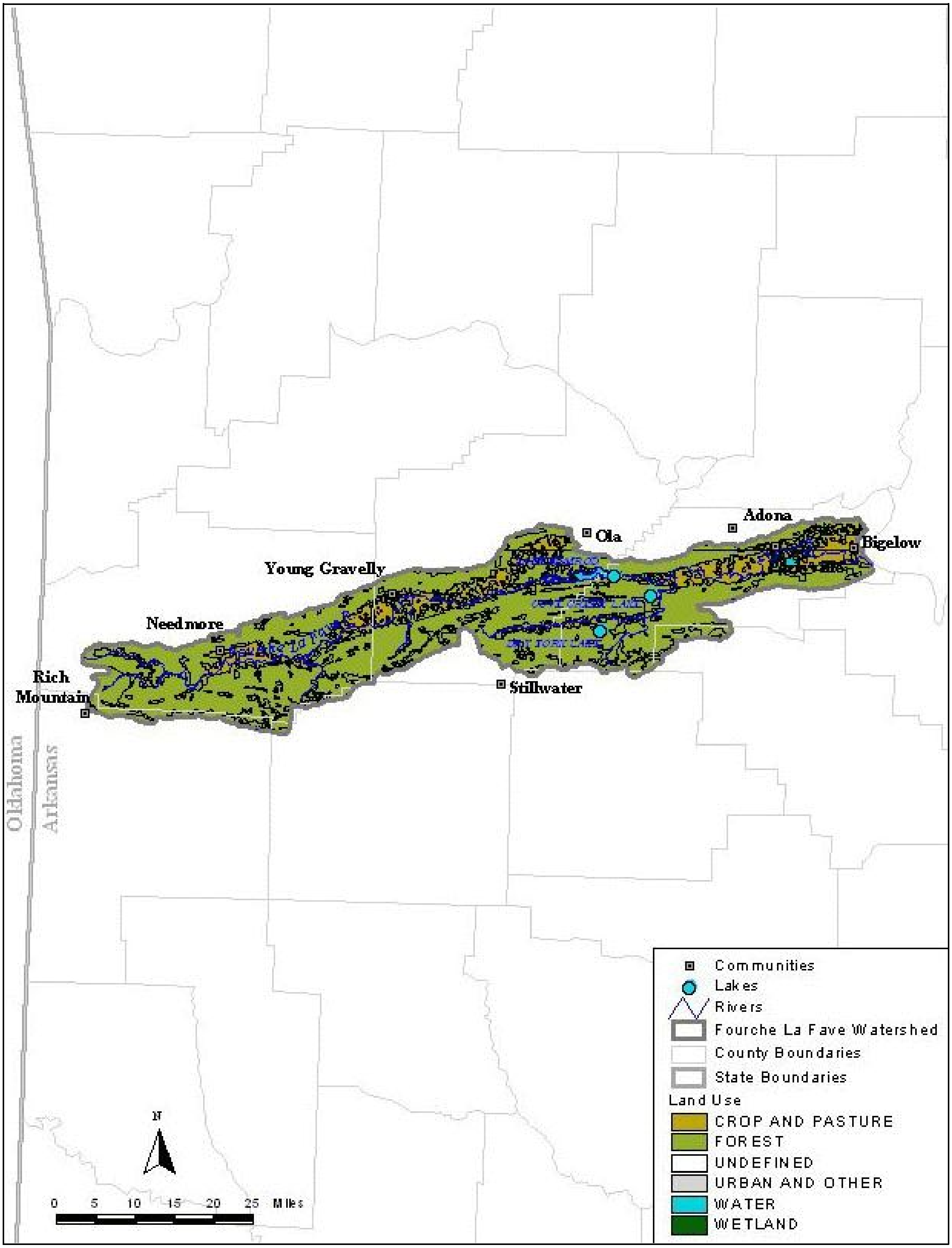
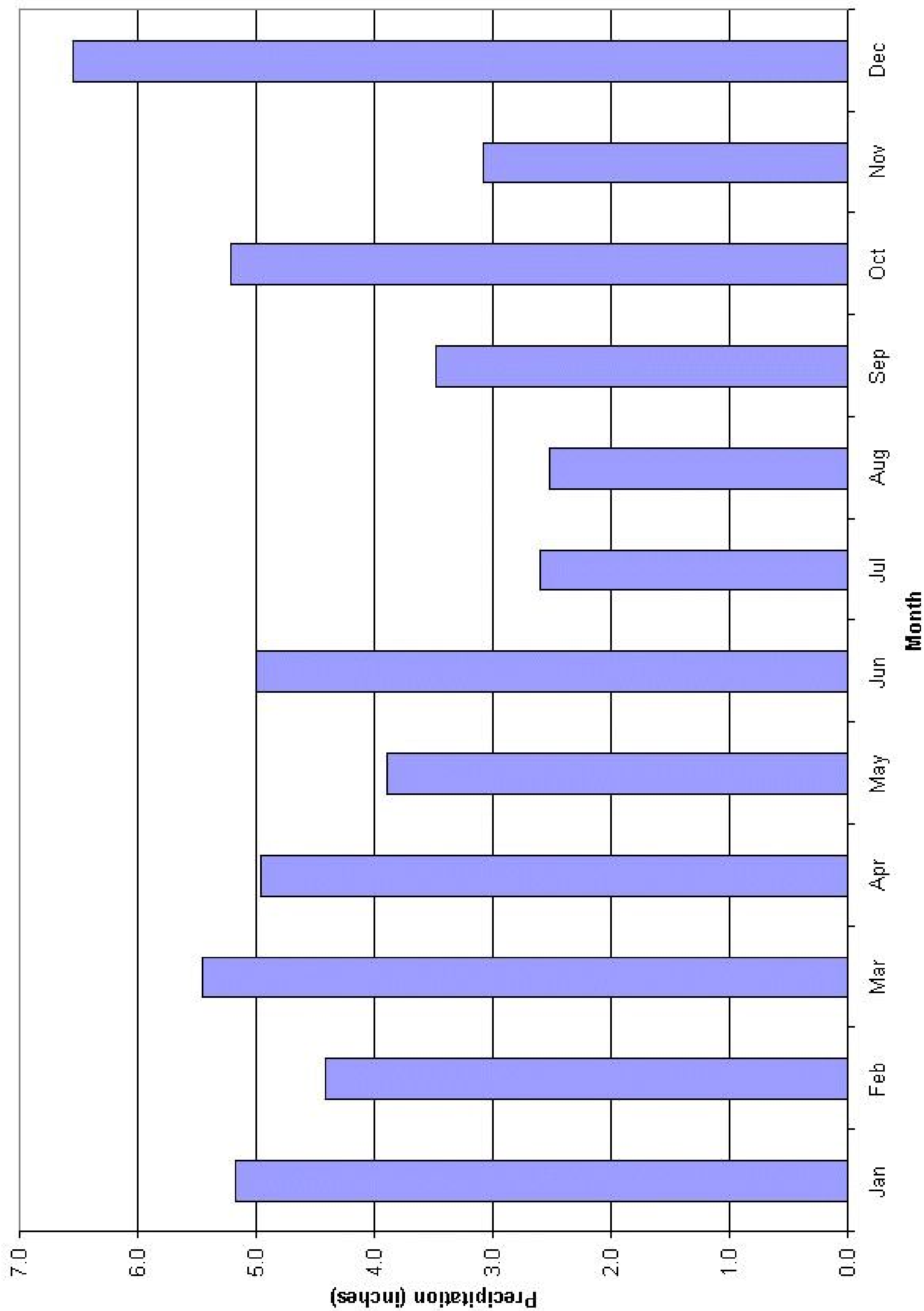


Figure 2.2. Fourche La Fave watershed major land use categories.


Precipitation (inches)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

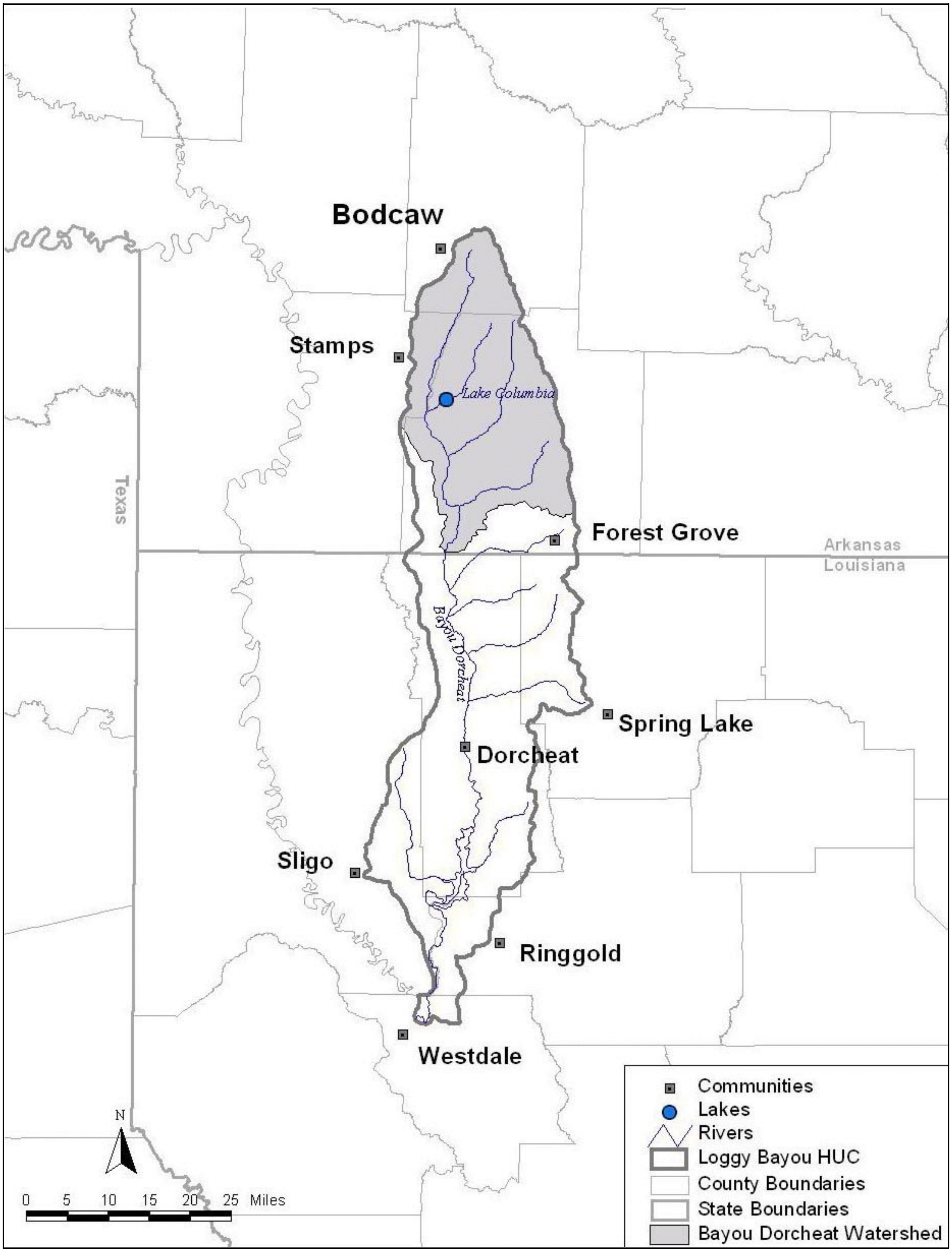


Figure 2.4. Loggy Bayou HUC 11140203.

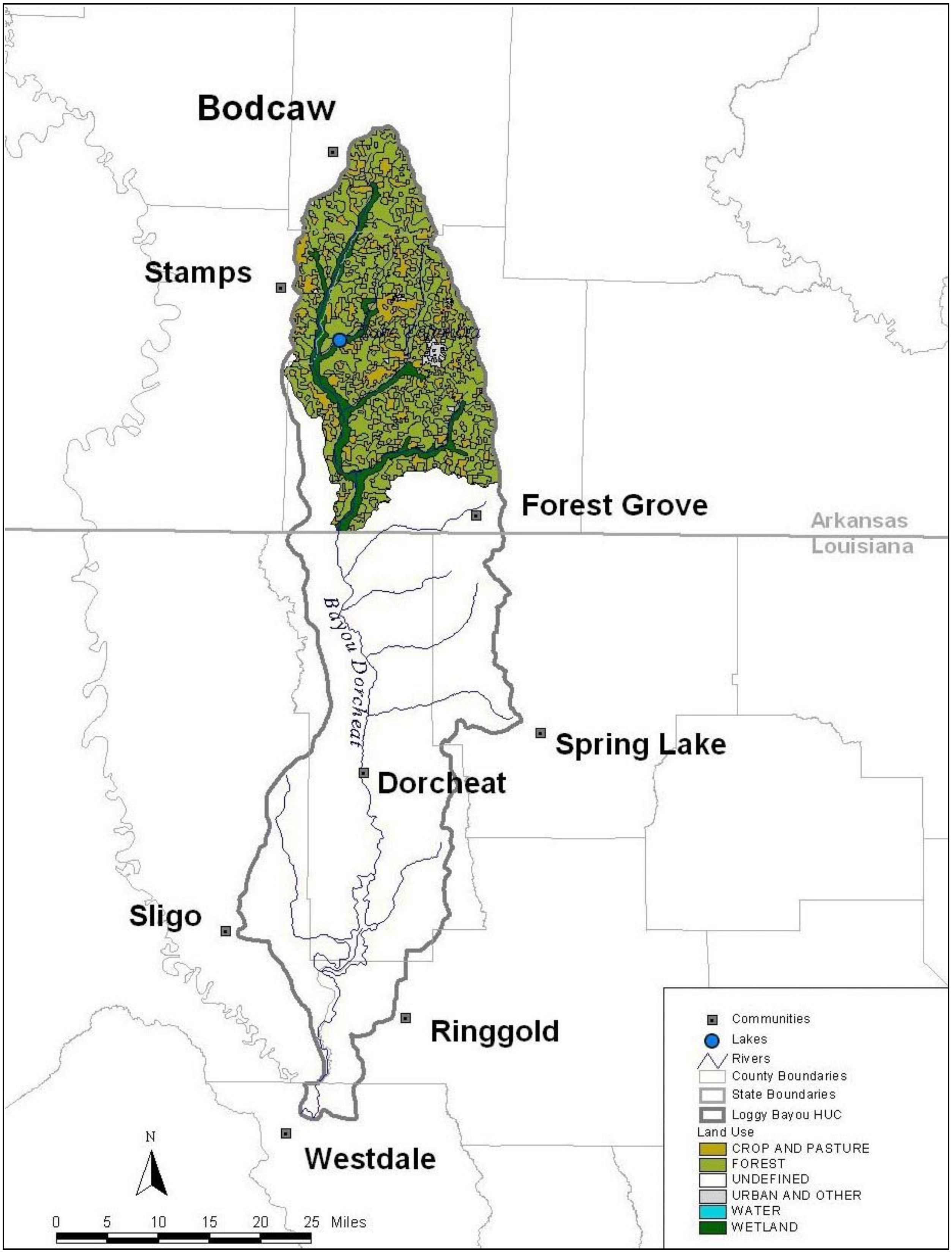
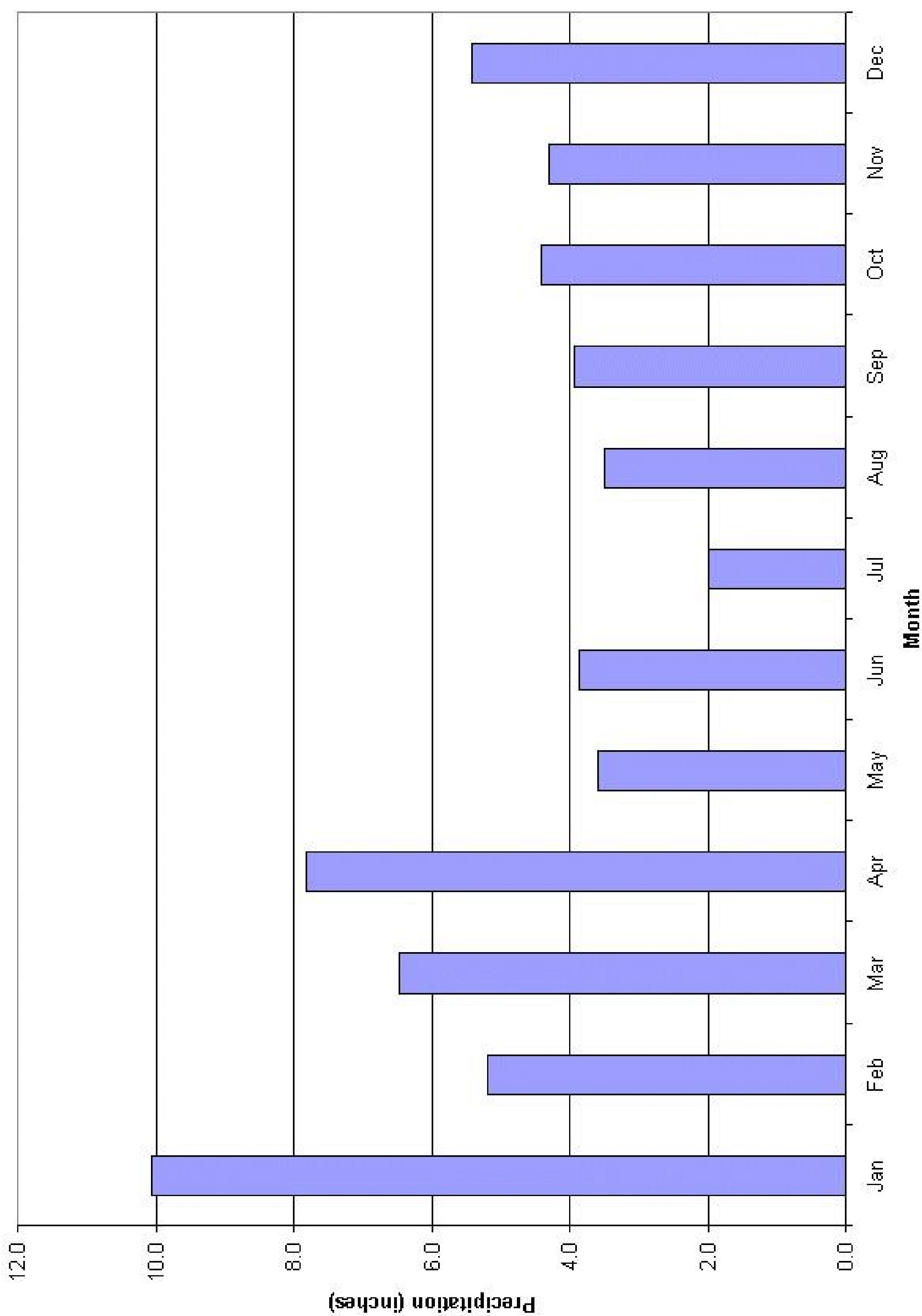


Figure 2.5. Bayou Dorcheat watershed major land use categories.


Precipitation (inches)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

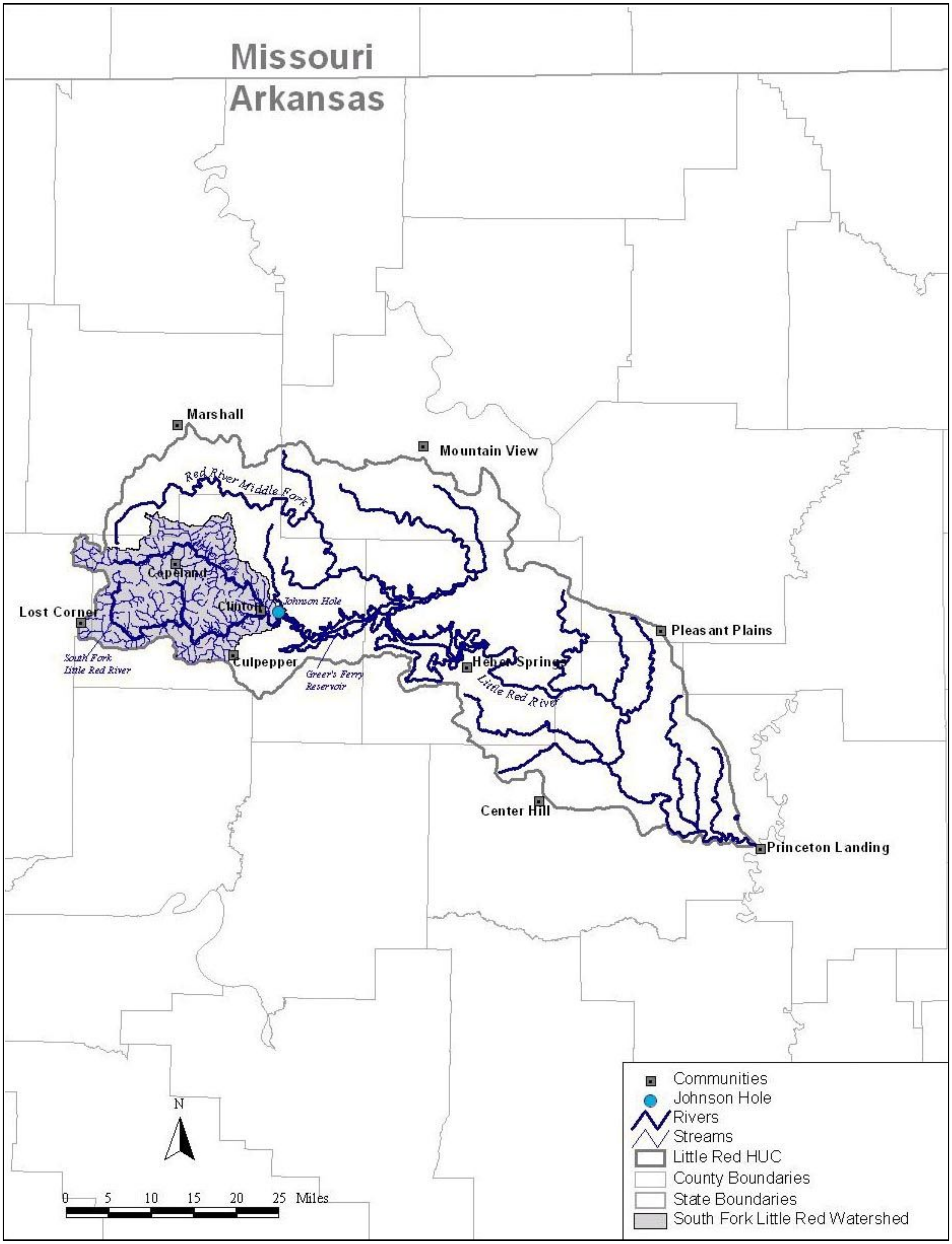


Figure 2.7. Little Red HUC 11010014.

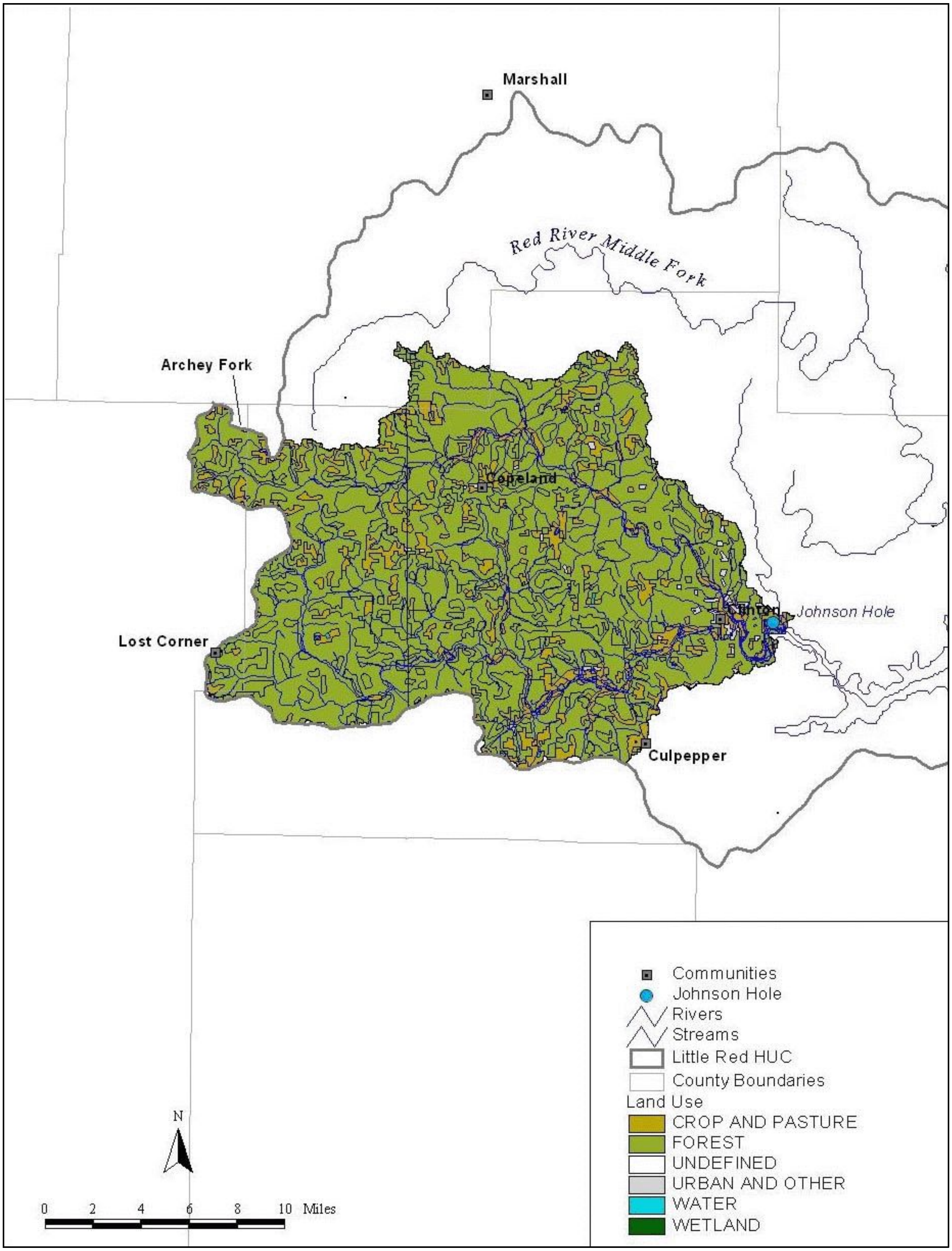
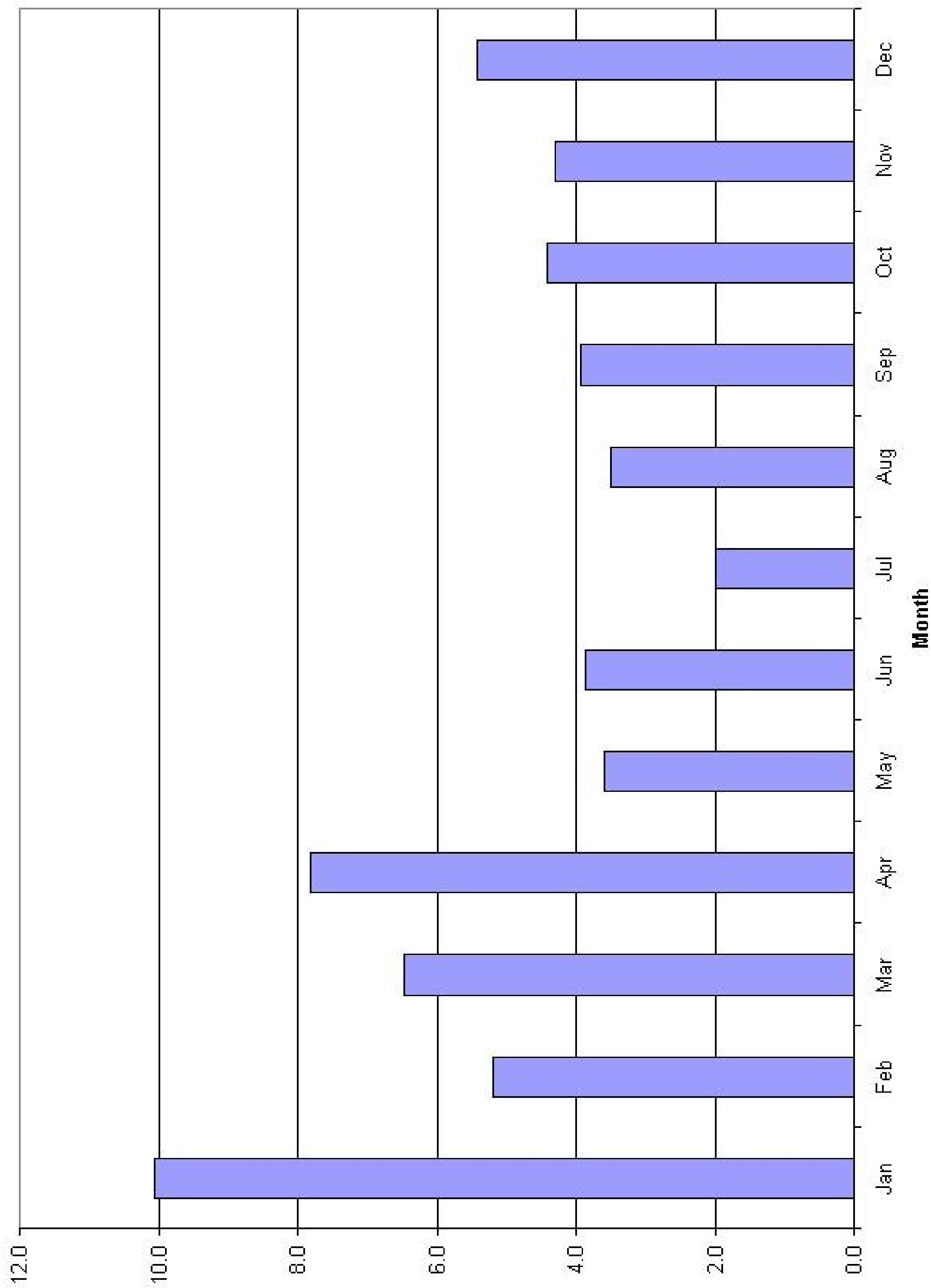


Figure 2.8. South Fork Little Red watershed major land use categories.


Precipitation (inches)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

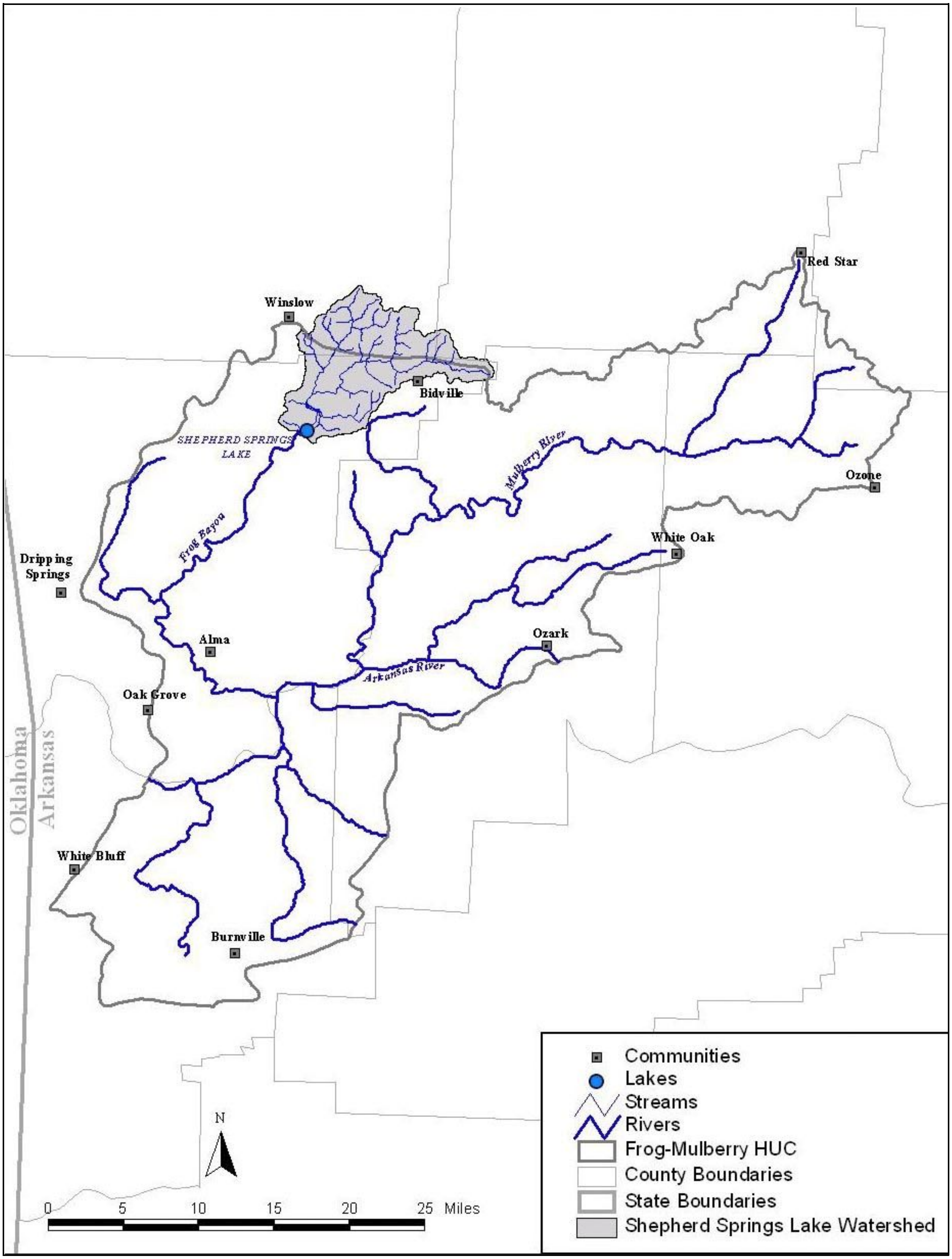


Figure 2.10. Frog-Mulberry HUC 11110201.

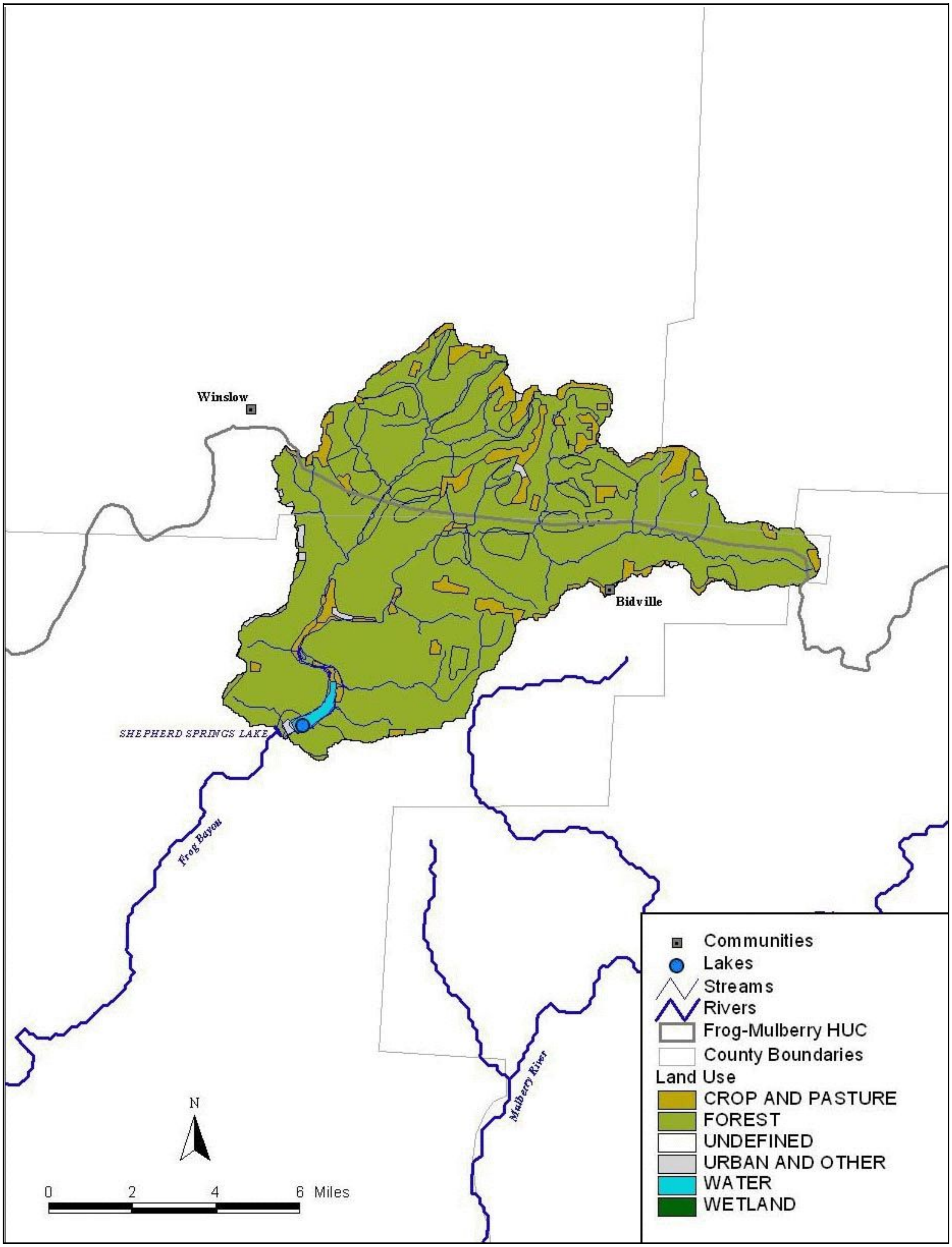


Figure 2.11. Shepherd Springs Lake watershed major land use categories.

Precipitation (inches)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

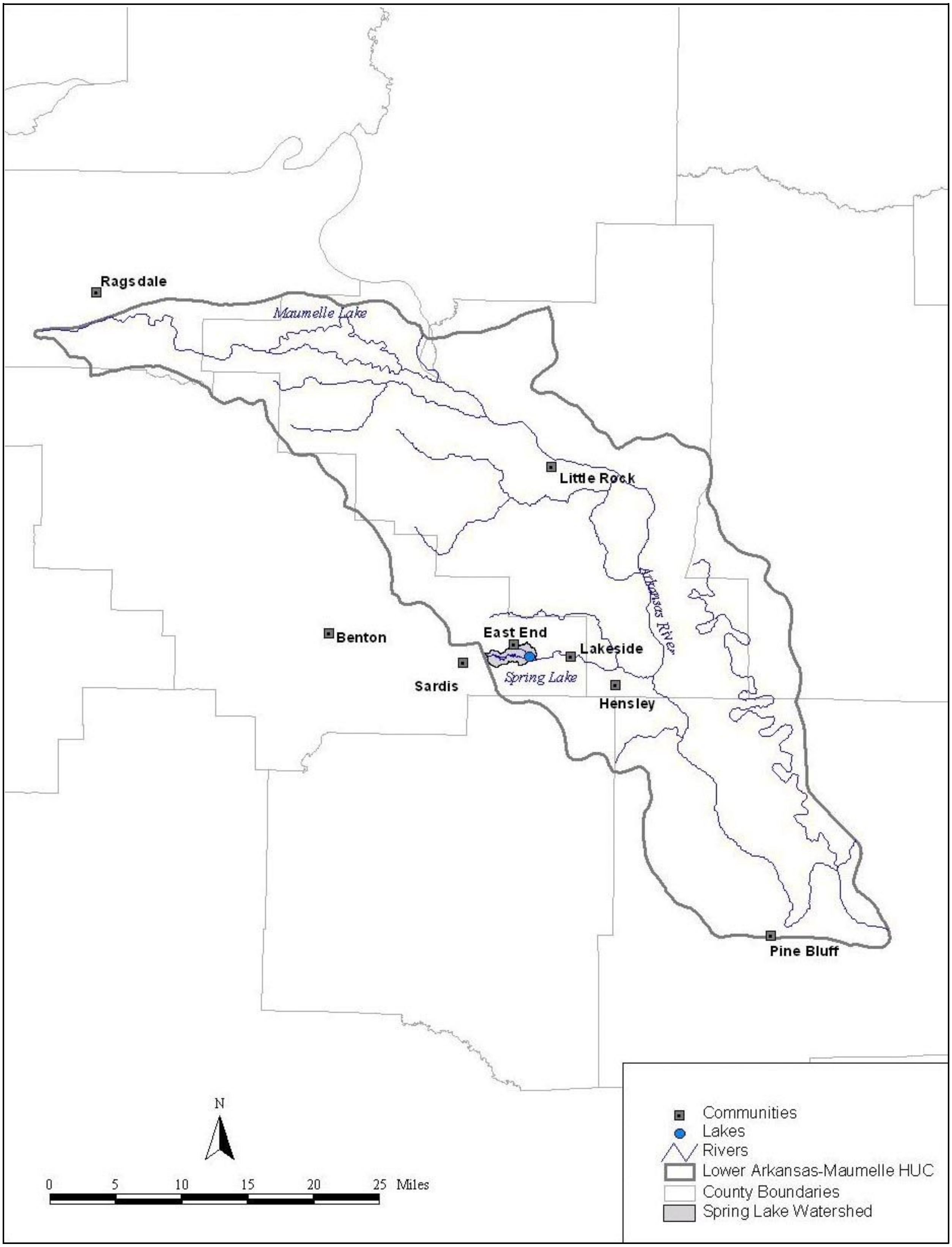


Figure 2.13. Lower Arkansas - Maumelle, HUC 11110207.

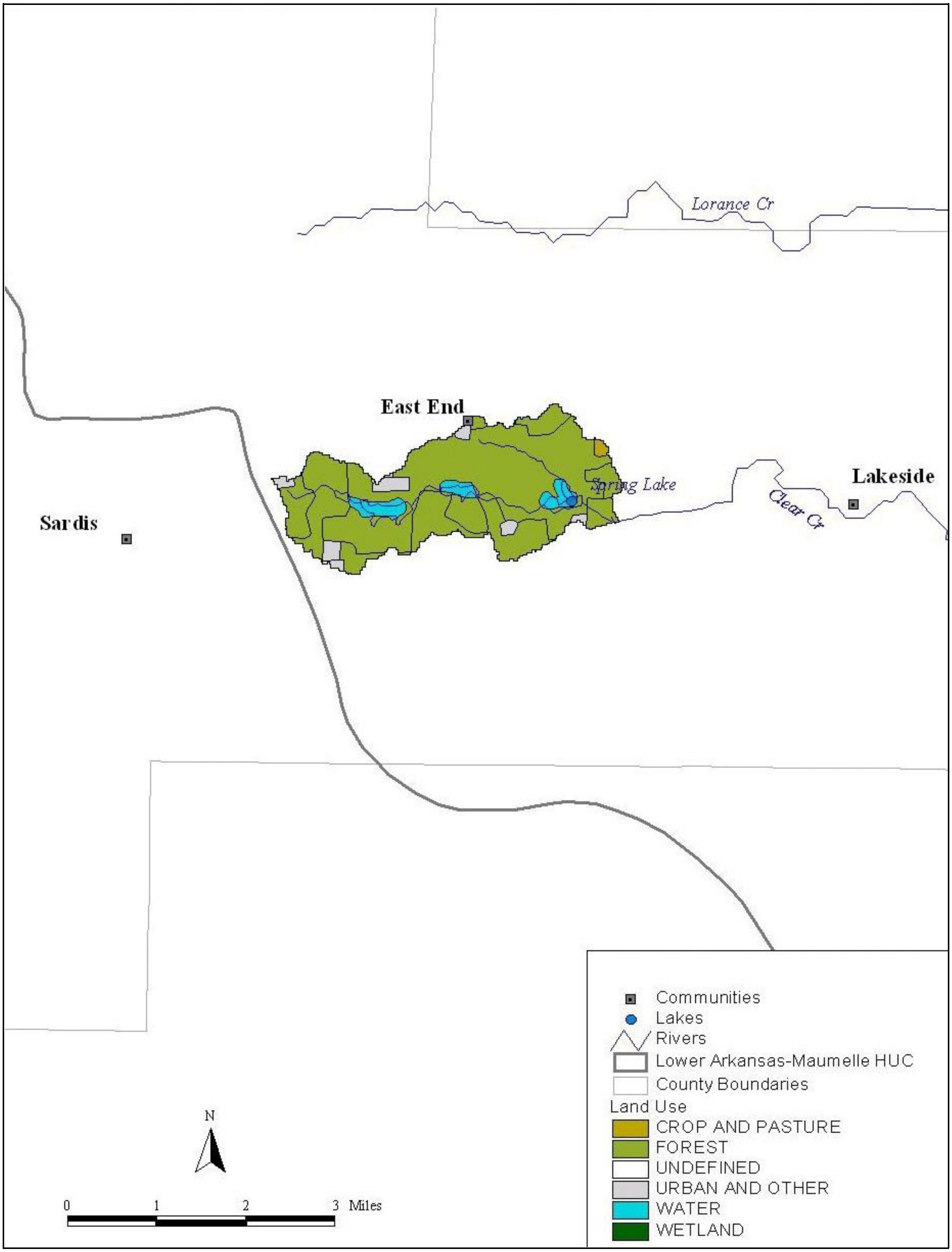


Figure 2.14. Spring Lake watershed major land use categories.


Precipitation (inches)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

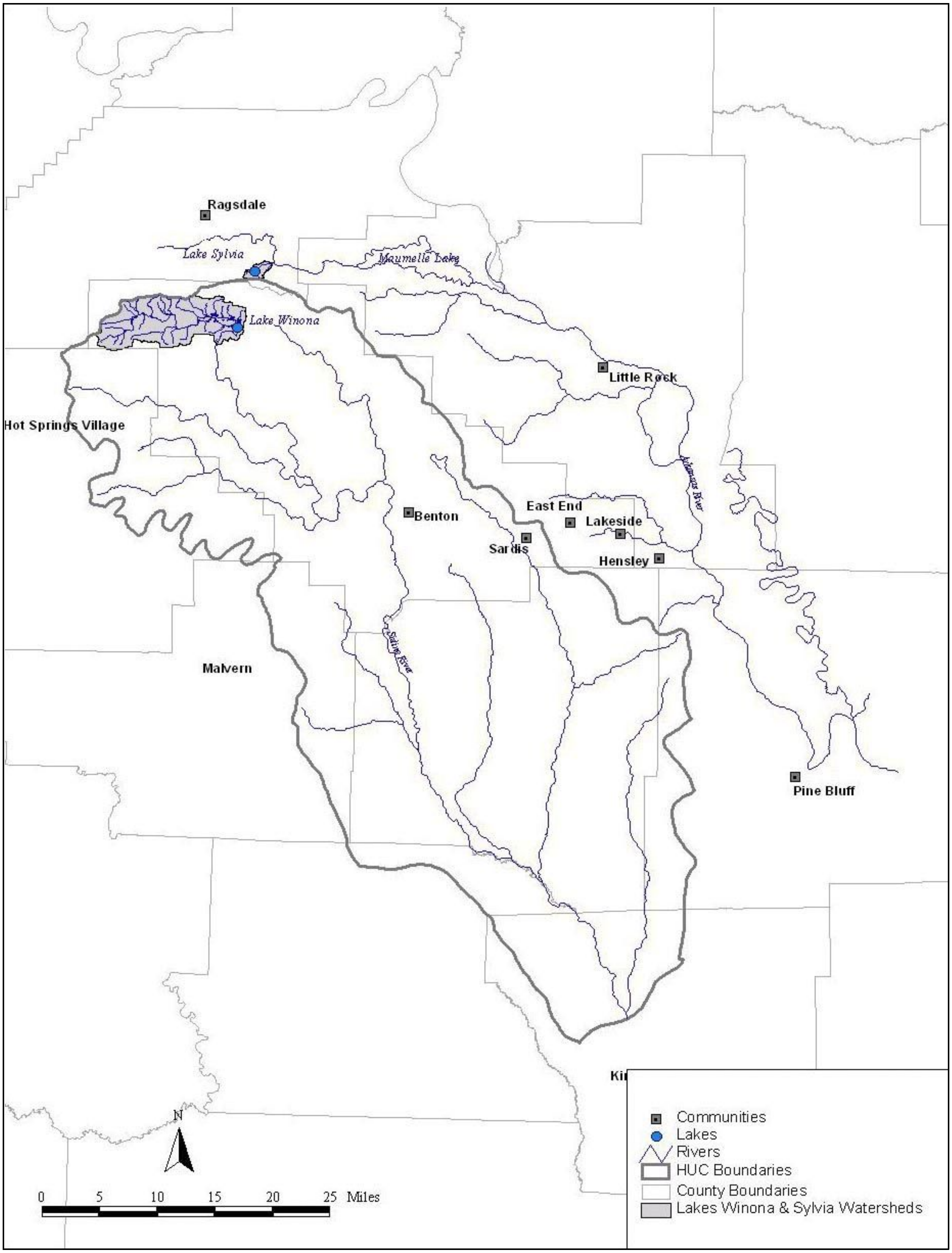


Figure 2.16. Lower Arkansas-Maumelle HUC 11110207 and Upper Saline HUC 08040203.

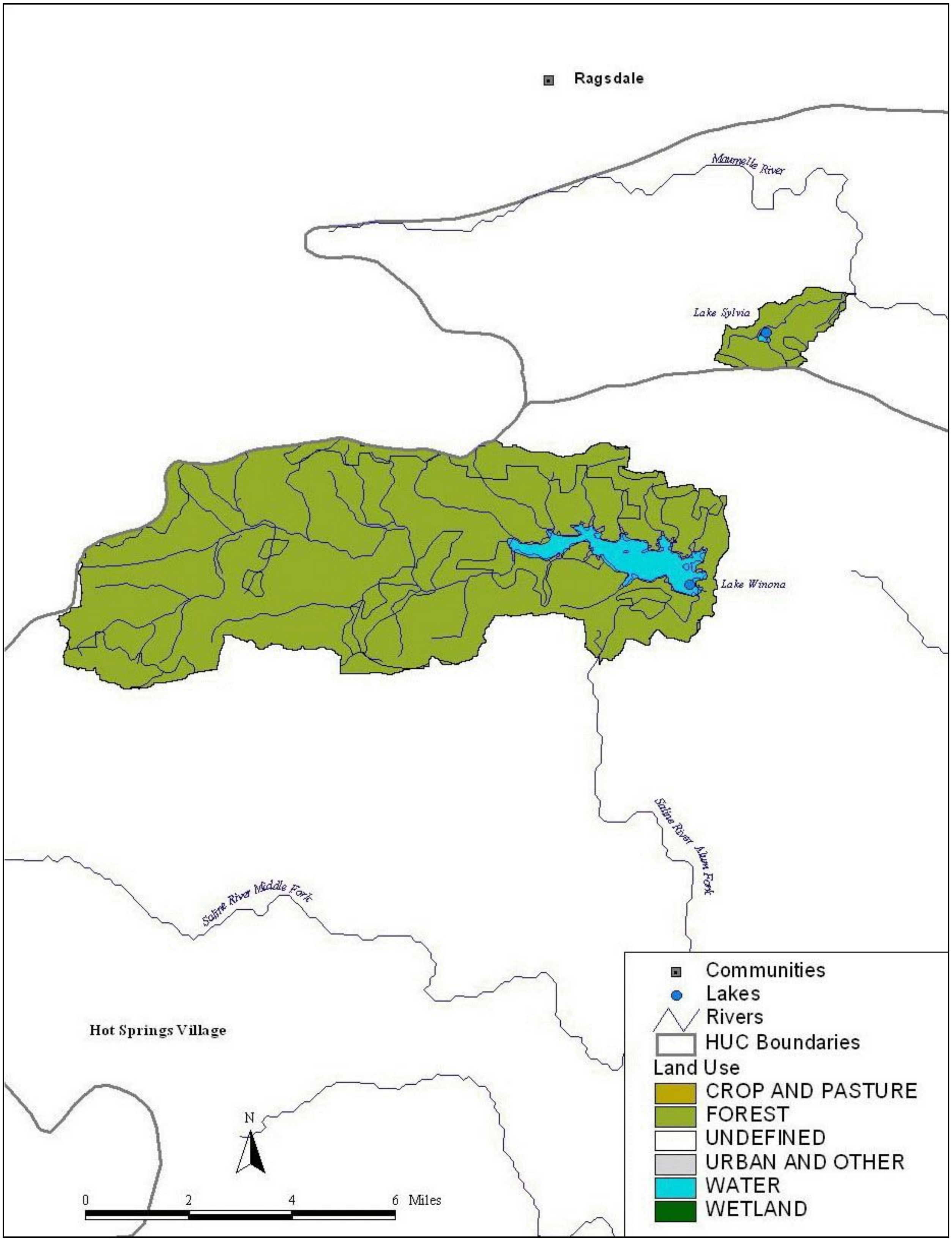


Figure 2.17. Lake Winona and Lake Sylvia watersheds major land use categories.

Precipitation (inches)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Jan
Feb
Mar
Apr
May
Jun
Jul
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Sep
Oct
Nov
Dec
Month

3.0 WATER QUALITY STANDARDS AND EXISTING WATER QUALITY CONDITIONS

3.1 Water Quality Standards

The State of Arkansas has developed water quality standards for waters of the State (ADEQ 1998). The standards are defined according to ecoregions and designated uses of the waterbodies. The mercury water quality standard for Arkansas waters for all ecoregions is 0.012 µg/L, expressed as total recoverable mercury. Although this water quality standard is to protect aquatic life, it was developed to protect humans from consuming aquatic life contaminated by mercury. There is no correction factor for hardness or other constituent concentrations. The narrative standard for toxic substances in Section 2.508 (Regulation No. 2, ADPCE 1998) is “Toxic substances shall not be present in receiving waters, after mixing, in such quantities as to be toxic to human, animal, plant or aquatic life or to interfere with the normal propagation, growth and survival of the indigenous aquatic biota.”

3.2 Existing Water Quality Conditions

There have been no recorded exceedances of the mercury water quality standard in the waterbodies being addressed in this TMDL study. The analytical procedures used previously had a detection limit of 0.2 µg/L and all samples were less than the detection limit.

However, there are fish consumption advisories for mercury contamination in the waterbodies being addressed in this TMDL study. The fish consumption Action Level in Arkansas is based on the previous FDA guideline of 1 mg/kg. The location of these fish consumption advisories and the highest average composite bass fish mercury concentrations for the stations sampled in these waterbodies are discussed in Section 3.3.

EPA recently promulgated a criterion for methylmercury in fish tissue. The EPA criterion is 0.3 mg/kg of methylmercury in fish tisue (EPA 2001). The State of Arkansas will need to consider adopting this criterion as part of its triennial review.

This TMDL study uses fish tissue monitoring data as a means to determine whether the “fishable” use is being met, and the reductions needed to achieve the designated use. The "fishable" use is not attained if: (1) the fish and wildlife propagation is impaired and/or (2) if there is a significant human health risk from consuming fish and shellfish resources. The waterbodies included in this TMDL study were listed in the 1998 303(d) List based on elevated fish tissue mercury concentrations, and/or are in violation of narrative standards for toxic substances. To achieve the designated use, the fish tissue mercury concentration of 1.0 mg/kg should not be exceeded. Therefore, the target tissue mercury level for all fish species in this TMDL study will be 0.8 mg/kg. This incorporates a 20% Margin of Safety in the analyses (see Section 5.0).

Water quality data for sulfate, total organic carbon (TOC), and pH were obtained from the EPA STORET system. The stations, agency, HUC, and period of record (POR) for the sulfate, TOC, and pH data used for this study are listed in Table 3.1. These water quality data are summarized in Figures 3.1 through 3.9. These three constituents have been demonstrated to be correlated with fish mercury concentrations and can affect the bioaccumulation and bioavailability of mercury for methylation and subsequent uptake of methylmercury through the food chain (Armstrong et al. 1995, EPA 1998). Areas with moderate sulfate and TOC concentrations and lower pH values provide an environment conducive to microorganisms that methylate mercury (Armstrong et al. 1995). These conditions likely contribute to the elevated fish mercury concentrations in Bayou Dorcheat and possibly other areas for which measurements of these parameters are not available. In addition, wetland ecosystems have conditions that are particularly suited to organisms that methylate mercury (Rudd 1995).

3.3 Fish Sampling and Analysis

ADEQ followed the sampling protocols recommended in *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories,* Vol 1 (EPA 1995). Fish were collected from 1993 through 1999 in rivers and lakes within the watersheds (Armstrong et al. 1995). The maximum and average composite fish mercury concentrations for largemouth bass are listed in Table 3.2 and the maximum values shown on Figures 3.10 through 3.15. Additional fish mercury concentrations for largemouth bass and other species are included in Appendix D.

Table 3.1. Water quality monitoring stations, agencies, HUC, and POR.

Location	ID	Station	Agency	HUC	POR
Fourche La Fave River below Cedar Creek confluence	050283	ARK52B	ADEQ	11110206	2/93-6/96
Fourche La Fave River near Gravelly	050131	ARK37	ADEQ	11110206	7/93-3/97
Fourche La Fave River near Bigelow	050130	ARK36	ADEQ	11110206	10/98-12/98
Fourche La Fave River near Nimrod, AR	0726500	---	USGS	11110206	5/90-8/95
Nimrod Lake near Nimrod, AR	07262000	---	USGS	11110206	5/90-8/95
Nimrod Lake near Carter Cove, AR	07261950	---	USGS	11110206	5/90-8/95
Nimrod Lake on Prairie Creek, AR	07261925	---	USGS	11110206	5/90-8/95
Nimrod Lake near Wards Crossing, AR	07261910	---	USGS	11110206	5/90-8/95
Nimrod Lake at Hwy 27 bridge, AR	07261820	---	USGS	11110206	5/90-8/95
Lake Columbia - lower	050055	LRED002A	ADEQ	11140203	7/25/94
Bayou Dorcheat at Hwy 355	05UWS079	UWBTD01	ADEQ	11140203	6/94-10/96
Bayou Dorcheat at Hwy 82 6 miles W. of Waldo	05UWS091	UWBTD02	ADEQ	11140203	6/94-9/97
Bayou Dorcheat E. of Taylor, AR	050152	RED15A	ADEQ	11140203	3/97-4/98
Bayou Dorcheat near Springhill, AR	050036	RED15	ADEQ	11140203	1/90-10/93
South Fork Little Red River at Hwy 65 at Clinton	05UWS072	UWSRR02	ADEQ	11010014	5/94-12/98
South Fork Little Red River at Hwy 95 near Scotland	05UWS074	UWSRR01	ADEQ	11010014	5/94-12/98

Table 3.2. Maximum and average fish tissue mercury concentration for largemouth bass.

This list of stations and maximum fish tissue Hg concentrations was derived from the fish tissue database provided by ADEQ. The data was compiled by FTN Associates. The stations represent fish tissue mercury concentrations in bass that were above Health Department fish consumption advisory levels.

Station	Maximum Fish Hg Concentration (mg/kg)	Average Fish Hg Concentration (mg/kg)	Mean Fish Weight (grams)	Common Name
Cove Creek Lake	2.43	1.36	490	Largemouth Bass
Bayou Dorcheat	2.06	2.06*	1420	Largemouth Bass
Dry Fork Lake	2.58	1.29	554 mm (mean length)	Largemouth Bass
Fourche La Fave River	1.24	0.89	1138	Largemouth Bass
Lake Columbia	1.61	0.85	1650	Largemouth Bass
Lake Nimrod	1.26	0.71	696	Largemouth Bass
Lake Sylvia	1.08	0.87	2125	Largemouth Bass
Lake Winona	1.48	0.76	2165	Largemouth Bass
Shepherd Springs Lake	2.69	0.82	2300	Largemouth Bass
South Fork Little Red River - Johnson Hole	2.12	1.00	394	Largemouth Bass
Spring Lake	1.05	1.05*	813	Largemouth Bass

*Only one sample available.

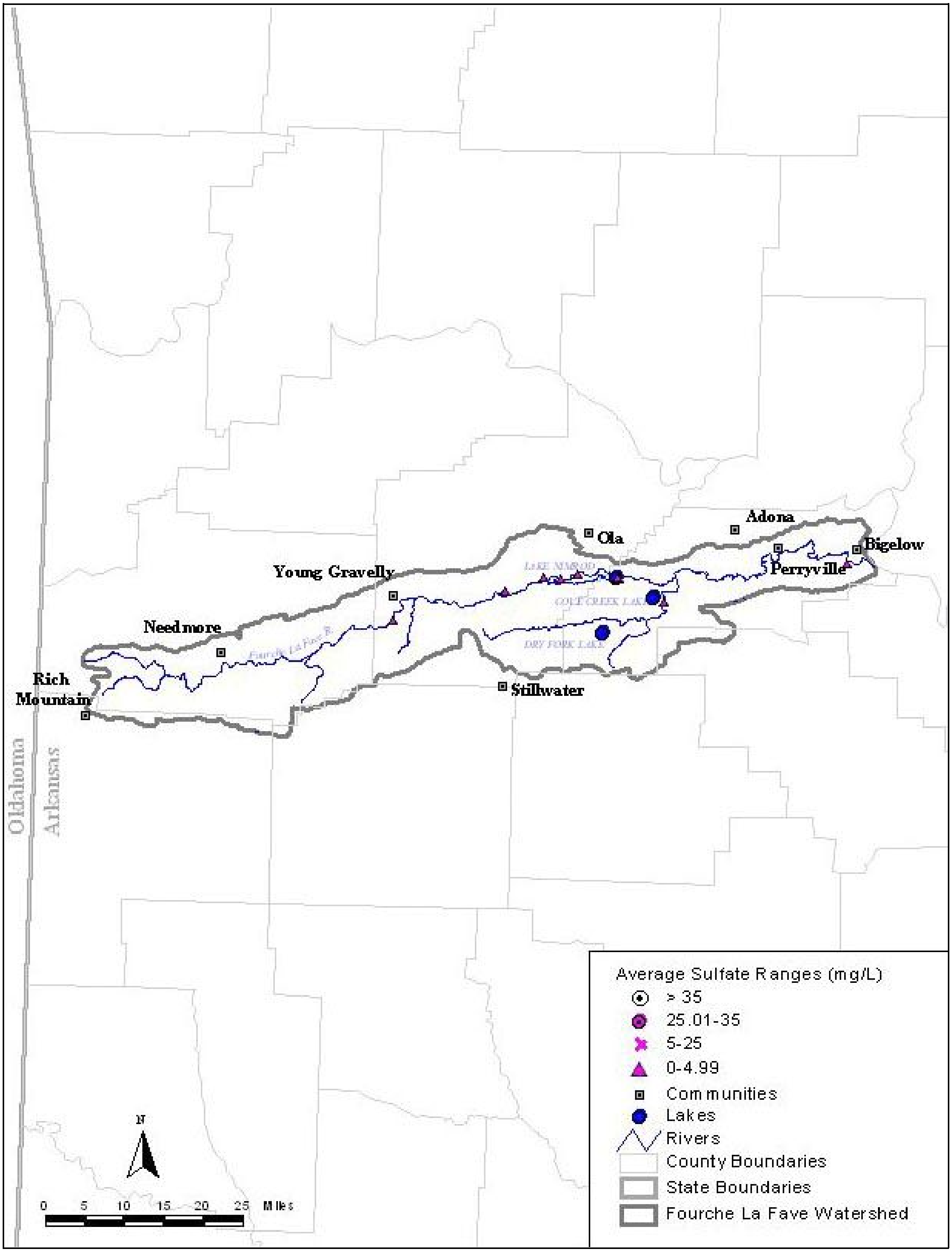

Figure 3.1. Fourche La Fave watershed sulfate ranges.

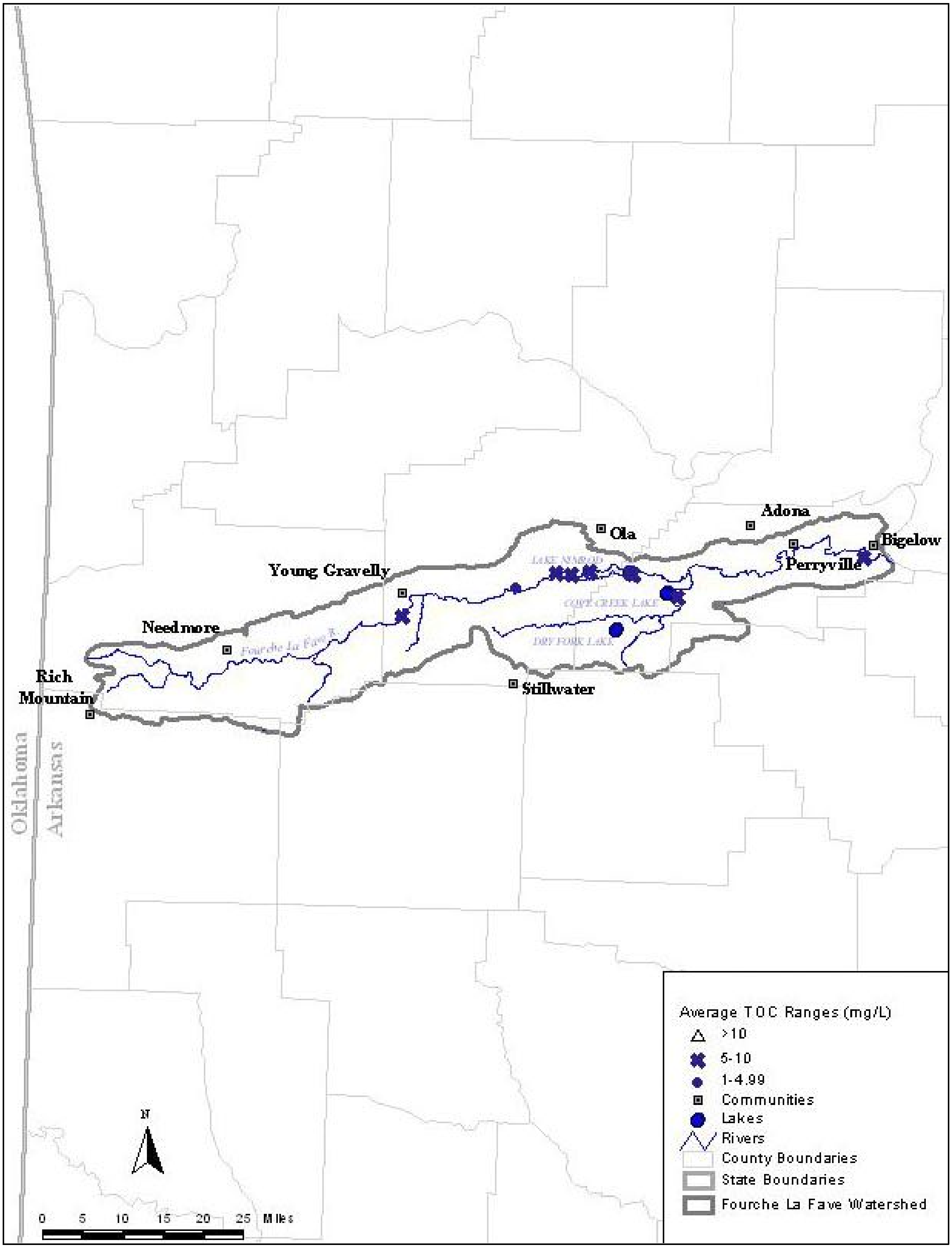

Figure 3.2. Fourche La Fave watershed TOC ranges.

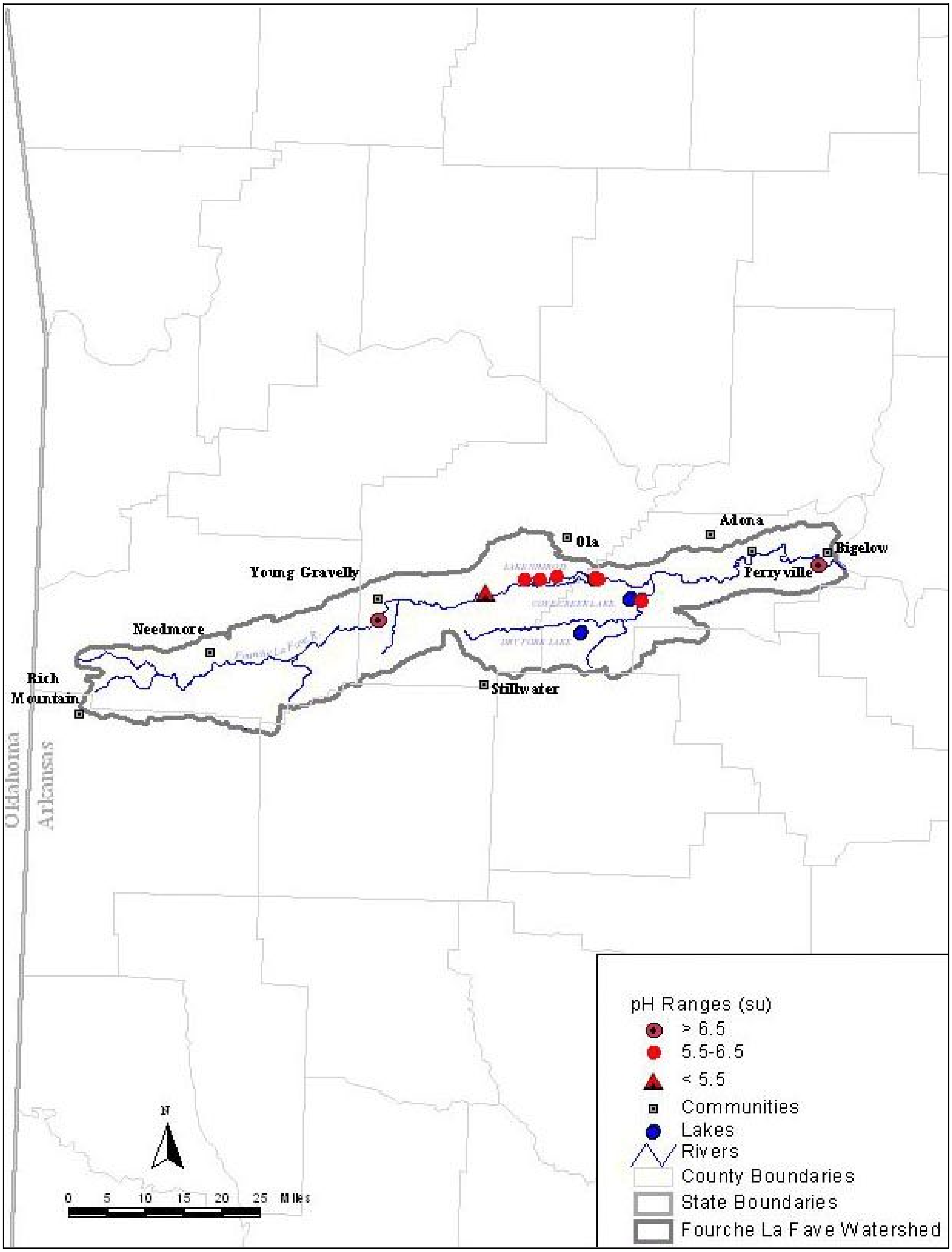

Figure 3.3. Fourche La Fave watershed pH ranges.

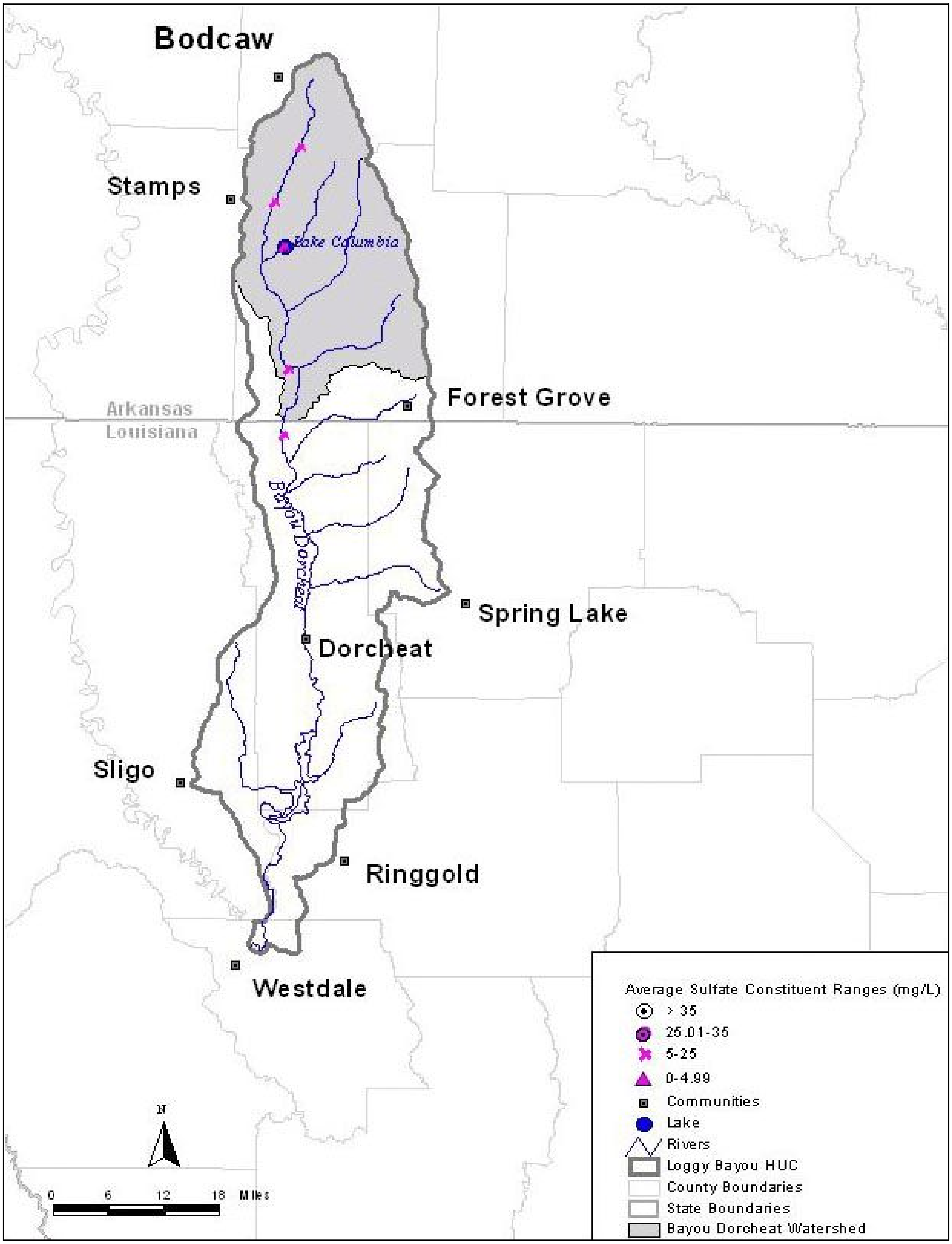

Figure 3.4. Bayou Dorcheat watershed sulfate ranges.

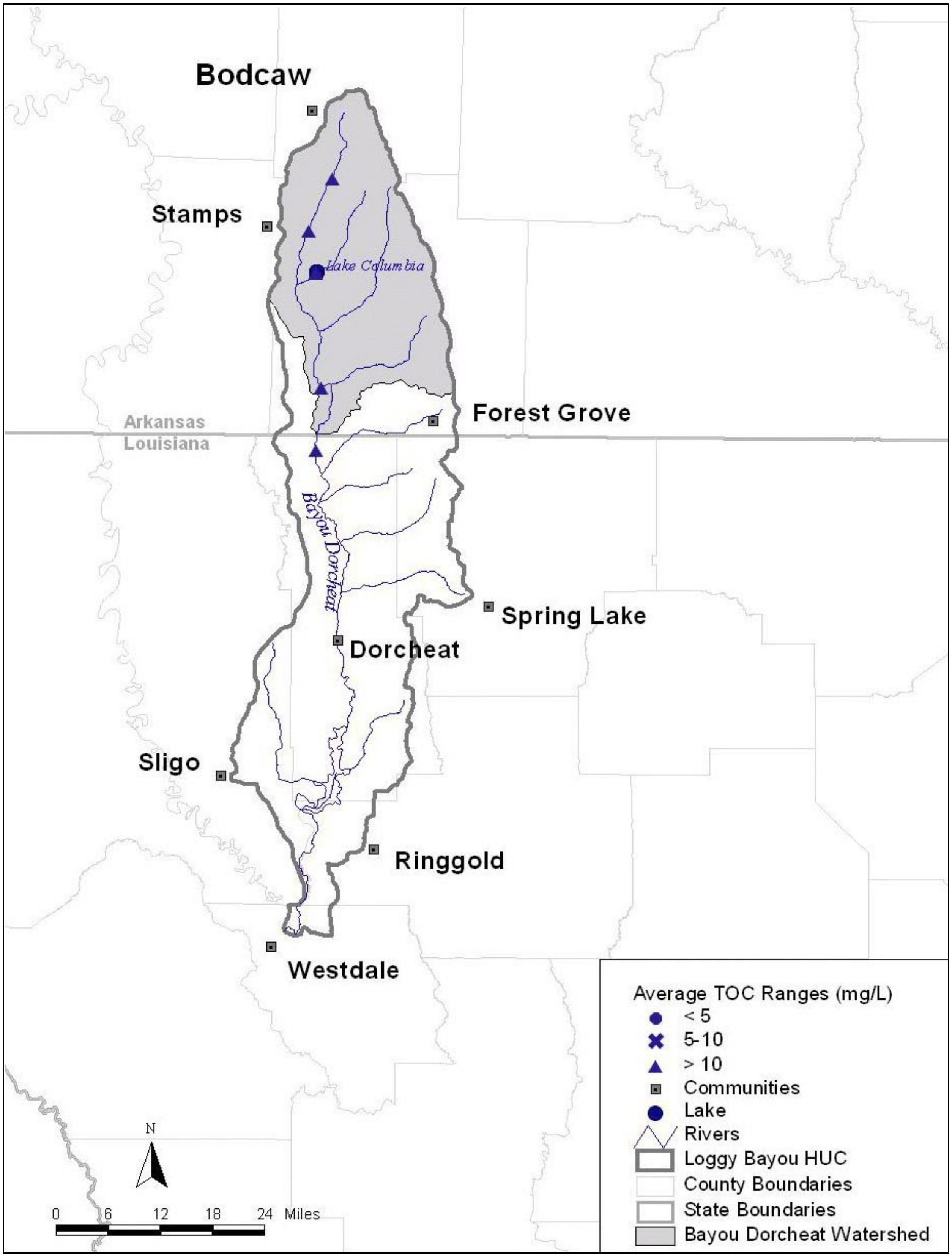

Figure 3.5. Bayou Dorcheat watershed TOC ranges.

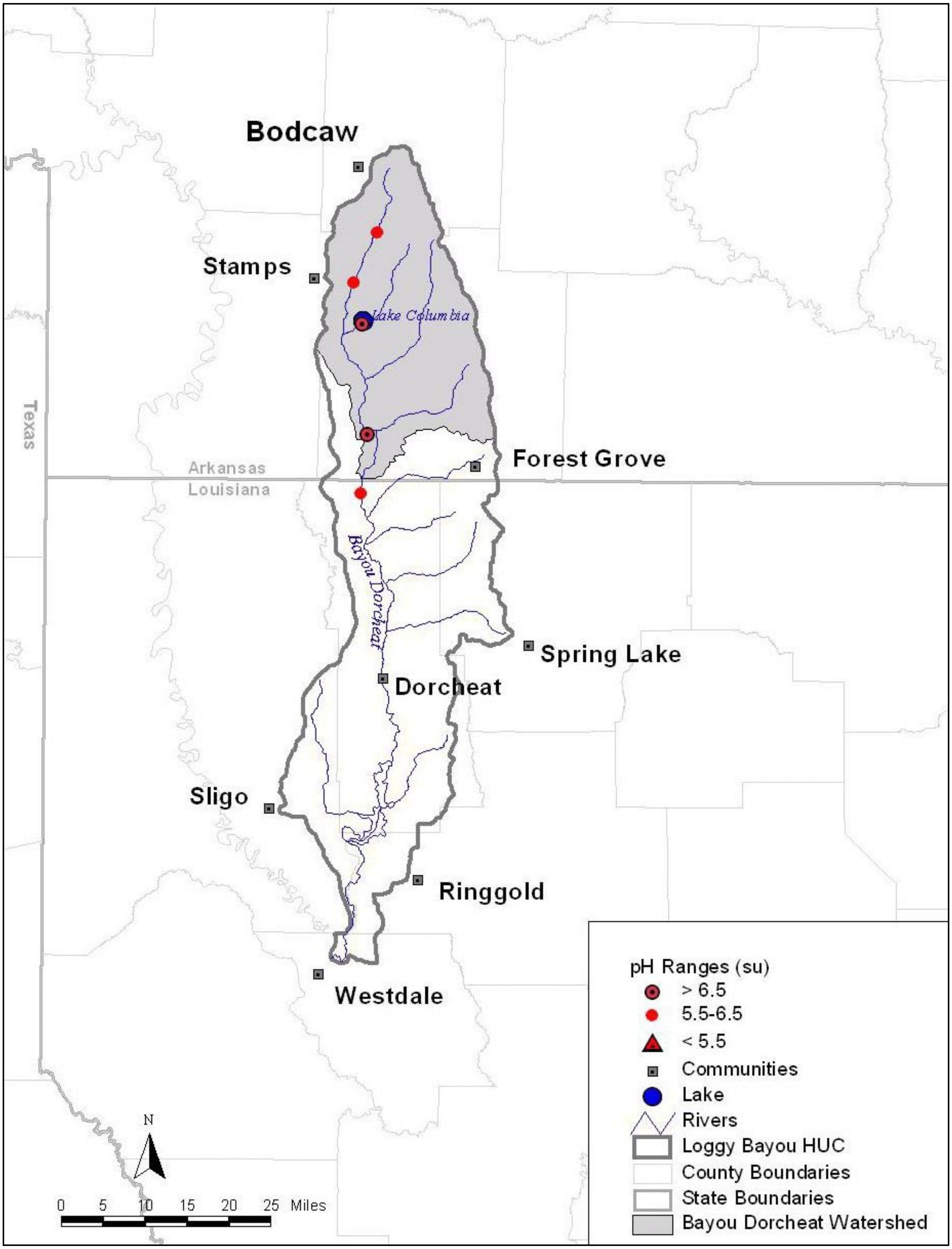

Figure 3.6. Bayou Dorcheat watershed pH ranges.

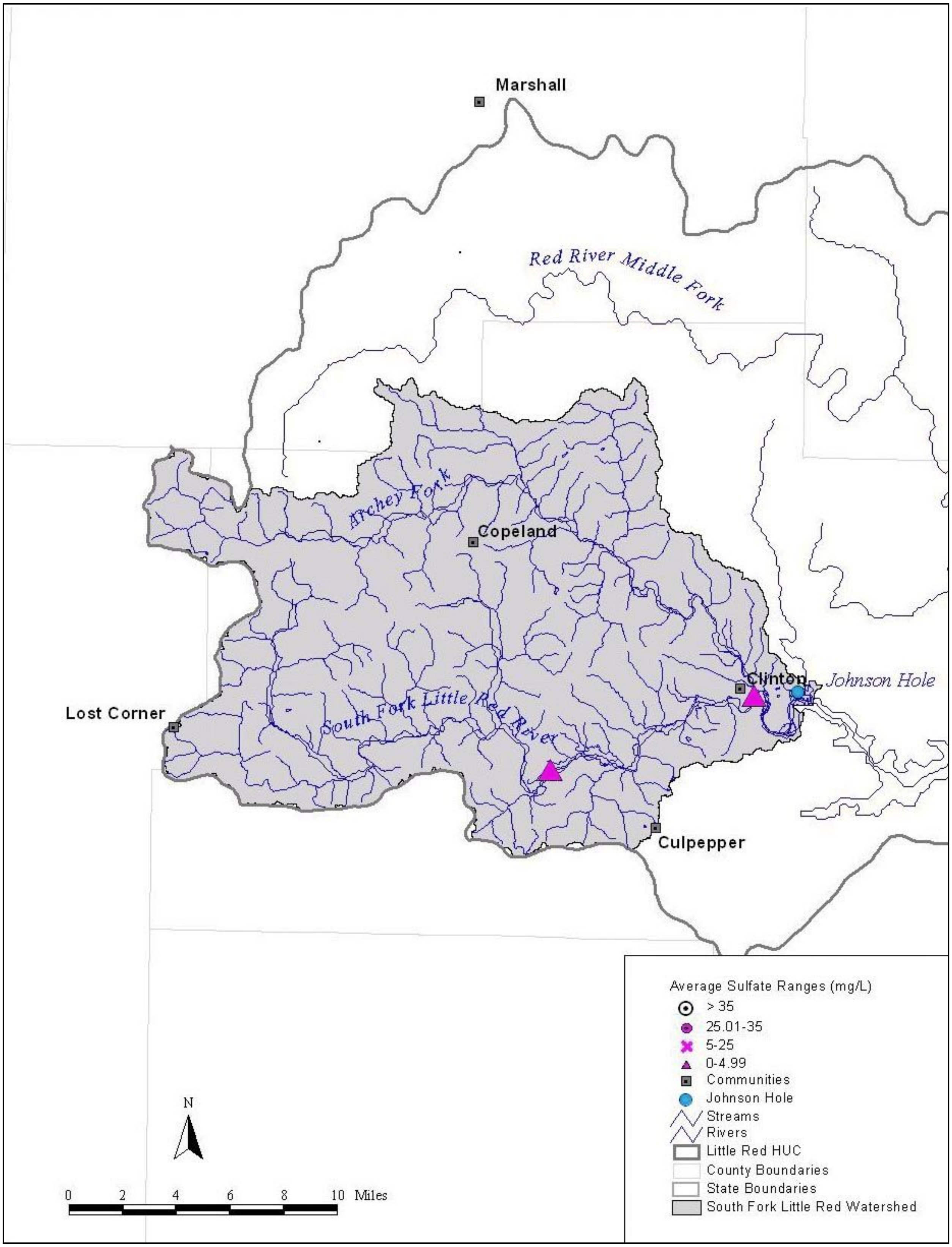

Figure 3.7. South Fork Little Red River watershed sulfate ranges.

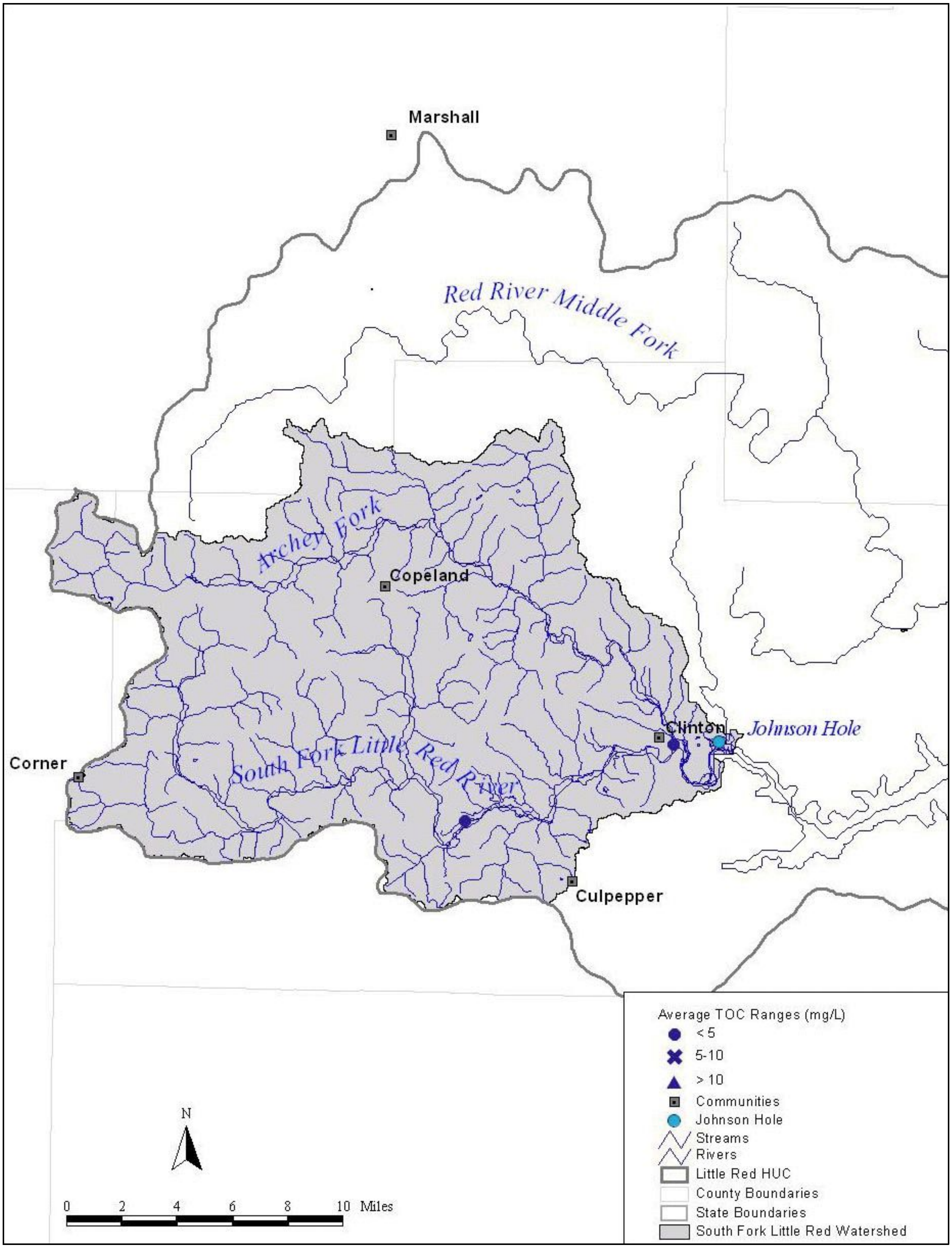

Figure 3.8. South Fork Little Red River watershed TOC ranges.

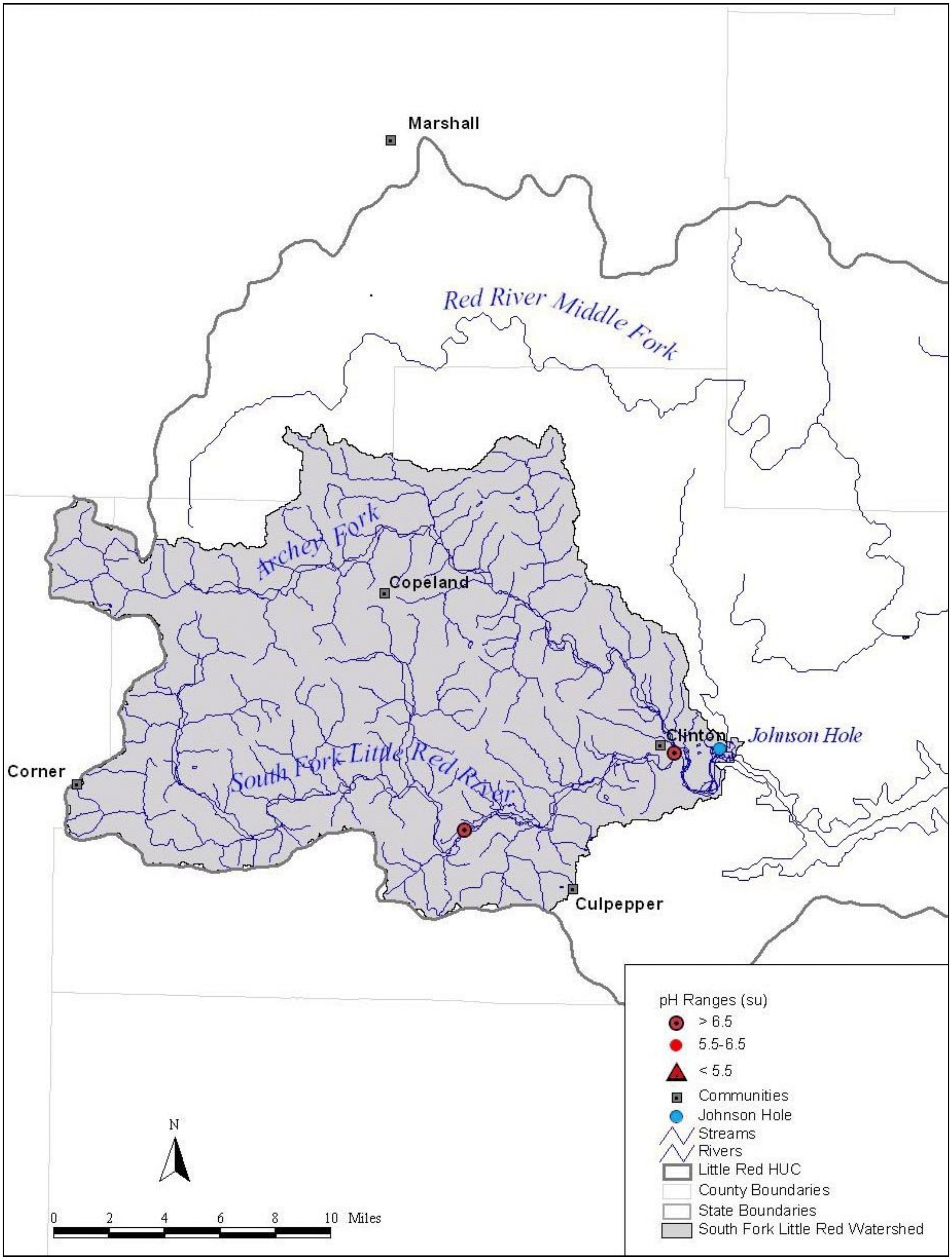

Figure 3.9. South Fork Little Red River watershed pH ranges.

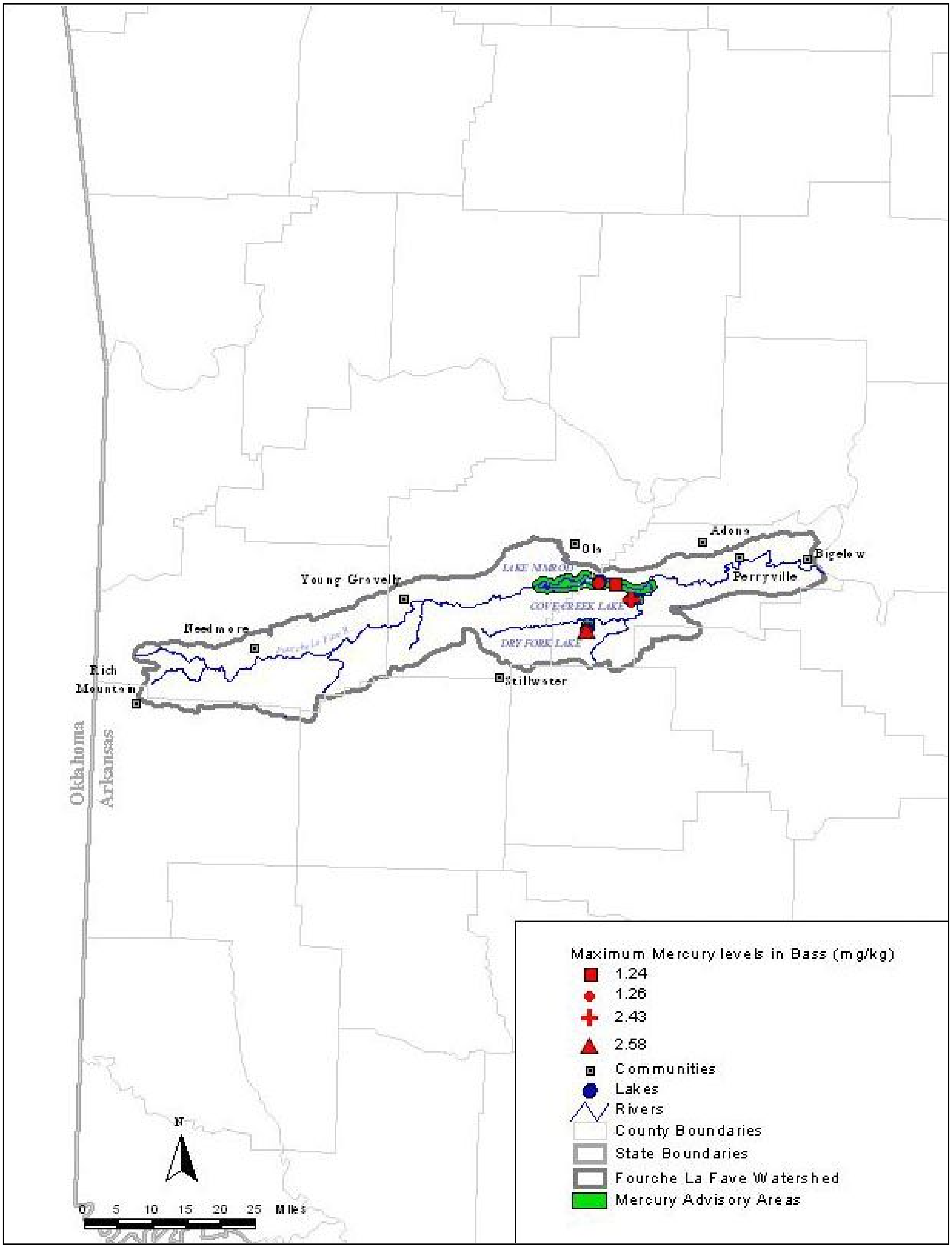

Figure 3.10. Fourche La Fave watershed advisory areas and mercury levels in bass.

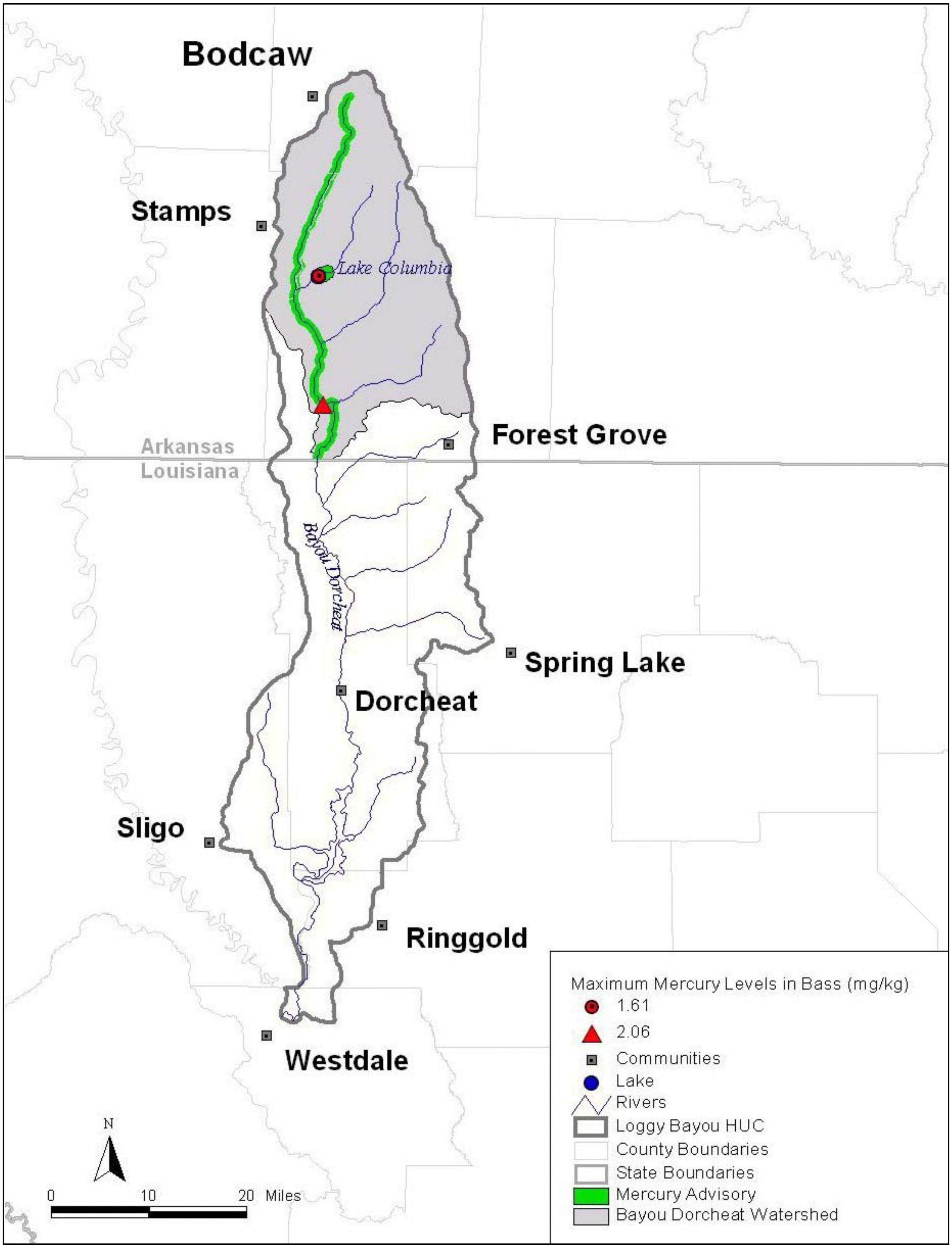

Figure 3.11. Bayou Dorcheat watershed advisory areas and mercury levels in bass.

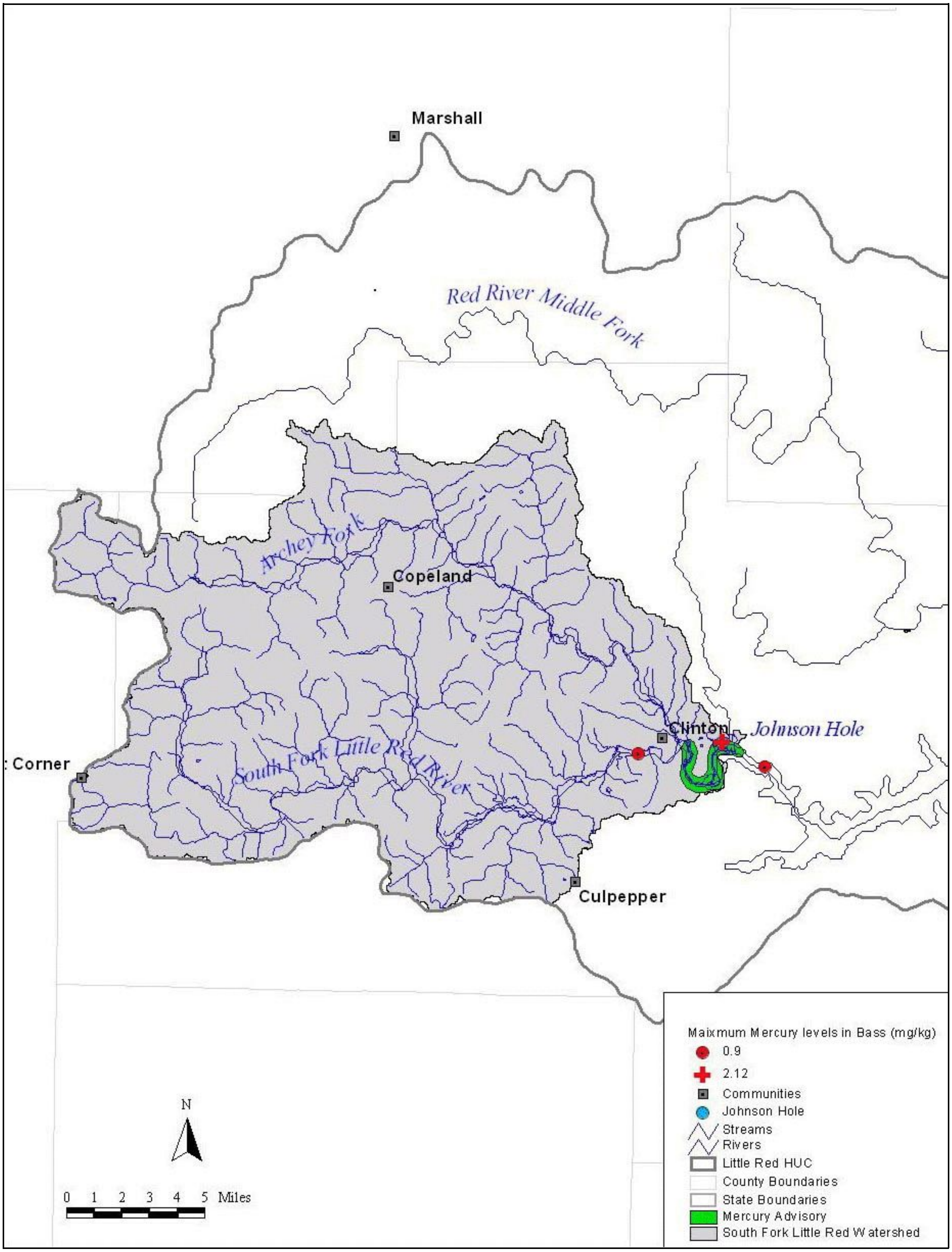

Figure 3.12. South Fork Little Red River watershed advisory areas and mercury levels in bass.

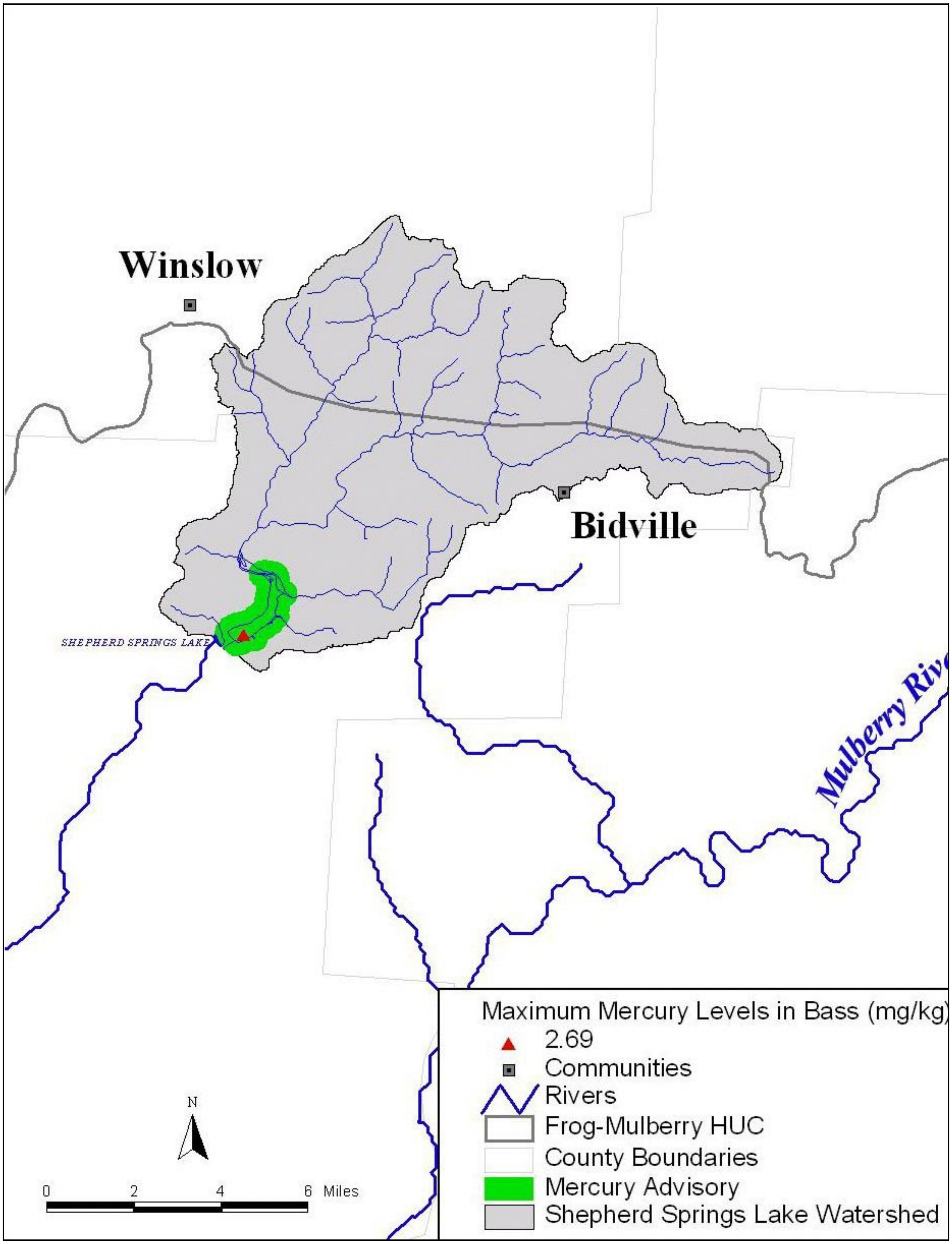

Figure 3.13. Shepherd Springs Lake advisory areas and mercury levels in bass.

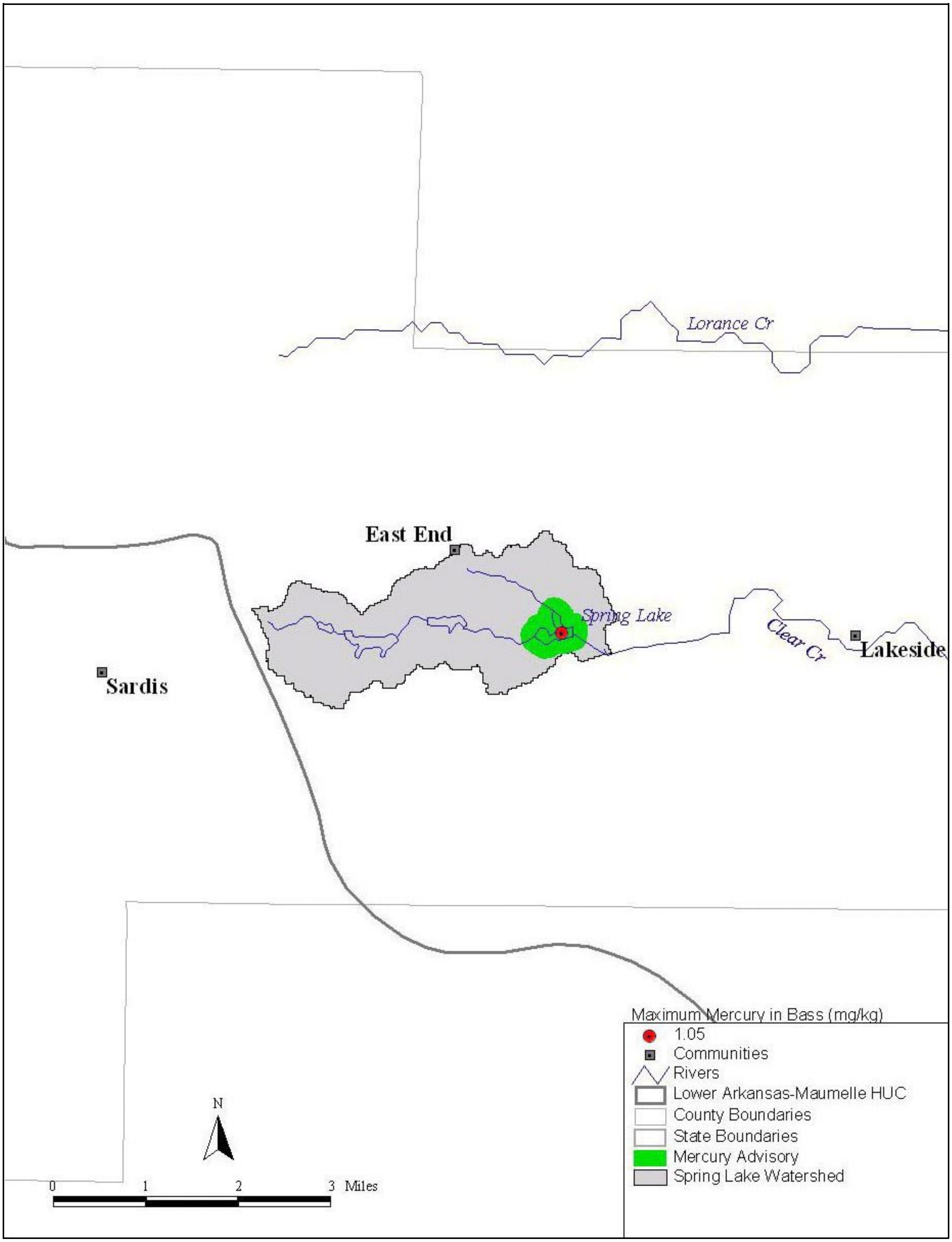

Figure 3.14. Spring Lake watershed advisory areas and mercury levels in bass.

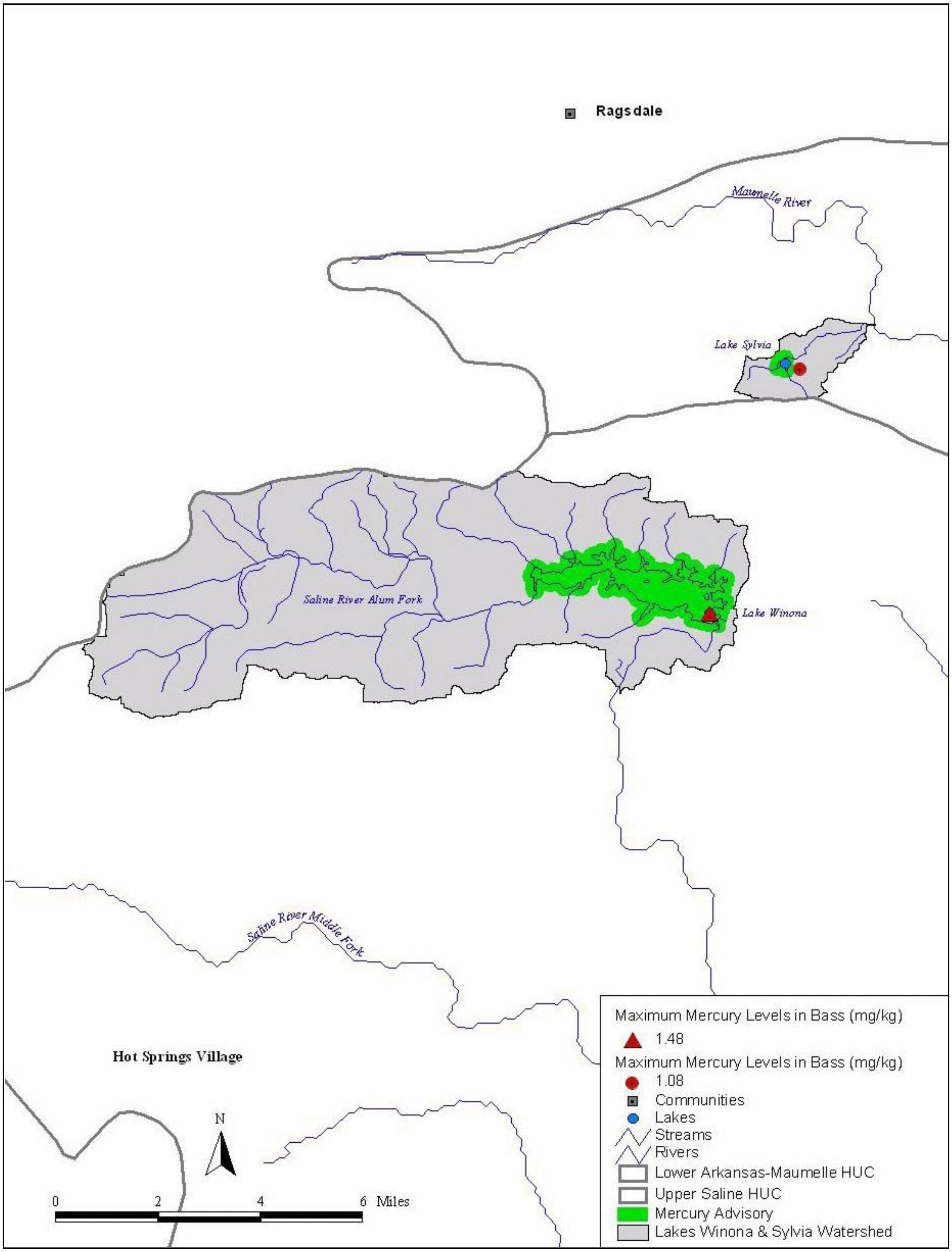

Figure 3.15. Lake Winona and Lake Sylvia watershed advisory areas an mercury levels in bass.

4.0 DEVELOPMENT OF THE TMDL

4.1 Loading Capacity

The loading capacity of waterbodies differ due to (1) inputs or load of mercury to the waterbody, (2) environmental conditions within the waterbody that mediate methylation and bioaccumulation, and (3) the food web or food chain through which mercury bioaccumulates (Armstrong et al.1995). Currently, the water body concentrations of mercury and methylmercury are unknown. In the future, clean sampling and analysis procedures might facilitate the estimation of loading capacity through water column monitoring.

4.2 Conceptual Framework

Mercury is unlike many other metals because it has a volatile phase at ambient temperatures and can be transported in a gaseous, soluble, or particulate form (Figure 4.1). Mercury is emitted to the atmosphere in both elemental gaseous Hg(0) and divalent Hg(II) forms. Anthropogenic direct emissions, natural emissions, and indirect re-emission of previously deposited mercury are major sources of mercury to the atmosphere (Figure 4.1). Gaseous Hg(0) is relatively insoluble and is capable of being transported long distances. However, ozone or other oxidizing agents in the atmosphere can convert Hg(0) to Hg(II). Hg(II) is much more soluble and can sorb onto particulates, resulting in both wet and dry mercury deposition within local (i.e., 100 km from the source, EPA 2001) and regional areas (EPRI 1994). Some Hg(II) can also be chemically reduced to Hg(0). Hg(0) can be transported long distances and contribute to regional and global background concentrations.

Local sources are typically considered to be those sources that are within about a 100 km radius of a site (EPA 2001). Regional sources are loosely defined as other sources within a geographical area such as the Southeast, South, or Upper Midwest, while global sources include intercontinental contributions of mercury. Atmospheric mercury deposition can include contributions from all three sources.

In addition to atmospheric deposition, mercury can also enter waterbodies from point source effluent discharges and watershed nonpoint source contributions. These watershed nonpoint sources include both naturally occurring mercury (e.g., geology) and anthropogenic mercury in soils from current and historical atmospheric deposition (Figure 4.1).

The primary mercury species of concern for bioaccumulation and biomagnification through the food chain, however, are not the inorganic mercury species, but the organic or methylmercury species (Figure 4.2). It is the transformation of inorganic mercury to organic or methylmercury that results in its accumulation and biological magnification through the food chain (Figure 4.2). Methylmercury binds with protein in muscle tissue of fish and other living organisms. Methylmercury is lost very slowly from fish tissue, on the order of years (Trudel and Rasmussen 1997). Therefore, methylmercury concentrations continue to increase throughout the life of the fish as long as methylmercury is in the environment and in its prey species. Older, larger fish typically have higher mercury concentrations than younger, smaller fish.

Recent studies have found that although mercury sulfur complexes have low solubilities in water, complex polysulfidic mercury compounds have greater solubilities than would be indicated from considering only cinnabar, the mercury sulfide ore (Benoit et al. 1999, Paquette and Hely 1995). In addition, it is likely the neutral HgS compound that moves across microbial cell membranes where the mercury is methylated or transformed from inorganic to organic mercury (Benoit et al. 2000). These microorganisms, such as sulfur reducing bacteria, live in anaerobic or zero dissolved oxygen environments in the sediments of wetlands, streams, rivers, and lakes or reservoirs. Therefore, reservoirs with anaerobic hypolimnions can be suitable environments for methylating mercury. New reservoirs (i.e., less than 15 to 20 years old) create environments that are particularly suitable for methylating bacteria so fish tissue mercury concentrations in new reservoirs are typically higher than fish tissue mercury concentrations in older reservoirs. Wetlands also create environments that are very conducive to mercury methylation.

In summary, TMDLs for mercury must consider that mercury can exist as a gas as well as in solution and particulate forms. Mercury loads arise from atmospheric deposition contributed by both local and regional/global emission sources, point source effluent discharges, natural geological formations, and soils. However, after deposition or loading to the system, it can also be lost through volatilization and re-enter the atmospheric pool. It is the organic form as methylmercury that is biologically accumulated and magnified through the food chain. Once in fish, methylmercury is lost very slowly and so accumulates through time.

4.3 TMDL Formulation

A two-step approach was used to estimate loading capacity and the reductions required to achieve the designated fishable use in the watersheds. Loading was estimated from both point and nonpoint sources in the first step, while reductions were estimated based on safe fish tissue Hg concentrations in the second step.

4.3.1 Nonpoint Source Loading Estimates

Nonpoint source load included regional atmospheric deposition inputs, local emission source contributions, and watershed geologic/erosional inputs and watershed soil/erosional inputs.

4.3.1.1 Regional Atmospheric Deposition

Data for regional atmospheric deposition was obtained from the National Atmospheric Deposition Program website. There are no mercury deposition monitoring stations in the state of Arkansas, therefore the two monitoring stations closest to the watershed were utilized (for a map showing locations of all the NADP mercury deposition monitoring sites, see http://nadp.sws.uiuc.edu/mdn/sites.asp). Data from monitoring locations LA10, in Franklin Parish, Louisiana, and TX21, in Gregg County, Texas, were used to represent atmospheric deposition of Hg in the watershed (Figure 4.3). Station LA10 is approximately 126 to 282 miles from the watersheds and Station TX21 is approximately 104 to 272 miles from the watersheds. Station LA10 had wet deposition data available for 1999 and station TX21 had wet deposition data available for 1996 through 1999. Wet deposition is the mercury removed from the atmosphere during rain fall or storm events. Dry deposition is mercury removed from the atmosphere on dust particles, sorption to vegetation, gaseous uptake by plants or other input during non-rainfall periods (EPA 1997). Table 4.1 shows the annual totals for mercury wet deposition measured at the two sites (Note: all tables are located at the end of the section). The total atmospheric deposition was estimated by assuming that dry deposition rates are half of wet deposition rates. Dry deposition rates from 40% to 60% of wet deposition rates are widely accepted (EPA 2001). The estimated total atmospheric deposition was 17.2 $\mu g/m^2/yr$.

Precipitation data was also available from the NADP website (NADP 2000). These data were compared with precipitation data for the watersheds obtained from Hydrosphere (2000) (see Appendix A). The TMDL watersheds received more precipitation than the NADP stations (Table 4.1). Since wet deposition of mercury is related to precipitation, an area receiving more precipitation could be assumed to receive a greater loading of mercury through wet deposition. Therefore, the mercury deposition for the NADP stations was adjusted based on the precipitation data from the NADP sites and the watersheds. Atmospheric deposition correction factors were obtained by dividing the average annual precipitation of the watersheds by the average annual precipitation at stations LA10 and TX21 (1.07 m/yr) (Table 4.1). Multiplying the total atmospheric deposition of 17.2 $\mu g/m^2/yr$ by the correction factors resulted in precipitation corrected total atmospheric deposition rates for each watershed (Table 4.1). Since the dry deposition was assumed to be 50% of the wet deposition, it was included in the adjustment. The corrected total atmospheric deposition rates were within the range (3-30 $\mu g/m^2/yr$) predicted for this area by the RELMAP model (EPA 1997). NADP data and Hydrosphere (2000) data are shown in Table 4.1.

4.3.1.2 Local Atmospheric Deposition

The Louisiana and Texas Deposition Monitoring Stations include both local emission sources similar to those in Arkansas and global/regional input. Local atmospheric deposition for the Arkansas watersheds was estimated based on data from the EPA Office of Air Quality Planning and Standards National Toxics Inventory (NTI) database. The NTI is a complete national inventory of stationary and mobile sources that emit hazardous air pollutants (HAPs). Data from the NTI web site was downloaded using the maximum achievable control technology (MACT) report format. The MACT report includes the number of sources and total 1996 HAP emissions for each MACT source category included in the NTI by county.MACT standards for emission limitations were developed under section 112(d) of the Clean Air Act. The limitations are based on the best demonstrated control technology or practices in similar sources to be applied to major sources emitting one or more of the listed toxic pollutants.

In this TMDL, local sources for a watershed are defined as sources within the watershed and within all counties within a distance of 100 km from the watershed boundary. The area within which these local sources are located is referred to as the "airshed". The NTI MACT report format has sources listed by county, therefore, the airshed boundary is determined by county boundaries and if a portion of a county falls within 100 km of the watershed boundary, then the entire county is included as part of the airshed. The county-based airshed boundary for each watershed is shown in Figures 4.4 through 4.9. The mercury emissions for each MACT category found within the airsheds are included in Appendix C. Table 4.2 shows the areas of each airshed and the local Hg(II) emissions calculated from the MACT data that contribute to the local atmospheric deposition. MACT source categories not included in Appendix C (e.g. medical waste incineration) were not present in the airsheds, and were not included as local sources in the TMDLs. MACT source categories not included in Appendix C could contribute to the global/regional atmospheric mercury load to the watersheds.

The distance from the emission source, the forms of the mercury in the emissions, other pollutants in the emissions and the atmosphere, and the weather patterns of precipitation are important factors in determining where mercury released to the air will deposit. Divalent mercury [Hg(II)] is the dominant form of mercury in both rainfall and most dry deposition processes. An estimate of the Hg(II) emitted from MACT category sources in the airshed was calculated based on source speciation percentages (EPA 2000b, Russ Bullock personal communication 2001). The speciation percentages used to estimate the Hg (II) emissions are shown in Appendix C. The mercury deposition rate for each watershed due to local sources was determined by dividing the total Hg(II) emissions for each airshed by the airshed area (Table 4.2). This calculation is a simplification of the methodology used in the Savannah River mercury TMDL (EPA 2001). The global/regional deposition rate was set equal to the precipitation corrected total atmospheric deposition rate minus the local source deposition rate (Table 4.2). Based on the analysis of local sources, the majority of the atmospheric mercury deposition to the watersheds can be attributed to global/regional sources.

The local source and global/regional deposition rates were used to determine the mercury loading to lakes, reservoirs, and wetlands in each of the watersheds. Table 4.3 shows the total area of the watersheds and the area of the watersheds covered by streams, lakes, reservoirs, and wetlands. The sum of the stream, lake, reservoir, and wetland areas was multiplied by the local and global/regional mercury atmospheric deposition rates to obtain the direct mercury atmospheric loads to the waterbodies on each watershed. The portions of the total mercury deposition that can be attributed to local sources versus global/regional sources in each watershed are shown in Table 4.3.

Indirect atmospheric mercury contributions in overland flow during rain events was not estimated. The watersheds are primarily forested (Table 4.4), and overland flow during rain events in forested lands is minimal (Waring and Schlesinger 1985). Therefore, it was assumed that indirect atmospheric contributions via overland flow during rain events would not be significant.

4.3.1.3 Watersheds Sediment Mercury Loading

Mercury can also enter the waterbodies sorbed to sediments. Sediment loads for the watersheds were based on erosion rates for agricultural, barren, and forestland areas reported in literature. The land use areas were based on USGS land use data from the 1970's provided as part of BASINS version 2.0 (1999). Erosion rates were set based on information from Bloodworth and Berc (1998), Handbook of Nonpoint Pollution (Novotny and Chesters 1981), and Ozark-Ouachita Highlands Assessment Report (USDA FS 1999). Cropland erosion rates reported in these sources average 3.4 tons/acre/year. Cropland with highly erodible soils reportedly have erosion rates of 6.2 to 6.4 tons/acre/year and cropland with soils that are not highly erodible reportedly have erosion rates of 2.3 to 2.4 tons/acre/year. Reported forestland erosion rates ranged from 0.2 to 0.8 tons/acre/year. There was a small percentage of barren land within some of the watersheds. Sediment loads for barren lands were calculated using cropland erosion rates. Table 4.4 shows the total area, agricultural area, forestland area, and barren land area for the watersheds. Percentages of the watersheds in these land uses are also included. Table

4.5 shows the sediment loads calculated using these land use areas and the erosion rates discussed above.

Mercury in sediment was assumed to come from two sources—geologic weathering and atmospheric deposition. Given that geologic weathering contributes to soils, a portion of the mercury in the soils would come from the underlying geology, which is known to contain mercury (Armstrong et al. 1995). In this TMDL study, the portion of the sediment mercury load contributed by geologic weathering was estimated (sediment/geologic mercury) and labeled as the background load. In addition, on-going and historical atmospheric mercury deposition over the past several decades, if not centuries, has also contributed mercury to the soils. While some of this mercury was likely re-emitted to the atmosphere, some of this previously deposited mercury would remain sorbed to the soils and could be transported to waterbodies. This portion of the sediment mercury load was reported as sediment/deposited mercury.

A number of measurements of mercury in rock formations in the Ouachita Mountains (Stone et al. 1995) and soils in the Ouachita River basin (Armstrong et al. 1995) were available. Figure 4.10 shows the sampling locations. Mercury concentrations measured in both rock and soils in Arkansas exhibited a large degree of variability (Figure 4.11). To get an idea of the range of possible geologic mercury and deposited mercury in sediment loads, three loads were calculated. The upper boundary loads were calculated using 90th percentile rock (0.25 mg/kg) and soil (0.3 mg/kg) mercury concentrations measured in Arkansas. The lower boundary loads were calculated using 10th percentile rock (0.01 mg/kg) and soil (0.02 mg/kg) mercury concentrations from the same data set. The load considered to be most realistic was calculated using the geometric mean of shale (0.09 mg/kg) and soil (0.16 mg/kg) mercury concentrations. Shale mercury was used for the most likely load calculation because it is common in the Ouachita and Boston Mountains and is the most easily erodible rock analyzed (Armstrong et al. 1995). Therefore it was deemed the most likely to contribute to the sediment mercury load.

Estimates of the sediment/geologic mercury loads for the watersheds were calculated by multiplying the rock mercury concentrations discussed above by the total watershed sediment loads in Table 4.5. The sediment/deposited mercury loads were estimated by multiplying the non-geologic soil mercury concentrations by the sediment loads. The non-geologic soil mercury concentrations were calculated as the soil mercury concentrations minus the rock mercury concentrations. Therefore, the upper boundary non-geologic soil mercury concentration was 0.05 mg/kg, the lower boundary concentration was 0.01 mg/kg, and the most likely concentration was 0.07 mg/kg. The loads calculated using these soil and rock concentrations are shown in Table 4.6.

4.3.2 Point Source Loading Estimate

There were no NPDES permitted sources with mercury limits in their permit discharging in any of the watersheds. Municipal wastewater treatment facilities were assumed to discharge some mercury because mercury at low levels has been measured in wastewater treatment plants (WWTPs) in Arkansas and other US regions. ADEQ conducted a monitoring study of five WWTPs in Arkansas using clean sampling procedures and ultra-trace level analyses and found an average concentration of about 15 ng/L in municipal discharges (Allen Price, ADEQ, personal communication 2001).

Because mercury had been found in WWTP discharges in Arkansas, an estimate of the contribution of mercury to the watersheds from municipal WWTPs was calculated (Table 4.7). A list of the municipal WWTPs in each watershed was obtained from the PCS search done for NPDES permitted facilities (Appendix B). A mercury concentration of 15 ng/L was assumed for each WWTP. This concentration was multiplied by the design flow for the municipal WWTPs to estimate the point source mercury loads. Design flows were included in the results of the PCS search.

4.3.3 Load Reduction Estimation

Load reduction estimates were based on concentrations of mercury in largemouth bass in the waterbodies of concern. Mercury concentrations have been measured in largemouth bass collected throughout Arkansas (Armstrong et al. 1995). These data are the basis for the fish consumption advisiories that have been issued for the waterbodies included in this TMDL. Although the fish consumption advisories were issued based on maximum measured tissue mercury concentrations, the average of measured tissue mercury concentrations in largemouth bass collected in the waterbodies of concern were used to calculate the decrease in fish tissue concentrations needed to result in a target fish tissue mercury concentration. Average fish tissue mercury concentrations have been used to calculate load reductions in other mercury TMDLs, and EPA considers such load reductions to be protective of human health.

If the mercury body burden of the primary fish species of concern (largemouth bass) were reduced to <1.0 mg/kg the waterbodies would achieve their designated, fishable uses with regard to mercury. The mercury reductions required to achieve the designated uses in the waterbodies of concern were based on a target level of 0.8 mg/kg fish tissue mercury concentration. This fish tissue concentration provides a 20% margin of safety in the target level. A linear relationship was assumed between mercury source reductions and fish tissue mercury concentrations. This relationship is consistent with steady-state assumptions and the use of bioaccumulation factors. However, interactions of both inorganic and organic mercury with sulfide, organic carbon, and other water quality constituents can affect its bioavailability for both methylation and uptake (Armstrong et al.1995, EPA 1997, 1998).

In order to establish the reduction needed in average largemouth bass tissue mercury concentrations to achieve designated uses in the waterbodies of concern, the average measured largemouth bass tissue mercury concentrations were divided by the target tissue mercury concentration (0.8 mg/kg). A hazard quotient is directly applied to estimate the load reduction (RF), as illustrated in the following equations:

$$RF = MC/SC$$, where

RF = Reduction Factor
MC = Measured tissue mercury concentration (worst case species of bass and water body average concentration, mg/kg wet weight)
SC = Safe tissue mercury concentration (with margin of safety, mg/kg wet weight)

and,

$$TMDL = (EL/RF) \times SF$$, where

TMDL = total maximum daily load (average value in $ng/m^2/d$)
RF = Reduction Factor
EL = Existing total load (includes point and nonpoint sources)

SF = Site specific factor(s) (requires study, but could be based on measured sulfate, organic carbon, alkalinity or pH values that influence mercury methylation and bioaccumulation. Assumed to be 1 in this study).

This approach follows and builds on the precedence established in *Mercury TMDLs for Segments Within Mermentau and Vermillion-Teche River Basins* (EPA 2000). Those averages of measured tissue mercury concentrations in largemouth bass collected in the waterbodies of concern that are greater than 0.8 mg/kg are listed in Table 4.8, along with the calculated reduction factors for each waterbody. Average measured largemouth bass tissue mercury concentrations were less than 0.8 mg/kg for Lake Nimrod and Lake Winona, so they were excluded from the calculations. Averages of the tissue concentrations and reduction factors were also calculated for each watershed from the values for the waterbodies of concern within the watershed, and included in Table 4.8.

To estimate the total and methylmercury concentrations that might be occurring in the water column given the reported fish tissue mercury concentrations, the average bioaccumulation factor (BAF) used in the EPA Mercury Report to Congress (EPA 1997) was used to back calculate to water methylmercury concentrations (Table 4.9). The ratio of MeHg/THg ranges from 0.01 to 0.3 (EPA 1998, Krabbenhoft et al. 1999). A MeHg/THg ratio of 0.1 was used to estimate water total mercury concentrations (Table 4.9). Both the methylmercury and total mercury concentrations appeared to be reasonable estimates of concentrations that might be expected in the watersheds.

4.4 Current Load

The estimated total mercury loads to the watersheds on both an annual and a daily basis are shown in Tables 4.10 through 4.15 . The municipal WWTP point source contributions are minor (<1%) compared to the atmospheric and watershed nonpoint source contributions. The upper boundary and most likely geologic erosion and soil erosion loads account for the majority of the mercury loads to the watersheds. The lower boundary geologic erosion and soil erosion loads also account for the majority of the mercury load for Fourche La Fave, South Fork Little

Red River, and Shepherd Springs Lake watersheds. In the Bayou Dorcheat and Lakes Winona and Sylvia watersheds, regional atmospheric deposition accounts for the majority of the mercury load with the lower boundary geologic erosion and soil erosion loads. Therefore, geology, soils, and regional atmospheric deposition are the primary sources of mercury loading to the watersheds.

4.5 TMDLs

Target mercury loads for each watershed were calculated using the watershed average reduction factors (see Section 4.3.3, and Table 4.8). The target loads are shown in Tables 4.10 through 4.15. The load allocations for the TMDLs for each watershed are shown in Tables 4.16 through 4.21. Annual mercury loads are used in the load allocations because the concern with this TMDL study is the long term accumulation of mercury, rather than short term acute toxicity events.

4.5.1 Wasteload Allocation

In watersheds with NPDES point sources, the point sources (i.e., municipal WWTPs) contribute less than 1% of the current mercury load to the watershed. Even if the TMDLs for these watersheds were to allocate none of the calculated allowable load to NPDES point sources (i.e., a wasteload allocation of zero), the required reduction in the watershed mercury load would not be attained because of the very high mercury loadings from nonpoint and background sources. At the same time, however, EPA recognizes that mercury is an environmentally persistent, bioaccumulative toxic with detrimental effects to human fetuses even at minute quantities, and as such, should be eliminated from discharges to the extent practicable. Regulations at 40 CFR Part 122.44(d)(1) require permitting authorities to determine "whether a discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above a narrative or numeric criterion within a state [or tribal] water quality standard," and to develop water quality-based NPDES permits accordingly. Although no specific reductions are required of point source discharges in this TMDL these factors suggest that additional efforts by ADEQ and EPA are necessary to demonstrate that discharges are meeting the assumed concentration of 0.12 ug/l.

Taking these two considerations into account, this TMDL provides that mercury contributions from the municipal WWTPs not exceed the mercury water quality standard for Arkansas (12 ng/L).

EPA will work with ADEQ to establish mechanisms for demonstration that these loads are being met. mechanisms that could be used to demonstrate compliance may include certification that there are no known or suspected operations that would reasonably be expected of discharging mercury for minor facilities and effluent sampling by major dischargers or any minors who cannot meet the certification requirement. Sampling requirements if applicable should include sampling and analyses using clean methods. EPA Method 1631 is now available which has a detection limit of 0.0002 ug/L or 0.2 ng/L. Mercury monitoring to meet the requirements of this TMDL should follow procedures as outlined in EPA Method 1631. With this additional data, EPA and ADEQ could consider the possibility of revising the TMDL at some point in the future if warranted.

If a facility is found to discharge mercury at levels above the criterion of 12 ng/L a mercury minimization plan would be a reasonable action to be taken. EPA expects that the State of Arkansas, as the duly authorized permitting authority, will determine the necessary elements of a mercury characterization/minimization plan, considering the size and nature of the affected facility. ADEQ should address the need for additional permit requirements on a case-by-case basis. Through these actions, over the long-term, demonstration will be made that waste load allocations are being met.

4.5.2 Load Allocation

The majority of the mercury load to the watersheds comes from nonpoint sources. Therefore, nonpoint mercury loads must be reduced to achieve the target watershed mercury loads. The reductions in nonpoint mercury loads to the watersheds shown in the TMDL allocations (Tables 4.16 through 4.21) are discussed below.

Reductions in atmospheric mercury loads are expected as a result of implementation of regulations to reduce/limit mercury emissions from certain MACT source categories. In the United States, a 50% reduction in mercury emissions is expected as a result of implementing existing regulations to limit mercury emissions. Therefore, a 50% reduction in the regional atmospheric mercury loads to all of the watersheds is assumed for the TMDL allocations. The regional atmospheric mercury loads in the TMDLs are half the current loads.

Reductions in the local atmospheric mercury loads to the watersheds would also be expected. Table 4.22 summarizes the expected percent reductions in the local atmospheric mercury loads from local sources to the airsheds as a result of implementing existing MACT mercury emissions limits. The local atmospheric mercury loads in the TMDLs are the current loads reduced by the percentages listed in Table 4.22.

Reducing the atmospheric deposition should reduce the amount of deposited mercury in sediments. Therefore, a reduction in the sediment/deposited mercury load would be expected as a result of implementation of MACT mercury emissions regulations since mercury deposited in soils come from both local and regional sources. Table 4.23 shows the percent reduction in the current total atmospheric loads (regional plus local) to the watersheds resulting from implementation of MACT mercury emissions regulations. The sediment/deposited mercury loads in the TMDLs are the current sediment/deposited mercury loads reduced by the percentages listed in Table 4.23.

Reductions in atmospheric deposition of mercury due to implementing MACT emission regulations were all that was needed to achieve the target watershed mercury loads for Shepherd Springs Lake, Spring Lake (except upper boundary scenario), and Lakes Winona and Sylvia watersheds. The remaining watersheds required further reductions of their mercury loads.

Additional reductions in the sediment mercury load to the waterbodies could be achieved by implementing best management practices (BMPs) to reduce the amount of eroded material entering the waterbodies. Although the watersheds are mostly forested, agricultural land uses (with higher erosion rates) often occur along streams in the river valleys (see land use maps in Chapter 2). Applying BMPs in the watersheds with agricultural and barren land uses would reduce the sediment mercury loads to the waterbodies from both the deposited mercury and the geologic mercury categories. Table 4.24 summarizes the reductions in the current sediment load required for watersheds with agricultural and/or barren land uses to achieve their target mercury loads. These reductions were determined by an iterative process of trying out percent reductions until a value as close as possible to the target watershed mercury load was achieved. These reduced sediment loads were used to calculate the sediment mercury loads shown in the TMDL allocations. Sediment/geologic mercury, and sediment/deposited mercury loads for the TMDLs were calculated by multiplying the reduced sediment loads by the appropriate geologic or non-geologic mercury concentrations (see Section 4.3.1.3 for more information on sediment load calculations). The sediment/deposited mercury loads calculated using the reduced sediment loads were then reduced by the percentages listed in Table 4.23 to account for changes in both erosion rates and atmospheric deposition of mercury to soils.

The forestlands in many of the watersheds are actively managed and experience activities that have the potential to increase erosion such as road-building, burning, and clear-cutting. Therefore, implementation of forestry BMPs is also important for controlling sediment mercury loads to the waterbodies in the watersheds.

4.5.3 Reserve Load

The conservative estimates used throughout these analyses, including the conservative reduction factors, should provide an unallocated reserve for mercury loading to the watersheds. However, watershed nonpoint sources of geologic and previously deposited mercury might sustain fish consumption advisories even if all other mercury sources were eliminated.

Table 4.1. Deposition rate estimates for the watersheds based on NADP data.

NADP Data Summary				Precipitation Data (1997 - 1999)			
Station	Year	Rain Gauge (m/yr)	Wet Hg Deposition (µg/m²/yr)	HUC	Average Precipitation (m/yr)	Atmospheric Deposition Correction Factor	Precipitation Corrected Total Atmospheric Deposition Rate (µg/m²/yr)
TX21	1996	0.8	9.0	11110206	1.33	1.24	21.3
TX21	1997	1.3	13.0	11140203	1.54	1.44	24.6
TX21	1998	1.1	11.6	11010014	1.23	1.15	19.7
TX21	1999	0.9	10.3	11110201	1.35	1.26	21.6
LA10	1999	1.3	13.3	11110207	1.19	1.11	19.1
	Average	1.07	11.4	08040203 and 11110207	1.27	1.18	20.3

Dry + Wet = Average Wet Deposition x 1.5 = 17.2 µg/m²/yr

Precipitation Corrected Total Atmospheric Deposition Rate = Atmospheric Deposition Correction Factor x 17.2 µg/m²/yr

Atmospheric Deposition Correction Factor = HUC Average Precipitation / NADP Rain Gauge Average

Table 4.2. Local point source emissions within the airsheds based on NTI MACT report data.

Watershed	Airshed Area (km²)	MACT Local Source Hg(II) Emissions in Airshed (g/yr)	Local Source Deposition Rate (µg/m²/yr)	Global/Regional Deposition Rate (µg/m²/yr)
Fourche La Fave	108,875	293,103	2.69	18.6
Bayou Dorcheat	84,798	255,316	3.01	21.6
South Fork Little Red	62,821	76,131	1.21	18.5
Shepherd Springs Lake	57,522	146,378	2.54	19.0
Spring Lake	53,793	99,163	1.84	17.2
Lake Winona/Lake Sylvia	60,423	94,426	1.56	18.8

Notes:

MACT local source Hg(II) emissions from data in Appendix B

Local Source Deposition Rate = MACT Local Source Hg(II) Emissions/Airshed Area

Global/Regional Deposition Rate = Precipitation Corrected Total Atmospheric Deposition Rate minus Local Source Deposition Rate

Precipitation Corrected Total Atmospheric Deposition Rate from Table 4.1

Table 4.3. Atmospheric mercury deposition load to the entire watersheds.

Watershed	Streams (acres)	Lakes and Reservoirs (Acres)	Wetlands (acres)	Streams, Lakes, Reservoirs, and Wetlands (km^2)	Local Hg Deposition (g/yr)	Global/Regional Hg Deposition (g/yr)
Fourche La Fave	0*	5,802	784	26.65	72	496
Bayou Dorcheat	0	120	32,986	134.0	403	2,896
South Fork Little Red	0	279	0*	1.13	1.4	21
Shepherd Springs Lake	0	270	0	1.09	2.8	21
Spring Lake	0	158	0	0.64	1.2	11
Lake Winona & Lake Sylvia	0	1,272	0	5.15	8.0	96

* No estimate of areas in streams and canals, or wetlands available in the BASINS land use data for these watersheds.

Notes:

Areas based on land use data from BASINS 2.0.

Local Hg Deposition = stream, lakes, reservoirs and wetland areas * local source deposition rate from Table 4.2.

Global/Regional Hg Deposition = stream, lakes, reservoirs and wetland areas * global/regional deposition rate from Table 4.2.

Table 4.4. Sources of erosion within the watersheds.

Watershed	Watershed Area (acre)	Agricultural Land		Forest Land		Barren Land		Total Percent of Watershed
		Acres	Percent of Watershed Area	Acres	Percent of Watershed Area	Acres	Percent of Watershed Area	
Fourche La Fave	715,688	106,197	14.8	601,263	84.0	33	0.004	98.9
Bayou Dorcheat	324,106	62,946	19.4	222,048	68.5	150	0.05	88.0
South Fork Little Red	177,212	21,572	12.2	153,910	86.9	—	—	99.0
Shepherd Springs Lake	44,908	3,936	8.8	40,533	90.3	---	---	99.0

Spring Lake	2,735	16	0.6	2,429	88.8	63	2.3	91.7
Lake Winona/Lake Sylvia	34,320	—	—	33,048	96.3	—	---	96.3

Note:

Land use areas based on land use data from BASINS 2.0

Watershed areas calculated by summing reported land use areas.

Table 4.5. Sediment load estimated from erosion sources in the watersheds.

Watershed	Agricultural Land Erosion Rate (tons/acre/yr)	Agricultural Land Sediment (tons/yr)	Forest Land Erosion Rate (tons/acre/yr)	Forest Land Sediment (tons/yr)	Barren Land Erosion Rate (tons/acre/yr)	Barren Land Sediment (tons/yr)	Total Sediment (tons/yr)
Fourche La Fave	2.4	254,873	0.2	120,253	2.4	79	375,205
Bayou Dorcheat	2.4	151,070	0.2	44,410	2.4	361	195,841
South Fork Little Red	2.4	51,773	0.2	30,782	2.4	—	82,555
Shepherd Springs Lake	2.4	9,446	0.2	8,107	2.4	—	17,553
Spring Lake	2.4	38	0.2	486	2.4	151	675
Lake Winona/Lake Sylvia	2.4	—	0.2	6,610	2.4	—	6,610

Note:

Land use data from BASINS 2.0.

Average land use based erosion rates from literature.

Table 4.6. Mercury loading to watersheds due to erosion.

Watershed	Scenario	Sediment/Geologic Mercury (g/yr)	Sediment/Deposited Mercury (g/yr)
Fourche La Fave	Upper Boundary	85,095	17,019
	Most Likely	30,634	23,827
	Lower Boundary	3,404	3,404
Bayou Dorcheat	Upper Boundary	44,416	8,883
	Most Likely	15,990	12,436
	Lower Boundary	1,777	1,777
S. Fork Little Red River	Upper Boundary	18,723	3,745
	Most Likely	6,740	5,242
	Lower Boundary	749	749
Shepherd Springs Lake	Upper Boundary	3,981	796
	Most Likely	1,433	1,115
	Lower Boundary	159	159
Spring Lake	Upper Boundary	153	31
	Most Likely	55	43
	Lower Boundary	6	6
Lake Winona and Lake Sylvia	Upper Boundary	1,499	300
	Most Likely	540	420
	Lower Boundary	60	60

Note: Sediment/Geologic mercury: Upper Boundary rock mercury = 0.25 mg/kg, Most Likely rock mercury = 0.09 mg/kg, Lower Boundary rock mercury = 0.01 mg/kg

Sediment/Deposited mercury: Upper Boundary non-geologic mercury = 0.05 mg/kg, Most Likely non-geologic mercury = 0.07 mg/kg, Lower Boundary non-geologic mercury = 0.01 mg/kg

Mercury loads = sediment load * geologic or non-geologic mercury concentrations.

Geologic mercury concentrations from measured mercury concentrations in rock

Non-geologic mercury concentrations = measured soil mercury concentrations - rock mercury concentrations

Measured rock and soil mercury concentrations from Armstrong et al. 1995.

Table 4.7. Mercury load estimated from municipal wastewater treatment plants assuming an average concentration of 15 ng/L.

Watershed	Discharge from Municipal Sources (MGD)	Estimated Mercury* (ng/L)	Mercury Load (ng/day)	Mercury Load (g/yr)
Fourche La Fave	0.2	15	1.19e+07	4.4
Bayou Dorcheat	3.05	15	1.73e+08	63.3
South Fork Little Red	2.7	15	1.53e+08	56
Shepherd Springs Lake	---	---	---	---
Spring Lake	---	---	---	---
Lake Winona/Lake Sylvia	---	---	---	---

* Average mercury concentration measured in Arkansas WWTPs (Allen Price, ADEQ, personal communication 2001).

Table 4.8. Reduction factor needed to reduce average fish tissue mercury concentrations to target level (0.8 mg/kg) and achieve fishable designated use.

Watershed	Waterbody	Average Largemouth Bass Hg Concentration (mg/kg)	Reduction Factor to Achieve Target Level
Fourche La Fave	Cove Creek Lake	1.36	1.70
	Dry Fork Lake	1.29	1.61
	Fourche La Fave River	0.89	1.11
	Average for Fourche La Fave watershed	1.18	1.47
Bayou Dorcheat	Lake Columbia	0.85	1.06
	Bayou Dorcheat	2.06	2.58
	Average for Bayou Dorcheat watershed	1.46	1.82
Lake Sylvia and Lake Winona	Lake Sylvia	0.87	1.1
Shepherd Springs Lake	Shepherd Springs Lake	0.82	1.02
South Fork Little Red	South Fork Little Red	1.00	1.25

	River - Johnson Hole		
Spring Lake	Spring Lake	1.05	1.31

Note: Largemouth bass concentrations from Armstrong et al. 1995

Table 4.9. Water methylmercury concentrations back-calculated from fish tissue mercury concentrations. Total mercury concentrations estimated from MeHg:THg ratio.

Location	Maximum LMB Hg Concentration (mg/kg)	MeHg Conc. in Water Back-Calculated from BAF** (ng/L)	Total Hg Conc. in Water from MeHg:THg Ratio+ (ng/L)
Cove Creek Lake	2.43	0.4	4.0
Bayou Dorcheat	2.06	0.3	3.0
Dry Fork Lake	2.58	0.4	4.0
Fourche La Fave River	1.24	0.2	2.0
Lake Columbia	1.61	0.2	2.0
Lake Nimrod	1.26	0.2	2.0
Lake Sylvia	1.08	0.2	2.0
Lake Winona	1.48	0.2	2.0
Shepherd Springs Lake	2.69	0.4	4.0
South Fork Little Red River	0.9	0.1	1.0
South Fork Little Red River - Johnson Hole	2.12	0.3	3.0
South Fork Little Red River - Old Water Works	0.52	0.08	0.8
Spring Lake	1.05	0.2	2.0

**BAF = 6.8×10^6 geometric mean (EPA 1997)

+ MeHg: THg Ratios ~ 0.01 to 0.3, 0.1 used for conversion to THg (EPA 1998)

Table 4.10. Estimated current mercury load to Fourche La Fave watershed.

	Upper Boundary			Most Likely			Lower Boundary		
	Load		Percent of Total Load	Loading Rate		Percent of Total Load	Loading Rate		Percent of Total Load
Source Type	(g/yr)	(g/d)		(g/yr)	(g/d)		(g/yr)	(g/d)	
Point Source									
Municipal WWTPs[1]	4.4	0.01	0.0%	4.4	0.01	0.0%	4.4	0.01	0.1%
Non-Point Source									
Regional Atmospheric Deposition[2]	496	1.4	0.5%	496	1.4	0.9%	496	1.4	6.7%
Local Atmospheric Deposition[2]	72	0.2	0.1%	72	0.2	0.1%	72	0.2	1.0%
Sediment/ Deposited Mercury[3]	17,019	47	16.6%	23,827	65	43.3%	3,404	9.3	46.1%
Background									
Sediment/ Geologic Mercury[3]	85,095	233	82.9%	30,634	84	55.7%	3,404	9.3	46.1%
Watershed Total	102,686	281	100%	55,033	151	100%	7,380	20	100%
Watershed Reduction Factor[4]	1.47	—		1.47	—		1.47	—	
Target Watershed Load[5]	69,854	—		37,437	—		5,020	—	

[1] From Table 4.7

[2] From Table 4.3

[3] From Table 4.6

[4] From Table 4.8

[5] Target watershed load = watershed total/watershed reduction factor

Table 4.11. Estimated current mercury load to Bayou Dorcheat watershed.

	Upper Boundary			Most Likely			Lower Boundary		
	Load		Percent of Total Load	Loading Rate		Percent of Total Load	Loading Rate		Percent of Total Load
Source Type	**(g/yr)**	**(g/d)**		**(g/yr)**	**(g/d)**		**(g/yr)**	**(g/d)**	
Point Source									
Municipal WWTPs[1]	63	0.2	0.1%	63	0.2	0.2%	63	0.2	0.9%
Non-Point Source									
Regional Atmospheric Deposition[2]	2,896	7.9	5.1%	2,896	7.9	9.1%	2,896	7.9	41.9%
Local Atmospheric Deposition[2]	403	1.1	0.7%	403	1.1	1.3%	403	1.1	5.8%
Sediment/ Deposited Mercury[3]	8,883	24	15.7%	12,436	34	39.1%	1,777	4.9	25.7%
Background									
Sediment/ Geologic Mercury[3]	44,416	122	78.4%	15,990	44	50.3%	1,777	4.9	25.7%
Watershed Total	56,661	155	100%	31,788	87	100%	6,916	19	100%
Watershed Reduction Factor[4]	1.82	—		1.82	—		1.82	—	
Target Watershed Load[5]	31,132	—		17,466	—		3,800	—	

[1] From Table 4.7

[2] From Table 4.3

[3] From Table 4.6

[4] From Table 4.8

[5] Target watershed load = watershed total/watershed reduction factor

Table 4.12. Estimated current mercury load to South Fork Little Red watershed.

	Upper Boundary			Most Likely			Lower Boundary		
	Load		Percent of Total Load	Loading Rate		Percent of Total Load	Loading Rate		Percent of Total Load
Source Type	(g/yr)	(g/d)		(g/yr)	(g/d)		(g/yr)	(g/d)	
Point Source									
Municipal WWTPs[1]	56	0.2	0.2%	56	0.2	0.5%	56	0.2	3.6%
Non-Point Source									
Regional Atmospheric Deposition[2]	21	0.1	0.1%	21	0.1	0.2%	21	0.1	1.3%
Local Atmospheric Deposition[2]	1.4	0.004	0.0%	1.4	0.004	0.0%	1.4	0.004	0.1%
Sediment/ Deposited Mercury[3]	3,745	10	16.6%	5,242	14	43.5%	749	2.1	47.5%
Background									
Sediment/ Geologic Mercury[3]	18,723	51	83.0%	6,740	18	55.9%	749	2.1	47.5%
Watershed Total	22,546	62	100%	12,060	33	100%	1,576	4.3	100%
Watershed Reduction Factor[4]	1.25	—		1.25	—		1.25	—	
Target Watershed Load[5]	18,037	—		9,648	—		1,261	—	

[1] From Table 4.7

[2] From Table 4.3

[3] From Table 4.6

[4] From Table 4.8

[5] Target watershed load = watershed total/watershed reduction factor

Table 4.13. Estimated current mercury load to Shepherd Springs Lake watershed.

	Upper Boundary			Most Likely			Lower Boundary		
	Load		Percent of Total	Loading Rate		Percent of Total	Loading Rate		Percent of Total
Source Type	(g/yr)	(g/d)	Load	(g/yr)	(g/d)	Load	(g/yr)	(g/d)	Load
Point Source									
Municipal WWTPs[1]	0	0	0.0%	0	0	0.0%	0	0	0.0%
Non-Point Source									
Regional Atmospheric Deposition[2]	21	0.06	0.4%	21	0.06	0.8%	21	0.06	6.1%
Local Atmospheric Deposition[2]	2.8	0.01	0.1%	2.8	0.01	0.1%	2.8	0.01	0.8%
Sediment/ Deposited Mercury[3]	796	2.2	16.6%	1,115	3.1	43.3%	159	0.4	46.6%
Background									
Sediment/ Geologic Mercury[3]	3,981	11	82.9%	1,433	3.9	55.7%	159	0.4	46.6%
Watershed Total	4,801	13	100%	2,572	7.0	100%	342	0.9	100%
Watershed Reduction Factor[4]	1.02	—		1.02	—		1.02	—	
Target Watershed Load[5]	4,707	—		2,521	—		335	—	

[1] From Table 4.7

[2] From Table 4.3

[3] From Table 4.6

[4] From Table 4.8

[5] Target watershed load = watershed total/watershed reduction factor

Table 4.14. Estimated current mercury load to Spring Lake watershed.

	Upper Boundary			Most Likely			Lower Boundary		
	Load		Percent of Total	Loading Rate		Percent of Total	Loading Rate		Percent of Total
Source Type	**(g/yr)**	**(g/d)**	**Load**	**(g/yr)**	**(g/d)**	**Load**	**(g/yr)**	**(g/d)**	**Load**
Point Source									
Municipal WWTPs[1]	0	0	0.0%	0	0	0.0%	0	0	0.0%
Non-Point Source									
Regional Atmospheric Deposition[2]	11	0.03	5.6%	11	0.03	10.0%	11	0.03	45.0%
Local Atmospheric Deposition[2]	1.2	0.003	0.6%	1.2	0.003	1.1%	1.2	0.003	4.7%
Sediment/ Deposited Mercury[3]	31	0.08	15.6%	43	0.1	38.9%	6.1	0.02	25.1%
Background									
Sediment/ Geologic Mercury[3]	153	0.4	78.2%	55	0.2	50.0%	6.1	0.02	25.1%
Watershed Total	196	0.5	100%	110	0.3	100%	24	0.07	100%
Watershed Reduction Factor[4]	1.3	—		1.3	—		1.3	—	
Target Watershed Load[5]	151	—		85	—		19	—	

[1] From Table 4.7

[2] From Table 4.3

[3] From Table 4.6

[4] From Table 4.8

[5] Target watershed load = watershed total/watershed reduction factor

Table 4.15. Estimated current mercury load for Lake Winona and Lake Sylvia watershed.

	Upper Boundary			Most Likely			Lower Boundary		
	Load		Percent of Total	Loading Rate		Percent of Total	Loading Rate		Percent of Total
Source Type	(g/yr)	(g/d)	Load	(g/yr)	(g/d)	Load	(g/yr)	(g/d)	Load
Point Source									
Municipal WWTPs[1]	0	0	0.0%	0	0	0.0%	0	0	0.0%
Non-Point Source									
Regional Atmospheric Deposition[2]	96	0.3	5.0%	96	0.3	9.0%	96	0.3	42.7%
Local Atmospheric Deposition[2]	8.0	0.02	0.4%	8.0	0.02	0.8%	8.0	0.02	3.6%
Sediment/ Deposited Mercury[3]	300	0.8	15.8%	420	1.1	39.5%	60	0.2	26.8%
Background									
Sediment/ Geologic Mercury[3]	1,499	4.1	78.8%	540	1.5	50.8%	60	0.2	26.8%
Watershed Total	1,903	5.2	100%	1,064	2.9	100%	224	0.6	100%
Watershed Reduction Factor[4]	1.1	—		1.1	—		1.1	—	
Target Watershed Load[5]	1,730	—		967	—		204	—	

[1] From Table 4.7

[2] From Table 4.3

[3] From Table 4.6

[4] From Table 4.8

[5] Target watershed load = watershed total/watershed reduction factor

Table 4.16. Fourche La Fave watershed TMDL allocation.

	Upper Boundary		Most Likely		Lower Boundary	
Source Type	**Load (g/yr)**	**Percent of Total Load**	**Load (g/yr)**	**Percent of Total Load**	**Load (g/yr)**	**Percent of Total Load**
Point Source						
Municipal WWTPs[1]	3.5	0.00%	3.5	0.01%	3.5	0.1%
Nonpoint Source						
Regional Atmospheric Deposition[2]	248	0.3%	248	0.5%	248	4.0%
Local Atmospheric Deposition[3]	67	0.1%	67	0.1%	67	1.1%
Sediment/Deposited Hg Erosion[4]	6,941	7.9%	11,180	23.9%	1,677	26.7%
Background						
Sediment/Geologic Mercury[5]	62,591	71.7%	25,925	55.4%	3,024	48.2%
Total Watershed Load	69,850	80.0%	37,423	80.0%	5,019	80.0%
Margin of Safety	17,462	20.0%	9,355	20.0%	1,255	20.0%
Total Maximum Load	87,312	100.0%	46,778	100.0%	6,274	100.0%

[1] WLA (g/yr) = flow (MGD) from Table 4.7 * 12ng/1 * 0.00037854 (conversion factor) * 365 days

[2] Regional Atmospheric Deposition (g/yr) = current load (g/yr) from Table 4.10 * 0.5

[3] Local Atmospheric Deposition (g/yr) = current load (g/yr) from Table 4.10 * (1-percent reduction from Table 4.22)

[4] Sediment/Deposited Mercury (g/yr) = reduced sediment load (tons/yr) from Table 4.24 * appropriate non-geologic mercury factor * 0.907185 (conversion factor) * (1-percent reduction factor form Table 4.23). Ther non-geologic mercury factors are 0.05 for the upper boundary, 0.07 for the most likely boundary and 0.01 for the lower boundary.

[5] Sediment/Geologic mercury (g/yr) = reduced sediment load (tons/yr) from Table 4.24 * appropriate rock mercury factor * 0.907185 (conversion factor). Rock mercury factors are 0.25 for the upper boundary, 0.09 for the most likely boundary and 0.01 for the lower boundary.

Table 4.17. Bayou Dorcheat watershed TMDL allocation.

Source Type	Upper Boundary Load (g/yr)	Upper Boundary Percent of Total Load	Most Likely Load (g/yr)	Most Likely Percent of Total Load	Lower Boundary Load (g/yr)	Lower Boundary Percent of Total Load
Point Source						
Municipal WWTPs[1]	51	0.1%	51	0.2%	51	1.1%
Nonpoint Source						
Regional Atmospheric Deposition[2]	1,448	3.7%	1,448	6.6%	1,448	30.5%
Local Atmospheric Deposition[3]	315	0.8%	315	1.4%	315	6.6%
Sediment/Deposited Hg Erosion[4]	2,831	7.3%	4,594	21.1%	691	14.6%
Background						
Sediment/Geologic Mercury[5]	26,484	68.1%	11,051	50.7%	1,294	27.3%
Total Watershed Load	31,129	80.0%	17,459	80.0%	3,799	80.0%
Margin of Safety	7,783	20.0%	4,365	20.0%	950	20.0%
Total Maximum Load	38,912	100.0%	21,824	100.0%	4,749	100.0%

[1] WLA (g/yr) = flow (MGD) from Table 4.7 * 12ng/1 * 0.00037854 (conversion factor) * 365 days

[2] Regional Atmospheric Deposition (g/yr) = current load (g/yr) from Table 4.11 * 0.5

[3] Local Atmospheric Deposition (g/yr) = current load (g/yr) from Table 4.11 * (1-percent reduction from Table 4.22)

[4] Sediment/Deposited Mercury (g/yr) = reduced sediment load (tons/yr) from Table 4.24 * appropriate non-geologic mercury factor * 0.907185 (conversion factor) * (1-percent reduction factor form Table 4.23). Ther non-geologic mercury factors are 0.05 for the upper boundary, 0.07 for the most likely boundary and 0.01 for the lower boundary.

[5] Sediment/Geologic mercury (g/yr) = reduced sediment load (tons/yr) from Table 4.24 * appropriate rock mercury factor * 0.907185 (conversion factor). Rock mercury factors are 0.25 for the upper boundary, 0.09 for the most likely boundary and 0.01 for the lower boundary.

Table 4.18. South Fork Little Red watershed TMDL allocation.

Source Type	Upper Boundary Load (g/yr)	Upper Boundary Percent of Total Load	Most Likely Load (g/yr)	Most Likely Percent of Total Load	Lower Boundary Load (g/yr)	Lower Boundary Percent of Total Load
Point Source						
Municipal WWTPs[1]	45	0.2%	45	0.4%	45	3.0%
Nonpoint Source						
Regional Atmospheric Deposition[2]	10	0.0%	10	0.1%	10	0.7%
Local Atmospheric Deposition[3]	1.3	0.0%	1.3	0.0%	1.3	0.1%
Sediment/Deposited Hg Erosion[4]	1,721	7.6%	2,775	23.2%	396	26.4%
Background						
Sediment/Geologic Mercury[5]	16,257	72.1%	6,740	56.3%	749	49.8%
Total Watershed Load	18,034	80.0%	9,571	80.0%	1,201	80.0%
Margin of Safety	4,508	20.0%	2,393	20.0%	300	20.0%
Total Maximum Load	22,542	100.0%	11,964	100.0%	1,501	100.0%

[1] WLA (g/yr) = flow (MGD) from Table 4.7 * 12ng/1 * 0.00037854 (conversion factor) * 365 days

[2] Regional Atmospheric Deposition (g/yr) = current load (g/yr) from Table 4.12 * 0.5

[3] Local Atmospheric Deposition (g/yr) = current load (g/yr) from Table 4.12 * (1-percent reduction from Table 4.22)

[4] Sediment/Deposited Mercury (g/yr) = reduced sediment load (tons/yr) from Table 4.24 * appropriate non-geologic mercury factor * 0.907185 (conversion factor) * (1-percent reduction factor form Table 4.23). Ther non-geologic mercury factors are 0.05 for the upper boundary, 0.07 for the most likely boundary and 0.01 for the lower boundary.

[5] Sediment/Geologic mercury (g/yr) = reduced sediment load (tons/yr) from Table 4.24 * appropriate rock mercury factor * 0.907185 (conversion factor). Rock mercury factors are 0.25 for the upper boundary, 0.09 for the most likely boundary and 0.01 for the lower boundary.

Table 4.19. Shepherd Springs Lake watershed TMDL allocation.

	Upper Boundary		Most Likely		Lower Boundary	
Source Type	**Load (g/yr)**	**Percent of Total Load**	**Load (g/yr)**	**Percent of Total Load**	**Load (g/yr)**	**Percent of Total Load**
Point Source						
Municipal WWTPs[1]	0	0.0%	0	0.0%	0	0.0%
Nonpoint Source						
Regional Atmospheric Deposition[2]	10	0.2%	10	0.4%	10	3.2%
Local Atmospheric Deposition[3]	2.5	0.0%	2.5	0.1%	2.5	0.8%
Sediment/Deposited Hg Erosion[4]	437	7.9%	611	23.8%	87	26.9%
Background						
Sediment/Geologic Mercury[5]	3,981	71.9%	1,433	55.7%	159	49.1%
Total Watershed Load	4,430	80.0%	2,056	80.0%	258	80.0%
Margin of Safety	1,108	20.0%	514	20.0%	64	20.0%
Total Maximum Load	5,538	100.0%	2,570	100.0%	322	100.0%

[1] WLA (g/yr) = flow (MGD) from Table 4.7 * 12ng/1 * 0.00037854 (conversion factor) * 365 days

[2] Regional Atmospheric Deposition (g/yr) = current load (g/yr) from Table 4.13 * 0.5

[3] Local Atmospheric Deposition (g/yr) = current load (g/yr) from Table 4.13 * (1-percent reduction from Table 4.22)

[4] Sediment/Deposited Mercury (g/yr) = reduced sediment load (tons/yr) from Table 4.24 * appropriate non-geologic mercury factor * 0.907185 (conversion factor) * (1-percent reduction factor form Table 4.23). Ther non-geologic mercury factors are 0.05 for the upper boundary, 0.07 for the most likely boundary and 0.01 for the lower boundary.

[5] Sediment/Geologic mercury (g/yr) = reduced sediment load (tons/yr) from Table 4.24 * appropriate rock mercury factor * 0.907185 (conversion factor). Rock mercury factors are 0.25 for the upper boundary, 0.09 for the most likely boundary and 0.01 for the lower boundary.

Table 4.20. Spring Lake watershed TMDL allocation.

Source Type	Upper Boundary Load (g/yr)	Upper Boundary Percent of Total Load	Most Likely Load (g/yr)	Most Likely Percent of Total Load	Lower Boundary Load (g/yr)	Lower Boundary Percent of Total Load
Point Source						
Municipal WWTPs[1]	0	0.0%	0	0.0%	0	0.0%
Nonpoint Source						
Regional Atmospheric Deposition[2]	5.5	2.9%	5.5	5.2%	5.5	29.0%
Local Atmospheric Deposition[3]	1.0	0.5%	1.0	1.0%	1.0	5.0%
Sediment/Deposited Hg Erosion[4]	14	7.4%	23	21.7%	3.3	16.0%
Background						
Sediment/Geologic Mercury[5]	130	69.2%	55	52.1%	6.1	30.0%
Total Watershed Load	150	80.0%	84	80.0%	16	80.0%
Margin of Safety	38	20.0%	21	20.0%	4.0	20.0%
Total Maximum Load	188	100.0%	105	100.0%	20	100.0%

[1] WLA (g/yr) = flow (MGD) from Table 4.7 * 12ng/1 * 0.00037854 (conversion factor) * 365 days

[2] Regional Atmospheric Deposition (g/yr) = current load (g/yr) from Table 4.14 * 0.5

[3] Local Atmospheric Deposition (g/yr) = current load (g/yr) from Table 4.14 * (1-percent reduction from Table 4.22)

[4] Sediment/Deposited Mercury (g/yr) = reduced sediment load (tons/yr) from Table 4.24 * appropriate non-geologic mercury factor * 0.907185 (conversion factor) * (1-percent reduction factor form Table 4.23). Ther non-geologic mercury factors are 0.05 for the upper boundary, 0.07 for the most likely boundary and 0.01 for the lower boundary.

[5] Sediment/Geologic mercury (g/yr) = reduced sediment load (tons/yr) from Table 4.24 * appropriate rock mercury factor * 0.907185 (conversion factor). Rock mercury factors are 0.25 for the upper boundary, 0.09 for the most likely boundary and 0.01 for the lower boundary.

Table 4.21. Lake Winona and Lake Sylvia watershed TMDL allocation.

	Upper Boundary		Most Likely		Lower Boundary	
Source Type	**Load (g/yr)**	**Percent of Total Load**	**Load (g/yr)**	**Percent of Total Load**	**Load (g/yr)**	**Percent of Total Load**
Point Source						
Municipal WWTPs[1]	0	0.0%	0	0.0%	0	0.0%
Nonpoint Source						
Regional Atmospheric Deposition[2]	48	2.2%	48	4.7%	48	26.1%
Local Atmospheric Deposition[3]	7.1	0.3%	7.1	0.7%	7.1	3.9%
Sediment/Deposited Hg Erosion[4]	159	7.4%	222	21.8%	32	17.3%
Background						
Sediment/Geologic Mercury[5]	1,499	70.0%	540	52.8%	60	32.7%
Total Watershed Load	1,713	80.0%	817	80.0%	147	80.0%
Margin of Safety	428	20.0%	204	20.0%	37	20.0%
Total Maximum Load	2,141	100.0%	1,021	100.0%	184	100.0%

[1] WLA (g/yr) = flow (MGD) from Table 4.7 * 12ng/1 * 0.00037854 (conversion factor) * 365 days

[2] Regional Atmospheric Deposition (g/yr) = current load (g/yr) from Table 4.15 * 0.5

[3] Local Atmospheric Deposition (g/yr) = current load (g/yr) from Table 4.15 * (1-percent reduction from Table 4.22)

[4] Sediment/Deposited Mercury (g/yr) = reduced sediment load (tons/yr) from Table 4.24 * appropriate non-geologic mercury factor * 0.907185 (conversion factor) * (1-percent reduction factor form Table 4.23). Ther non-geologic mercury factors are 0.05 for the upper boundary, 0.07 for the most likely boundary and 0.01 for the lower boundary.

[5] Sediment/Geologic mercury (g/yr) = reduced sediment load (tons/yr) from Table 4.24 * appropriate rock mercury factor * 0.907185 (conversion factor). Rock mercury factors are 0.25 for the upper boundary, 0.09 for the most likely boundary and 0.01 for the lower boundary.

Table 4.22. Expected reductions in local atmospheric mercury loads to airsheds due to implementation of MACT mercury emission regulations.

Airshed	Current Hg (II) (g/yr)	Reduced Hg (II) (g/yr)	Percent Reduction
Fourche La Fave River Airshed	293,103	272,926	6.9%
Bayou Dorcheat Airshed	255,316	199,780	21.8%
South Fork Little Red River Airshed	75,995	74,317	2.2%
Shepherd Springs Lake Airshed	146,378	145,064	0.9%
Spring Lake Airshed	99,163	85,595	13.7%
Lake Winona and Lake Sylvia Airshed	94,426	83,746	11.3%

Table 4.23. Reduction in mercury atmospheric deposition (regional and local) as a result of MACT mercury emission regulations implementation.

Watershed	Current Mercury Load (g/yr)	Reduced Mercury Load (g/yr)	Percent Reduction
Fourche La Fave	568	315	44.6%
Bayou Dorcheat	3,299	1,763	46.6%
South Fork Little Red River	22.4	11.3	47.1%
Shepherd Springs Lake	23.8	12.5	45.2%
Spring Lake	12.2	6.5	46.5%
Lake Winona and Lake Sylvia	104	55.1	47.0%

Table 4.24. Reductions in erosion rates for agricultural and barren land to achieve target watershed mercury loads, with reduced sediment loads.

Watershed	Reduced Erosion Rate[1] (tons/ac/yr)	Percent Reduction[2]	Reduced Sediment Load[3] (tons/yr)	Scenario
Fourche La Fave	1.47	38.9%	275,980	Upper Boundary
	1.86	22.6%	317,524	Most Likely
	2.01	16.4%	333,326	Lower Boundary
Bayou Dorcheat	1.15	52.1%	116,772	Upper Boundary
	1.44	39.8%	135,354	Most Likely
	1.56	35.0%	142,605	Lower Boundary
South Fork Little Red River	1.90	21.0%	71,683	Upper Boundary
Spring Lake	1.13	53.0%	575	Upper Boundary

Note: Sediment loads did not need to be reduced to achieve the target watershed mercury loads for Shepherd Springs Lake and the Lake Winona and Lake Sylvia watersheds, nor for the most likely and lower boundary scenarios for South Fork Little Red, and Spring Lake watersheds.

[1] Reduced agricultural and barren land erosion rate = 2.4, the original rate used in Table 4.5 * (1-percent reduction column value).

[2] Percent reduction was determined by iteratively trying different reductions until a watershed mercury load less than the target watershed mercury load was achieved.

[3] Reduced sediment load = (acres of agricultural land in watershed from Table 4.4 * reduced erosion rate above) + (acres of forest lands in watershed from Table 4.4 * 0.2, the original rate used in Table 4.5) + (acres of barren lands in watersed from Table 4.4 * reduced erosion rate above).

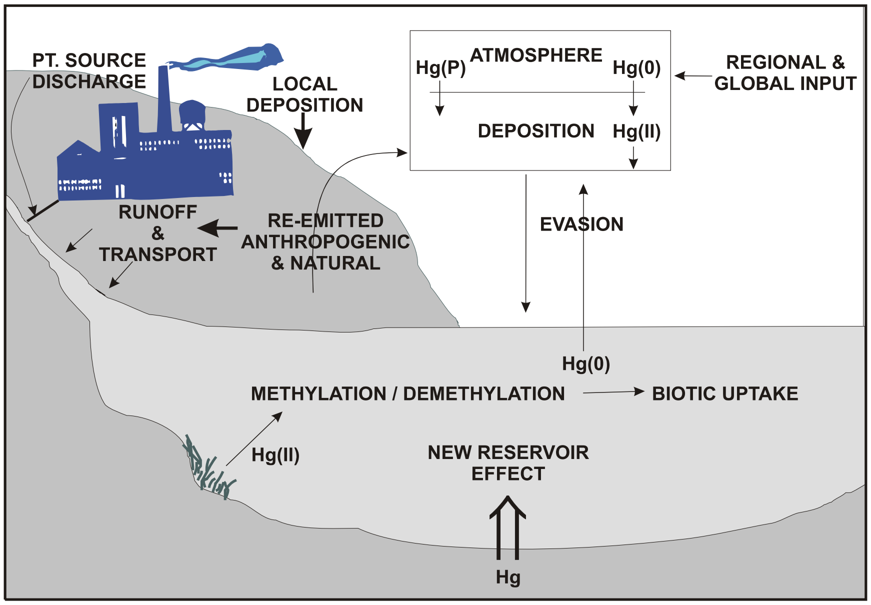

Figure 4.1. General mercury cycle showing atmospheric transport and deposition, point, nonpoint source and natural background contributions, and the effects of new reservoirs on mercury release into the environment (after Mason et.al. 1994).

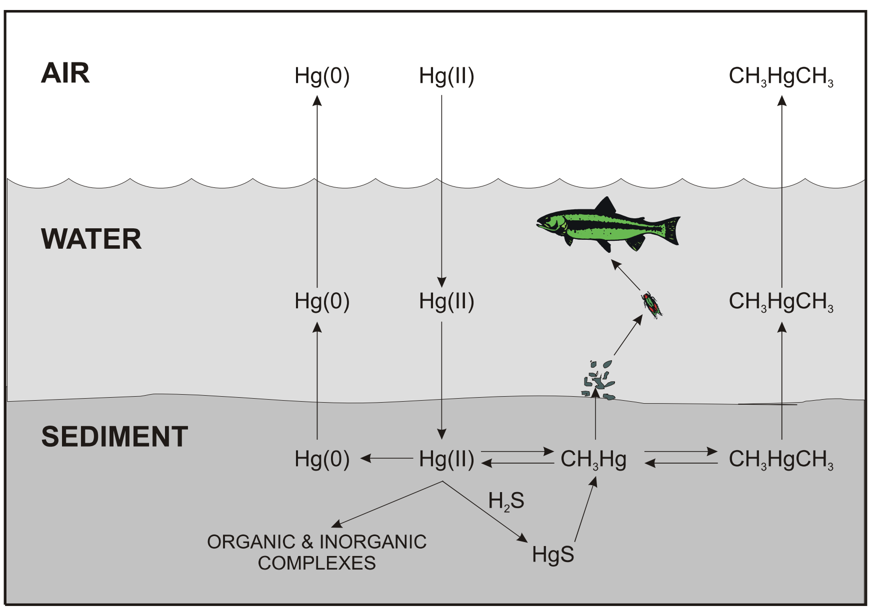

Figure 4.2. Pathways for mercury species through the aquatic ecosystem, including methylation and demethylation, evasion or loss from the water to the atmosphere, and sedimentation and burial in the sediment (After Winfrey and Rudd 1990).

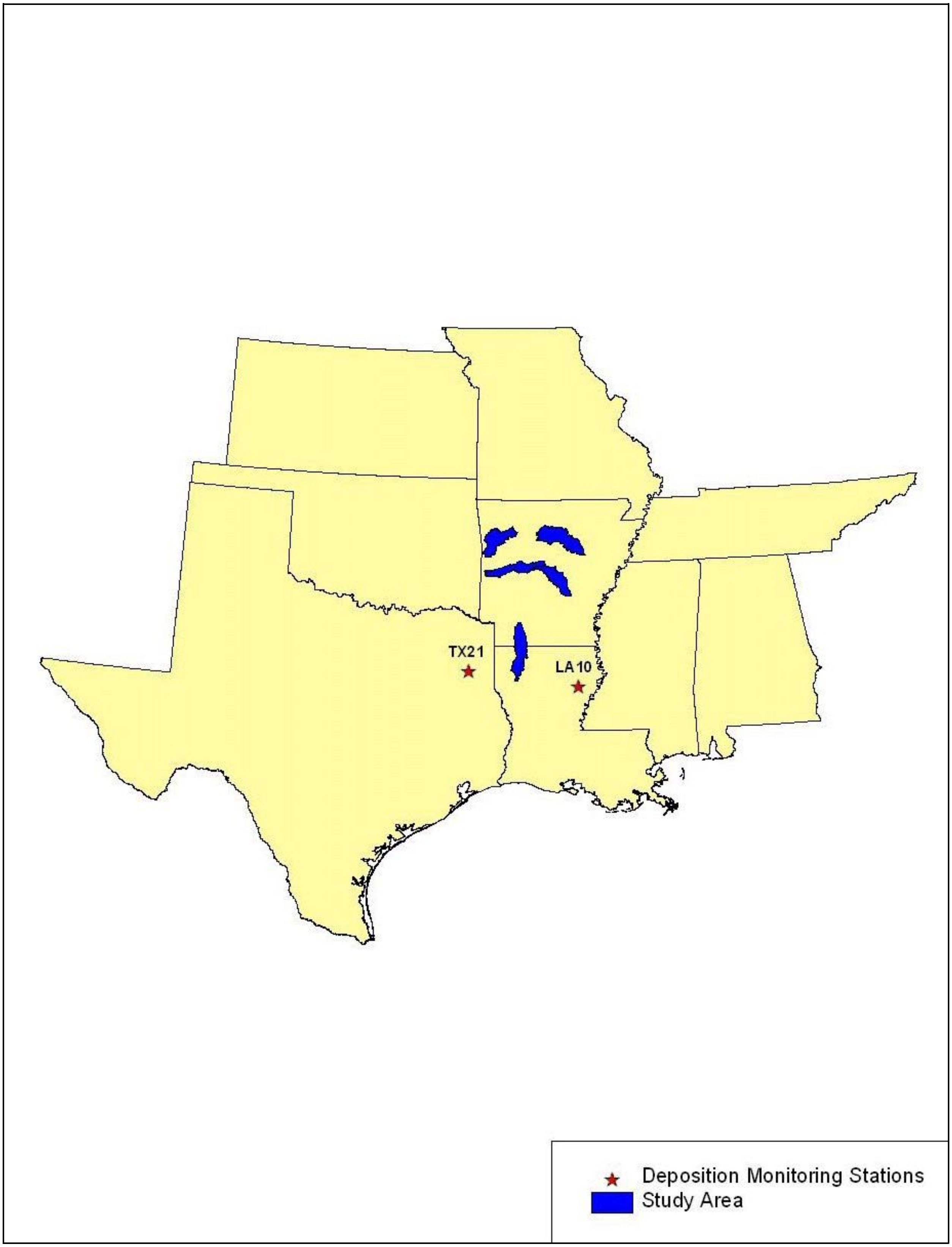

Figure 4.3. Location of National Atmospheric Deposition Program monitoring stations LA10 and TX21 relative to the HUCs included in this study.

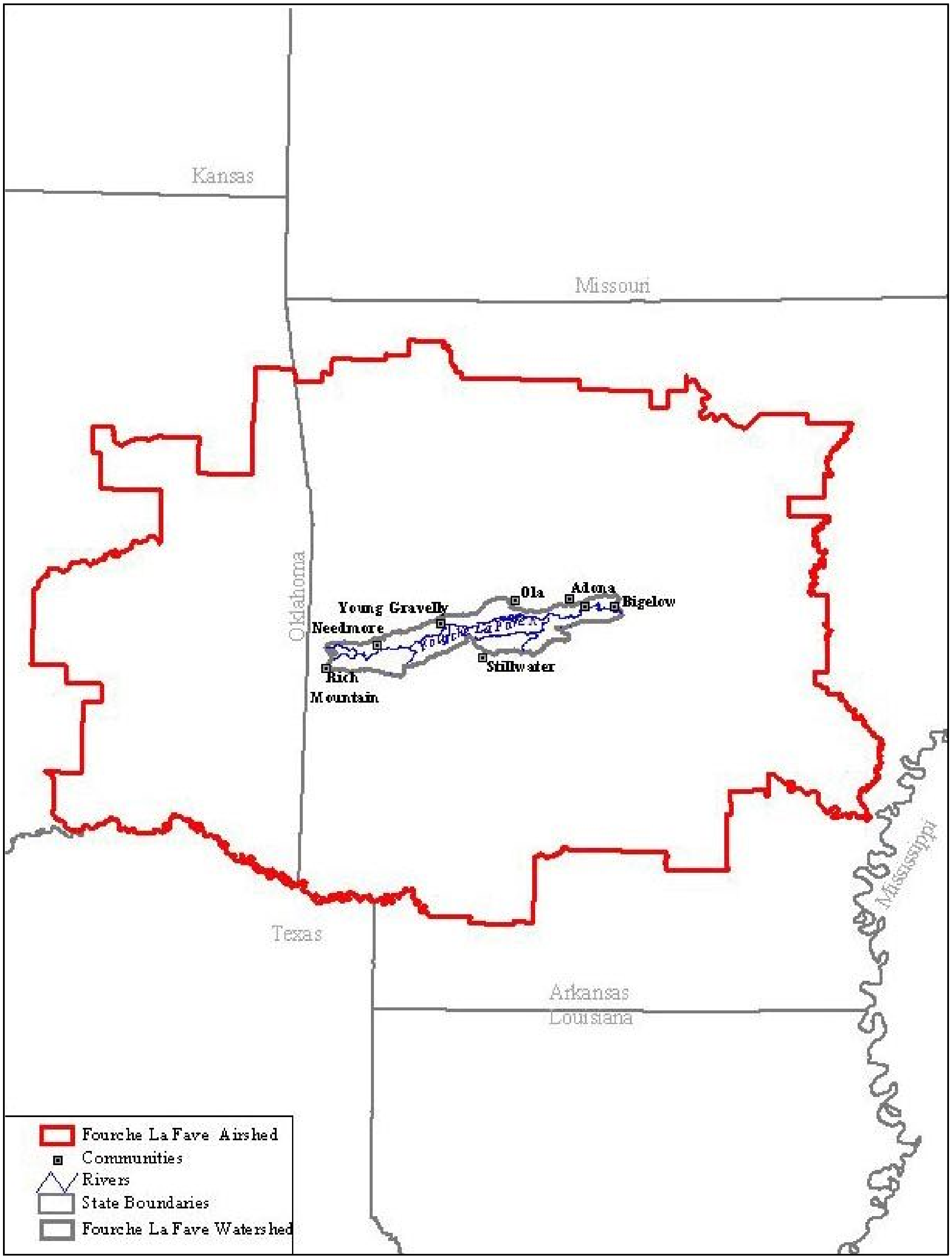
Kansas
Missouri
Oklahoma
Young Gravelly
Needmore
Ola
Adona
Bigelow
Fourche La Fave R.
Stillwater
Rich Mountain
Texas
Arkansas
Louisiana
Mississippi
Fourche La Fave Airshed
Communities
Rivers
State Boundaries
Fourche La Fave Watershed

Figure 4.4. Airshed boundary for the Fourche La Fave watershed (includes all counties within 100 km of watershed).

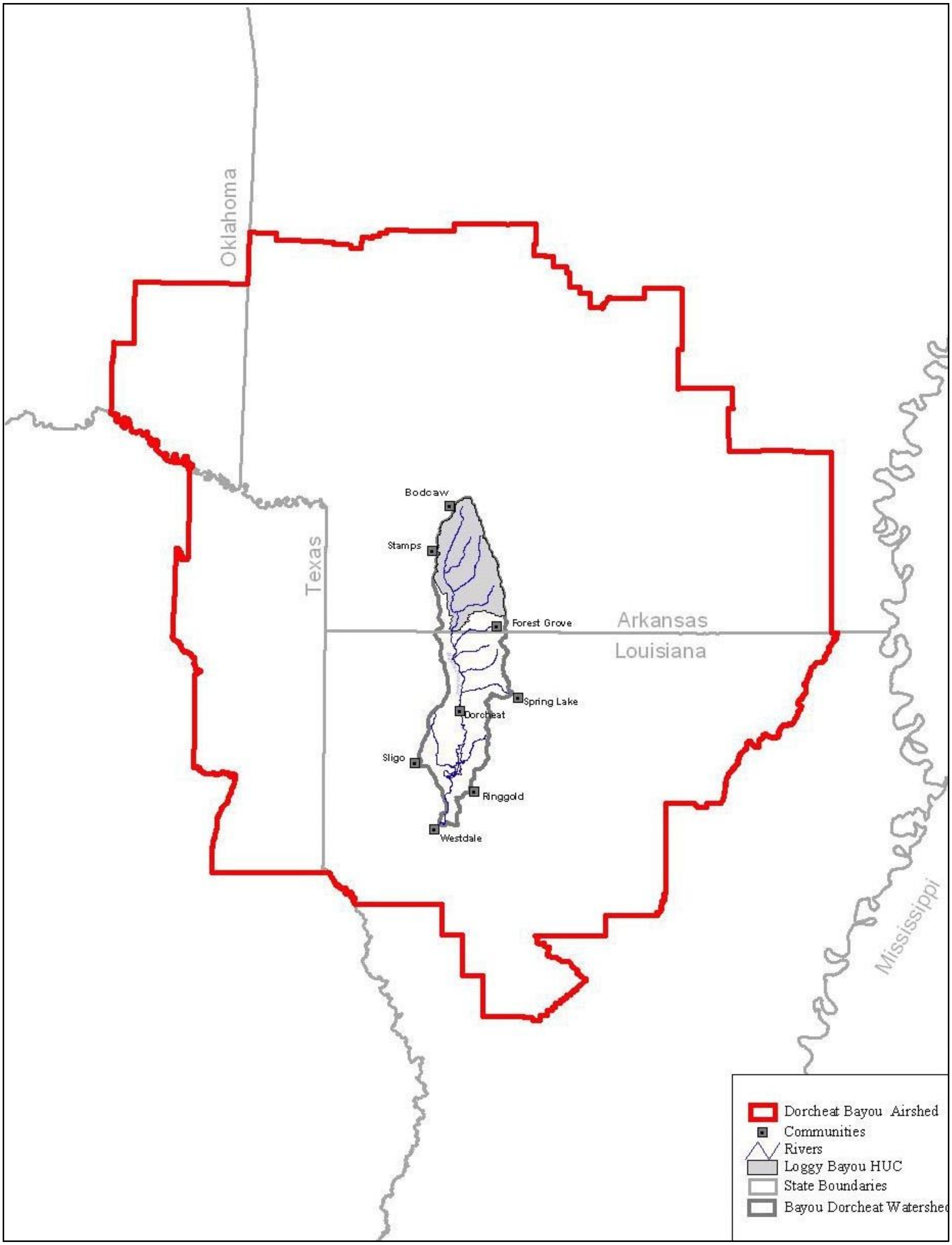

Figure 4.5. Airshed boundary for the Bayou Dorcheat watershed (includes all counties within 100 km of watershed).

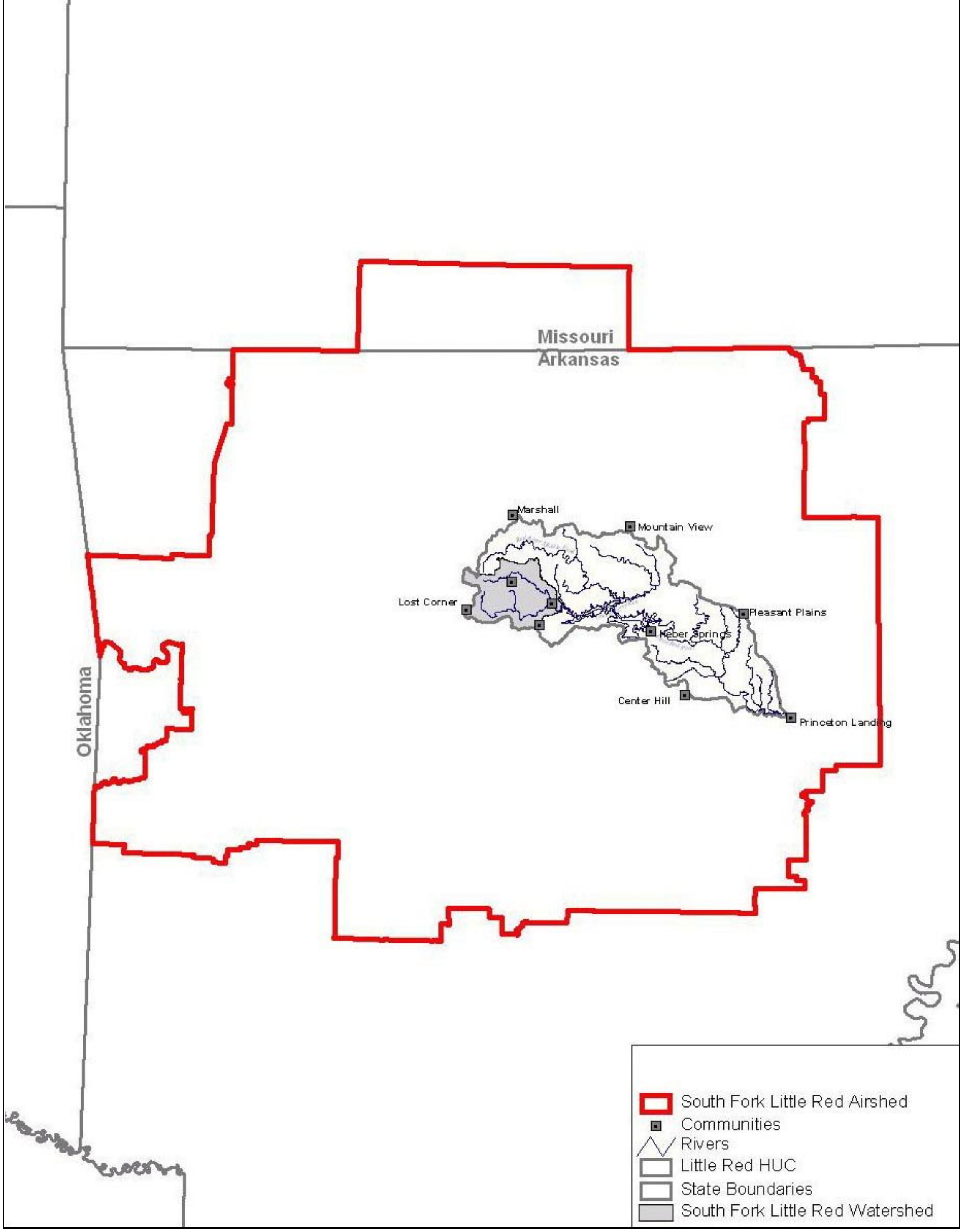

Figure 4.6. Airshed boundary for the South Fork Little Red watershed (includes all counties within 100 km of watershed).

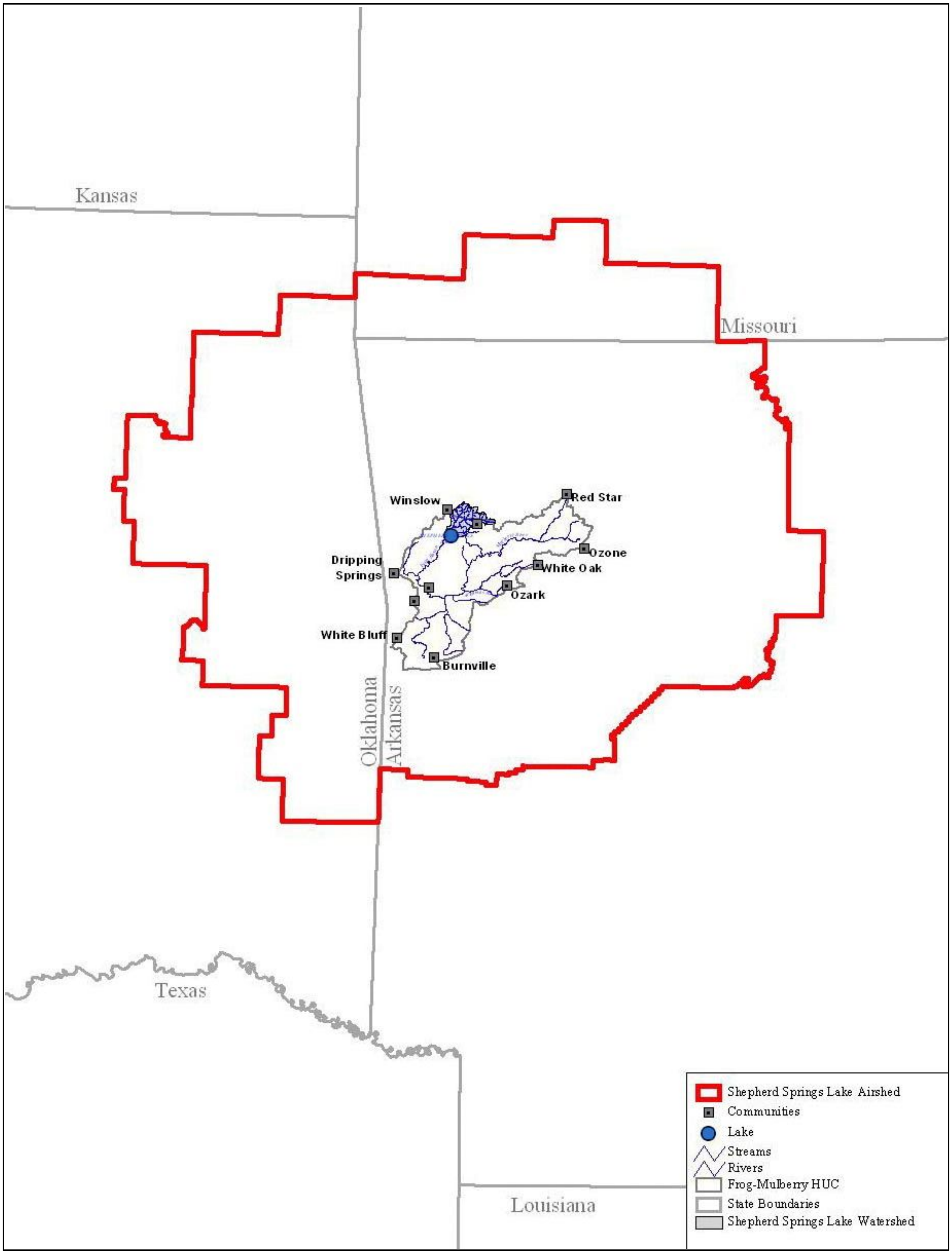

Figure 4.7. Airshed boundary for the Shepherd Springs Lake watershed (includes all counties within 100 km of watershed).

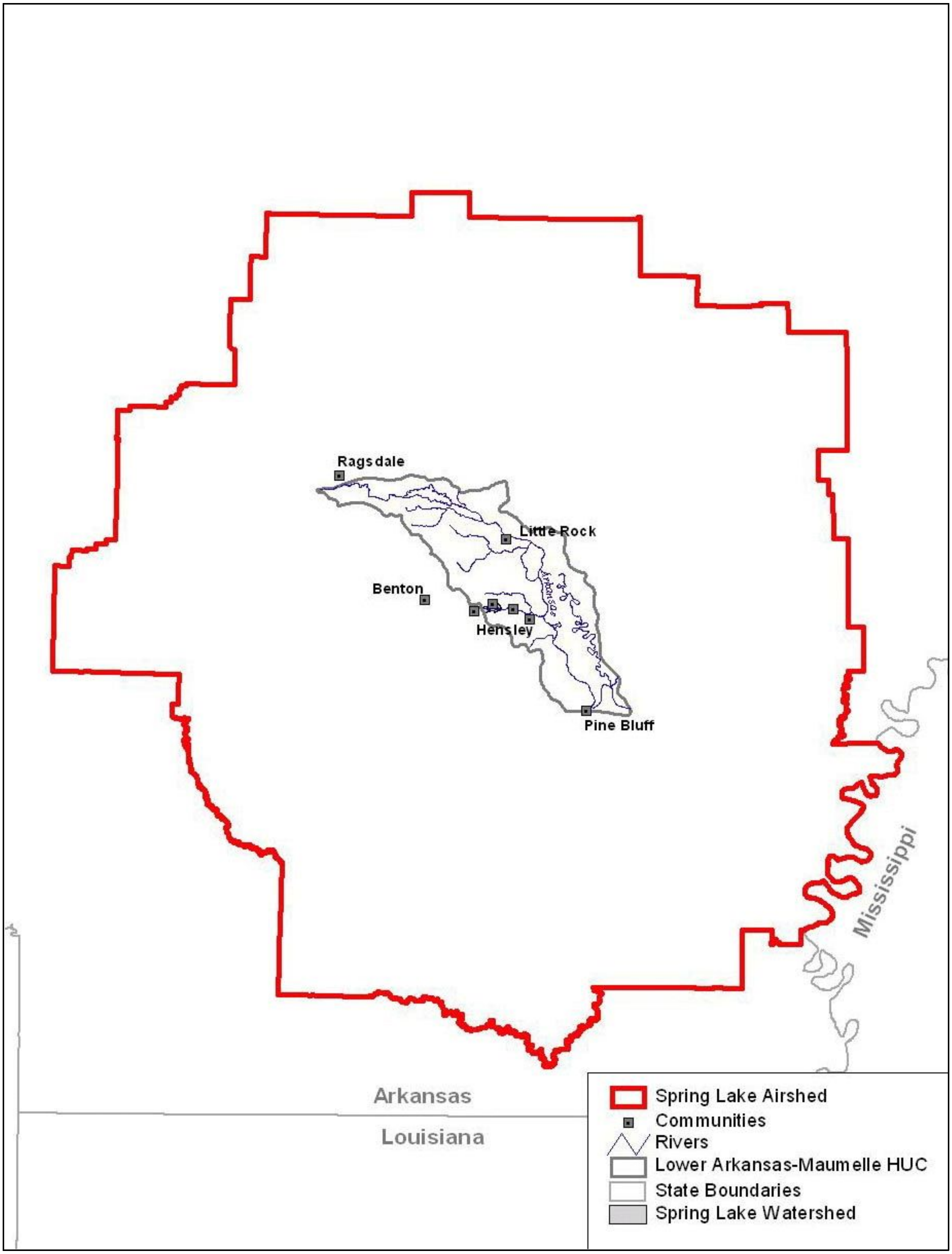

Figure 4.8. Airshed boundary for the Spring Lake watershed (includes all counties within 100 km of watershed).

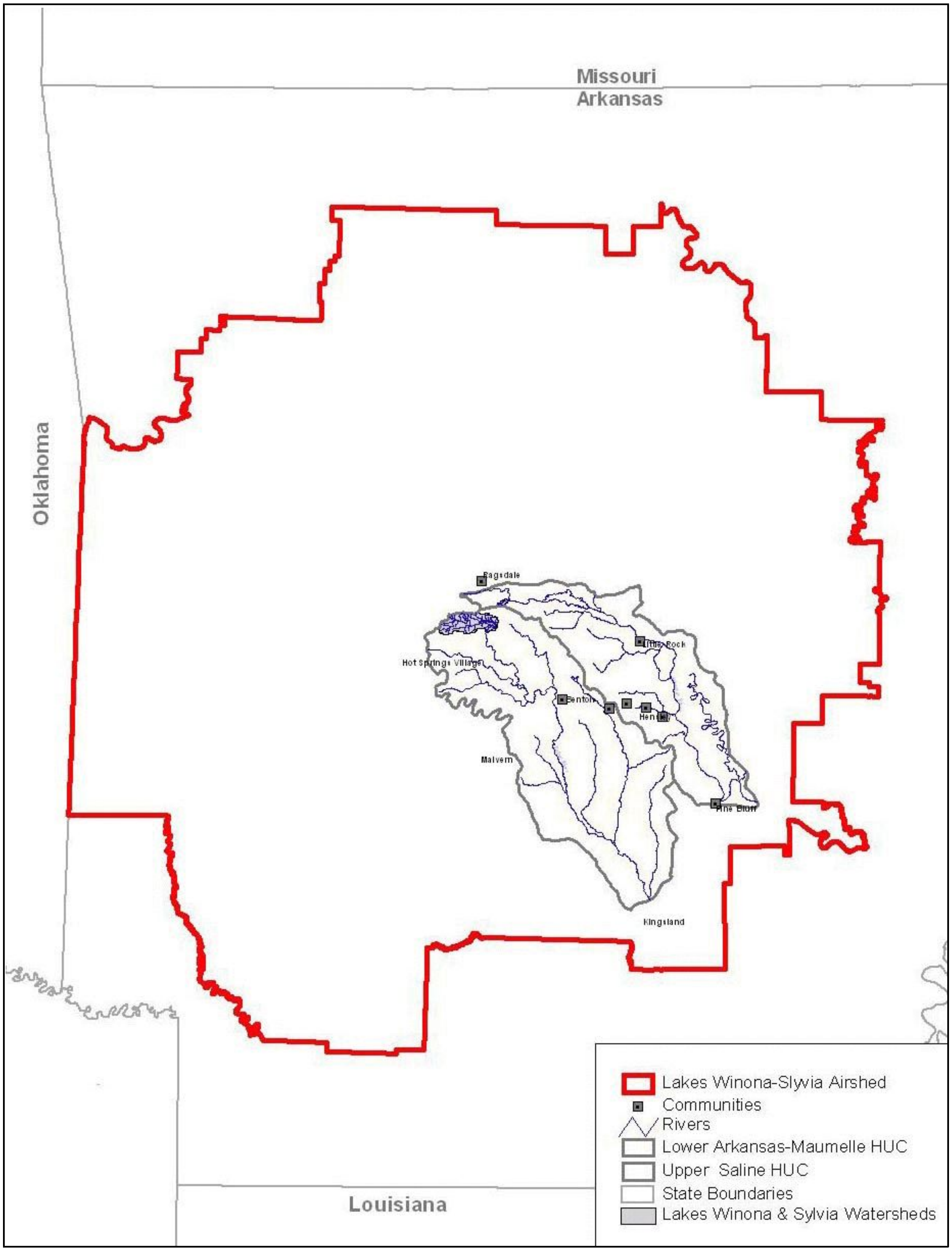
Missouri
Arkansas
Oklahoma
Louisiana
Hot Springs Village
Benton
Malvern
Kingsland
Lakes Winona-Slyvia Airshed
Communities
Rivers
Lower Arkansas-Maumelle HUC
Upper Saline HUC
State Boundaries
Lakes Winona & Sylvia Watersheds

Figure 4.9. Airshed boundary for the Lake Winona and Lake Sylvia watershed (includes all counties within 100 km of watershed).

5.0 MARGIN OF SAFETY, SEASONAL VARIATIONS AND CRITICAL CONDITIONS

5.1 Margin of Safety

A margin of safety (MOS) accounts for any lack of knowledge or uncertainty concerning the relationship between load allocations and water quality. In these TMDLs, it accounts for uncertainty and variability related to fish tissue mercury concentrations, estimates of loading, and the assumption of a linear relationship between fish tissue concentration and watershed load. These TMDLs incorporated MOS in the reduction factors, the wasteload allocations, and the load allocations through conservative assumptions. Use of a safe target level of 0.8 mg/kg results in an explicit MOS of 20%. In addition, implicit MOS are included because only largemouth bass (trophic level 4) fish tissue mercury concentrations were used for estimating reductions rather than weighted trophic level fish tissue mercury concentrations accounting for expected human consumption ratios at each station. An advantage of using a regional approach is that waters which may be threatened by mercury (as opposed to impaired) are also protected. However, a limitation of the approach is that watershed-specific TMDLs might not sufficiently address long-range emissions which contribute to bioaccumulation of mercury. Regulatory mechanisms to address mercury on a national and/or global scale are needed.

5.2 Seasonal Variations and Critical Conditions

Wet deposition is greatest in the winter and spring seasons. Mercury loads fluctuate based on the amount and distribution of rainfall, and variability of localized and global/regional sources. While an average daily load is established here, the average annual load is of greatest significance because mercury bioaccumulates over the life of the fish and the resulting risk to human health from fish consumption is a long-term phenomenon. Thus, daily or weekly inputs are less meaningful than total annual loads over many years. The use of annual loads allows for integration of short-term and seasonal variability. Inputs should continue to be estimated through wet deposition and additional monitoring.

Mercury methylation is expected to be highest during the summer. High temperatures promote biological activity and lakes and reservoirs are stratified with anoxic hypolimnions. Based on the enhanced methylation and higher predator feeding rates during this period, mercury bioaccumulation is expected to be greatest during the summer. However, given the long depuration times for fish and relatively mild winters in Arkansas, seasonal changes in fish tissue mercury body burden are expected to be relatively small. Inherent variability of mercury concentrations between individual fish of the same and/or different size categories is expected to be greater than seasonal variability.

Because of local geology, soils, natural vegetation, and topography, some areas are more susceptible to mercury methylation than others.

6.0 REASONABLE ASSURANCE: ONGOING AND FUTURE REDUCTIONS IN EMISSIONS

Reasonable assurance is needed that water quality standards will be attained. Mechanisms to assess and control mercury loads, including strategies and regulatory controls, which would be national in scope, will aid implementation of TMDLs for specific basins. In addition, these TMDLs will be reassessed periodically and may be modified to take into account available data and information, and the state of the science.

As rules and standards pursuant to the Clean Air Act have been developed, proposed, and promulgated since 1990, compliance by emitting sources as well as actions taken voluntarily have already begun to reduce emissions of mercury to the air across the US. EPA expects a combination of ongoing activities will continue to reduce mercury emissions to the air over the next decade. EPA currently regulates emissions of mercury and other hazardous air pollutants (HAPs) under the maximum achievable control technology (MACT) program of Section 112 of the Clean Air Act, and under a corresponding new source performance standard (NSPS) program under Sections 111 and 129 of the Act. Section 112 authorizes EPA to address categories of major sources of HAPs, including mercury, by issuing emissions standards that, for new sources, are at least as stringent as the emissions control achieved by the best performing similar source in the category, and, for existing sources, are at least as stringent as the average of the best performing top 12% (or 5 facilities whichever is greater) of similar sources. EPA may also apply these standards to smaller area sources, or choose to apply less stringent standards based on generally available control technologies (GACT). Sections 111 and 129 direct EPA to establish MACT-equivalent standards for each category of new and existing solid waste incineration units, regulating several specified air pollutants, including mercury. In addition, in 1996 the US eliminated the use of mercury in most batteries under the Mercury Containing and Rechargeable Battery Management Act. This action is reducing the mercury content of the waste stream which is further reducing mercury emissions from waste combustion. In addition, voluntary measures to reduce use of mercury containing products, such as the voluntary measures committed to by the American Hospital Association, also will contribute to reduced emissions from waste combustion.

Based on the EPA's National Toxics Inventory, the highest emitters of mercury to the air include coal-burning electric utilities, municipal waste combustors, medical waste incinerators, chlor-alkali plants, and hazardous waste combustors. EPA has issued a number regulations under Sections 112, 111, and 129 to reduce mercury pollution from several of these source categories. Relevant regulations that EPA has established to date under the Clean Air Act include, among others, those listed below.

- The source category of municipal waste combustion (MWC) emitted about 20% of total national mercury emissions into the air in 1990. EPA issued final regulations under Sections 111 and 129 for large MWCs on October 31, 1995. Large combustors or incinerators must comply with the rule by December, 2000. These regulations reduce mercury emissions from these facilities by about 90% from 1990 emission levels.

- Medical waste incinerators (MWIs) emitted about 24% of total national mercury emissions into the air in 1990. EPA issued emission standards under Sections 111 and 129 for MWIs on August 15, 1997. When fully implemented, in 2002, EPA's final rule will reduce mercury emissions from MWIs by about 94% from 1990 emission levels.

- Hazardous waste combustors (HWCs) emitted about 2.5% of total national mercury emissions in 1990. In February 1999, EPA issued emission standards under Section 112 for these facilities, which include incinerators, cement kilns, and light weight aggregate kilns that burn hazardous waste. When fully implemented, these standards will reduce mercury emissions from HWCs by more than 50% from 1990 emission levels.

These promulgated regulations when fully implemented and considered together with actions discussed above that will reduce the mercury content of waste are expected to reduce national mercury emissions caused by human activities by about 50% from 1990 levels.

In February 2002 President Bush announced the Clear Skies Initiative. This initiative proposed to reduce mercury emissions from power plants (electric utilities) by 69%. An intermediate cap of 26 tons of mercury per year was proposed for 2010. Current mercury emissions from power plants are 48 tons per year.

EPA expects to propose a regulation under Section 112 that will limit mercury emissions from chlor-alkali plants, chlorine production facilities which use the mercury cell technology. In addition, under the Integrated Urban Air Toxics Strategy, which was published in 1999, EPA is developing emissions standards under Section 112 for categories of smaller sources of air toxics, including mercury, that pose the greatest risk to human health in urban areas. These standards are expected to be issued by 2004.

It is possible that the cumulative effect of additional standards and voluntary actions will reduce mercury emissions from human activities in the US by more than 50% from 1990 levels. However, whether the overall, total percent reduction in national mercury emissions in the future will exceed 50% cannot be estimated at this time. EPA will continue to track emissions of mercury and evaluate additional approaches to reduce releases of mercury into the environment.

Because of the persistence of mercury in tissue, it could take decades for mercury levels in predatory fish to drop as a result of reductions in mercury loading to the watersheds. Changes in factors such as levels of sulfate, TOC, pH, and DO, that affect methylation may cause some sites to react more slowly to reductions in mercury loads. Also, the age of the reservoirs in this TMDL study will affect how they react to reductions in mercury loads. It typically takes 20 to 30 years for organic matter concentrations in new reservoirs to drop below levels that are suitable for supporting methylating bacteria. Therefore, an adaptive management approach is recommended for the watersheds included in this TMDL study. This approach would include public education on the potential effects and sources of mercury, implementation of BMPs, and management of fisheries based on local characteristics. The goal should be to move toward use attainment while protecting human health.

The environmental indicators that will be used to evaluate success will be monitoring of wet deposition rates at the LA10 site and monitoring fish tissue mercury concentrations in the watersheds. Initiation of long term mercury deposition monitoring in Arkansas would improve estimates of existing mercury loadings, and tracking of mercury reductions.

7.0 PUBLIC PARTICIPATION

When EPA establishes a TMDL, 40 CFR §130.7(d)(2) requires EPA to publicly notice and seek comment concerning the TMDL. Pursuant to a May 2000 consent decree, these TMDLs were prepared under contract to EPA. After completion of these draft TMDLs, EPA commenced preparation of a notice seeking comments, information and data from the general and affected public. Comments, data, and information were submitted during the public comment period, and the TMDLs were revised accordingly. Responses to the submitted comments and information are included in Appendix E, along with the submittals. EPA has transmitted these revised TMDLs to ADEQ for incorporation into the ADEQ current water quality management plan.

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APPENDIX A

Calculations of Annual and Monthly Mean Precipitation for Watersheds

1997 - 1999 monthly total precip data in TMDL watersheds (inches)

STATION	Station #	HUC	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
GRAVELLY	2922	11110206	1997	1.73	6.18	4.63	4.63	1.04	6.3	2.54	2.63	2.83	6.73	4.12	5.6	48.96	
GRAVELLY	2922	11110206	1998	6.27	5.33	8.18	3.95	5.65	1.81	5.47	3.37	5.82	5.83	3.53	4.93	60.14	
GRAVELLY	2922	11110206	1999	3.72	1.35	1.24	6.59	6.15	7.44	2.8	1.84	2.03	7.73	2.95	9.1	52.94	
NIMROD DAM	5200	11110206	1997	2.04	6.8	6.84	7.77	1.57	5.29	3.54	2.38	3.98	5.36	4.18	5.1	54.85	
NIMROD DAM	5200	11110206	1998	6.14	5.73	6.78	2.5	4.26	1.87	2.87	3.51	5.66	8.72	2.8	5.03	55.87	
NIMROD DAM	5200	11110206	1999	2.48	1.55	4.79	4.91	5.39	4.36	1.03	2.9	0.89	5.9	0.97	4.41	39.58	
HAMBURG	3088	11110206	1997	5.72	7.1	5.1	5.11	3.86	5.53	2.15	3.14	4.55	4.13	1.52	5.17	53.08	
HAMBURG	3088	11110206	1998	6.2	4.48	---	3.45	0.12	---	2.59	1.38	2.42	0.1	4.63	6.25	31.62	
HAMBURG	3088	11110206	1999	8.24	1.17	---	3.29	---	9.47	0	1.55	0.61	2.41	---	---	26.74	
			AVERAGE	4.73	4.41	5.37	4.69	3.51	5.26	2.55	2.52	3.20	5.21	3.09	5.70	47.09	1.20 m
MAGNOLIA	4548	11140203	1997	5.22	6.62	6.22	16.54	2.39	5.17	0.7	3.81	2.8	5.81	5.17	5.44	65.89	
MAGNOLIA	4548	11140203	1998	7.55	7.45	5.46	2.18	3.59	1.15	2.32	5.2	6.3	3.97	0	0	45.17	
MAGNOLIA	4548	11140203	1999	0	0	---	---	---	---	0.3	0.17	1.24	2.05	1.62	3.28	8.66	
MINDEN	6244	11140203	1997	6.11	8.23	9.88	12.06	7.54	2.51	2.79	2.89	3.96	4	4.95	6.26	71.18	
MINDEN	6244	11140203	1998	9.31	6.12	5.95	2.29	0.86	1.91	2.96	7.43	7.26	5.31	7.14	7.54	64.08	
MINDEN	6244	11140203	1999	16.43	1.66	4.98	8.21	4.05	8.52	3.18	0.35	2.26	1.8	1.09	3.73	56.26	
KORAN	4931	11140203	1997	6.4	8.15	9.71	10.02	4.41	2.72	1.25	5.61	2.39	7.28	4.95	6.26	69.15	
KORAN	4931	11140203	1998	7.88	6.4	6.08	2.47	0.51	0.62	1.86	4.82	6.7	3.88	5.68	7.08	53.98	
KORAN	4931	11140203	1999	15.29	0.98	4.69	8.34	2.36	5.31	2.48	0.63	1.63	1.77	1.15	3.91	48.54	
			AVERAGE	8.24	5.07	6.62	7.76	3.21	3.49	1.98	3.43	3.84	3.99	3.53	4.83	53.66	1.36 m
GREERS FERRY DAM	2978	11010014	1997	2.99	6.43	7.40	9.38	5.18	5.76	2.38	1.81	3.80	7.58	3.89	4.54	61.14	
GREERS FERRY DAM	2978	11010014	1998	4.46	3.99	6.65	3.11	3.23	2.74	3.01	2.77	2.1	4.95	2.1	2.97	42.08	
GREERS FERRY DAM	2978	11010014	1999	4.07	1.36	4.55	4.76	3.27	6.7	1.84	0.56	0.88	4.74	1.69	7.08	41.5	
CHIMES 12 ESE	1419	11010014	1997	2.11	5.7	5.13	8.11	2.05	2.85	2.6	2.01	2.7	6.07	2.99	2.94	45.26	
CHIMES 12 ESE	1419	11010014	1998	7.06	5.9	7.17	3.7	4.5	1.49	1.91	2.48	6.46	13.67	3.85	2.93	61.12	
CHIMES 12 ESE	1419	11010014	1999	4.43	0.88	5.78	5.9	3.78	2.88	4.21	1.49	1.47	2.43	3.04	6.58	42.87	
CLINTON	1492	11010014	1997	2.35	5.68	6.15	8.52	2.53	2.85	4.16	2.93	2.32	5.6	3.54	3.77	50.4	
CLINTON	1492	11010014	1998	6.96	5.01	7.91	3.67	3.56	2.29	3.02	6.21	3.6	11.65	3.19	2.98	60.05	
CLINTON	1492	11010014	1999	6.17	1.11	5.95	5.62	3.5	3.24	2.29	0.64	1.47	2.22	3.04	5.88	41.13	
			AVERAGE	4.51	4.01	6.30	5.86	3.51	3.42	2.82	2.32	2.76	6.55	3.04	4.41	49.51	1.26 m
OZARK 2	5512	11110201	1997	0.61	8.14	5.47	4.32	3.56	6.24	1.32	2.32	1.23	5.67	4.12	4.85	47.85	
OZARK 2	5512	11110201	1998	7.62	4.63	6.19	2.95	4.22	4.9	3.62	0.54	7.18	6.14	2.96	4.17	55.12	
OZARK 2	5512	11110201	1999	4.22	1.36	7.05	7.98	8.88	4.05	3.8	1.37	2.76	3.13	2.23	6.55	53.38	
MOUNTAINBURG 2 NE	5018	11110201	1997	1.27	7.28	4.73	4.31	3.39	6.21	0.95	3.39	2.33	6.92	3.47	5.13	49.38	
MOUNTAINBURG 2 NE	5018	11110201	1998	8.25	3.7	6.63	1.46	2.95	4.96	4.47	2.21	6.61	5.73	4.82	2.69	54.48	
MOUNTAINBURG 2 NE	5018	11110201	1999	3.05	2.18	6.04	7.8	7.64	7.45	4.55	0.25	2.61	2.35	3.56	5.66	53.14	
GREENWOOD	2976	11110201	1997	0.71	9.64	5.07	5.14	1.78	6.36	1.37	3.19	4.37	7.24	4.98	7.09	56.94	
GREENWOOD	2976	11110201	1998	8.81	5.68	5.93	1.64	4.23	5.1	2	1.32	7.18	5.67	3.11	2.3	52.97	
GREENWOOD	2976	11110201	1999	3.75	1.26	5.49	5.93	11.05	5.94	3.77	0	4.4	2.38	2.91	4.37	51.25	
			AVERAGE	4.25	4.87	5.84	4.61	5.30	5.69	2.87	1.62	4.30	5.03	3.57	4.76	52.72	1.34 m
KEO	3862	11110207	1997	3.15	4.75	4.54	12.51	2.65	7.26	1.5	1.93	4.91	4.31	4.15	4.19	55.85	
KEO	3862	11110207	1998	4.51	2.89	4.39	1.14	2.91	1.04	1.59	1.8	3.9	5.45	2.15	4.93	36.7	
KEO	3862	11110207	1999	6.46	1.1	6.89	5.83	4.1	4.51	1.83	0.33	1.43	3.33	2.13	4.31	42.25	
LITTLE ROCK FCWOS AP	4248	11110207	1997	1.88	4.65	6.48	7.73	3.92	5.41	1.88	2.18	3.75	4.35	3.87	3.66	49.76	
LITTLE ROCK FCWOS AP	4248	11110207	1998	4.7	4.11	4.8	3.31	2.86	2.16	2.96	3.23	3.45	3.39	2.3	4.41	41.68	
LITTLE ROCK FCWOS AP	4248	11110207	1999	6.11	1.1	4.85	5.33	3.4	6.1	2.41	0.91	1.56	4.97	0.26	5.25	42.25	
LAKE MAUMELLE	4010	11110207	1997	2.44	3.96	6.4	7.06	3.23	4.53	1.66	2.06	4.58	4.78	3.5	3.72	47.92	
LAKE MAUMELLE	4010	11110207	1998	4.23	6.87	4.16	1.75	3.89	1.87	3.44	5.11	3.91	6.58	1.43	2.7	45.94	
LAKE MAUMELLE	4010	11110207	1999	7.43	0.77	5.22	5.24	3.18	2.26	1.28	1.24	2.16	6.04	3.26	4.23	42.31	
			AVERAGE	4.55	3.36	5.30	5.54	3.35	3.90	2.06	2.09	3.29	4.80	2.56	4.16	44.96	1.14 m

1997 - 1999 monthly total precip data in TMDL watersheds (inches)

STATION	**Station #**	**HUC**	**Year**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**	
CALHOUN RESEARCH STN	1411	8040207	1997	7.92	9.43	6.21	8.69	7.16	2.72	2.86	2.65	1.16	5.89	4.60	6.69	65.98	
CALHOUN RESEARCH STN	1411	8040207	1998	10.57	6.77	6.16	3.63	0.89	1.69	1.50	3.55	7.93	1.00	5.75	7.94	57.38	
CALHOUN RESEARCH STN	1411	8040207	1999	16.68	0.61	6.26	5.04	2.04	5.26	1.72	0.54	2.73	2.74	0.69	3.95	48.26	
COLUMBIA LOCKS	1979	8040207	1997	3.15	9.75	4.68	8.86	8.10	5.25	3.25	2.70	6.15	7.15	4.28	7.98	71.30	
COLUMBIA LOCKS	1979	8040207	1998	11.69	9.94	5.70	3.59	0.61	1.88	2.99	3.61	7.22	1.97	5.98	10.23	65.41	
COLUMBIA LOCKS	1979	8040207	1999	13.02	1.47	7.47	7.07	2.25	12.14	3.08	0.00	4.29	2.63	0.84	4.52	58.78	
MONROE NLU	6314	8040207	1997	9.52	9.37	5.90	7.41	6.07	4.59	3.55	3.53	2.40	5.20	5.10	6.57	69.21	
MONROE NLU	6314	8040207	1998	10.85	6.89	4.96	4.26	0.54	1.14	1.94	3.07	6.96	1.51	5.96	7.66	55.74	
MONROE NLU	6314	8040207	1999	17.26	1.19	6.78	6.65	3.18	10.39	4.94	0.98	2.29	1.88	0.84	4.49	60.87	
STERLINGTON # 2	8788	8040207	1997	9.16	7.31	5.95	7.78	6.25	2.76	2.11	3.54	2.06	6.42	4.10	6.16	63.60	
STERLINGTON # 2	8788	8040207	1998	10.37	6.51	4.81	3.89	0.31	1.59	3.01	5.07	7.19	1.15	5.06	7.95	56.91	
STERLINGTON # 2	8788	8040207	1999	14.09	0.80	7.24	6.06	3.32	8.94	1.82	1.94	4.86	1.38	0.79	3.94	55.18	
			AVERAGE	11.19	5.84	6.01	6.08	3.39	4.86	2.73	2.60	4.60	3.24	3.67	6.51	60.72	1.54 m
OUACHITA RIVER BASIN AVERAGE				6.30	4.65	5.88	5.78	3.85	4.44	2.61	2.39	3.79	4.89	3.24	5.07	52.76	1.31 m

APPENDIX B

NPDES Permitted Facilities

NPDES	SIC CODE	FLOW RATE (MGD)	LATITUDE	LONGITUDE	LOCATION	LOCATION NAME	STATE	RECEIVING WATERS	HUC
HUC 11110206 Fourche La Fave									
AR0020125	4952	0.15	3459500	-9247200	PERRYVILLE	PERRYVILLE CITY OF-STP	AR	FOURCHE LAFAVE RV	11110206
AR0046957	8211	0.01	3501410	-9238320	BIGELOW	ANNE WATSON ELEMENTARY SCHOOL	AR	TRIB MILL CK FOURCHE LAFAVE RV AR R	11110206
ARG640097	4941	0.05	3458150	-9316280	PLAINVIEW	PLAINVIEW, CITY OF-PWTP	AR	NEGRO BR,NIMROD L,FOUCHE LA FAVE, AR	11110206
HUC 11140203 Loggy Bayou									
LA0005452	1321		3230510	-9331480	HAUGHTON	DYNERGY MIDSTREAM SVCS	LA	FOXSKIN B-CLARKE B-LK BISTINEAU	11140203
LA0073458	1321		3246500	-9315360	MINDEN	DUKE ENERGY FIELD	LA	BAYOU DORCHEAT-FLAT LICK BAYOU	11140203
LA0105759	1321		3247050	-9322300	COTTON VALLEY	MARATHON OIL CO.	LA	GRAY CREEK-DAVIS SLOUGH-B DORCHEAT	11140203
AR0047953	2421	0.01	3319520	-9318180	WALDO	DELTIC FARM & TIMBER-WALDO	AR	TRIB BEECH CK LK COLUMBIA	11140203
AR0048054	2421		3323500	-9317150	WALDO	QUAD HARDWOOD PRODUCTS	AR	TRIB BIG CK DORCHEAT CK	11140203
AR0043923	2436	0.0115	3302300	-9310320	EMERSON	WILLAMETTE INDUSTRIES-EMERSON	AR	S CYPRESS CK DORCHEAT BU L BISTINEA	11140203
LA0098515	2436				SPRINGHILL	INTERNATIONAL PAPER CO.	LA	BODCAU BAYOU	11140203
LA0000442	2621		3234370	-9317020	CULLEN	INTERNATIONAL PAPER CO.	LA	BODCAU B-RED CHUTE B-RED RIVER	11140203
AR0038857	2812	0.556	3310320	-9312590	MAGNOLIA	ALBEMARLE CORP-SOUTH PLANT	AR	HORSEHEAD CK DORCHEAT BU	11140203
AR0047635	2819	0.41	3315290	-9318500	MAGNOLIA	ALBEMARLE CORP-WEST PLANT	AR	DISMUKES BR BIG CK BU DORCHEAT	11140203
LA0005312	2911		3247560	-9324400	COTTON VALLEY	CALUMET LUBRICANTS	LA	FRENCH CREEK	11140203
AR0000434	3069	1.1	3316400	-9314450	MAGNOLIA	AMFUEL - PLANT I	AR	TRIB BIG CK DORCHEAT BU RED RV	11140203
AR0047627	3312	0.005	3312300	-9313450	MAGNOLIA	SMI STEEL - ARKANSAS	AR	DIT HURRICANE CK BU DORCHEAT	11140203
LA0003549	3483		3234390	-9323510	DOYLINE	US DEPT OF THE ARMY(& THIOKOL)	LA	CANEY BRANCH C-BOONE CR-L BISTENEAU	11140203
LA0103497	4213		3233490	-9330550	PRINCETON	GENESIS CRUDE OIL LP	LA		11140203
LA0109894	4911		3236140	-9317350	MINDEN	LA ENERGY & POWER AUTHORITY (L	LA	MILE CREEK-BAYOU DORCHEAT	11140203
LA0109886	4911		3236330	-9317250	MINDEN	LA ENERGY & POWER AUTHORITY (L	LA	MILE CREEK-BAYOU DORCHEAT	11140203
LA0097403	4922		3224571	-9326341	HAUGHTON	KOCH GATEWAY PL	LA	LAKE BISTINEAU	11140203
LA0075396	4952	0.13	3232370	-9317180	SIBLEY	TOWN OF SIBLEYF	LA	BRUSHY CREEK- LAKE BISTENAU	11140203
LA0020401	4952	0.15	3248550	-9324420	COTTON VALLEY	TOWN OF COTTON VALLEY	LA	SEG 100501 RED RIVER BASIN	11140203
LA0032301	4952	0.3	3258300	-9325350	CULLEN	CULLEN TOWN OF	LA	BRALEY CREEK-BAYOU DORCHEAT	11140203
LA0041386	4952	0.4	3230570	-9330060	HAUGHTON	TOWN OF HAUGHTON	LA	FOXSKIN B-CLARKE B-LK BISTIENEAU	11140203
AR0039594	4952	0.05	3305020	-9311230	EMERSON	EMERSON CITY OF-MWTP	AR	TRIB LTL CYPRESS CK DORCHEAT BU	11140203
AR0021555	4952	0.2	3321100	-9313150	MCNEIL	MCNEIL CITY OF	AR	O'REAR CK BIG CK	11140203
AR0043508	4952	0.35	3320300	-9317560	WALDO	WALDO CITY OF-WWTP	AR	TRIB BIG CK	11140203
LA0033227	4952	1.5	3259310	-9326320	SPRINGHILL	CITY OF SPRINGHILL	LA	CROOKED CREEK-BAYOU DORCHEAT	11140203
LA0038130	4952	2.44	3234530	-9317370	MINDEN	MINDEN CITY OF	LA	SEG 1005 RED RIVER BASIN	11140203
AR0043613	4952	2.5	3315570	-9316220	MAGNOLIA	MAGNOLIA CITY OF-BIG CREEK	AR	DIT BIG CK DORCHEAT BU RED RV	11140203
LA0108413	4952		3259290	-9308480	HAYNESVILLE	HAYNESVILLE TOWN OF	LA	CYPRESS CREEK	11140203
AR0046973	7997	0.0035	3311220	-9313000	MAGNOLIA	MAGNOLIA COUNTRY CLUB	AR	TRIB HORSEHEAD CK DORCHEAT BU RED R	11140203
HUC 11010014 Little Red									
AR0034509	921	0.0075	3530450	-9159000	HEBER SPRINGS	USDIFWS-GREERS FERRY NATL FISH	AR	LITTLE RED RV	11010014
AR0029181	921	15.12	3530450	-9159000	HEBER SPRINGS	USDIFWS-GREERS FERRY NATL FISH	AR	LITTLE RED RV	11010014
AR0049093	1429	0.2	3516550	-9141000	JUDSONIA	VULCAN MATERIALS CO-JUDSONIA	AR	TRIB ADLER CK LTL RED RV	11010014
AR0042714	3621	0.028	3518370	-9133450	BALD KNOB	ARKANSAS GENERAL INDUSTRIES	AR	DIT GUM CK LTL RED RV WHITE RV	11010014
ARG640002	4941	0.7	3516450	-9143070	SEARCY	SEARCY WATER TREATMENT CENTER	AR	LTL RED RV TRIB	11010014
AR0043460	4952	0.0125	3535060	-9214400	FAIRFIELD BAY	FAIRFIELD BAY-HOOTEN HOLLOW	AR	HOOTEN HOLLOW GREERS FERRY LK	11010014
AR0034657	4952	0.06	3549300	-9233240	LESLIE	LESLIE CITY OF	AR	COVE CK	11010014
AR0034428	4952	0.1	3534540	-9217430	FAIRFIELD BAY	FAIRFIELD BAY-HIDDEN VALLEY	AR	TRIB LYNN CK GREERS FERRY LK	11010014
AR0037303	4952	0.1	3533030	-9218280	FAIRFIELD BAY	FAIRFIELD BAY-HAMILTON HILLS	AR	TRIB LYNN CK GREERS FERRY LK	11010014
AR0034401	4952	0.2	3535490	-9215430	FAIRFIELD BAY	FAIRFIELD BAY-DAVE CREEK WWTP	AR	DAVE CK GREERS FERRY LK	11010014
AR0039233	4952	0.2	3526070	-9150430	PANGBURN	PANGBURN CITY OF-WWTF	AR	LTL RED RV	11010014
AR0022322	4952	0.25	3514080	-9139180	KENSETT	KENSETT CITY OF-WWTP	AR	BLACK CK LTL RED RV	11010014
AR0035807	4952	0.675	3517310	-9132070	BALD KNOB	BALD KNOB CITY OF-WWTF	AR	BIG MINGO CK LTL RED RV	11010014
AR0035742	4952	0.2	3515470	-9138220	JUDSONIA	JUDSONIA CITY OF	AR	LTL RED RV	11010014
AR0048836	4952	1.2	3534250	-9227000	CLINTON	CLINTON CITY OF-EAST WWTP	AR	TRIB S FRK LT RED RV GREERS FERRY L	11010014
AR0048747	4952	1.5	3534530	-9229030	CLINTON	CLINTON CITY OF-WEST WWTP	AR	TRIB S FK LT RED RV GREERS FERRY LK	11010014
AR0022381	4952	1.75	3529230	-9200040	HEBER SPRINGS	HEBER SPRINGS CITY OF-WWTP	AR	LTL RED RV	11010014

NPDES	SIC CODE	FLOW RATE (MGD)	LATITUDE	LONGITUDE	LOCATION	LOCATION NAME	STATE	RECEIVING WATERS	HUC
AR0021601	4952	5	3516040	-9143150	SEARCY	SEARCY CITY OF-WWTF	AR	LTL RED RV	11010014
AR0044920	6552	0.017	3530590	-9210000	HIGDEN	DIAMOND BLUFF ESTATES	AR	GREERS FERRY LK	11010014
AR0024066	6552	0.18	3530430	-9206080	HEBER SPRINGS	EDEN ISLE CORP-WWTP	AR	GREERS FERRY RSVR LTL RED RV	11010014
AR0046078	7041	0.0075	3459590	-9214280	FAIRFIELD BAY	FAIRFIELD BAY-GRAND ISLE	AR	HOOTEN HOLLOW CK GREERS FERRY LK	11010014
AR0044580	7041	0.5	3535490	-9217590	FAIRFIELD BAY	FAIRFIELD BAY-LYNN CREEK WWTP	AR	LYNN CK GREERS FERRY LK	11010014
AR0042919	7542	0.003	3539200	-9219100	SHIRLEY	SHIRLEY CAR WASH & LAUNDRY	AR	DIT LTL RED RV	11010014
AR0043940	8211	0.014	3534480	-9209520	GREERS FERRY	WEST SIDE SCHOOL DISTRICT #4	AR	TRIB GREERS FERRY RSRV	11010014

APPENDIX C

Mercury Emissions for MACT Source Categories in the Airsheds

MACT Category	Total Emissions (lbs/year)	Total Emissions (kg/year)	Reduction Factor	Hg2+ (g/yr)
Fourche La Fave River Airshed				
0102 - Industrial Combustion Coord Rule: Industrial Boilers	7.98E+01	3.62E+01	0.3	10,863
0103 - Industrial Combustion Coord Rule: Institutional/Commercial Boilers	1.07E+01	4.87E+00	0.3	1,461
0105 - Industrial Combustion Coord Rule: Stationary Internal Combustion Engines	3.86E-02	1.75E-02	0.1	2
0410 - Portland Cement Manufacturing	4.60E+02	2.09E+02	0.1	20,865
0801 - Hazardous Waste Incineration	6.69E+01	3.04E+01	0.2	6,070
0802 - Municipal Landfills	4.70E-01	2.13E-01	0	0
1626 - Pulp & Paper Production	1.43E+02	6.48E+01	0.3	19,432
1803 - Utility Boilers: Coal	1.71E+03	7.77E+02	0.3	233,237
1805 - Utility Boilers: Oil	7.04E-01	3.20E-01	0.3	96
1807 - Industrial Combustion Coord Rule: Industrial, Commercial & Other Waste Incineration	1.19E+01	5.39E+00	0.2	1,077
Total	2.49E+03	1.13E+03		293,103
Dorcheat Bayou Airshed				
0102 - Industrial Combustion Coord Rule: Industrial Boilers	7.12E+01	3.23E+01	0.3	9,693
0103 - Industrial Combustion Coord Rule: Institutional/Commercial Boilers	9.21E+00	4.18E+00	0.3	1,254
0105 - Industrial Combustion Coord Rule: Stationary Internal Combustion Engines	4.16E-02	1.89E-02	0.1	2
0410 - Portland Cement Manufacturing	4.61E+02	2.09E+02	0.1	20,890
0502 - Petroleum Refineries - Catalytic Cracking, Catalytic Reforming, & Sulfur Plant Units	2.09E+00	9.48E-01	0.3	284
0801 - Hazardous Waste Incineration	1.40E+02	6.35E+01	0.2	12,701
0802 - Municipal Landfills	5.79E-01	2.62E-01	0	0
1626 - Pulp & Paper Production	4.23E+02	1.92E+02	0.3	57,602
1802 - Municipal Waste Combustors	1.21E+02	5.50E+01	0.45	24,739
1803 - Utility Boilers: Coal	3.63E+03	1.65E+03	0.3	494,506
1805 - Utility Boilers: Oil	3.42E-02	1.55E-02	0.3	5
1807 - Industrial Combustion Coord Rule: Industrial, Commercial & Other Waste Incineration	1.23E+01	5.58E+00	0.2	1,117
Total	4.87E+03	2.21E+03		622,791

MACT Category	Total Emissions (lbs/year)	Total Emissions (kg/year)	Reduction Factor	Hg2+ (g/yr)
Spring Lake Airshed				
0102 - Industrial Combustion Coord Rule: Industrial Boilers	2.53E+01	1.15E+01	0.3	3,444
0103 - Industrial Combustion Coord Rule: Institutional/Commercial Boilers	7.09E+00	3.22E+00	0.3	965
0105 - Industrial Combustion Coord Rule: Stationary Internal Combustion Engines	2.94E-02	1.34E-02	0.1	1
0801 - Hazardous Waste Incineration	6.08E+01	2.76E+01	0.2	5,519
0802 - Municipal Landfills	2.93E-01	1.33E-01	0	0
1626 - Pulp & Paper Production	8.56E+01	3.88E+01	0.3	11,648
1803 - Utility Boilers: Coal	5.65E+02	2.56E+02	0.3	76,884
1805 - Utility Boilers: Oil	4.97E-01	2.25E-01	0.3	68
1807 - Industrial Combustion Coord Rule: Industrial, Commercial & Other Waste Incineration	6.97E+00	3.16E+00	0.2	633
Total	7.52E+02	3.41E+02		99,163
Lake Winona and Lake Sylvia Airshed				
0102 - Industrial Combustion Coord Rule: Industrial Boilers	2.53E+01	1.15E+01	0.3	3,445
0103 - Industrial Combustion Coord Rule: Institutional/Commercial Boilers	8.01E+00	3.63E+00	0.3	1,089
0105 - Industrial Combustion Coord Rule: Stationary Internal Combustion Engines	3.00E-02	1.36E-02	0.1	1
0801 - Hazardous Waste Incineration	6.08E+01	2.76E+01	0.2	5,519
0802 - Municipal Landfills	3.00E-01	1.36E-01	0	0
1626 - Pulp & Paper Production	4.93E+01	2.24E+01	0.3	6,709
1803 - Utility Boilers: Coal	5.65E+02	2.56E+02	0.3	76,884
1805 - Utility Boilers: Oil	4.93E-01	2.24E-01	0.3	67
1807 - Industrial Combustion Coord Rule: Industrial, Commercial & Other Waste Incineration	7.85E+00	3.56E+00	0.2	712
Total	7.17E+02	3.25E+02		94,426

MACT Category	Total Emissions (lbs/year)	Total Emissions (kg/year)	Reduction Factor	Hg2+ (g/yr)
South Fork Little Red River Airshed				
0102 - Industrial Combustion Coord Rule: Industrial Boilers	9.58E+00	4.34E+00	0.3	1,303
0103 - Industrial Combustion Coord Rule: Institutional/Commercial Boilers	7.53E+00	3.42E+00	0.3	1,025
0105 - Industrial Combustion Coord Rule: Stationary Internal Combustion Engines	3.03E-02	1.37E-02	0.1	1
0801 - Hazardous Waste Incineration	6.91E+00	3.14E+00	0.2	627
0802 - Municipal Landfills	2.40E-01	1.09E-01	0	0
1626 - Pulp & Paper Production	1.37E+01	6.21E+00	0.3	1,864
1803 - Utility Boilers: Coal	5.18E+02	2.35E+02	0.3	70,488
1807 - Industrial Combustion Coord Rule: Industrial, Commercial & Other Waste Incineration	7.57E+00	3.43E+00	0.2	686
Total	5.64E+02	2.56E+02		75,995
Shepherd Springs Lake Airshed				
0102 - Industrial Combustion Coord Rule: Industrial Boilers	4.41E+01	2.00E+01	0.3	5,998
0103 - Industrial Combustion Coord Rule: Institutional/Commercial Boilers	5.12E+00	2.32E+00	0.3	697
0105 - Industrial Combustion Coord Rule: Stationary Internal Combustion Engines	1.08E-02	4.90E-03	0.1	0
0802 - Municipal Landfills	2.65E-01	1.20E-01	0	0
1626 - Pulp & Paper Production	1.37E+01	6.21E+00	0.3	1,864
1803 - Utility Boilers: Coal	1.01E+03	4.57E+02	0.3	137,166
1805 - Utility Boilers: Oil	1.55E-01	7.03E-02	0.3	21
1807 - Industrial Combustion Coord Rule: Industrial, Commercial & Other Waste Incineration	6.95E+00	3.15E+00	0.2	630
Total	1.08E+03	4.89E+02		146,378

APPENDIX D

Fish Tissue Mercury Concentration for Largemouth Bass and Other Species of Concern

DEQ Log No.	Lake or Stream	Common Name	Species	Mercury (mg/Kg)	No. in sample	Minimum Length (mm)	Maximum Length (mm)	Mean Length (mm)	Minimum Weight (g)	Maximum Weight (g)	Mean Weight (g)	Date Collected	Latitude	Longitude
FOURCHE LA FAVE RIVER, NIMROD LAKE, COVE CREEK LAKE, AND DRY FORK LAKE														
69586	COVE CREEK LAKE	Largemouth bass	Micropterus salmoides	1.43	3	322	365	343				950719	34.90000	-93.07917
68087	COVE CREEK LAKE	Largemouth bass	Micropterus salmoides	2.43	3	308	344	330	357	575	490	950419	34.90000	-93.07917
62909	COVE CREEK WATERSHED LAKE PERRY CO.	Largemouth bass	Micropterus salmoides	1.25	1			470			1560	940420	34.90000	-93.07917
62908	COVE CREEK WATERSHED LAKE PERRY CO.	Largemouth bass	Micropterus salmoides	1.00	1			350			558	940420	34.90000	-93.07917
68095	DRY FORK LAKE	Largemouth bass	Micropterus salmoides	1.51	1			478			1600	950421	34.85139	-93.19139
69588	DRY FORK LAKE	Largemouth bass	Micropterus salmoides	2.58	1			554				950720	34.85139	-93.19139
69587	DRY FORK LAKE	Largemouth bass	Micropterus salmoides	0.90	5	304	354	337				950720	34.85139	-93.19139
68094	DRY FORK LAKE	Largemouth bass	Micropterus salmoides	0.86	2	323	344	334	400	505	453	950421	34.85139	-93.19139
62652	DRY FORK LAKE (USFS)	Largemouth bass	Micropterus salmoides	0.64	3	302	374	326	290	652	421	940411	34.86917	-93.19139
62654	DRY FORK LAKE (USFS) - PERRY CO.	Largemouth bass	Micropterus salmoides	1.27	1			495			1750	940411	34.86917	-93.19139
62653	DRY FORK LAKE (USFS) - PERRY CO.	White crappie	Pomoxis annularis	0.63	4	213	342	263	110	590	259	940411	34.86917	-93.19139
60352	FOURCHE LA FAVE	Largemouth bass	Micropterus salmoides	0.54	3	308	364	329	300	600	427	930919	34.94556	-93.12167
60354	FOURCHE LA FAVE	Largemouth bass	Micropterus salmoides	1.24	2	403	470	437	975	1300	1138	930919	34.94556	-93.12167
60353	FOURCHE LA FAVE RIVER	Hybrid striped bass	Morone	0.39	1			610			2850	930919	34.94556	-93.12167
55445	NIMROD LAKE	Largemouth bass	Micropterus salmoides	1.26	3	305	387	358	454	907	696	910805	34.95306	-93.16167
60437	NIMROD LAKE	Largemouth bass	Micropterus salmoides	1.23	2	493	531	512	1470	2500	1985	931011	34.95306	-93.16167
60436	NIMROD LAKE	Largemouth bass	Micropterus salmoides	0.47	6	293	395	338	260	655	521	931011	34.95306	-93.16167
	NIMROD LAKE	Channel catfish		0.65	2	540	546					910805	34.95306	-93.16167
57422	NIMROD LAKE - SUNLIGHT BAY	Largemouth bass	Micropterus salmoides	0.60	5	290	463	339	300	1500	640	930216	34.95306	-93.16167
57417	NIMROD LAKE-SUNLIGHT BAY	Largemouth bass	Micropterus salmoides	0.37	1			312			450	930216	34.95306	-93.16167
57418	NIMROD LAKE-SUNLIGHT BAY	Largemouth bass	Micropterus salmoides	0.71	1			320			500	930216	34.95306	-93.16167
57419	NIMROD LAKE-SUNLIGHT BAY	Largemouth bass	Micropterus salmoides	0.44	1			310			450	930216	34.95306	-93.16167
57420	NIMROD LAKE-SUNLIGHT BAY	Largemouth bass	Micropterus salmoides	0.38	1			290			300	930216	34.95306	-93.16167
57421	NIMROD LAKE-SUNLIGHT BAY	Largemouth bass	Micropterus salmoides	0.95	1			463			1500	930216	34.95306	-93.16167
57416	NIMROD LAKE-SUNLIGHT BAY ACCESS	White crappie	Pomoxis annularis	0.25	5	233	260	246	150	250	210	930216	34.95306	-93.16167
DORCHEAT BAYOU AND LAKE COLUMBIA														
59992	DORCHEAT BAYOU	Largemouth bass	Micropterus salmoides	2.06	5	419	477	452	1120	1700	1420	930827	33.10000	-93.38611
71203	LAKE COLUMBIA	Blue catfish	Ictalurus furcatus	0.10	5	551	656	601	1600	3630	2578	951024	33.29167	-93.39417
72023	LAKE COLUMBIA	Bluegill	Lepomis macrochirus	0.24	3	155	174	164	80	115	98	960117	33.29167	-93.39417
72024	LAKE COLUMBIA	Bluegill	Lepomis macrochirus	0.38	3	190	200	195	150	240	163	960117	33.29167	-93.39417
72025	LAKE COLUMBIA	Bluegill	Lepomis macrochirus	0.35	3	211	215	614	210	290	237	960117	33.29167	-93.39417
72026	LAKE COLUMBIA	Bluegill	Lepomis macrochirus	0.36	3	222	223	223	270	320	292	960117	33.29167	-93.39417
71195	LAKE COLUMBIA	Channel catfish	Ictalurus punctatus	0.03	4	408	435	423	700	880	820	951024	33.29167	-93.39417
71198	LAKE COLUMBIA	Channel catfish	Ictalurus punctatus	0.19	4	504	520	510	1300	1740	1544	951024	33.29167	-93.39417
71200	LAKE COLUMBIA	Channel catfish	Ictalurus punctatus	0.14	5	560	594	572	1810	2370	2104	951024	33.29167	-93.39417
71196	LAKE COLUMBIA	Channel catfish	Ictalurus punctatus	0.03	3	430	433	432	760	795	772	951024	33.29167	-93.39417
71197	LAKE COLUMBIA	Channel catfish	Ictalurus punctatus	0.11	4	463	473	470	920	1170	1028	951024	33.29167	-93.39417
71199	LAKE COLUMBIA	Channel catfish	Ictalurus punctatus	0.11	3	533	540	536	1570	1750	1650	951024	33.29167	-93.39417
71201	LAKE COLUMBIA	Channel catfish	Ictalurus punctatus	0.27	4	612	630	619	2280	3180	2625	951024	33.29167	-93.39417
56641	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	1.36	3	412	554	489	1060	3300	2083	921007	33.29167	-93.39417
58272	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.37	3	281	293	285	270	280	273	930421	33.29167	-93.39417
58273	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.46	3	277	298	286	220	310	270	930421	33.29167	-93.39417
58274	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.33	3	278	288	284	225	275	252	930421	33.29167	-93.39417
58275	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.63	3	314	324	319	340	400	368	930421	33.29167	-93.39417
58276	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.54	3	302	320	311	335	370	348	930421	33.29167	-93.39417
58277	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.50	3	301	321	313	325	420	368	930421	33.29167	-93.39417
58278	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.48	3	333	348	343	420	515	472	930421	33.29167	-93.39417
58279	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.64	3	341	343	342	470	550	500	930421	33.29167	-93.39417
58280	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.46	3	335	340	337	440	450	447	930421	33.29167	-93.39417
58281	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.70	3	355	366	360	535	670	618	930421	33.29167	-93.39417
58282	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.73	3	352	371	359	550	670	597	930421	33.29167	-93.39417

DEQ Log No.	Lake or Stream	Common Name	Species	Mercury (mg/Kg)	No. in sample	Minimum Length (mm)	Maximum Length (mm)	Mean Length (mm)	Minimum Weight (g)	Maximum Weight (g)	Mean Weight (g)	Date Collected	Latitude	Longitude
65264	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.51	1			360			705	940913	35.69167	-94.11111
65265	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.54	1			364			590	940913	35.69167	-94.11111
65266	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.48	1			363			600	940913	35.69167	-94.11111
65267	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.50	1			360			515	940913	35.69167	-94.11111
65268	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.55	1			364			655	940913	35.69167	-94.11111
65269	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.79	1			372			665	940913	35.69167	-94.11111
65270	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	1.10	1			375			790	940913	35.69167	-94.11111
65271	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.95	1			365			630	940913	35.69167	-94.11111
65272	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.62	1			373			745	940913	35.69167	-94.11111
65273	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.90	1			404			1000	940913	35.69167	-94.11111
65274	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.27	1			402			900	940913	35.69167	-94.11111
65275	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.64	1			397			875	940913	35.69167	-94.11111
65276	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	1.10	1			485			810	940913	35.69167	-94.11111
65277	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.62	1			385			760	940913	35.69167	-94.11111
65278	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.79	1			398			800	940913	35.69167	-94.11111
65280	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.59	1			400			905	940913	35.69167	-94.11111
65281	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.63	1			417			1000	940913	35.69167	-94.11111
65282	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.65	1			414			1000	940913	35.69167	-94.11111
65283	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.96	1			450			1150	940913	35.69167	-94.11111
65284	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.75	1			463			1500	940913	35.69167	-94.11111
65285	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	1.79	1			475			1450	940913	35.69167	-94.11111
65286	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	1.60	1			487			1300	940913	35.69167	-94.11111
65287	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	1.68	1			532			2150	940913	35.69167	-94.11111
65288	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	1.15	1			516			1850	940913	35.69167	-94.11111
65289	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	2.04	1			530			2200	940913	35.69167	-94.11111
65290	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	2.69	1			540			2300	940913	35.69167	-94.11111
63470	SHEPHERD SPRINGS LAKE	Spotted bass	Micropterus punctulatus	0.23	1			300			318	940609	35.69167	-94.11111
63471	SHEPHERD SPRINGS LAKE	Spotted bass	Micropterus punctulatus	0.17	1			305			408	940609	35.69167	-94.11111
63472	SHEPHERD SPRINGS LAKE	Spotted bass	Micropterus punctulatus	0.27	1			305			363	940609	35.69167	-94.11111
63473	SHEPHERD SPRINGS LAKE	Spotted bass	Micropterus punctulatus	0.44	1			330			499	940609	35.69167	-94.11111
65279	SHEPHERD SPRINGS LAKE	Spotted bass	Micropterus punctulatus	0.87	1			398			900	940913	35.69167	-94.11111
63459	SHEPHERD SPRINGS LAKE	White crappie	Pomoxis annularis	0.58	2	235	260	248				940609	35.69167	-94.11111
63474	SHEPHERD SPRINGS LAKE	Channel catfish	Ictalurus punctatus	2.57	1			1000			13610	940609	35.69167	-94.11111
63087	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.45	4	345	370	356	454	680	584	940517	35.69167	-94.11111
63088	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	1.12	3	440	470	452	1020	1315	1194	940517	35.69167	-94.11111
SPRING LAKE														
54875	SPRING LAKE	Largemouth bass	Micropterus salmoides	1.05	3	356	425	394	680	1021	813	920723	35.15000	-93.42556
LAKE WINONA AND LAKE SYLVIA														
68092	LAKE SYLVIA	Largemouth bass	Micropterus salmoides	0.70	3	317	324	320	393	410	401	950420	34.86806	-92.81583
68093	LAKE SYLVIA	Largemouth bass	Micropterus salmoides	1.08	1			510			2125	950420	34.86806	-92.81583
69585	LAKE SYLVIA	Largemouth bass	Micropterus salmoides	0.82	4	295	385	346	300	755	560	950710	35.86806	-92.81583
54264	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.86	5	318	349	327	454	567	500	920604	34.79861	-92.84750
60786	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.54	5	318	393	369	408	771	658	931105	34.79861	-92.84750
60787	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.96	3	428	485	455	964	1474	1176	931105	34.79861	-92.84750
65294	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.70	1			415			925	940920	34.79861	-92.84750
65295	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.61	1			379			630	940920	34.79861	-92.84750
65296	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.63	1			387			650	940920	34.79861	-92.84750
65297	LAKE WINONA	Largemouth bass	Micropterus salmoides	1.03	1			457			1125	940920	34.79861	-92.84750
65298	LAKE WINONA	Largemouth bass	Micropterus salmoides	1.37	1			471			1200	940920	34.79861	-92.84750
62100	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.35	1			280			230	940316	34.79861	-92.84750
62101	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.32	1			292			302	940316	34.79861	-92.84750

DEQ Log No.	Lake or Stream	Common Name	Species	Mercury (mg/Kg)	No. in sample	Minimum Length (mm)	Maximum Length (mm)	Mean Length (mm)	Minimum Weight (g)	Maximum Weight (g)	Mean Weight (g)	Date Collected	Latitude	Longitude
62102	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.41	1			303			345	940316	34.79861	-92.84750
62103	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.40	1			309			369	940315	34.79861	-92.84750
62104	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.29	1			311			370	940315	34.79861	-92.84750
62105	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.76	1			313			366	940316	34.79861	-92.84750
62106	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.50	1			325			435	940315	34.79861	-92.84750
62107	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.35	1			330			434	940316	34.79861	-92.84750
62108	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.27	1			335			462	940316	34.79861	-92.84750
62109	LAKE WINONA	Largemouth bass	Micropterus salmoides	1.05	1			340			443	940315	34.79861	-92.84750
62113	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.61	1			340			530	940316	34.79861	-92.84750
62114	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.49	1			340			512	940316	34.79861	-92.84750
62115	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.47	1			340			419	940316	34.79861	-92.84750
62116	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.46	1			350			568	940316	34.79861	-92.84750
62117	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.59	1			357			546	940316	34.79861	-92.84750
62118	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.43	1			360			700	940316	34.79861	-92.84750
62119	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.63	1			360			673	940316	34.79861	-92.84750
62120	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.70	1			362			551	940316	34.79861	-92.84750
62121	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.60	1			364			571	940316	34.79861	-92.84750
62122	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.97	1			365			535	940316	34.79861	-92.84750
62126	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.55	1			366			599	940316	34.79861	-92.84750
62127	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.85	1			366			610	940315	34.79861	-92.84750
62128	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.76	1			369			589	940316	34.79861	-92.84750
62129	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.76	1			369			600	940316	34.79861	-92.84750
62130	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.80	1			370			670	940316	34.79861	-92.84750
62131	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.70	1			370			670	940316	34.79861	-92.84750
62132	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.67	1			374			661	940316	34.79861	-92.84750
62133	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.84	1			375			687	940316	34.79861	-92.84750
62134	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.74	1			380			756	940316	34.79861	-92.84750
62135	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.96	1			381			861	940316	34.79861	-92.84750
62139	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.48	1			381			702	940316	34.79861	-92.84750
62140	LAKE WINONA	Largemouth bass	Micropterus salmoides	1.40	1			385			667	940316	34.79861	-92.84750
62141	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.58	1			400			831	940316	34.79861	-92.84750
62142	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.65	1			404			1083	940315	34.79861	-92.84750
62143	LAKE WINONA	Largemouth bass	Micropterus salmoides	1.31	1			420			1006	940316	34.79861	-92.84750
62144	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.90	1			421			958	940316	34.79861	-92.84750
62145	LAKE WINONA	Largemouth bass	Micropterus salmoides	1.04	1			431			1026	940316	34.79861	-92.84750
62146	LAKE WINONA	Largemouth bass	Micropterus salmoides	0.93	1			460			1173	940316	34.79861	-92.84750
62147	LAKE WINONA	Largemouth bass	Micropterus salmoides	1.33	1			462			1583	940315	34.79861	-92.84750
62148	LAKE WINONA	Largemouth bass	Micropterus salmoides	1.48	1			495			2165	940315	34.79861	-92.84750
62152	LAKE WINONA	Largemouth bass	Micropterus salmoides	1.30	1			508			1766	940316	34.79861	-92.84750
62153	LAKE WINONA	Spotted bass	Micropterus punctulatus	0.63	1			274			310	940315	34.79861	-92.84750
62154	LAKE WINONA	Spotted bass	Micropterus punctulatus	0.88	1			292			335	940315	34.79861	-92.84750
62155	LAKE WINONA	Spotted bass	Micropterus punctulatus	0.99	1			306			403	940315	34.79861	-92.84750
62156	LAKE WINONA	Spotted bass	Micropterus punctulatus	0.82	1			345			654	940315	34.79861	-92.84750
62157	LAKE WINONA	Spotted bass	Micropterus punctulatus	1.03	1			354			654	940315	34.79861	-92.84750
62158	LAKE WINONA	Spotted bass	Micropterus punctulatus	0.74	1			360			729	940316	34.79861	-92.84750
62159	LAKE WINONA	Spotted bass	Micropterus punctulatus	1.11	1			397			1134	940315	34.79861	-92.84750
62160	LAKE WINONA	Spotted bass	Micropterus punctulatus	0.90	1			401			1078	940315	34.79861	-92.84750

DEQ Log No.	Lake or Stream	Common Name	Species	Mercury (mg/Kg)	No. in sample	Minimum Length (mm)	Maximum Length (mm)	Mean Length (mm)	Minimum Weight (g)	Maximum Weight (g)	Mean Weight (g)	Date Collected	Latitude	Longitude
58283	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.59	3	364	368	366	600	700	655	930421	33.29167	-93.39417
58284	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.80	3	380	393	388	700	810	750	930421	33.29167	-93.39417
58285	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	1.01	3	391	398	395	745	840	793	930421	33.29167	-93.39417
58286	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.71	3	392	399	395	735	900	815	930421	33.29167	-93.39417
58287	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.95	3	415	443	426	845	1060	952	930421	33.29167	-93.39417
58288	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	1.02	3	405	415	409	850	1010	923	930421	33.29167	-93.39417
58289	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.75	3	407	423	417	820	1120	977	930421	33.29167	-93.39417
58290	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	1.27	3	430	448	442	1140	1390	1283	930421	33.29167	-93.39417
58291	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.86	3	428	434	431	1090	1180	1137	930421	33.29167	-93.39417
58292	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	1.06	3	430	445	436	1020	1150	1103	930421	33.29167	-93.39417
58293	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	0.93	3	453	463	459	1220	1430	1333	930421	33.29167	-93.39417
58294	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	1.08	3	461	470	467	1590	1700	1653	930421	33.29167	-93.39417
58295	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	1.09	3	461	466	463	1300	1360	1323	930421	33.29167	-93.39417
58296	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	1.14	3	485	495	491	1350	1940	1613	930421	33.29167	-93.39417
58297	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	1.14	3	478	482	480	1550	1810	1700	930421	33.29167	-93.39417
58298	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	1.61	3	483	495	490	1520	1750	1650	930421	33.29167	-93.39417
58299	LAKE COLUMBIA	Largemouth bass	Micropterus salmoides	1.46	3	502	508	505	1770	2000	1870	930421	33.29167	-93.39417
65750	LAKE COLUMBIA COMPOSITE 1 OF 2 176 - 200 MM	White crappie	Pomoxis annularis	0.12		176	200					941004	33.29167	-93.39417
65751	LAKE COLUMBIA COMPOSITE 2 OF 2 176 - 200 MM	White crappie	Pomoxis annularis	0.15		176	200					941004	33.29167	-93.39417
65752	LAKE COLUMBIA COMPOSITE 1 OF 3 201 - 225 MM	White crappie	Pomoxis annularis	0.18		201	225					941004	33.29167	-93.39417
65753	LAKE COLUMBIA COMPOSITE 2 OF 3 201 - 225 MM	White crappie	Pomoxis annularis	0.16		201	225					941004	33.29167	-93.39417
65754	LAKE COLUMBIA COMPOSITE 3 OF 3 201 - 225 MM	White crappie	Pomoxis annularis	0.16		201	225					941004	33.29167	-93.39417
65755	LAKE COLUMBIA COMPOSITE 1 OF 3 226 - 250 MM	White crappie	Pomoxis annularis	0.16		226	250					941004	33.29167	-93.39417
65756	LAKE COLUMBIA COMPOSITE 2 OF 3 226 - 250 MM	White crappie	Pomoxis annularis	0.15		226	250					941004	33.29167	-93.39417
65757	LAKE COLUMBIA COMPOSITE 3 OF 3 226 - 250 MM	White crappie	Pomoxis annularis	0.16		226	250					941004	33.29167	-93.39417
SOUTH FORK LITTLE RED RIVER AND JOHNSON HOLE														
59851	SOUTH FORK LITTLE RED RIVER (JOHNSON HOLE)	Largemouth bass	Micropterus salmoides	0.99	2	449	452	451	1080	1160	1120	930817	35.58917	-92.42194
59852	SOUTH FORK LITTLE RED RIVER (JOHNSON HOLE)	Largemouth bass	Micropterus salmoides	2.12	6	300	390	321	325	625	394	930823	35.58917	-92.42194
	SOUTH FORK LITTLE RED RIVER (JOHNSON HOLE)	Walleye		0.82	2				1270	1450		930325	35.58917	-92.42194
60358	SOUTH FORK LITTLE RED RIVER-LEWIS ACRES	Largemouth bass	Micropterus salmoides	0.90	1			455			1400	930928	35.57611	-92.39417
60357	SOUTH FORK LITTLE RED RIVER-LEWIS ACRES	Largemouth bass	Micropterus salmoides	0.41	5	312	335	322	365	470	431	930928	35.57611	-92.39417
60351	SOUTH FORK LITTLE RED RIVER-OLD WATERWORKS	Channel catfish	Ictalurus punctatus	0.79	2	505	591	548	950	1860	1405	931003	35.58333	-92.47528
60356	SOUTH FORK LITTLE RED RIVER-OLD WATERWORKS	Black bass	Micropterus spp.	0.52	5	306	345	329	355	470	425	931003	35.58333	-92.47528
SHEPHERD SPRINGS LAKE														
63475	SHEPHERD SPRINGS LAKE	Flathead catfish	Pylodictis olivaris	1.21	1			775			5310	940609	35.69167	-94.11111
63460	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	1.07	1			540			2720	940609	35.69167	-94.11111
63461	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	2.18	1			565			2810	940609	35.69167	-94.11111
63462	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.64	1			335			590	940609	35.69167	-94.11111
63463	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.43	1			335			499	940609	35.69167	-94.11111
63464	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.37	1			340			499	940609	35.69167	-94.11111
63465	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.31	1			315			408	940609	35.69167	-94.11111
63466	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.47	1			357			590	940609	35.69167	-94.11111
63467	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.45	1			330			544	940609	35.69167	-94.11111
63468	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.41	1			310			363	940609	35.69167	-94.11111
63469	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.21	1			310			363	940609	35.69167	-94.11111
65258	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.60	1			343			518	940803	35.69167	-94.11111
65259	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.70	1			318			448	940803	35.69167	-94.11111
65260	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.60	1			363			672	940803	35.69167	-94.11111
65261	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.27	1			318			364	940803	35.69167	-94.11111
65262	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.57	1			336			648	940803	35.69167	-94.11111
65263	SHEPHERD SPRINGS LAKE	Largemouth bass	Micropterus salmoides	0.60	1			358			782	940803	35.69167	-94.11111

APPENDIX E

Public Comments to Mercury TMDLs and Responses

11/18/02 9:03 pm

To Ellen Caldwell

I have clipped and underlined some text from the following report: http://www.adeq.state.ar.us/water/tmdls/epa_tmdls_mercury_021018.pdf to illustrate the idea that "forestlands" should not be considered as lands that are greatly protected from erosion due to their vegetative cover. Soil erosion from forestlands is much more significant than recognized in this report. The Ozark-Ouachita Highlands Assessment Report is not a worthy source for the establishment of erosion rates. As everyone has seen, forestlands becomes bare lands in the hands of industry. The Forest Service also regularly deforests forestlands. The use of prescribed burning on Forest Service lands greatly diminshes the water-holding capacity of the leaf litter, plants, and soils. Over 100,000 acres have been burned on the Ouachita NF for several years - much of it is focused in the Fourche La Fave Watershed. Some areas have been repeatedly burned.

There is a need to get more detailed information about how forestlands are actually managed - at the site specific level - before using the word “forestlands.” Until such data is collected, I would refer to such lands as industrial-forestlands so that no one gets the idea that vegetative cover is a constant in your equations.

Vernon Bates, Chairman
Ouachita Watch League
820 Beech Bend Dr.
Nashville, TN 37221
ouachita@comcast.net

4.3.1.3 Watersheds Sediment Mercury Loading

Mercury can also enter the waterbodies sorbed to sediments. Sediment loads for the watersheds were based on erosion rates for agricultural, barren, and **forestland areas** reported in literature. The land use areas were based on USGS land use data from the 1970's provided as part of BASINS version 2.0 (1999). Erosion rates were set based on information from Bloodworth and Berc (1998), Handbook of Nonpoint Pollution (Novotny and Chesters 1981), and **Ozark-Ouachita Highlands Assessment Report (USDA FS 1999).** Cropland erosion rates reported in these sources average 3.4 tons/acre/year. Cropland with highly erodible soils reportedly have erosion rates of 6.2 to 6.4 tons/acre/year and cropland with soils that are not highly erodible reportedly have erosion rates of 2.3 to 2.4 tons/acre/year. **Reported forestland erosion rates ranged from 0.2 to 0.8 tons/acre/year.**

RESPONSE: While there is uncertainty associated with erosion estimates, it was beyond the scope of this project to conduct detailed studies of erosion in the watersheds. Therefore, it was necessary to use available, published erosion rates. The focus of this TMDL was mercury, not sediment, so the uncertainty in erosion estimates was considered acceptable. The estimate of mercury inputs to the waterbodies that were associated with the estimated sediment loads (based on the given erosion rates) were considered by EPA to be conservative (i.e., possibly greater than what actually occurs). Therefore, although the erosion rates that were chosen may not be absolutely accurate in characterizing the watershed conditions, they were adequate for estimating mercury loads to the system.

Erosion control was recommended in the TMDL as an element of the TMDL implementation. Use of forestry BMPs has been added to this discussion.

Jerry Williams
531 Windamere Terr.
Hot Springs, AR 71913
(501) 767-2103 (Home)

November 18, 2002

U.S. Environmental Protection Division
Region 6
1445 Ross Avenue
Dallas, Texas 75202-2733

Attn: Ellen Caldwell, Environmental Protection Specialist Water Quality Protection Division

Re: EPA-Developed TMDL Plans, 37 Stream Segments,
34 of 37 Developed for Mercury Contamination

Dear Ms. Caldwell:

I am writing to provide comments for EPA's TMDL Plans for 34 of 37 stream segments developed for mercury contamination.

In particular, in articles I have read, it appears that elemental mercury eroding from the Ouachita and Ozark Mountains accumulates in lake and stream bottoms in the presence of decaying organic matter. It is ten taken up by microorganisms and moved up the food chain. My comments are written particularly to address the concern for erosion from the Ouachita and Ozark Mountains, especially regarding the significant impact of national forest activities.

I have been involved in national forest management issues for many years. A major impact of national forest management has to do with erosion from logging and road building activities, especially since these are done on steep mountainous terrain. However, an even more damaging aspect of these activities has to do with increased storm run-off for localized, frequent storms. Such storms can cause severe channel scour. Forest practice studies do acknowledge that downstream channel scour impacts are more damaging than site disturbance erosion. Of course, site erosion and downstream channel scour can cause hundreds of thousands of tons of erosion into streams and lakes.

This is a very serious concern since the national forests in Arkansas build hundreds of miles of log roads and log tens of thousands of acres each year. In addition, the Ouachita National Forest alone bums 100,000 acres per year. All of these activities cause on site erosion and especially increased storm flow and potential for downstream channel erosion.

National Forest long range plans as well as project timber sales admit to hundreds of thousand of tons of erosion just from site activities. In fact, the Ouachita and Ozark National Forests base their environmental analysis on an assumption that their activities can increase sediment yield by as much as 115% above a highly impacted, cumulative background sediment contamination and not degrade water quality. Their analysis does not even calculate and assess the impact of downstream channel scour.

As a result of stream damage observed in the Ouachita Mountains, I submitted comments to ADEQ for its 303(d) list requesting that several Ouachita streams be added to their list of impaired streams. A copy of my comments to ADEQ is attached.

As I indicated to ADEQ, I am hoping to perform a photographic analysis of Ouachita Mountain streams to look at stream channel damages over time to assess the magnitude of this problem. I am enclosing copies of strip aerial photographs for one stream which we submitted to the Ouachita National Forest in the past to request that they assess the stream channel erosion impact in their programmatic and site specific environmental analysis.

I respectfully request that EPA incorporate the matters addressed above in its TMDL. Plan for streams impacted by mercury contamination as it relates to sediment caused by activities in the Ouachita and Ozark Mountains.

Please keep me informed about this process. Also, please let me know if there are any grant find sources that might assist me in performing a photographic analysis of Ouachita Mountain stream channel changes over time.

Yours sincerely,

Jerry Williams

RESPONSE: See response to Vernon Bates.

November 15, 2002

Ellen Caldwell
Environmental Protection Specialist
Water Quality Protection Division
U.S. Environmental Protection Agency Region VI
1445 Ross Avenue
Dallas, TX 75202-2733

RE: Comments on Proposed Arkansas TMDLs

Dear Ms. Caldwell,

The City's main concern with any activity is the water quality of both the Lee Creek and Frog Bayou watersheds. These watersheds are the source of drinking water for citizens of Fort Smith, Arkansas and surrounding communities. Shepherd Springs Lake, which is one of the water bodies a proposed TMDL has been developed, lies in the Frog Bayou watershed and is one of the City of Fort Smith's drinking water supply reservoirs. It is in our best interest to take every precaution to ensure a safe and reliable source of drinking water for these people. It is with that in mind that the following comments are made regarding the proposed TMDLs prepared by EPA Region 6 for waters listed in the state of Arkansas, under section 303(d) of the Clean Water Act (CWA).

I. Report Errors

Several errors were noted upon review of the document entitled, "TMDLs for Segments Listed for Mercury in Fish Tissue for Selected Arkansas Watersheds" from which the TMDL for Shepherd Springs Lake was derived.

1. Page 2-13, Section 2.4.5 Point Sources states in the last sentence, "A listing of the air emission sources is included in Appendix C."

Comment: Upon reviewing Appendix C it should be noted that no air emission sources are provided. What is provided in Appendix C is fish tissue mercury concentration for largemouth bass and other species of concern.

RESPONSE: Appendices have been corrected.

2. Page 3-8, the caption for Figure 3.4 states, "Shepherd Springs Lake watershed advisory areas and mercury levels in bass."

Comment: The graphic provided is for the Dorcheat watershed.

RESPONSE: Figure title corrected.

II. TMDL Comments

1. The Executive Summary states, "The Arkansas 1998 Section 303(d) List-included stream reaches that were impaired due to excessive concentrations of mercury in fish. This TMDL study addresses 5 of the listed stream reaches~ In addition, 8 lakes in Arkansas and 1 additional river reach are under fish consumption advisories as a result of high mercury concentrations in fish. These waterbodies are also addressed in this TMDL study. While there have been no known violations of the numeric mercury water quality standard and fishable designated use for these waterbodies, they are not meeting the narrative water quality standard-and designated uses of fishable waterbodies.

The waterbodies included in this TMDL study are located predominantly in central and northern Arkansas, although there are a couple in the southwest corner of the state. Waterbodies that were close together and had similar watershed characteristics were grouped together because of similar causative factors such as atmospheric and geologic contributions. As a result, TMDLs were completed for 5 watersheds that included the waterbodies of interest for this study.

Arkansas has a numeric mercury water quality standard of 0.012 ug/L. There have been no known violations of this numeric mercury water quality standard in any of the waterbodies included in this TMDL study, but clean sampling procedures and ultra-trace level analyses have not been used. There are fish consumption advisories in all of these waterbodies because of mercury contamination of fish. The mercury Action Level for fish consumption advisories in Arkansas is 1 mg/kg. The safe target level for all fish species used in this TMDL study is 0.8 mg/kg. This incorporates a 20% margin of safety (MOS) for the Action Level.

The predominant sources of mercury loading to the watersheds were watershed nonpoint sources, watershed natural background, and non-local source atmospheric deposition. NPDES point sources accounted for less than 1% of the watershed mercury loads. Half of the watersheds did not have NPDES point sources of mercury. Watershed reduction factors for mercury loads ranged from 1.02 to 3.2. Even with these reductions, the character of mercury bioaccumulation makes it likely to be a long time before reductions in fish mercury levels are seen as a result of reduced loads to the watersheds."

Comment: The sources of mercury loading to the Shepherd Springs Lake watershed are not from any point source. Therefore, only nonpoint sources must be from geologic formations and non-local source atmospheric deposition. However, no site-specific data was provided to either confirm or deny these allegations. Institution of a TMDL in this watershed is overly restrictive.

RESPONSE: Unfortunately, data on mercury concentrations in air, soil, and water in the Shepherd Springs Lake watershed were not available at the time this study was completed. Collection of additional data was beyond the scope of this study. However, if site-specific mercury data collected after this study indicate that the assumptions utilized in this TMDL are not correct, the TMDL can be amended based on the new data.

2. Section 1.0 INTRODUCTION states, "The Arkansas 1998 Section 303(d) List included waterbodies impaired due to excessive concentrations of mercury in fish. Stream reaches listed for mercury in the Ouachita River basin in Arkansas were addressed in a separate TMDL study (FTN 2002). The current TMDL study addresses the remaining stream reaches listed for mercury in Arkansas. This TMDL study also addresses waterbodies where fish consumption advisories have been issued by the State of Arkansas. Table 1.1 identifies the stream reaches and lakes included in this TMDL study."

Comment: Recent sampling for mercury in fish conducted by Arkansas Department of Environmental Quality (ADEQ) demonstrate that the average concentration in largemouth bass to be 0.42 mg/kg (personal email from Nat Nehus, Chief Ecologist for ADEQ). This value is well below the 1 mg/kg threshold value. Originally, Shepherd Springs Lake was issued a mercury advisory based upon only one data set. City staff contested the results of this data set, and subsequent sampling and analyses contradicted the earlier results. Therefore, the mercury advisory for Shepherd -Springs Lake is questionable and conversely, th& need to establish a TMDL for this waterbody should be negated.

RESPONSE: A fish consumption advisory for mercury in largemouth bass was issued for Shepherd Springs Lake because the maximum concentration of mercury in largemouth bass collected in the early 1990s was greater than the 1 mg/kg mercury action level. Analysis of multiple fish collected at Shepherd Springs Lake by multiple laboratories confirmed that consumable largemouth bass had tissue mercury concentrations greater than 1 mg/kg (a detailed discussion of these analyses can be found in the report "Mercury in Arkansas: 1993-1994 Biennium Report," Armstrong et al. 1995). Based on the existing fish consumption advisory, Shepherd Springs Lake has been classified by EPA as not attaining its designated use as a fishery and has been included on Arkansas' 2002 Section 303(d) list as an impaired waterbody. Under the Clean Water Act, TMDLs must be developed for all waterbodies included on the Section 303(d) list.

Waterbodies can be removed from the Section 303(d) list through a procedure called delisting. There are specific requirements for data used to prove that a waterbody on the Section 303(d) list is in fact achieving all of its designated uses. Until a waterbody is either proven to be achieving the uses it was considered not to be achieving when it was put on the Section 303(d) list, or that use designation is removed from the waterbody (through a Use Attainability Analysis (UAA)), the waterbody remains on the 303(d) list and under the TMDL program. For more information about the delisting procedure for Arkansas waterbodies you can contact Bill Keith at ADEQ.

It should be noted that the water supply use of Shepherd Springs Lake is NOT considered to be impaired by mercury. The purpose of the TMDL is to lower mercury concentrations in fish (particularly largemouth bass) to levels that would not cause harm to people eating those fish. The phenomenon of bioaccumulation of mercury makes it possible for bass with toxic levels of mercury in their tissues to occur in waterbodies where water mercury concentrations are at safe levels.

3. Section 3.2 Existing Water Quality Conditions states, "There have been no recorded exceedances of the mercury water quality standard in the waterbodies being addressed in this TMDL study. The analytical procedures used previously had, a detection limit of 0.2 ug/L and all samples were less than the detection limit.

However, there are fish consumption advisories for mercury contamination in the waterbodies being addressed in this TMDL study. The fish consumption Action Level in Arkansas is based on the previous FDA guideline of 1 mg/kg. The location of these fish consumption advisories and the highest average composite bass fish mercury concentrations for the stations sampled in these waterbodies are discussed in Section 3.3. EPA recently promulgated a criterion -for methylmercury in fish tissue. The EPA criterion is 0.3 mg/kg of methylmercury in fish tissue (EPA 2001). The State of Arkansas will need to consider adopting this criterion as part of its triennial review.

This TMDL study uses fish tissue monitoring data as a means to determine whether the "fishable" use is being met, and the reductions needed to achieve the designated use. The "fishable" use is not attained if: (1) the fish and wildlife propagation is impaired and/or (2) if there is a significant human health risk from consuming fish and shellfish resources. The waterbodies included in this TMDL study were listed in the 1998 303(d) List based on elevated fish tissue mercury concentrations, and/or are in violation of narrative standards for toxic substances. To achieve the designated use, the fish tissue mercury concentration of 1.0 mg/kg should not be exceeded. Therefore, the target tissue mercury level for all fish species in this TMDL study will be 0.8 mg/kg. This-incorporates a 20% Margin of Safety in-the analyses (see Section 5.0)."

Comment: As the report states, there have been no recorded exceedances of the mercury water quality standard in the waterbodies being addressed in the TMDL study. The City's own monitoring -data confirms that there has not been one instance where mercury has been detected in either the watershed or lake system. Also, recent sampling for mercury in fish conducted by ADEQ show that the average concentration in largemouth bass to be 0.42 mg/kg (personal email from Nat Nehus, Chief Ecologist for ADEQ). This value is well below the 1 mg/kg threshold value. Therefore, the mercury advisory for Shepherd Springs Lake is questionable and conversely, the need for a TMDL for this waterbody should be negated. I recommend that additional analyses be performed with the newly established criterion of 0.3 mg/kg of methylmercury to determine if a mercury advisory for this waterbody is necessary. If it is not, then a TMDL would not be required.

RESPONSE: Please see response to previous comment.

4. Section 4.3.1.3 Watersheds Sediment Mercury Loading states on page 4-6, "Mercury can also enter the waterbodies sorbed to sediments." And further goes on to state on page 4-8, "Shale mercury-was used for the most likely load calculation because it is common in the Ouachita and Boston Mountains and is the most easily erodible rock analyzed (Armstrong et al. l995)~ Therefore it was deemed the most likely to contribute to the sediment mercury load."

Comment: No site-specific data was utilized to determine if indeed sediments or shale were a source of mercury in Shepherd Springs Lake.

RESPONSE: No site-specific data were available for mercury concentrations in rocks or soils in Shepherd Springs Lake watershed. Collection of site-specific data was beyond the scope of this study. If new, site-specific data should indicate that the assumptions used in developing this TMDL are incorrect, the TMDL can be modified.

III. Summary

In summary, the proposed TMDL for Shepherd-Springs Lake is not based upon sound scientific data and should not be adopted. No site-specific data was provided to justify the issuance of the TMDL for Shepherd Springs Lake. However data do exist that contradict the need to establish a TMDL.

RESPONSE: See previous response to similar comments.

As the report states, the only sources of mercury that could exist in the watershed of this lake are from geologic and non-local- atmospheric sources. Establishing a TMDL for this waterbody would not help control these sources. Primarily because nothing can be done about the geologic sources and the atmospheric sources exist beyond the boundaries of the watershed, therefore a TMDL would not reduce or eliminate these sources.

RESPONSE: As noted on page 4-12, the TMDL for Shepherd Springs Lake is expected to be achieved because the atmospheric mercury load to Shepherd Springs Lake is expected to be reduced to the levels specified in the TMDL. Reductions in atmospheric loads are expected due to new regulations requiring reductions in mercury emissions from specific source categories (e.g., coal fired utilities). Therefore, no activities are expected to be required in the watershed itself.

Prior to establishing a TMDL for this waterbody, additional analyses should be conducted to determine if an advisory is necessary as your report recommends.

RESPONSE: The TMDL is completed. It can be modified if additional analyses warrant.

If you have any questions, please don't hesitate to contact me.

Sincerely,

Paul R. Easley
Environmental Manager
City of Fort Smith

November 13, 2002

Ms. Ellen Caldwell
Environmental Protection Specialists
Water Quality Protection Division
EPA—Region VI
1445 Ross Avenue
Dallas, TX 75202-273 3

Dear Ms. Caldwell:

I am contacting you on behalf of the Arkansas Forestry Association (AFA) and our 1,300+ members concerning proposed mercury total maximum daily loads (TMDLs) for six stream segments and eight lakes in central, northern and southwestern Arkansas. It is our understanding that the water bodies involved with this proposal have been on Arkansas' impaired waters list due to fish consumption advisories from mercury in fish tissues.

Arkansas reviewed and established new forestry best management practices (BMPs) for water quality protection earlier this year, and we strongly believe that these BMPs will positively protect our state's streams, lakes and rivers. The establishment of the new BMPs was done with an understanding of the technological advances in the timber and forest products community and included the latest in scientific and professional data. Additionally, I would add that a BMP effectiveness study is currently being conducted over the next three years through Arkansas State University in Jonesboro to investigate how effective our BMPs are in protecting water quality.

The Arkansas Forestry Commission has recently compiled and released a BMP compliance report for 2000-2001. (The entire report can be viewed at http://www.forestry.state.ar.us/bmp/bmp report 2002.pdf) The findings in this report show that our BMPs are implemented overall at a rate of 83%. This is an increase from the 1998-1999 reporting period, which showed an 80% rate of implementation. Our community strives to educate others and ourselves as to the importance of our BMPs, and we are proud of our continuing efforts.

We believe that our BMPs are more than sufficient to control any potential impact from silviculture related to the proposed TMDLs, and trust that Arkansas' timber and forest products community will not be adversely affected by the final decision in this matter. Please do not hesitate to let me know if you need additional information or have any questions or concerns.

Sincerely,

Jerry Robbins
Executive Vice President

RESPONSE: Thank you for your comment.