FINAL

TMDLs for Copper and Zinc for the Caddo River Basin, Arkansas

(HUC-reach 08040102-016, -018, -019, and -023)

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EXECUTIVE SUMMARY

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (at Title 40 of the Code of Federal Regulations [CFR] Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for impaired waterbodies. A TMDL establishes the amount of a pollutant that a waterbody can assimilate without exceeding its water quality standard for that pollutant. TMDLs provide the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991).

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the lack of knowledge concerning the relationship between pollutant loads and the water quality of the receiving waterbody. The TMDL components are illustrated using the following equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

The study area for this TMDL is the Caddo River Basin in central Arkansas, which is part of Planning Segment 2F. The Caddo River originates in the Ouachita Mountains and flows through Montgomery, Pike, and Clark counties before its confluence with the Ouachita River just north of Arkadelphia, Arkansas. Forest is the dominant land use in the Caddo River Basin.

This document includes four stream segments in the Caddo River Basin on the state's 2004 section 303(d) list for copper and zinc impairments (Table ES-1). The impaired designated use for the four segments is fisheries (subcategory streams, Typical Gulf Coastal Ecoregion).

The numeric water quality criteria that apply to the impaired segments in the Caddo River Basin and were used to calculate the total allowable loads are presented in Table ES-2.

Table ES-1. Section 303(d) and Integrated Report information for the Caddo River Basin

HUC-reach number	Reach name	Impaired use	Cause of impairment	Suspected sources of impairment
08040102-016	Caddo River	Aquatic life	Copper and zinc	Unknown
08040102-018	Caddo River	Aquatic life	Copper and zinc	Unknown
08040102-019	Caddo River	Aquatic life	Copper and zinc	Unknown
08040102-023	South Fork Caddo River	Aquatic life	Copper and zinc	Resource extraction

Source: ADEQ 2005.

The TMDLs for all copper and zinc were developed using the load duration curve methodology. This method illustrates allowable loading at a wide range of stream flow conditions. The steps for applying the methodology were as follows: (1) develop a flow duration curve; (2) convert the flow duration curve to load duration curves; (3) plot observed loads with load duration curves;

and (4) calculate the TMDL, MOS, WLA, and LA. The TMDLs for the copper and zinc were not developed for a particular season, and they apply year-round.

Table ES-2. Numeric water quality criteria for the Caddo River Basin

HUC-reach number	Stream segment name	Acute dissolved copper[a]	Chronic dissolved copper[b]	Acute dissolved zinc[c]	Chronic dissolved zinc[d]
		(µg/L)	(µg/L)	(µg/L)	(µg/L)
08040102-016	Caddo River	5.6	4.2	42.4	38.7
08040102-018	Caddo River	5.6	4.2	42.4	38.7
08040102-019	Caddo River	5.6	4.2	42.4	38.7
08040102-023	South Fork Caddo River	5.6	4.2	42.4	38.7

Note: µg/L = micrograms per liter.
Note: The hardness of 31 mg/L used to calculate the metals criteria is the default hardness for the Gulf Coastal Plain Ecoregion of Arkansas.
[a] The acute dissolved copper criterion was calculated using the following equation with a hardness of 31 mg/L: (e^[0.9422(lnhardness)]-1.464) × 0.960.
[b] The chronic dissolved copper criterion was calculated using the following equation with a hardness of 31 mg/L: (e^[0.8545(lnhardness)]-1.465) × 0.960.
[c] The acute dissolved zinc criterion was calculated using the following equation with a hardness of 31 mg/L: (e^[0.8473(lnhardness)]+0.8604) × 0.978.
[d] The chronic dissolved zinc criterion was calculated using the following equation with a hardness of 31 mg/L: (e^[0.8473(lnhardness)]+0.7614) × 0.986.
Source: APCEC 2007.

In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established, thereby providing the basis for establishing water quality-based controls. WLAs were given to permitted point source discharges. The LAs include background loadings as well as human-induced nonpoint sources. An explicit MOS of 10 percent was included. A summary of the TMDLs for the segments addressed in this report is presented in Table ES-3.

Table ES-3. Summary of dissolved copper and zinc TMDLs, MOS, WLAs, and LAs for the Caddo River Basin

HUC-reach number	Water quality station	Pollutant	Total allowable loading	Explicit MOS (10%)	Σ WLA	Σ LA
			lb/day			
08040102-016	OUA0023	Dissolved copper	13.30	1.33	0.00	11.97
08040102-016	OUA0023	Dissolved zinc	122.51	12.25	0.00	110.26
08040102-018		Dissolved copper	9.67	0.97	0.00	8.70
08040102-018		Dissolved zinc	89.11	8.91	0.00	80.20
08040102-019		Dissolved copper	9.09	0.91	0.00	8.18
08040102-019		Dissolved zinc	83.71	8.37	0.00	75.34
08040102-023	OUA0044	Dissolved copper	2.01	0.20	0.46	1.35
08040102-023	OUA0044	Dissolved zinc	18.50	1.85	3.44	13.21

Note: Loadings for segment 08040102-023 are included in segment 08040102-019. Loadings for segment 08040102-019 are included in segment 08040102-018. Loadings for segment 08040102-018 are included in segment 08040102-016.

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1 INTRODUCTION

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (at Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not supporting their designated uses even after pollutant sources have implemented technology-based controls. A TMDL establishes the maximum allowable load (mass per unit of time) of a pollutant that a waterbody is able to assimilate and still support its designated uses. The maximum allowable load is determined on the basis of the relationship between pollutant sources and in-stream water quality. A TMDL provides the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991).

Monitoring data collected by the Arkansas Department of Environmental Quality (ADEQ) indicate that observed pollutant levels sometimes exceed water quality criteria for four stream segments in the Caddo River Basin. The impaired designated use for the four segments is fisheries (subcategory streams, Typical Gulf Coastal Ecoregion). The pollutants causing the impairment include copper and zinc. Table 1-1 presents information from Arkansas's 2004 Integrated Report (ADEQ 2005) for the four segments.

Table 1-1. Section 303(d) and Integrated Report information for the Caddo River Basin

HUC-reach number	Reach name	Impaired use	Cause of impairment	Suspected sources of impairment
08040102-016	Caddo River	Aquatic life	Copper (Cu) and zinc (Zn)	Unknown
08040102-018	Caddo River	Aquatic life	Copper (Cu) and zinc (Zn)	Unknown
08040102-019	Caddo River	Aquatic life	Copper (Cu) and zinc (Zn)	Unknown
08040102-023	South Fork Caddo River	Aquatic life	Copper (Cu) and zinc (Zn)	Resource extraction

Source: ADEQ's 2005

2 BACKGROUND INFORMATION

2.1 General Description

The four stream segments addressed in this TMDL report are in central Arkansas (Figure 2-1) in portions of U.S. Geological Survey (USGS) hydrologic unit code (HUC) 08040102. The Caddo River originates in the Ouachita Mountains and flows through Montgomery, Pike, and Clark counties before its confluence with the Ouachita River just north of Arkadelphia, Arkansas. Table 2-1 lists the counties in which the segments are located and the approximate drainage area of each segment.

Table 2-1. County and drainage area for each listed segment in the Caddo River Basin

HUC-reach number	Reach name	County	Total drainage area (acres)	Unique subwatershed Area (acres)
08040102-016	Caddo River	Clark	196,564	53,588
08040102-018	Caddo River	Clark, Pike	142,976	8,658
08040102-019	Caddo River	Pike, Montgomery	134,318	104,639
08040102-023	South Fork Caddo River	Pike, Montgomery	29,679	29,679

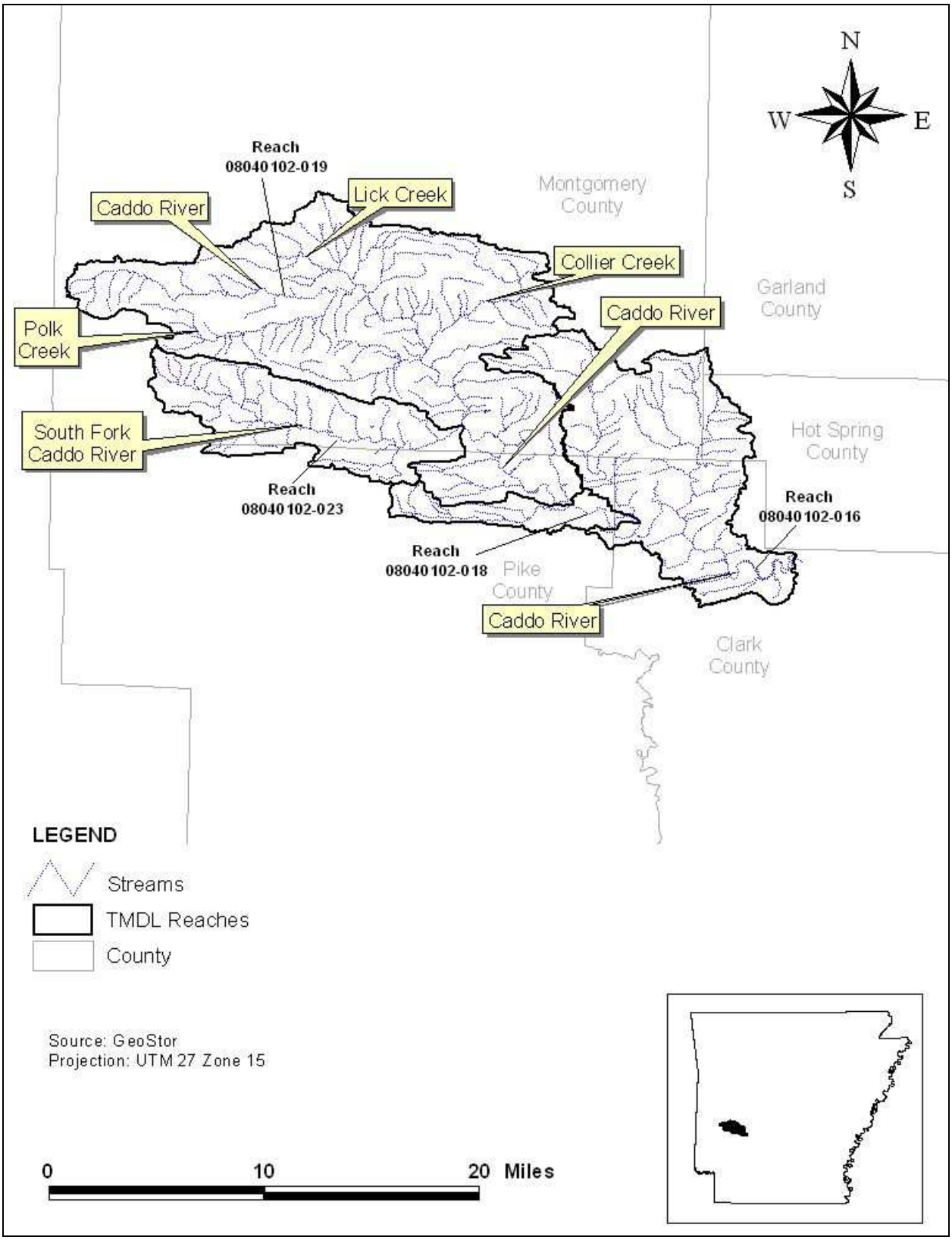

Figure 2-1. Location of the Caddo River Basin.

2.2 Land Use

Land use data were obtained from the Center for Advanced Spatial Technologies (CAST) at the University of Arkansas in Fayetteville (2005). Table 2-2 and Figure 2-2 present the percentage of segment area covered by each land use and the land use coverage, respectively. Forest constitutes more than 85 percent of the land area in all four segments in the Caddo River Basin. The second largest land use is pasture/forage in all four segments. Three of the four segments contain small urban areas (approximately 1.5 percent); segment 023 has no urban area.

Table 2-2. Land use by stream reach

Land use	HUC-reach number							
	08040101-016		08040101-018		08040101-019		08040101-023	
	Area (acres)	Percent coverage	Area (acres)	Percent coverage	Area (acres)	Percent coverage	Area (acres)	Percent coverage
Barren	580	0.3	448	0.3	389	0.3	48	0.2
Forest	171,345	87.3	125,704	88.0	119,396	89.0	27,772	93.6
Pasture/ forage	21,093	10.7	14,312	10.0	12,259	9.1	1,806	6.1
Urban	2,840	1.5	2,214	1.6	1,994	1.5	0	0.0
Water	518	0.2	179	0.1	161	0.1	43	0.1
TOTAL	**196,375**	**100**	**142,858**	**100**	**134,199**	**100**	**29,669**	**100**

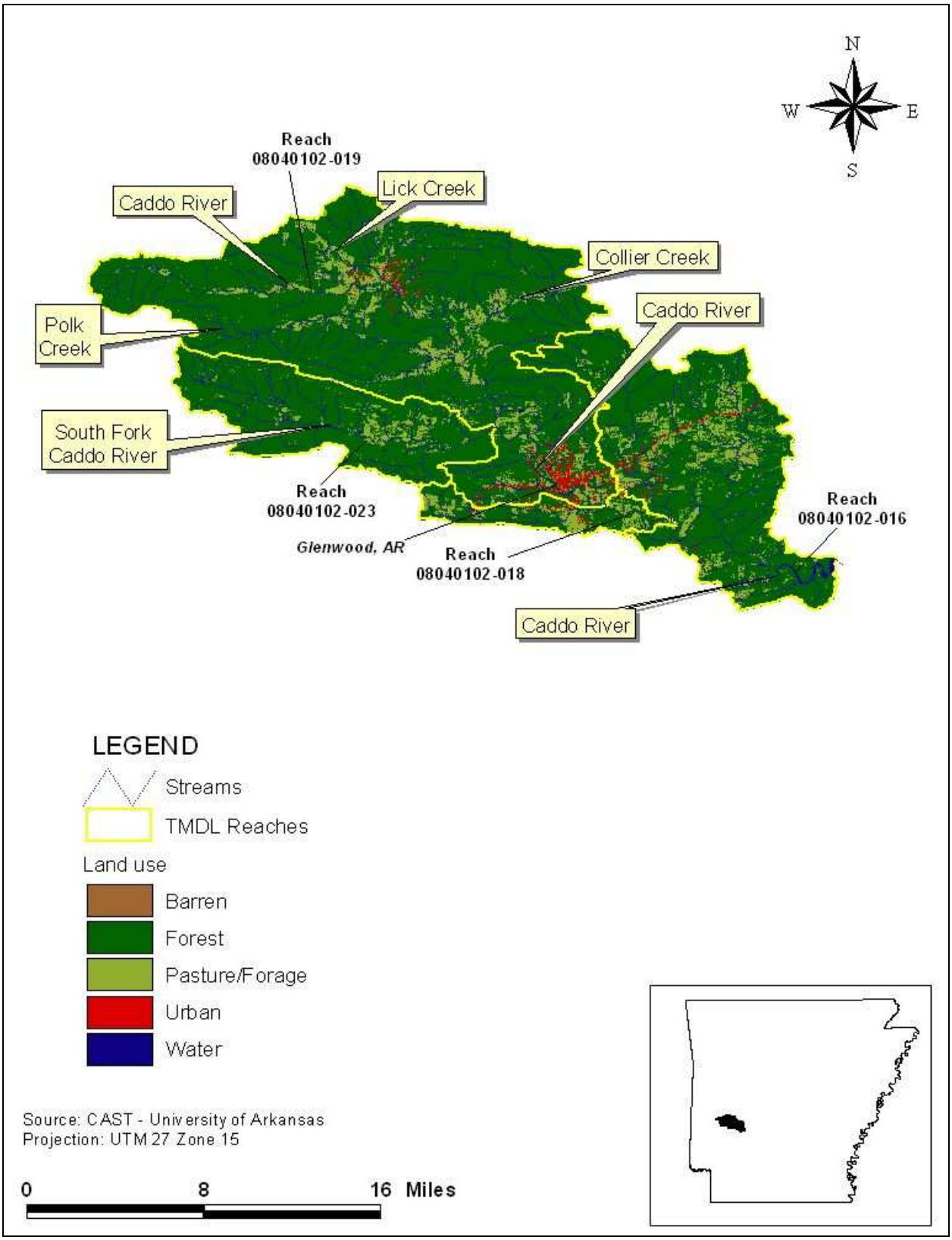

Figure 2-2. Land use in the Caddo River Basin.

2.3 Flow Characteristics

Because there is only one active USGS flow-monitoring gauge in any of the listed segments, no flow data are available for the segments in the Caddo River Basin. Table 2-3 presents information for the one flow gauge in the listed segments.

Table 2-3. USGS flow gauge information for the Caddo River Basin

Station number	Station name	Period of record	Drainage area (square miles)
07359610	Caddo River near Caddo Gap	1989 - 2006	136

The Caddo Gap gauge (07359610) is just upstream of the mouth of segment 019 and parallel to segment 023. It is about 13 mile upstream of the mouth of segment 018 and about 30 miles upstream of the mouth of segment 016. The location of the USGS gauge is shown in Figure 2-3.

The seasonal distribution of flow at the gauging station is shown in Figure 2-4. Low flow occurs in the summer and early fall, and high flow tends to occur in late winter and early spring.

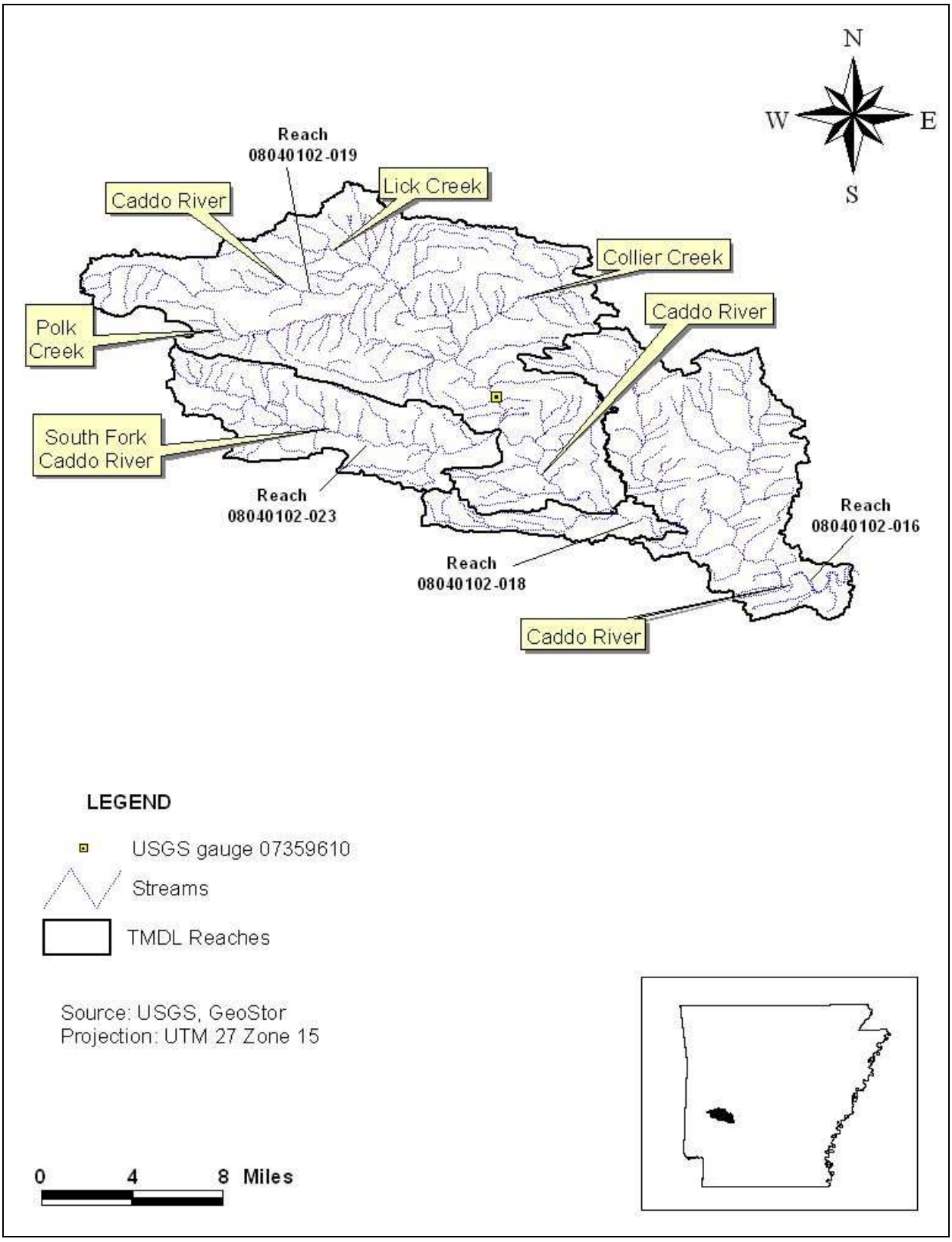

Figure 2-3. Location of USGS gauge in the Caddo River Basin.

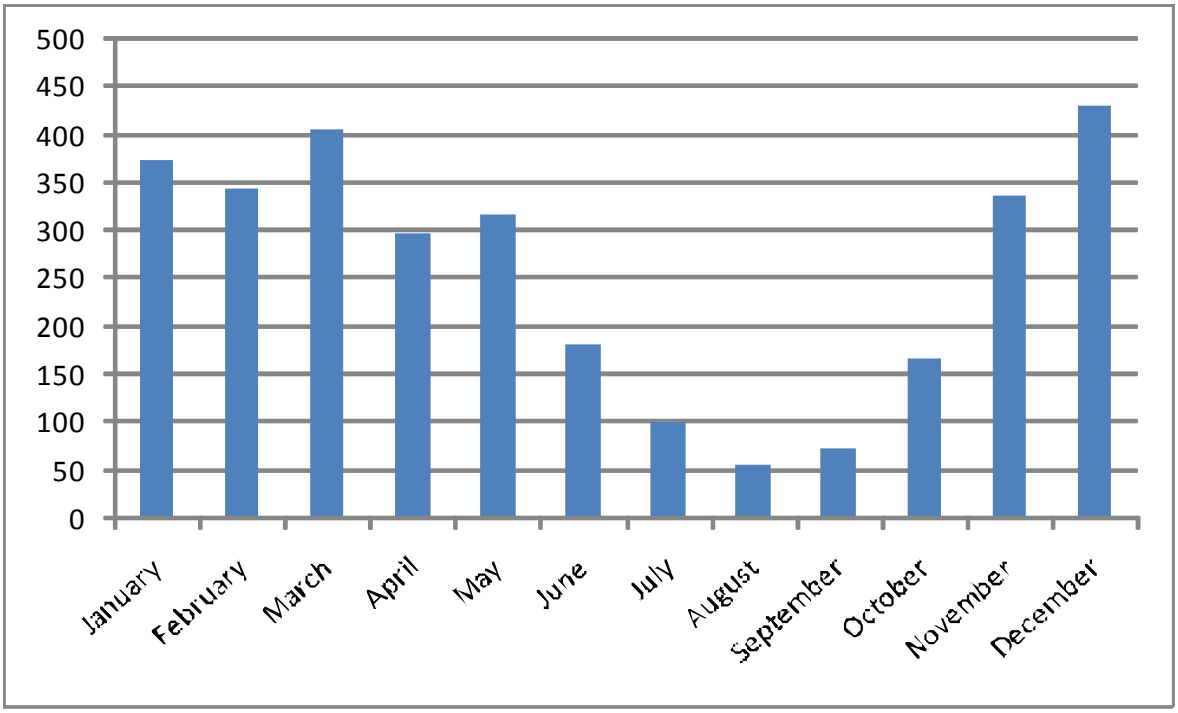

Figure 2-4. Seasonal distribution of flow at Caddo River near Caddo Gap, Arkansas (USGS 07359610) for 1989 through 2006.

2.4 Water Quality Standards

2.4.1 Designated Uses

The designated uses for the Caddo River are extraordinary resource waters (above De Gray Reservoir); ecologically sensitive waterbody (above De Gray Reservoir); primary contact recreation; secondary contact recreation; domestic, industrial, and agricultural water supply; and fisheries (subcategory streams, Typical Gulf Coastal Ecoregion) (APCEC 2007). The designated uses for the South Fork Caddo River are extraordinary resource waters; primary contact recreation; secondary contact recreation; domestic, industrial, and agricultural water supply; and fisheries (subcategory streams, Typical Gulf Coastal Ecoregion) (APCEC 2007). Arkansas's 2004 Integrated Report (ADEQ 2005) indicates that the four listed segments have impairments due to copper and zinc.

The designated use of fisheries "provides for the protection and propagation of fish, shellfish, and other forms of aquatic life (APCEC 2007, p. 3-1)". The subcategory of "streams" indicates "water which is suitable for the protection and propagation of fish and other forms of aquatic life adapted to flowing water systems whether or not the flow is perennial (APCEC 2007, p. 3-2)". The subcategory of "Typical Gulf Coastal Ecoregion" designates "Streams supporting diverse communities of indigenous or adapted species of fish and other forms of aquatic life. Fish communities are characterized by a limited proportion of sensitive species; sunfishes are distinctly dominant followed by darters and minnows (APCEC 2007, p. 3-4)". The Typical Gulf Coastal Ecoregion fish community may generally be characterized by the key species of redfin shiner, spotted sucker, yellow bullhead, warmouth, slough darter, and grass pickerel and the

indicator species of pirate perch, flier, spotted sunfish, dusky darter, creek chubsucker, and banded pygmy sunfish. Agricultural water supply designates waters that will be protected for irrigation of crops and/or consumption by livestock (APCEC 2007). Industrial water supply indicates waters that will be protected for use as process or cooling water (APCEC 2007).

2.4.2 Water Quality Criteria

Water quality criteria for the impaired segments are discussed below and presented in Table 2-4.

Table 2-4. Dissolved metal numeric criteria for the Caddo Red River Basin

HUC-reach number	Reach name	Acute dissolved copper[a] (µg/L)	Chronic dissolved copper[b] (µg/L)	Acute dissolved zinc[c] (µg/L)	Chronic dissolved zinc[d] (µg/L)
08040102-016	Caddo River	5.6	4.2	42.4	38.7
08040102-018	Caddo River	5.6	4.2	42.4	38.7
08040102-019	Caddo River	5.6	4.2	42.4	38.7
08040102-023	South Fork Caddo River	5.6	4.2	42.4	38.7

Note: µg/L = micrograms per liter.
Note: The hardness of 31 mg/L used to calculate the metals criteria is the default hardness for the Gulf Coastal Plain Ecoregion of Arkansas.
[a] The acute dissolved copper criterion was calculated using the following equation with a hardness of 31 mg/L: (e^[0.9422(lnhardness)]-1.464) × 0.960.
[b] The chronic dissolved copper criterion was calculated using the following equation with a hardness of 31 mg/L: (e^[0.8545(lnhardness)]-1.465) × 0.960.
[c] The acute dissolved zinc criterion was calculated using the following equation with a hardness of 31 mg/L: (e^[0.8473(lnhardness)]+0.8604) × 0.978.
[d] The chronic dissolved zinc criterion was calculated using the following equation with a hardness of 31 mg/L: (e^[0.8473(lnhardness)]+0.7614) × 0.986.
Source: APCEC 2007.

The Arkansas water quality standards provide both narrative and numeric criteria for toxic substances like dissolved copper and dissolved zinc. The narrative criterion states that "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 (APCEC 2007, p.5-5)." The numeric water quality criterion for dissolved copper and dissolved zinc is based on hardness and applies to both acute and chronic conditions. The acute criteria are based on toxicity resulting from short-term exposure to high pollutant concentrations, whereas the chronic criteria are based on toxicity resulting from long-term exposure to lower pollutant concentrations. Because this TMDL focuses on critical conditions over the long term, the chronic criteria were used to calculate the TMDLs for dissolved copper and dissolved zinc. Based on ADEQ's monitoring data, the average hardness in the Caddo River Basin is 41 milligrams per liter (mg/L). ADEQ's Continuing Planning Process (CPP) (ADEQ 2000) specifies the default hardness for each ecoregion, which is 31 mg/L for the Gulf Coastal Plain ecoregion, in which the Caddo River Basin is located. The lower default hardness value of 31 mg/L, as opposed to the average value of 41 mg/L for the Caddo River Basin, was used to calculate metals criteria for the Caddo River (Table 2-7) based on best professional judgment because it is more protective of downstream waterbodies.

2.4.3 Antidegradation Policy

The Arkansas water quality standards also include an antidegradation policy (APCEC 2007), which states that existing in-stream water uses and the level of water quality necessary to protect the existing uses must be maintained and protected.

State water exhibiting high water quality must be maintained and protected unless the state finds that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. In allowing such degradation or lower water quality, the state must ensure water quality adequate to protect the existing uses fully.

Those uses and water quality for which the outstanding resource waters were designated must be protected by (1) implementing water quality controls, (2) maintaining the natural flow regime, (3) protecting in-stream habitat, and (4) encouraging land management practices protective of the watershed.

In cases where potential water quality impairment associated with a thermal discharge is involved, the antidegradation policy and implementing method must be consistent with section 316 of the federal Clean Water Act.

2.5 Point Sources

Two point sources are permitted to discharge total copper and total zinc (Tables 2-5 and 2-6). Table 2-7 presents additional point source facilities that are in the Caddo River Basin, but not included in the TMDLs. Figure 2-5 shows the location of the National Pollutant Discharge Elimination System (NPDES)-permitted facilities included in the Caddo River TMDL..

Table 2-5. Point source discharge information for total copper in the Caddo River Basin

NPDES permit	Facility name	Location	Outfall	Discharge (mgd)	Receiving waters	Average limit concentration	Maximum limit concentration
						µg/L	µg/L
Reach 023							
AR0036609	Tremont Corporation; D/B/A Dempsey reclaimed mine site	Sulphur Mtn; 2 mi west of City, Fancy Hill	2	0.13	Black Valley Creek Trib, South Fork Caddo River	11[a]	21[a]
			4	0.5		11[a]	21[a]
AR0038270	Baker-Hughes Inteq	296 Milchem Dr, Caddo Gap	2	12.479	South Fork Caddo River, Caddo River	11[b]	22[b]

[a] Effective 9/1/2009; only monitoring required before then.
[b] Effective 10/1/2009; only monitoring required before then.
Note: mgd = million gallons per day; µg/L = micrograms per liter.

Table 2-6. Point source discharge information for total zinc in the Caddo River Basin

NPDES permit	Facility name	Location	Outfall	Discharge (mgd)	Receiving waters	Average limit concentration	Maximum limit concentration
						µg/L	µg/L
Reach 023							
AR0036609	Tremont Corporation; D/B/A Dempsey reclaimed mine site	Sulphur Mtn; 2 mi west of City, Fancy Hill	2	0.13	Black Valley Creek Trib, South Fork Caddo River	95[a]	191[a]
			4	0.5		95[a]	191[a]
AR0038270	Baker-Hughes Inteq	296 Milchem Dr, Caddo Gap	2	12.479	South Fork Caddo River, Caddo River, Ouachita River	97[b]	194[b]

[a] Effective 9/1/2009; only monitoring required before then
[b] Effective 10/1/2009; only monitoring required before then
Note: mgd = million gallons per day; µg/L = micrograms per liter.

Table 2-7. Point source discharges not included in the TMDLs for the Caddo River Basin

NPDES permit	Facility name	Location	Reason for not including
Reach 019			
AR0035645	City of Glenwood	Baker Road	This permit contained limits for total ammonia nitrogen (as N), $CBOD_5$, and TSS. None of these were of interest to the TMDL and were not included.
AR0043125	City of Norman	320 North First Street	This permit contained limits for total ammonia nitrogen (as N), $CBOD_5$, and TSS. None of these were of interest to the TMDL and were not included.
AR0044814	GS Roofing Products Company	Hwy 8 N, 5 miles north of city	This permit contained limits for oil and grease TSS, and pH. None of these were of interest to the TMDL and were not included.
AR0049263	Bean Lumber Company	Sweet Gum Lane & MS Pacific Railroad	This permit contained limits for floating debris, pH, BOD_5, and TSS. None of these were of interest to the TMDL and were not included.
ARG640161	City of Glenwood WTP	320 North First Street	This permit contained limits for pH, TSS, and total residual chlorine. None of these were of interest to the TMDL and were not included.

2.6 Nonpoint Sources

The nonpoint sources of copper and zinc in the watershed are unknown. Potential nonpoint sources include runoff from land uses in the surrounding watershed.

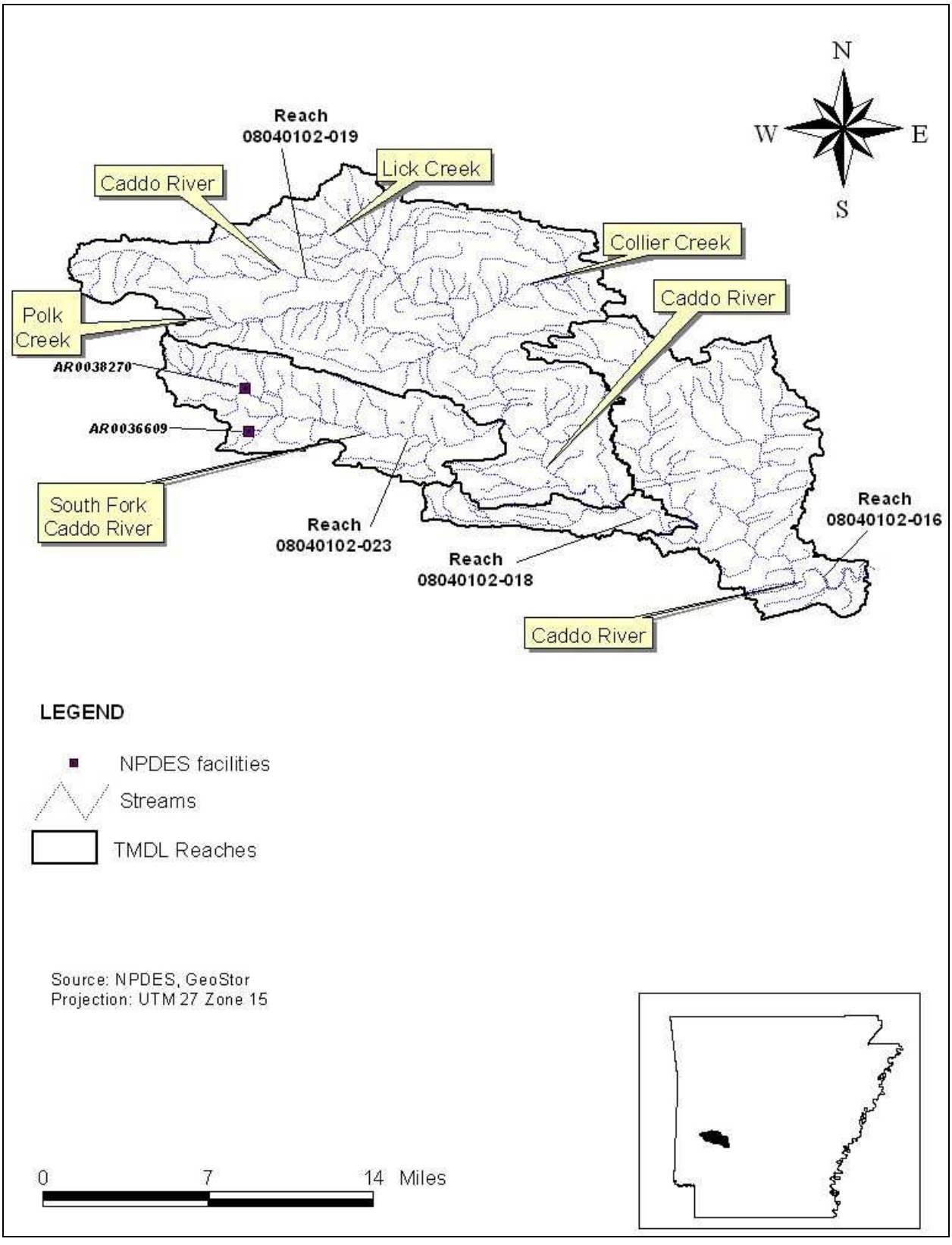

Figure 2-5. NPDES facilities in the Caddo River Basin.

3 CHARACTERIZATION OF EXISTING WATER QUALITY

ADEQ has collected water quality data for dissolved copper, dissolved zinc, and other parameters in the Caddo River Basin at stations OUA0023 (Caddo River near Amity, Arkansas, upstream of Highway 84 bridge) and OUA0044 (South Fork Caddo River at Fancy Hill, Arkansas). Station OUA0023 is approximately 6.5 miles upstream of where the Caddo River flows into De Gray Lake, and station OUA0044 is at the confluence of D.C. Creek and the South Fork Caddo River (Figure 3-1).

3.1 Comparison of Observed Data to Criteria

3.1.1 Copper

There are two water quality monitoring stations with dissolved copper observations in the Caddo River Basin. Station OUA0023 has 75 dissolved copper observations from 1995 to 2007, and station OUA0044 has 78 dissolved copper observations from 1995 to 2007. Table A-1 in Appendix A provides a summary of the observations at each water quality station, including the number of observations; the minimum, maximum, mean, and median observations; the number of exceedances of the criterion; and the percentage of observations exceeding the criterion at each station. Appendix B contains the original dissolved copper water quality data.

Three percent of the dissolved copper observations at station OUA0023 exceed the dissolved copper criterion of 4.2 µg/L, while 8 percent of the dissolved copper observations at station OUA0044 exceed the criterion.

3.1.2 Zinc

Station OUA0023 has 73 dissolved zinc observations from 1995 to 2007, and station OUA0044 has 77 dissolved zinc observations from 1995 to 2007. Table A-21 in Appendix A provides a summary of the observations at each water quality station, including the number of observations; the minimum, maximum, mean, and median observations; the number of exceedances of the criterion; and the percentage of observations exceeding the criterion at each station. Appendix B contains the original dissolved zinc water quality data.

Nineteen percent of the dissolved zinc observations at station OUA0023 exceed the dissolved zinc criterion of 38.7 µg/L, while 14 percent of the dissolved zinc observations at station OUA0044 exceed the criterion.

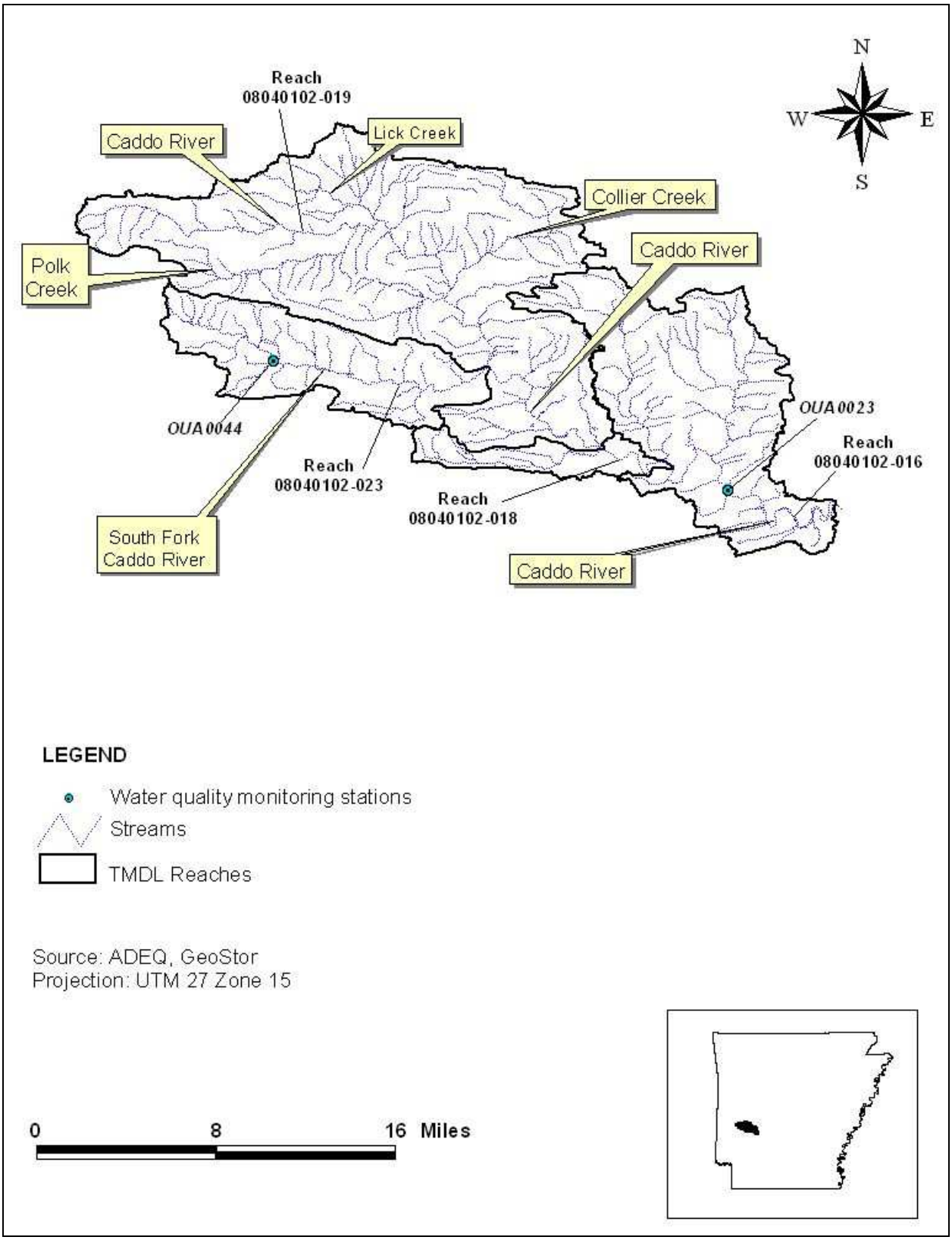

Figure 3-1. Location of water quality monitoring stations in the Caddo River Basin.

3.2 Trends and Patterns in Observed Data

3.2.1 Copper

Dissolved copper observations at stations OUA0023 and OUA0044 do not show a strong correlation with season. High dissolved copper levels were observed during low flows; however, not enough samples were collected during high flows to allow a valid comparison. Appendix C contains the dissolved copper sampling results plotted over time, seasonally, and versus flow.

3.2.2 Zinc

Dissolved zinc observations at stations OUA0023 and OUA0044 do not show a strong correlation with season either. High dissolved zinc levels were observed during low flows; however, not enough samples were collected during high flows to allow a valid comparison. Appendix D contains the dissolved zinc sampling results plotted over time, seasonally, and versus flow.

4 TMDL DEVELOPMENT

A TMDL is the total amount of a pollutant that can be assimilated by the receiving waterbody while still achieving water quality standards. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established, thereby providing the basis for establishing water quality-based controls.

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the lack of knowledge in the relationship between pollutant loads and the water quality of the receiving waterbody. The TMDL components are illustrated using the following equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

TMDLs are generally expressed on a mass loading basis (e.g., kilograms per day).

4.1 TMDL Analytical Approach

The methodology used to determine the TMDL for each impaired segment is the load duration curve. Because loading capacity varies as a function of the flow present in the stream, these TMDLs represent a continuum of desired loads over all flow conditions rather than a fixed, single value. The basic elements of this procedure are documented on the Kansas Department of Health and Environment Web site (KDHE 2003). This method was used to illustrate allowable loading for a wide range of flows. The steps for applying this methodology to develop the TMDLs in this report can be summarized as follows:

1. Develop a flow duration curve.
2. Convert the flow duration curve to load duration curves for each impairment.
3. Plot the observed loads with load duration curves.
4. Calculate the TMDL, MOS, WLA, and LA (see Section 4.2).
5. Calculate the loadings required to meet Arkansas's water quality standards.

4.1.1 Flow Duration Curve

A flow duration curve was developed for the USGS gauge used for these TMDLs. Daily stream flow measurements from the USGS gauge were sorted in increasing order, and the percentile ranking of each flow was calculated. The load duration curve methodology requires that the same flow period be used for both developing the flow duration and calculating observed loads from sampling data. The flows are then plotted against the corresponding percent flow that exceeds a specific flow to create the flow duration curves.

Figure 4-1 is an example of a flow duration curve. The plot shows the flow (e.g., cubic feet per second) on the Y axis. The X axis shows the percentage of days on which the plotted flow is exceeded. Points at the low end of the plot (0 through 10 percent) represent high-flow conditions,

where only 0 through 10 percent of the flow exceeds the plotted point. Conversely, points at the high end of the plot (90 to 100 percent) represent low-flow conditions.

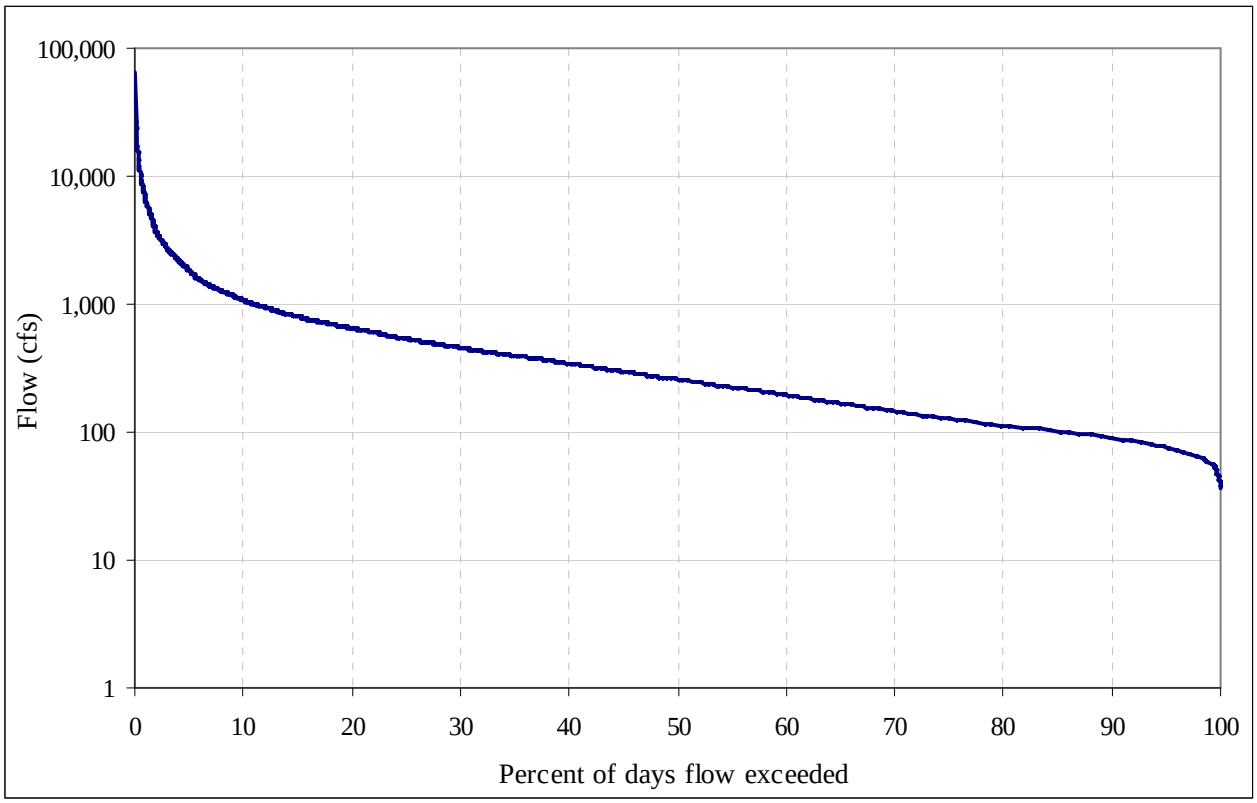

Figure 4-1. Example of a flow duration curve.

There was only one active USGS gauge in the area of concern to represent flow. Table 4-1 presents the USGS gauge that was used, the period of record used in the TMDL analysis, and the segments represented. For the TMDL calculations, the most recent flow data were used. Data from 1989 through 2006 for USGS gauge 07359610 were used. Flows were area weighted for each stream segment and those flows were used to create a unique flow duration curve for each segment (Appendix E).

Table 4-1. USGS flow gauges and represented reaches for the Caddo River Basin

Station number	Station name	Drainage Area (square miles)	Period of record used in TMDL development	Reaches represented
07359610	Caddo River near Caddo Gap, AR	136	1989–2006	016, 018, 019, 023

4.1.2 Load Duration Curve

For each TMDL parameter (copper and zinc), the flows from the flow duration curves were multiplied by the appropriate numeric criterion concentration (Table 2-4) to compute an allowable load duration curve. Each load duration curve is a plot of mass per day versus the percent flow exceedance from the flow duration curves.

The load duration curve is beneficial when analyzing monitoring data with their corresponding flow information plotted as a load. This approach allows the monitoring data to be placed in relation to their position in the flow continuum. Assumptions of the probable source or sources of the impairment can then be made from the plotted data. The load duration curve shows the calculation of the TMDL at any flow rather than at a single critical flow. The official TMDL number is reported as a single number, but the curve is provided to demonstrate the value of the acceptable load at any flow. This approach will allow analysis of load cases in the future for different flow regimes.

4.1.3 Observed Loads

For each sampling station, observed loads were calculated by multiplying the observed concentration of the parameter of concern by the flow on the sampling day. These observed loads were then plotted versus the percent flow exceedance of the flow on the sampling day and placed on the same plot as the load duration curve. Reductions were applied to the observed loads for each parameter until its water quality criteria and allowable percent exceedance were met to obtain an overall percent reduction for each segment. These plots are shown in the appendices of this report as follows:

Appendix F: Load Duration Calculations for All TMDLs (CD-ROM)
Appendix G: Load Duration Curve Summaries and Plots for Dissolved Copper
Appendix H: Load Duration Curve Summaries and Plots for Dissolved Zinc

These plots provide visual comparisons between observed and allowable loads under different flow conditions. Observed loads that are plotted above the load duration curve represent conditions under which observed water quality concentrations exceed the numeric criterion concentrations. Observed loads plotted below the load duration curve represent conditions under which observed water quality concentrations are less than the numeric criterion concentrations (i.e., do not exceed the water quality standards).

4.2 TMDL

Each TMDL was calculated as the area under the load duration curve. Table 4-2 presents the TMDLs and allocations for the segments in this report.

Both section 303(d) of the Clean Water Act and the regulations at 40 CFR 130.7 require that TMDLs include an MOS to account for lack of knowledge in the available data or in the actual effect that controls will have on the loading reductions and receiving water quality. The MOS may be expressed explicitly as unallocated assimilative capacity or implicitly by using conservative assumptions in establishing the TMDL. For a more detailed discussion of the MOS, see section 4.4. TMDLs for the reaches, which did not have water quality stations, were determined from the reaches with monitoring data and using a ratio of the total drainage area of each reaches.

Table 4-2. Summary of dissolved copper and zinc TMDLs, MOS, WLAs, and LAs for the Caddo River Basin

HUC-reach number	Water quality station	Pollutant	Total allowable loading	Explicit MOS (10%)	Σ WLA	Σ LA
			lb/d			
08040102-016	OUA0023	Dissolved copper	13.30	1.33	0.00	11.97
08040102-016	OUA0023	Dissolved zinc	122.51	12.25	0.00	110.26
08040102-018		Dissolved copper	9.67	0.97	0.00	8.70
08040102-018		Dissolved zinc	89.11	8.91	0.00	80.20
08040102-019		Dissolved copper	9.09	0.91	0.00	8.18
08040102-019		Dissolved zinc	83.71	8.37	0.00	75.34
08040102-023	OUA0044	Dissolved copper	2.01	0.20	0.46	1.35
08040102-023	OUA0044	Dissolved zinc	18.50	1.85	3.44	13.21

Note: Loadings for segment 08040102-023 are included in segment 08040102-019. Loadings for segment 08040102-019 are included in segment 08040102-018. Loadings for segment 08040102-018 are included in segment 08040102-016.

4.3 Wasteload Allocation

The WLA portion of the TMDL equation is the total loading of a pollutant that is assigned to point sources. The point sources in the Caddo River Basin include construction and mining. Wasteload allocations are based on the current permit limits and discharge flow levels.

Table 4-3 lists the individual copper and zinc WLAs for each point source in the Caddo River Basin. Both dissolved and total WLAs are presented. Federal regulations at Title 40 of the *Code of Federal Regulations* [CFR] Part 130 require permit limits to be expressed as total metals. WLAs for dissolved metals are provided to allow a comparison with the TMDLs in Table 4-2. The total metals values were derived from the dissolved water quality criteria using the translator mechanism described in Attachment V of the *State of Arkansas Continuing Planning Process* (ADEQ 2000).

Table 4-3. Copper and zinc WLAs for the Caddo River Basin

HUC-reach number	NPDES permit	Outfall	Facility name	Discharge (mgd)	Dis. copper (lb/d)	Total copper (lb/d)	Dis. zinc (lb/d)	Total zinc (lb/d)
08010102-023	AR0036609	2	Tremont Corporation; D/B/A Dempsey Reclaimed Mine Site	0.13	0.005	0.012	0.033	0.103
08010102-023	AR0036609	4	Tremont Corporation; D/B/A Dempsey Reclaimed Mine Site	0.50	0.018	0.046	0.129	0.396
08010102-023	AR0038270	2	Baker-Hughes Inteq	12.48	0.437	1.146	3.275	10.102

4.4 Load Allocation

The LA is the portion of the TMDL assigned to natural background loadings as well as nonpoint sources like urban runoff and agricultural practices. For this TMDL, the LA was calculated by subtracting the WLA and MOS from the total TMDL. LAs were not allocated to separate nonpoint sources because there was a lack of available source characterization data. The LAs are presented in Table 4-2.

4.5 Margin of Safety

The MOS is the portion of the pollutant loading reserved to account for any lack of knowledge in the data. There are two ways to incorporate the MOS (USEPA 1991). One way is to implicitly incorporate it by using conservative model assumptions to develop the allocations. The other way is to explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. In this analysis, the MOS is explicit: 10 percent of each targeted TMDL was reserved as the MOS to account for any lack of knowledge in the TMDL. Using 10 percent of the TMDL load provides an additional level of protection to the designated uses of the segments of concern.

4.6 Seasonality and Critical Conditions

The federal regulations at 40 CFR 130.7 require that TMDLs include seasonal variations and take into account critical conditions for stream flow, loading, and water quality parameters. For this TMDL, the sampling results for all pollutants were plotted over time and reviewed for any seasonal patterns (see Section 3.2).

By accounting for critical conditions, the TMDL makes sure that water quality standards are maintained for infrequent occurrences and not only for average conditions.

Because of the way the criteria are written (i.e., including critical and noncritical conditions), the TMDL for a pollutant of concern can be developed by reviewing pollutant loads at all flow conditions within applicable periods of the year and evaluating the percentage of values exceeding the criteria. The load duration curve, which determines the allowable loading at a wide range of flows, was chosen as the approach for these TMDLs (see Section 4.1). Therefore, the TMDLs were calculated at all flows rather than at a single critical flow.

4.7 Future Growth

Compliance with these copper and zinc TMDLs is based on keeping loadings in the stream below the assimilative capacity of the stream. Allocations between the WLA and LA may be re-evaluated if there is future growth of existing or new point sources discharging to the impaired reaches or their tributaries.

5 FUTURE WATERSHED ACTIVITIES

In accordance with section 106 of the federal Clean Water Act and under its own authority, ADEQ has established a comprehensive program for monitoring the quality of the state's surface waters. ADEQ collects surface water samples at various locations, using appropriate sampling methods and procedures to ensure the quality of the data collected. Two of the locations where ADEQ will continue to monitor water quality are the Caddo River near Amity (station OUA0023) and the South Fork Caddo River at Fancy Hill (station OUA0044). The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term database for long-term trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program are used to develop the state's biennial 305(b) report and 303(d) list of impaired waters, which were most recently published as the *State of Arkansas 2004 Integrated Water Quality Monitoring and Assessment Report* (ADEQ 2005).

6 PUBLIC PARTICIPATION

The federal regulations at 40 CFR 130.7(c)(1)(ii) specify that TMDLs "shall be subject to public review as defined in the State's CPP." These TMDLs were developed under contract to EPA, and EPA held a public review period seeking comments, information, and data from the public and any other interested parties. The notice for the public review period was published in the *Federal Register* on December 17, 2007, and the review period closed on January 16, 2008.

Audubon Arkansas submitted general comments for several TMDLs listed in the same public notice. Idle Mines submitted comments specific to this TMDL document. Comments and additional information submitted during the public comment period were used to inform or revise this TMDL document. The comments and responses to these TMDLs, along with comments on similar TMDLs with the same public review period, will be included in the document: *EPA Responses to Comments for TMDLs in the Big Creek, Caddo River, Cornie Bayou, Bayou de L'Outre, Ouachita River, and Saline River Basins, in Arkansas.*

EPA will submit the final TMDLs to ADEQ for implementation and incorporation into ADEQ's current water quality management plan.

7 REFERENCES

ADEQ (Arkansas Department of Environmental Quality). 2004. *Arkansas' 2004 List of Impaired Waterbodies*. Arkansas Department of Environmental Quality, Little Rock, AR.

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USEPA (U.S. Environmental Protection Agency). 1991. *Guidance for Water Quality-based Decisions: The TMDL Process*. EPA 440/-4-91-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USGS (U.S. Geological Survey). 1992. *Flow Duration and Low-Flow Characteristics of Selected Arkansas Streams*. Water-Resources Investigations Report 92-4026. Prepared by A.H. Ludwig. U.S. Geological Survey, Little Rock, Arkansas.

Appendix A
Summary of Water Quality Data

Table A-1. Summary of dissolved copper data for the Caddo River Basin..... 2
Table A-2. Summary of dissolved zinc data for the Caddo River Basin..... 2

Table A-1. Summary of dissolved copper data for the Caddo River Basin

Pollutant	Station number	Station name	Period of record	Number of observations	Minimum	Maximum	Mean	Median	Number of observations above criterion[c]	% of observations above criterion[c]
					µg/L	µg/L	µg/L	µg/L		
Dissolved copper[a]	OUA0023	Caddo River near Amity, Arkansas upstream of Hwy 84 bridge	1/17/1995–3/20/07	75	0.25	6.4	1.5	1.2	2	3
Dissolved copper[b]	OUA0044	South Fork Caddo River at Fancy Hill, Arkansas	1/17/95–1/9/07	78	0.25	29.7	2.1	1.3	6	8

[a] Note that 22 of the dissolved copper observations at station OUA0023 on the Caddo River were below the detection limit (DL) of 0.5 µg/L, therefore one-half the DL was used for data analysis.
[b] Note that 20 of the dissolved copper observations at station OUA0044 on the South Fork Caddo River were below the detection limit (DL) of 0.5 µg/L, therefore one-half the DL was used for data analysis.
[c] The water quality data were compared to the chronic water quality criterion for dissolved copper, which is 4.2 µg/L.

Table A-2. Summary of dissolved zinc data for the Caddo River Basin

Pollutant	Station number	Station name	Period of record	Number of observations	Minimum	Maximum	Mean	Median	Number of observations above criterion[c]	% of observations above criterion[c]
					µg/L	µg/L	µg/L	µg/L		
Dissolved zinc[a]	OUA0023	Caddo River near Amity, Arkansas upstream of Hwy 84 bridge	1/17/95–3/20/07	73	0.5	335	25	11	14	19
Dissolved zinc[b]	OUA0044	South Fork Caddo River at Fancy Hill, Arkansas	1/17/95–1/9/07	77	0.5	138	18	11	11	14

[a] Note that seven of the dissolved zinc observations at station OUA0023 on the Caddo River were below the detection limit (DL) of 1.0 µg/L, therefore one-half the DL was used for data analysis.
[b] Note that five of the dissolved zinc observations at station OUA0044 on the South Fork Caddo River were below the detection limit (DL) of 1.0 µg/L, therefore one-half the DL was used for data analysis.
[c] The water quality data were compared to the chronic water quality criterion for dissolved zinc, which is 38.7 µg/L.

Appendix B
Water Quality Data by Sampling Location

Table B-1. Copper, zinc, and hardness data for the Caddo River Basin at station OUA0023 2
Table B-2. Copper, zinc, and hardness data for the Caddo River Basin at station OUA0044 3

Table B-1. Copper, zinc, and hardness data at station OUA0023

Date collected	Copper (µg/L)	Zinc (µg/L)	Hardness (mg/L)
1/17/1995	0.25	0.5	26
2/14/1995	0.25	0.5	16.71
3/21/1995	0.25	3.9	19
4/4/1995	0.25	0.5	37
5/30/1995	0.25	7.52	25
6/13/1995	0.25	11.3	32
8/1/1995	2.3	13.3	20
8/22/1995	2.5	14.7	14
9/19/1995	0.25	14.9	45
10/17/1995	0.25	3.3	54
11/20/1995	0.25	4.5	19
11/28/1995	0.25	2	47
1/2/1996	3.7	3.7	25
2/6/1996	0.25	2.6	45
3/12/1996	0.25	4.1	33
4/16/1996	0.25	0.5	13
5/7/1996	0.25	0.5	16
6/25/1996	0.25	2.5	36
7/30/1996	0.25	18	21
9/17/1996	0.25	7.4	21
11/5/1996	0.25	0.5	32
1/21/1997	0.25	3.1	32
7/13/1998	0.78	9.3	20.6
9/15/1998	1.62	20.2	40
11/3/1998	0.6	8.8	46
1/19/1999	0.67	8.2	31
3/2/1999	0.74	3.8	37
5/4/1999	2.16	8.2	34
7/6/1999	1.15	10.9	47
9/7/1999	5.35		46
11/2/1999	1.05	6.1	21
3/7/2000	0.25	4.4	18
5/8/2000	1.41	79.8	38
7/5/2000	2	6.4	36
9/5/2000	1.22	75.39	50
10/31/2000	1.81	7.4	55
1/9/2001	2.15	13.7	25
3/6/2001	0.7	5.4	19
5/1/2001	2.38	28	38
6/5/2001	0.25	4.7	(BDL)
7/3/2001	1.07	15.9	34
9/4/2001	0.51	8.5	51
11/6/2001	2	11.1	50
1/8/2002	0.83	5.2	35
5/14/2002	4	32.5	27
7/9/2002	1.16	28.5	52

Table B-1 (continued)

Date collected	Copper (µg/L)	Zinc (µg/L)	Hardness (mg/L)
9/10/2002	2.2	43	50
11/19/2002	1.63	80.6	54
1/28/2003	6.41	88.7	45
5/27/2003	0.98	19.1	41
7/8/2003	1.67	22.2	35
9/16/2003	2.59	56.1	41
11/4/2003	2.75	25.5	60
3/2/2004	1.83	58.1	26
5/4/2004	1.89	? 434	27
9/7/2004	0.88	80.8	406
11/9/2004	1.34	14.1	
1/4/2005	3.34	12.1	14
3/15/2005	1.69	20.7	45
5/3/2005	1.82	8.72	22
5/17/2005	0.61	0.5	51
5/17/2005	0.8	11.6	52
7/5/2005	3.68	92.6	54
9/13/2005	3.72	63.4	65
11/8/2005	2.26	10.3	72
1/17/2006	0.25	53.8	55
3/14/2006	2.17	76.3	29
5/16/2006	1.61	335	33
7/18/2006	2.46	29.8	50
8/1/2006	1.31	1.61	24
9/12/2006	1.84	6.07	47
10/31/2006	2.24	22.4	36
1/9/2007	0.93	3.04	20
3/20/2007	2.13	25.8	38
3/20/2007	3.07	16.3	22

Table B-2. Copper, zinc, and hardness data at station OUA0044

Date collected	Copper (µg/L)	Zinc (µg/L)	Hardness (mg/L)
1/17/95	0.25	7.87	17
2/14/95	0.25	7.16	20.53
3/21/95	0.25	6.6	18
4/4/95	0.25	6.2	18
5/30/95	2.49	14.6	27
6/13/95	2.02	7.14	19
8/1/95	0.25	52.8	26
8/22/95	0.25	6.7	26
9/19/95	0.25	7.5	45
10/17/95	0.25	4.9	24
11/20/95	0.25	2.8	26

Table B-2 (continued)

Date collected	Copper (µg/L)	Zinc (µg/L)	Hardness (mg/L)
11/28/95	0.25	0.5	25
12/7/95			
1/2/96	2.3	13.5	16
2/6/96	2	7.8	23
3/12/96	0.25	7.9	16
4/16/96	2.1	19.5	13
5/7/96	0.25	14.1	9
6/25/96	0.25	7.6	24
7/30/96	0.25	0.5	28
9/17/96	0.25	0.5	29
11/19/96	0.25	13.3	12
1/21/97	0.25	13	19
3/11/97	5.8	22.5	19
7/13/98	0.79	5.2	28
9/15/98	1.7	12.8	26
11/3/98	1.71	5.6	27
1/19/99	2.09	11	23
3/2/99	1.54	6.2	24
5/4/99	0.25	0.5	16
7/6/99	0.66	9.1	27
9/7/99	1.17		26
11/2/99	0.77	13.2	25
3/7/00	1.15	16	16
5/8/00	1.18	19.8	23
7/5/00	1.5	3.8	21
9/5/00	0.74	18.08	20
10/31/00	0.6	11.4	26
3/6/01	0.91	12.9	16
5/1/01	1.3	8.4	22
7/3/01	0.94	14.4	23
9/4/01	0.61	5.4	23
11/6/01	1.4	6.4	22
1/8/02	0.95	12.1	25
5/14/02	3.88	22.6	18
7/9/02	2.87	45.3	23
9/10/02	2.21	20.8	21
11/19/02	5.71	57.3	24
1/28/03	15.4	54.7	27
3/18/03	29.7	90.2	22
5/27/03	2.35	24.4	20
7/8/03	1.98	29.2	24
9/16/03	1.83	39.2	24
11/4/03	1.19	8.43	24
3/2/04	1.93	10.6	20
9/7/04	2.21	9.52	23

Table B-2 (continued)

Date collected	Copper (µg/L)	Zinc (µg/L)	Hardness (mg/L)
11/9/04	4.02	81.5	
1/4/05	4.98	26.7	9
3/15/05	1.68	15	21
5/2/05	0.84	2.87	16
5/3/05	2.45	10.5	21
5/17/05	0.51	2.22	21
5/17/05	0.86	5.05	21
6/27/05	2.07	2.71	20
7/5/05	3.8	19.3	22
9/13/05	1.84	24.5	20
11/8/05	1.85	12.5	29
1/17/06	0.25	18.6	24
3/13/06	1.33	2.55	19
3/14/06	2.16	47.4	19
5/8/06	0.88	3.15	18
5/16/06	2.9	39.9	17
7/18/06	3.37	138	24
8/1/06	1.18	1.12	24
8/7/06	8.31	0.5	20
9/12/06	2.85	85.8	19
10/31/06	2.96	13.6	18
11/6/06	2.13	5.86	11
1/9/07	0.25	15	17

Appendix C
Dissolved Copper Figures for the Caddo River Basin

Figure C-1. Time series dissolved copper observations at the Caddo River near Amity, Arkansas, upstream of Highway 84 bridge (station OUA0023)..... 2
Figure C-2. Seasonal dissolved copper observations at the Caddo River near Amity, Arkansas, upstream of Highway 84 bridge (station OUA0023)..... 3
Figure C-3. Dissolved copper versus flow at the Caddo River near Amity, Arkansas, upstream of Hwy 84 bridge (station OUA0023). 4
Figure C-4. Time series dissolved copper observations at the South Fork Caddo River at Fancy Hill, Arkansas (station OUA0044). 5
Figure C-5. Seasonal dissolved copper observations at the South Fork Caddo River at Fancy Hill, Arkansas (station OUA0044). 6
Figure C-6. Dissolved copper versus flow at the South Fork Caddo River at Fancy Hill, Arkansas (station OUA0044)..... 7

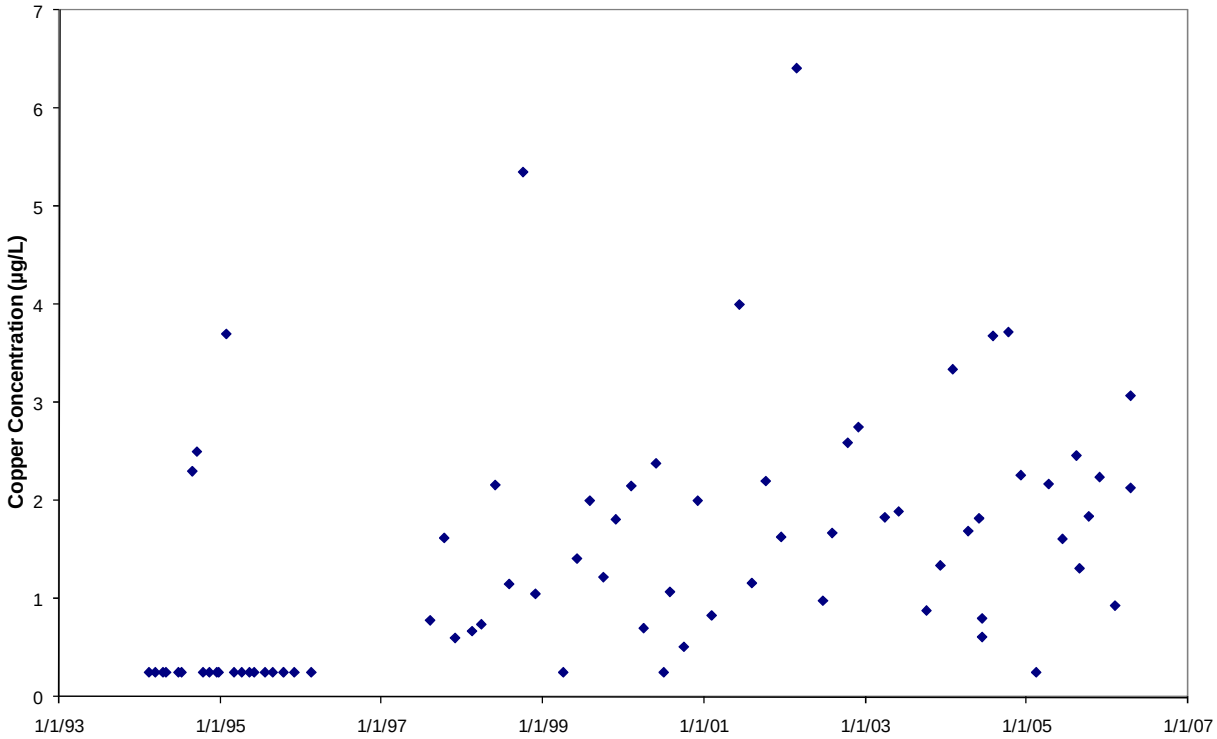

Figure C-1. Time series dissolved copper observations at the Caddo River near Amity, Arkansas, upstream of Highway 84 bridge (station OUA0023).

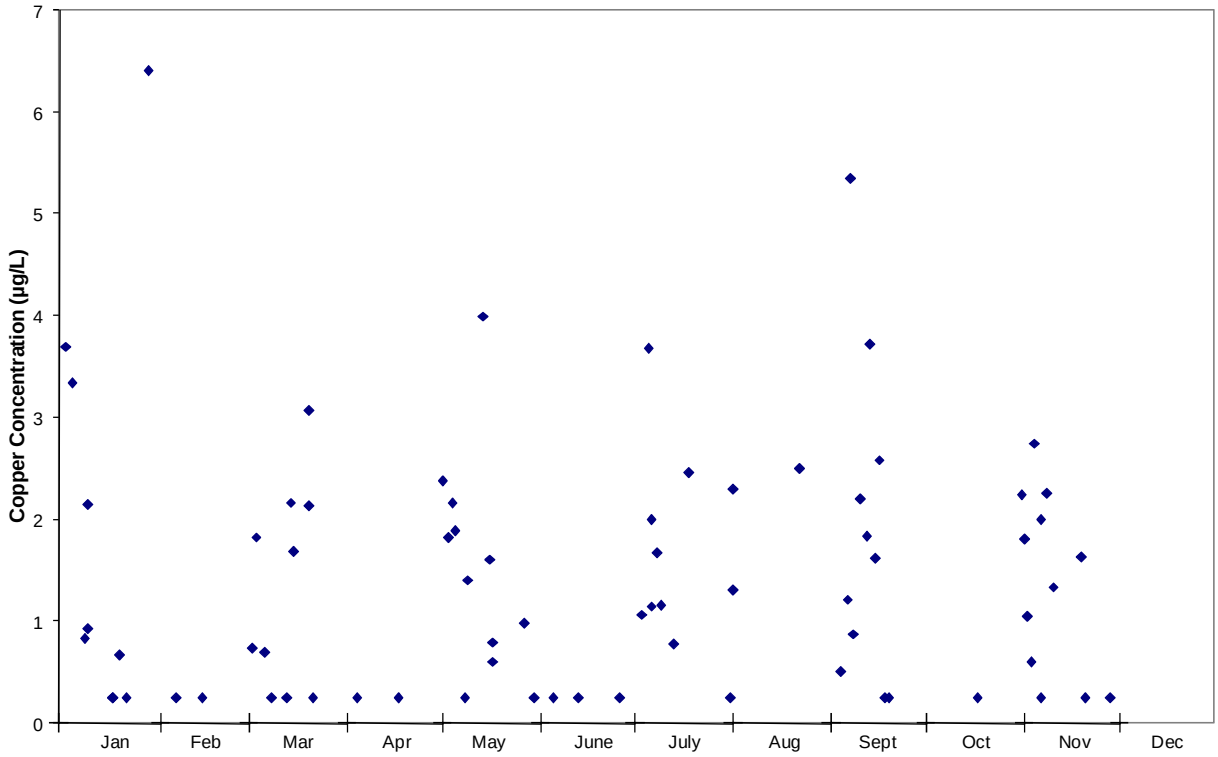

Figure C-2. Seasonal dissolved copper observations at the Caddo River near Amity, Arkansas, upstream of Highway 84 bridge (station OUA0023).

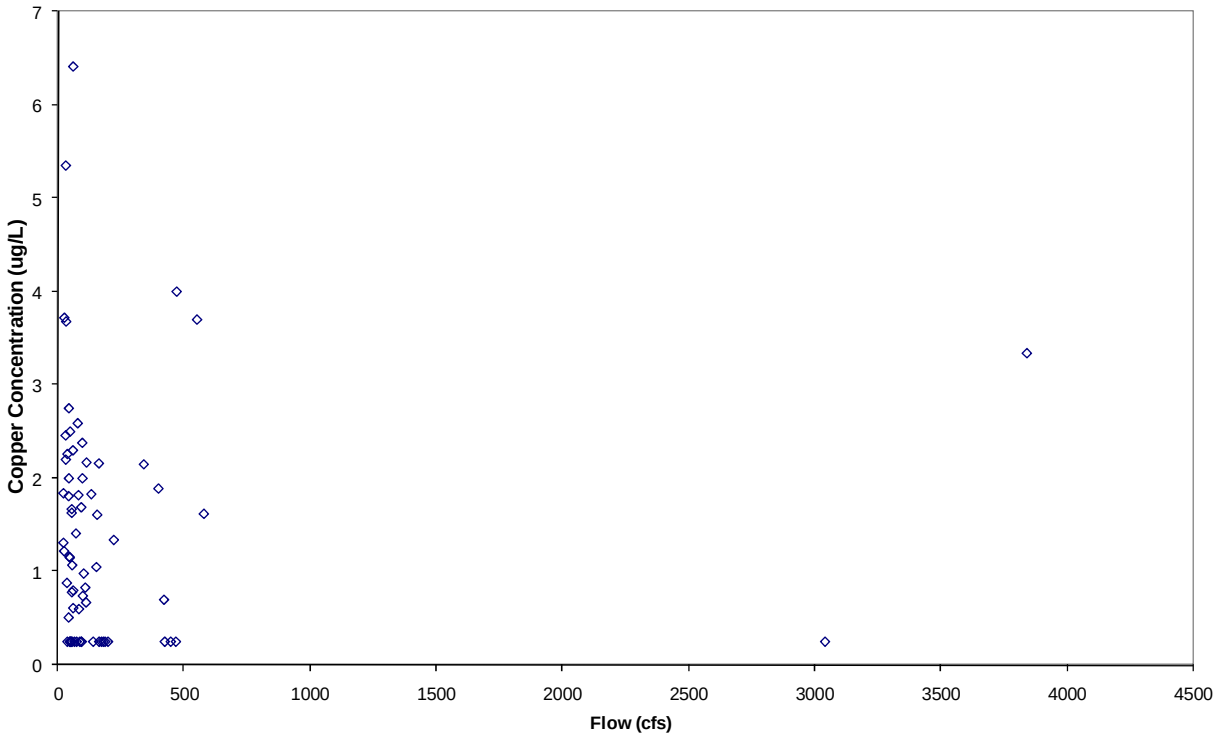

Figure C-3. Dissolved copper versus flow at the Caddo River near Amity, Arkansas, upstream of Highway 84 bridge (station OUA0023).

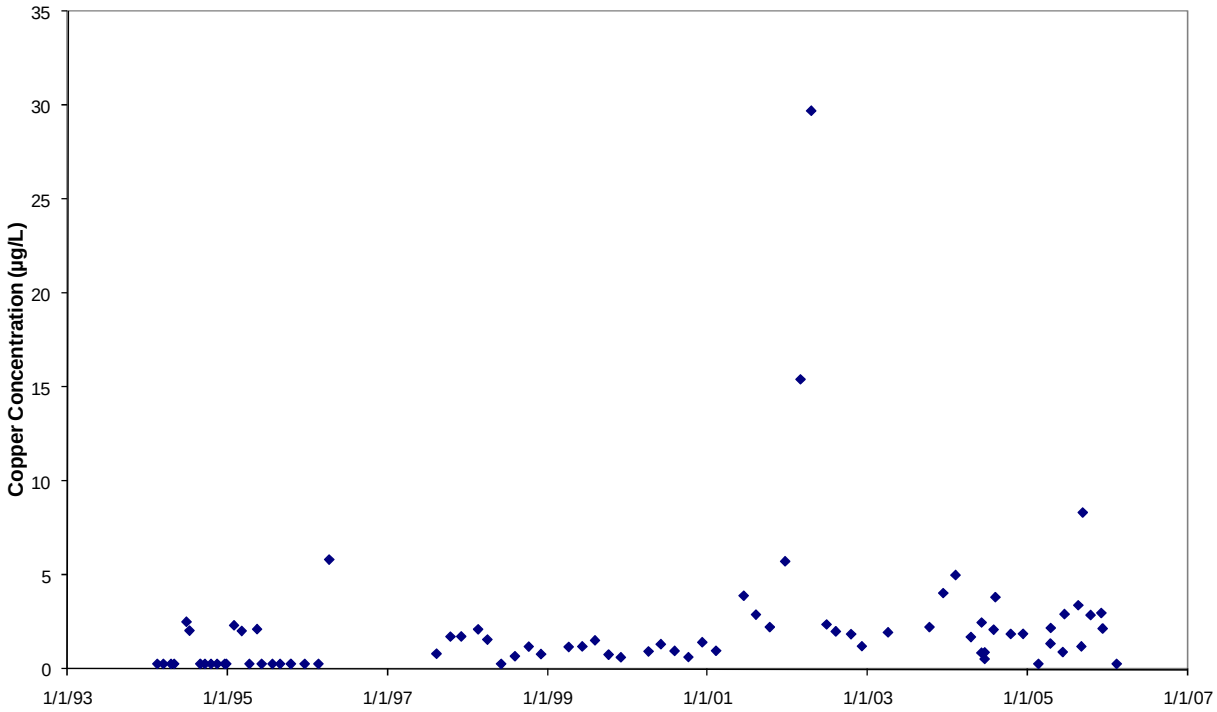

Figure C-4. Time series dissolved copper observations at the South Fork Caddo River at Fancy Hill, Arkansas (station OUA0044).

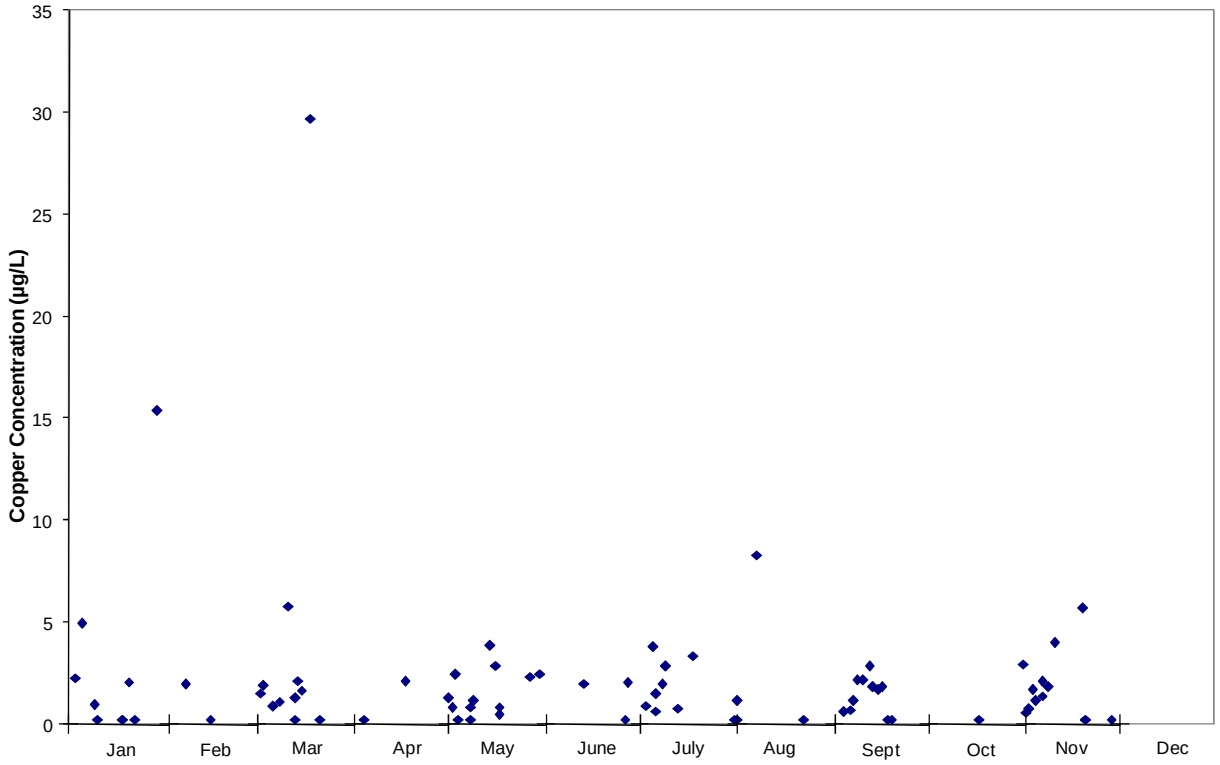

Figure C-5. Seasonal dissolved copper observations at the South Fork Caddo River at Fancy Hill, Arkansas (station OUA0044).

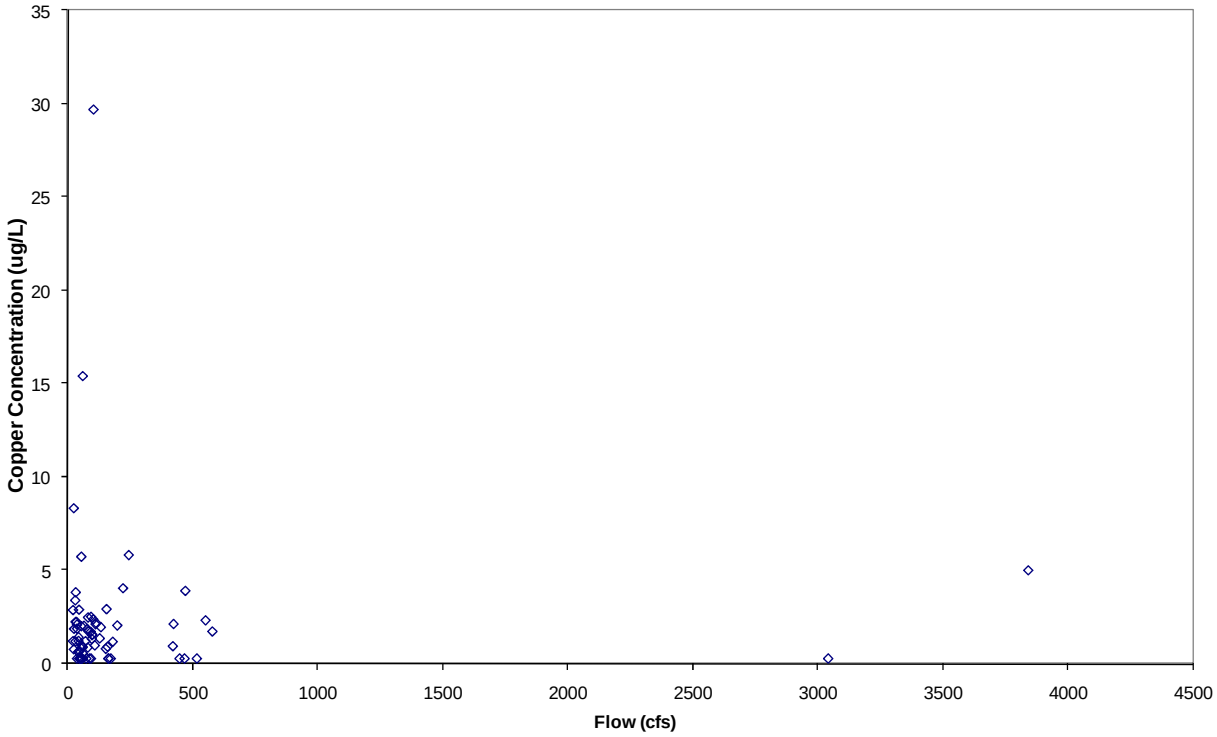

Figure C-6. Dissolved copper versus flow at the South Fork Caddo River at Fancy Hill, Arkansas (station OUA0044).

Appendix D
Dissolved Zinc Figures for the Caddo River Basin

Figure D-1. Time series dissolved zinc observations at the Caddo River near Amity, Arkansas, upstream of Highway 84 bridge (station OUA0023). 2
Figure D-2. Seasonal dissolved zinc observations at the Caddo River near Amity, Arkansas, upstream of Hwy 84 bridge (station OUA0023). 3
Figure D-3. Dissolved zinc versus flow at the Caddo River near Amity, Arkansas, upstream of Highway 84 bridge (station OUA0023). 4
Figure D-4. Time series dissolved zinc observations at the South Fork Caddo River at Fancy Hill, Arkansas (station OUA0044). 5
Figure D-5. Seasonal dissolved zinc observations at the South Fork Caddo River at Fancy Hill, Arkansas (station OUA0044). 6
Figure D-6. Dissolved Zinc versus flow at the South Fork Caddo River at Fancy Hill, Arkansas (station OUA0044). 7

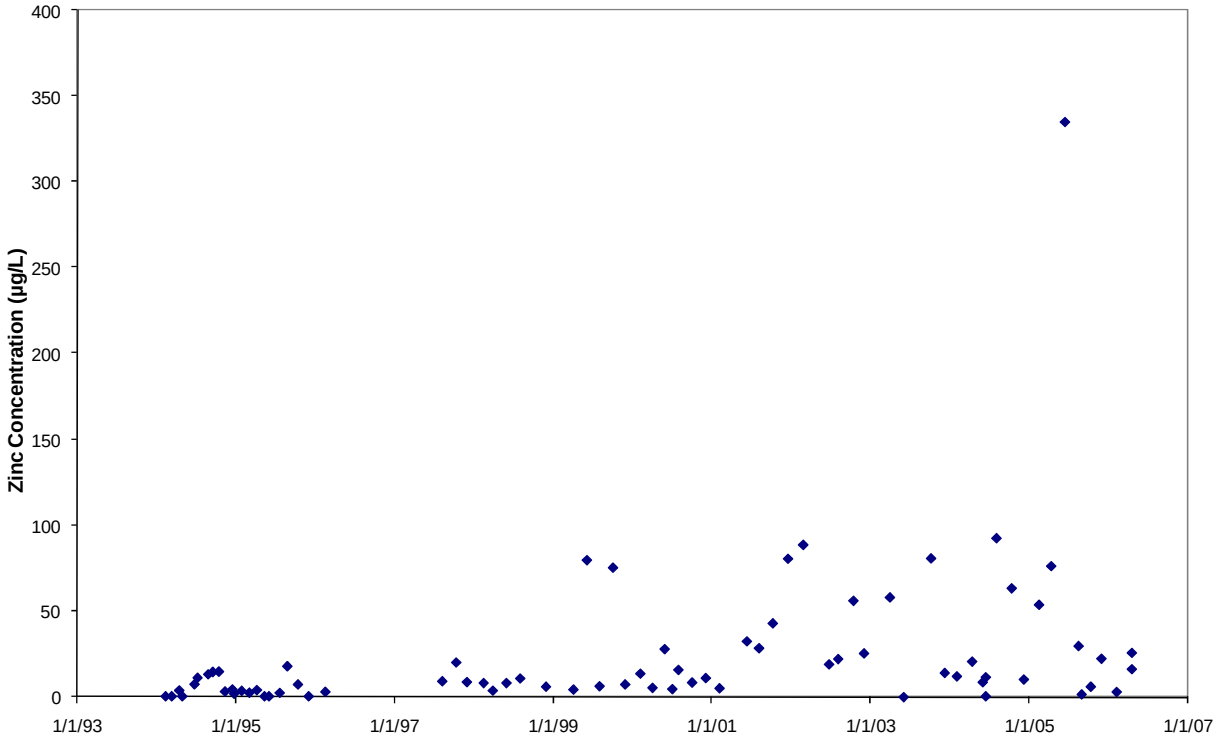

Figure D-1. Time series dissolved zinc observations at the Caddo River near Amity, Arkansas, upstream of Highway 84 bridge (station OUA0023).

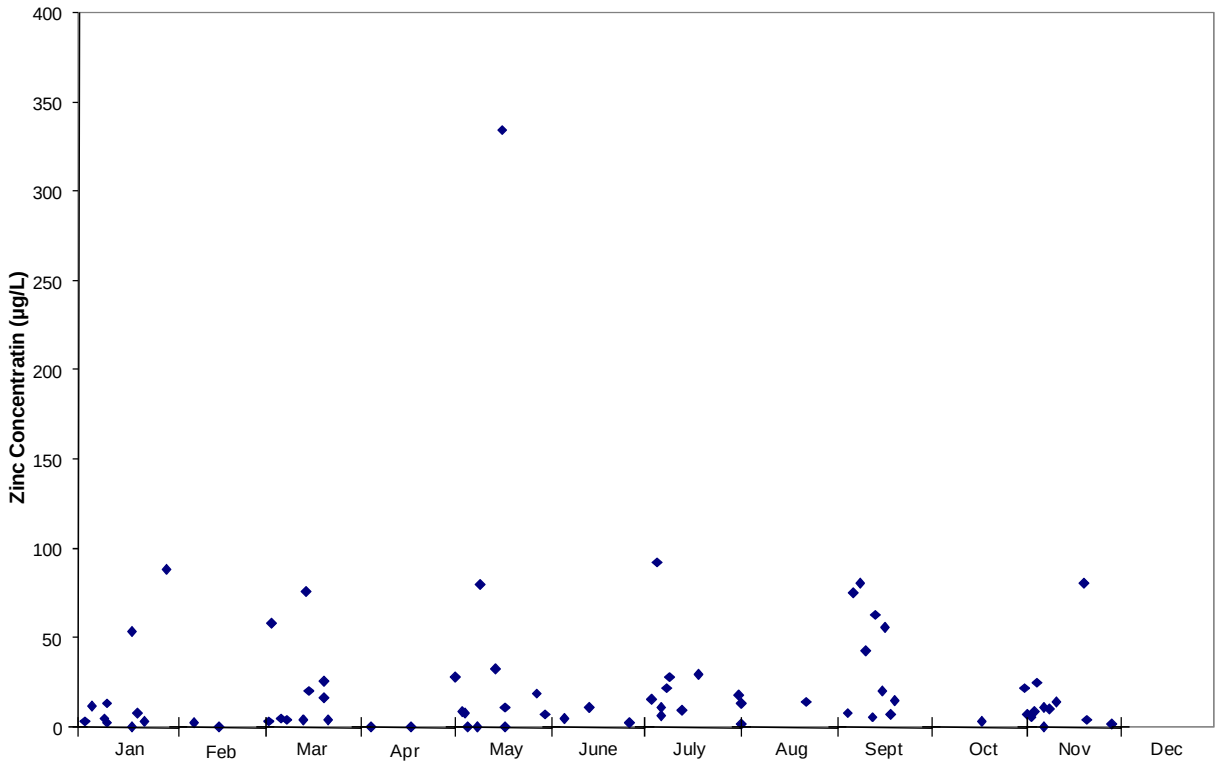

Figure D-2. Seasonal dissolved zinc observations at the Caddo River near Amity, Arkansas, upstream of Highway 84 bridge (station OUA0023).

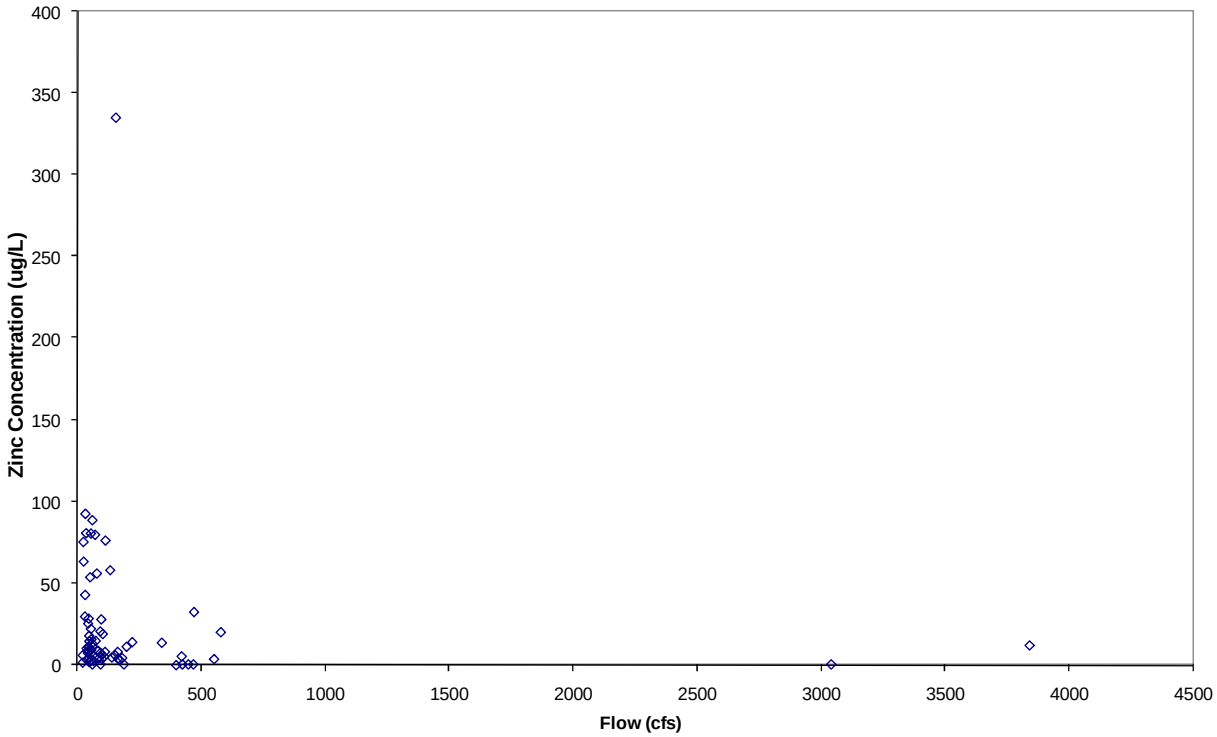

Figure D-3. Dissolved zinc versus flow at the Caddo River near Amity, Arkansas, upstream of Highway 84 bridge (station OUA0023).

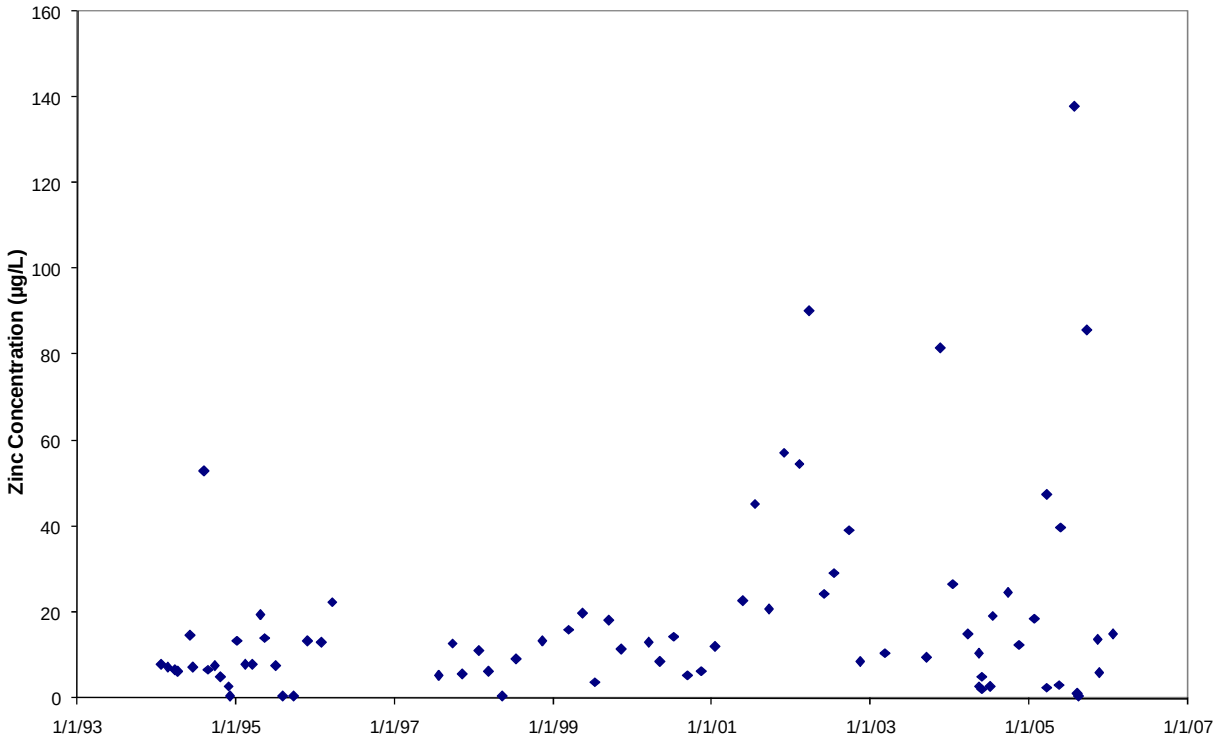

Figure D-4. Time series dissolved zinc observations at the South Fork Caddo River at Fancy Hill, Arkansas (station OUA0044).

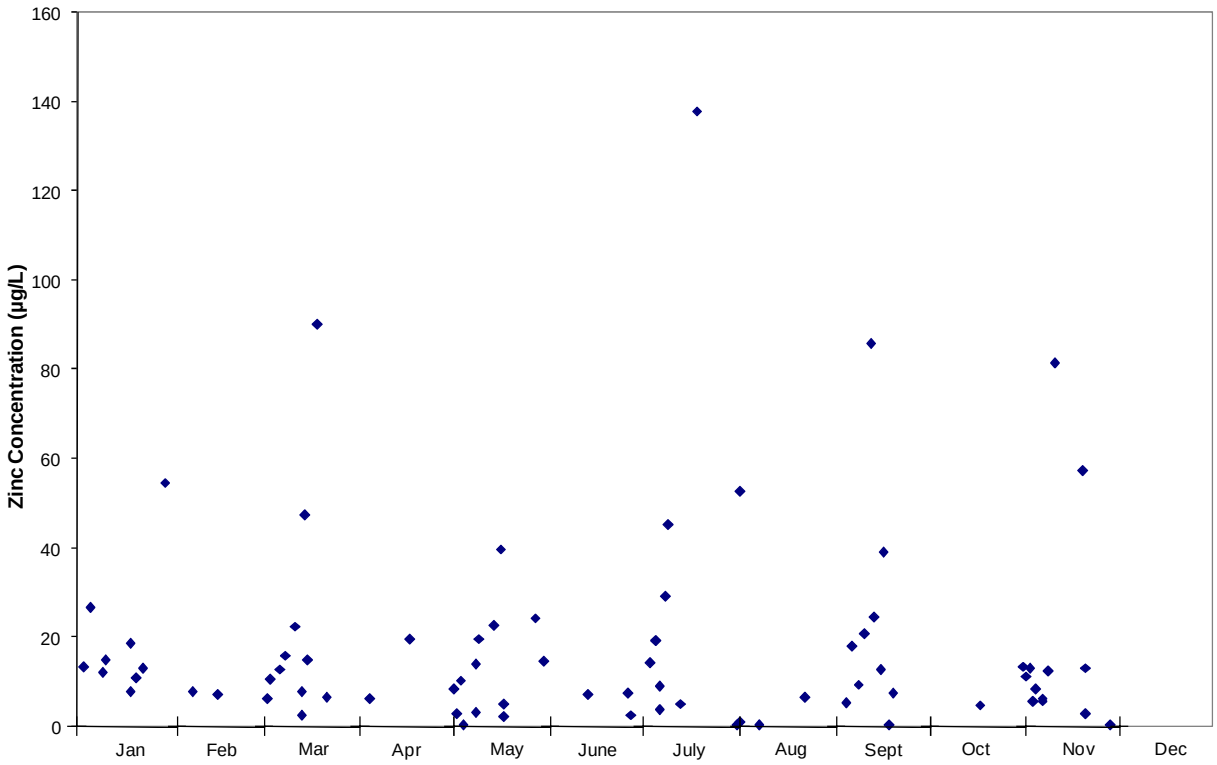

Figure D-5. Seasonal dissolved zinc observations at the South Fork Caddo River at Fancy Hill, Arkansas (station OUA0044).

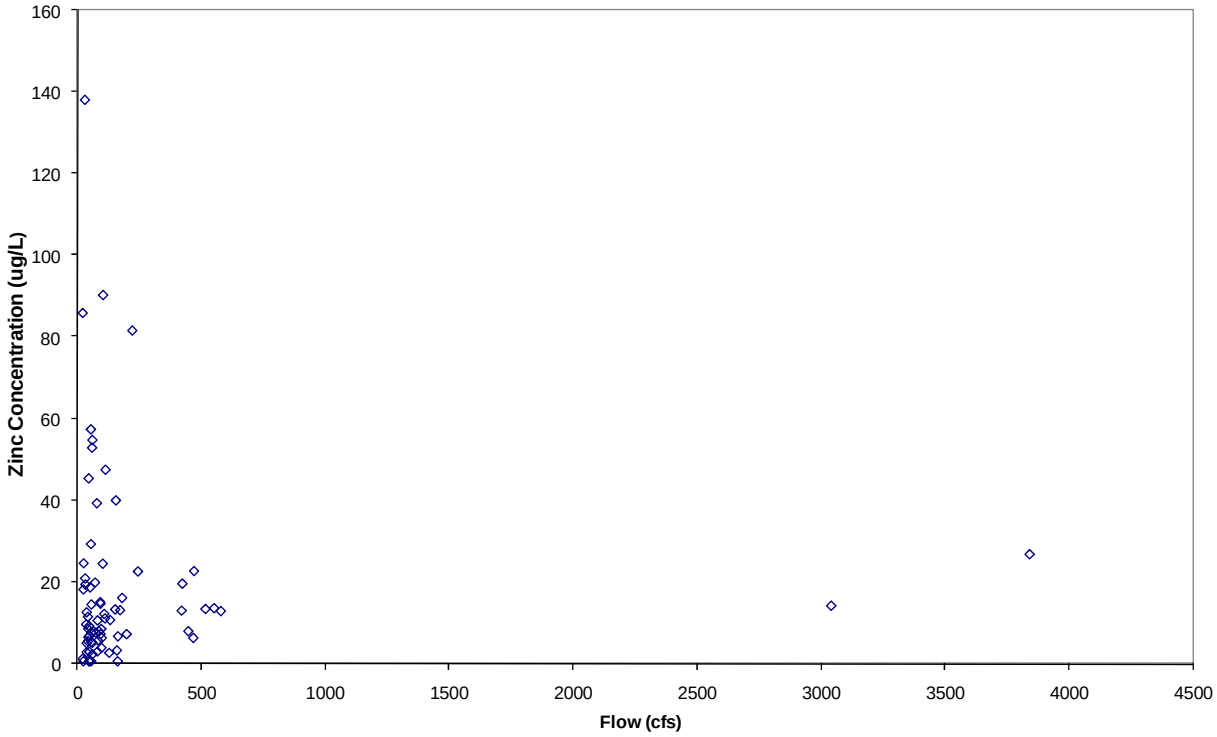

Figure D-6. Dissolved zinc versus flow at the South Fork Caddo River at Fancy Hill, Arkansas (station OUA0044).

Appendix E
Flow Duration Curves for the Caddo River Basin

Figure E-1. Flow duration curve for HUC-reach 08040102-016 in the Caddo River Basin. 2
Figure E-2. Flow duration curve for HUC-reach 08040102-018 in the Caddo River Basin. 2
Figure E-3. Flow duration curve for HUC-reach 08040102-019 in the Caddo River Basin. 3
Figure E-4. Flow duration curve for HUC-reach 08040102-023 in the Caddo River Basin. 3

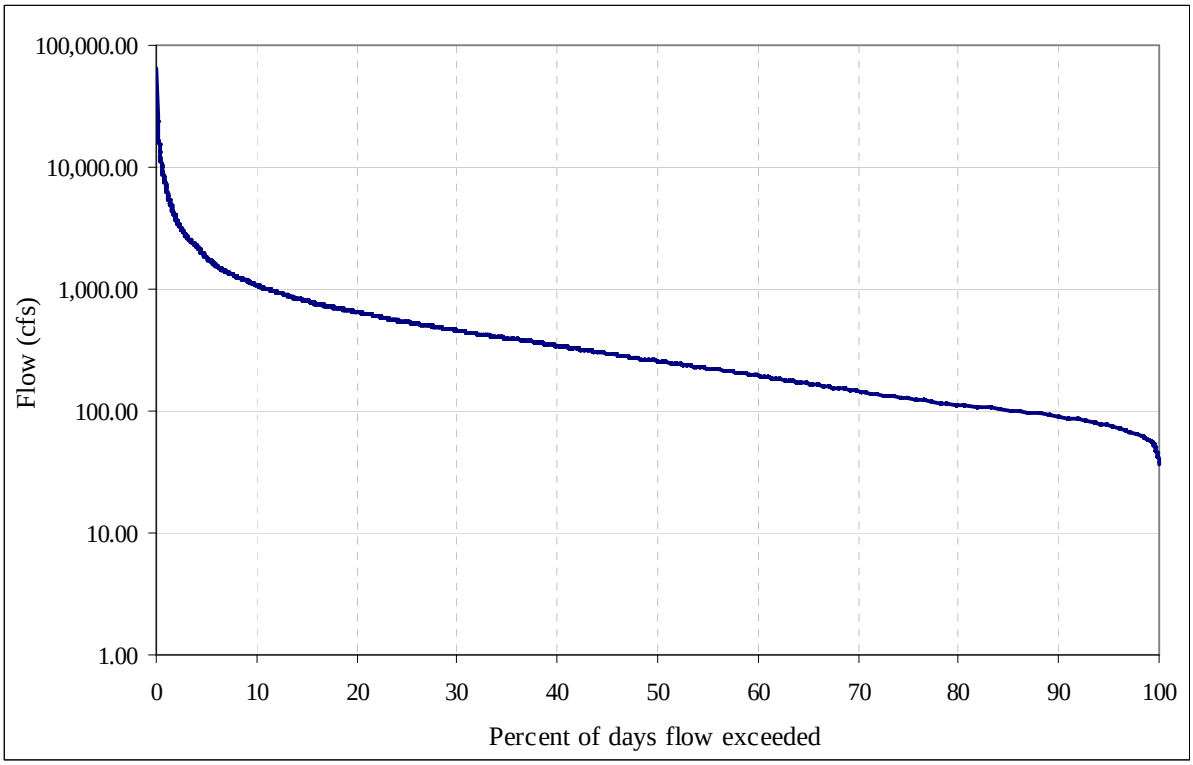

Figure E-1. Flow duration curve for HUC-reach 08040102-016 in the Caddo River Basin.

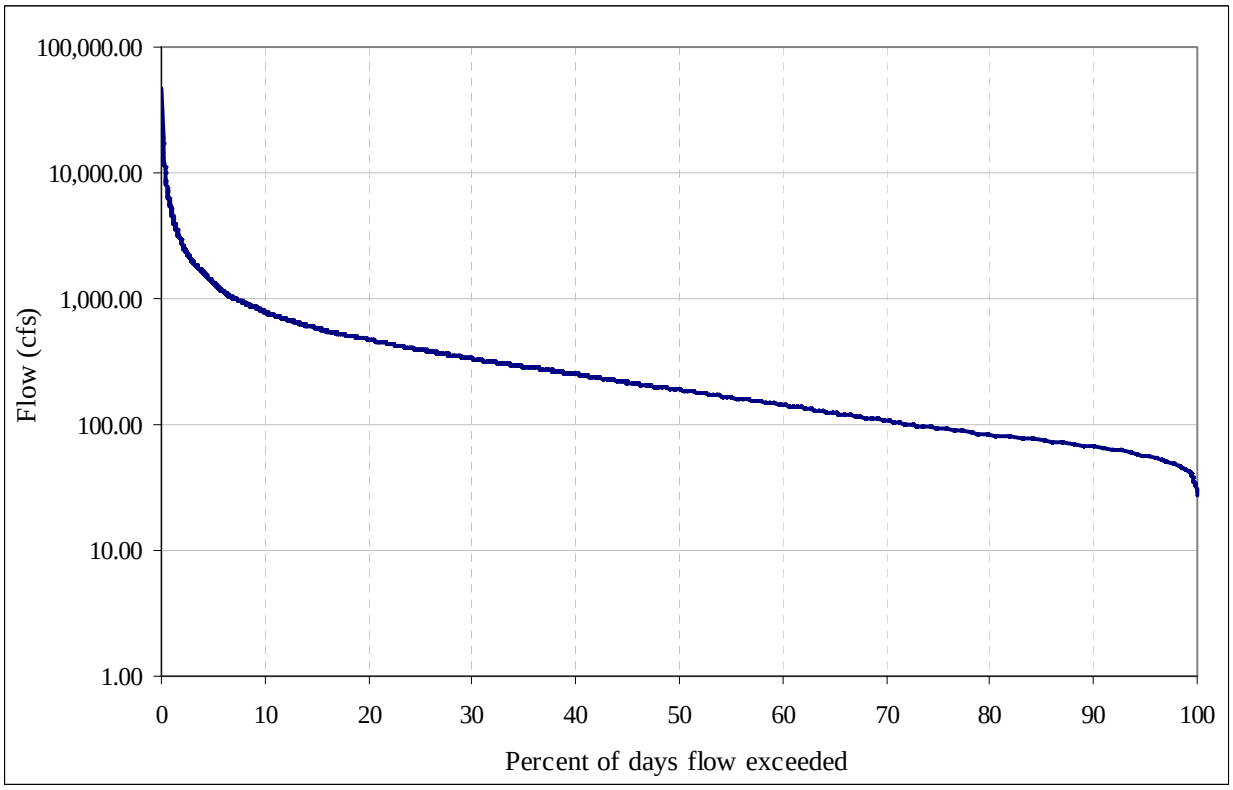

Figure E-2. Flow duration curve for HUC-reach 08040102-018 in the Caddo River Basin.

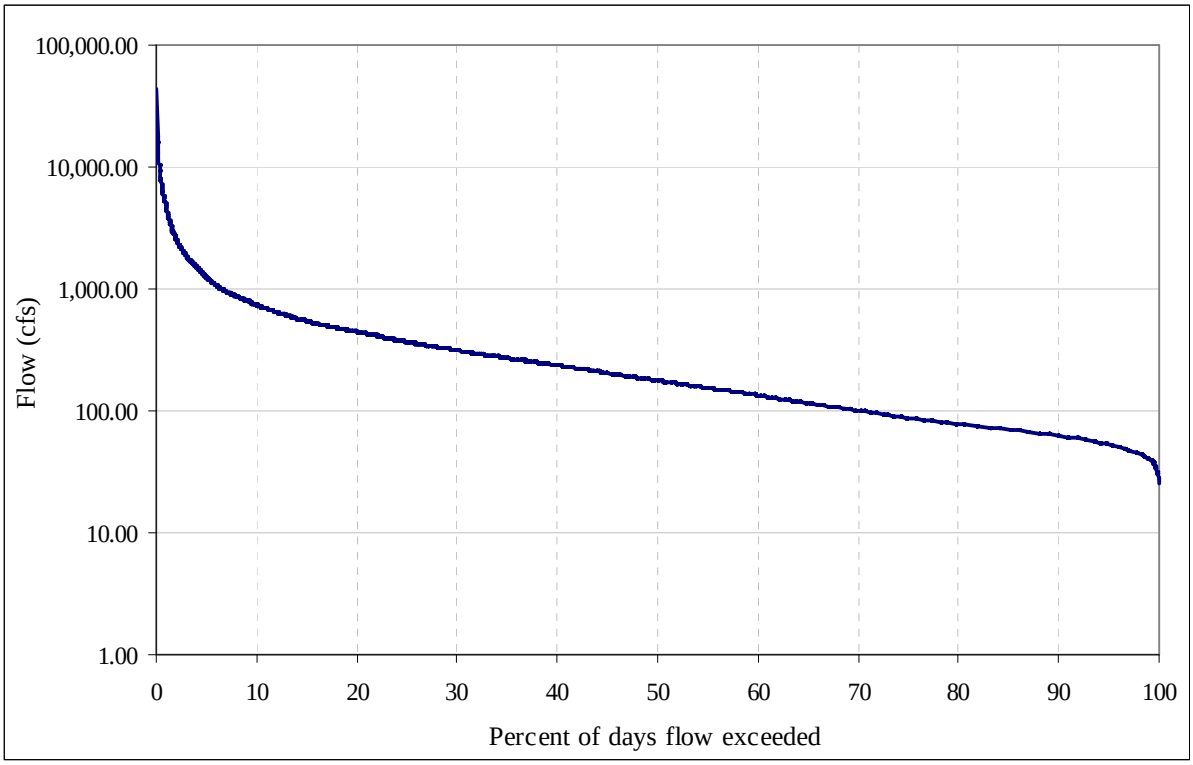

Figure E-3. Flow duration curve for HUC-reach 08040102-019 in the Caddo River Basin.

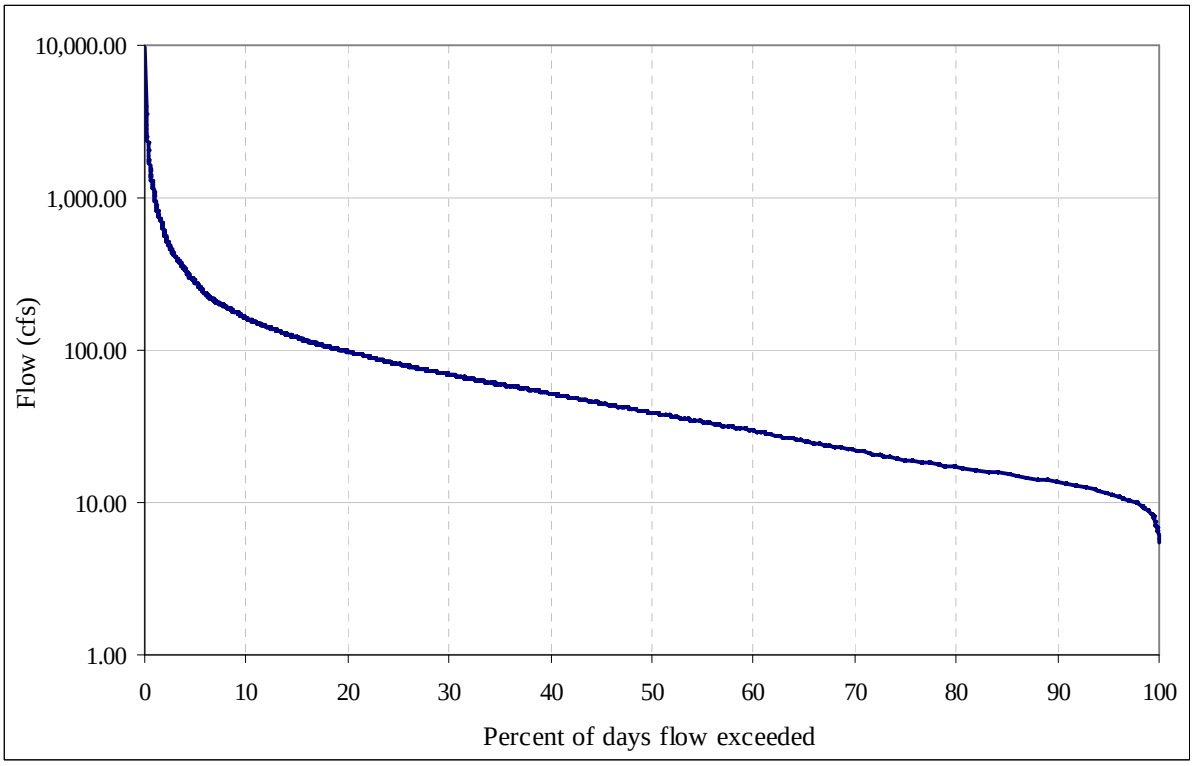

Figure E-4. Flow duration curve for HUC-reach 08040102-023 in the Caddo River Basin.

Appendix F
Load Duration Curve Calculations for All TMDLs (CD-ROM)

This appendix contains extremely large files, which are included only on a CD-ROM. To obtain a copy of this appendix, please contact EPA.

Appendix G
Load Duration Curve Summaries and Plots for Copper

Figure G-1. Copper load duration curve for station OUA0023 for Caddo River (HUC-reach 08040102-016) 2
Figure G-2. Copper load duration curve for station OUA0044 for South Fork Caddo River (HUC-reach 08040102-023) 4
Figure G-3 Copper load duration curve for Caddo River (HUC-reach 08040102-018) 8
Figure G-4 Copper load duration curve for Caddo River (HUC-reach 08040102-019) 9

Table G-1. Allowable copper load for station OUA0023 for Caddo River (HUC-reach 08040102-016) 2
Table G-2. Existing load for copper for station OUA0023 for Caddo River (HUC-reach 08040102-016) 3
Table G-3. Allowable copper load for station OUA0044 for South Fork Caddo River (HUC-reach 08040102-023) 5
Table G-4. Existing load station OUA0044 for South Fork Caddo River (HUC-reach 08040102-023) 6
Table G-5. Allowable copper load for Caddo River (HUC-reach 08040102-018) 8
Table G-6. Allowable copper load for Caddo River (HUC-reach 08040102-019) 9

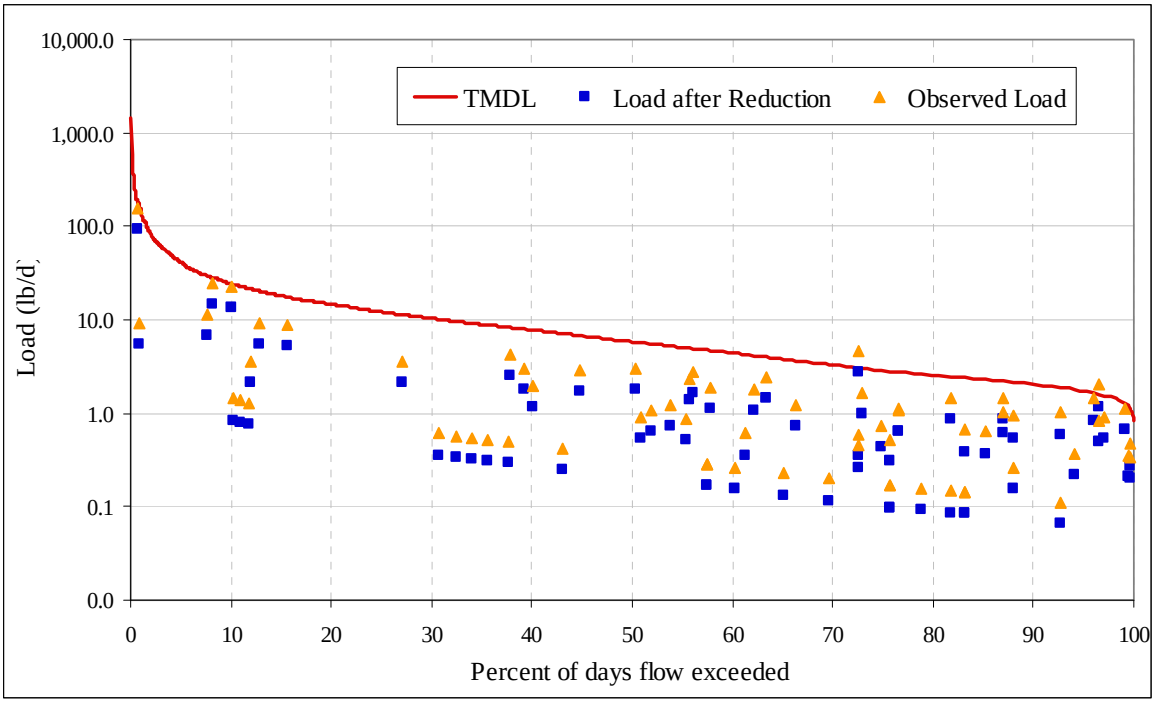

Figure G-1. Copper load duration curve for station OUA0023 for Caddo River (HUC-reach 08040102-016)

Table G-1. Allowable copper load for station OUA0023 for Caddo River (HUC-reach 08040102-016)

Date	Observed flow (cfs)	Percent exceedance for observed flow	Adjusted flow for entire basin (cfs)	Width for area under curves (%)	Allowable load to meet standard (lb/day)	Area under TMDL curve (lb/day)
						13.30
08/19/06	16	100	36.13	0.00	0.82	0.00
08/11/06	17	100	38.39	0.00	0.87	0.00
08/18/06	17	100	38.39	0.00	0.87	0.00
08/20/06	17	100	38.39	0.00	0.87	0.00
09/11/06	17	100	38.39	0.00	0.87	0.00
09/16/06	17	100	38.39	0.00	0.87	0.00
08/03/06	18	100	40.65	0.00	0.92	0.00
08/21/06	18	100	40.65	0.00	0.92	0.00
09/09/06	18	100	40.65	0.00	0.92	0.00
09/10/06	18	100	40.65	0.00	0.92	0.00
09/15/06	18	100	40.65	0.00	0.92	0.00
09/17/06	18	100	40.65	0.10	0.92	0.00
Fro brevity, most cells have been hidden.						
03/18/04	8210	0.1	18,540.72	0.00	420.02	0.00
03/20/06	8660	0.1	19,556.95	0.00	443.04	0.00
11/24/96	10500	0.1	23,712.24	0.00	537.17	0.00
02/16/01	10500	0.1	23,712.24	0.00	537.17	0.00
03/08/90	11600	0.1	26,196.38	0.10	593.45	0.59
12/03/93	28600	0	64,587.63	0.00	1,463.16	0.00

Table G-2. Existing load for copper for station OUA0023 for Caddo River (HUC-reach 08040102-016)

Date	Observed Concentration (mg/L)	Flow/unit area on sampling day (cfs)	Percent exceedance for flow on sampling day	Current load (lbs/day)	Reduced load (lbs/day)	Allowable load with MOS incorporated (lbs/day)	Reduced load less than or equal to allow load?
01/28/03	0.00641	135.50	72.5	4.68	2.76	2.76	Yes
09/07/99	0.00535	70.01	96.5	2.02	1.19	1.43	Yes
05/14/02	0.004	1,061.41	10.1	22.90	13.50	21.64	Yes
09/13/05	0.00372	56.46	99.2	1.13	0.67	1.15	Yes
01/02/96	0.0037	1,244.33	8.2	24.83	14.64	25.37	Yes
07/05/05	0.00368	72.27	96	1.43	0.85	1.47	Yes
01/04/05	0.00334	8,671.91	0.7	156.23	92.13	176.81	Yes
11/04/03	0.00275	97.11	86.9	1.44	0.85	1.98	Yes
09/16/03	0.00259	176.15	63.4	2.46	1.45	3.59	Yes
08/22/95	0.0025	108.40	81.8	1.46	0.86	2.21	Yes
07/18/06	0.00246	67.75	97	0.90	0.53	1.38	Yes
05/01/01	0.00238	216.80	56.1	2.78	1.64	4.42	Yes
08/01/95	0.0023	133.24	72.9	1.65	0.97	2.72	Yes
11/08/05	0.00226	83.56	92.7	1.02	0.60	1.70	Yes
09/10/02	0.0022	70.01	96.5	0.83	0.49	1.43	Yes
03/14/06	0.00217	255.19	50.3	2.99	1.76	5.20	Yes
05/04/99	0.00216	365.85	37.8	4.26	2.51	7.46	Yes
01/09/01	0.00215	767.83	15.7	8.90	5.25	15.65	Yes
07/05/00	0.002	219.06	55.7	2.36	1.39	4.47	Yes
11/06/01	0.002	97.11	86.9	1.05	0.62	1.98	Yes
05/04/04	0.00189	898.81	12.8	9.16	5.40	18.33	Yes
09/12/06	0.00184	47.42	99.7	0.47	0.28	0.97	Yes
03/02/04	0.00183	298.10	44.8	2.94	1.74	6.08	Yes
05/03/05	0.00182	182.92	62.1	1.80	1.06	3.73	Yes
10/31/00	0.00181	94.85	88.1	0.93	0.55	1.93	Yes
03/15/05	0.00169	207.76	57.8	1.89	1.12	4.24	Yes
07/08/03	0.00167	121.95	76.5	1.10	0.65	2.49	Yes
11/19/02	0.00163	121.95	76.5	1.07	0.63	2.49	Yes
09/15/98	0.00162	1,305.30	7.7	11.41	6.73	26.61	Yes
05/16/06	0.00161	350.04	39.3	3.04	1.79	7.14	Yes
05/08/00	0.00141	160.34	66.4	1.22	0.72	3.27	Yes
11/09/04	0.00134	499.09	27.1	3.61	2.13	10.18	Yes
08/01/06	0.00131	47.42	99.7	0.34	0.20	0.97	Yes
09/05/00	0.00122	54.20	99.5	0.36	0.21	1.11	Yes
07/09/02	0.00116	101.62	85.2	0.64	0.37	2.07	Yes
07/06/99	0.00115	106.14	83.2	0.66	0.39	2.16	Yes
07/03/01	0.00107	126.47	74.9	0.73	0.43	2.58	Yes
11/02/99	0.00105	343.26	40.1	1.94	1.15	7.00	Yes
05/27/03	0.00098	230.35	53.8	1.22	0.72	4.70	Yes
09/07/04	0.00088	79.04	94.1	0.38	0.22	1.61	Yes
01/08/02	0.00083	243.90	51.9	1.09	0.64	4.97	Yes
05/17/05	0.0008	135.50	72.5	0.58	0.34	2.76	Yes
07/13/98	0.00078	124.21	75.7	0.52	0.31	2.53	Yes
03/02/99	0.00074	221.31	55.4	0.88	0.52	4.51	Yes
03/06/01	0.0007	948.49	11.9	3.58	2.11	19.34	Yes
01/19/99	0.00067	250.67	50.8	0.91	0.53	5.11	Yes
05/17/05	0.00061	135.50	72.5	0.45	0.26	2.76	Yes
11/03/98	0.0006	187.44	61.3	0.61	0.36	3.82	Yes
09/04/01	0.00051	94.85	88.1	0.26	0.15	1.93	Yes
01/17/95	0.00025	1,009.46	10.9	1.36	0.80	20.58	Yes
02/14/95	0.00025	210.02	57.4	0.28	0.17	4.28	Yes
03/21/95	0.00025	368.10	37.7	0.50	0.29	7.51	Yes
04/04/95	0.00025	1,054.63	10.2	1.42	0.84	21.50	Yes
05/30/95	0.00025	210.02	57.4	0.28	0.17	4.28	Yes
06/13/95	0.00025	447.15	30.7	0.60	0.36	9.12	Yes
09/19/95	0.00025	167.11	65.1	0.23	0.13	3.41	Yes

Table G-2 Continued.

10/17/95	0.00025	83.56	92.7	0.11	0.07	1.70	Yes
11/20/95	0.00025	108.40	81.8	0.15	0.09	2.21	Yes
11/28/95	0.00025	106.14	83.2	0.14	0.08	2.16	Yes
02/06/96	0.00025	146.79	69.7	0.20	0.12	2.99	Yes
03/12/96	0.00025	194.21	60.3	0.26	0.15	3.96	Yes
04/16/96	0.00025	955.26	11.8	1.29	0.76	19.48	Yes
05/07/96	0.00025	6,865.26	0.9	9.26	5.46	139.97	Yes
06/25/96	0.00025	124.21	75.7	0.17	0.10	2.53	Yes
07/30/96	0.00025	106.14	83.2	0.14	0.08	2.16	Yes
09/17/96	0.00025	124.21	75.7	0.17	0.10	2.53	Yes
11/05/96	0.00025	422.30	32.5	0.57	0.34	8.61	Yes
01/21/97	0.00025	388.43	35.6	0.52	0.31	7.92	Yes
03/07/00	0.00025	406.50	34.1	0.55	0.32	8.29	Yes
06/05/01	0.00025	313.90	43.1	0.42	0.25	6.40	Yes
01/17/06	0.00025	115.17	78.8	0.16	0.09	2.35	Yes

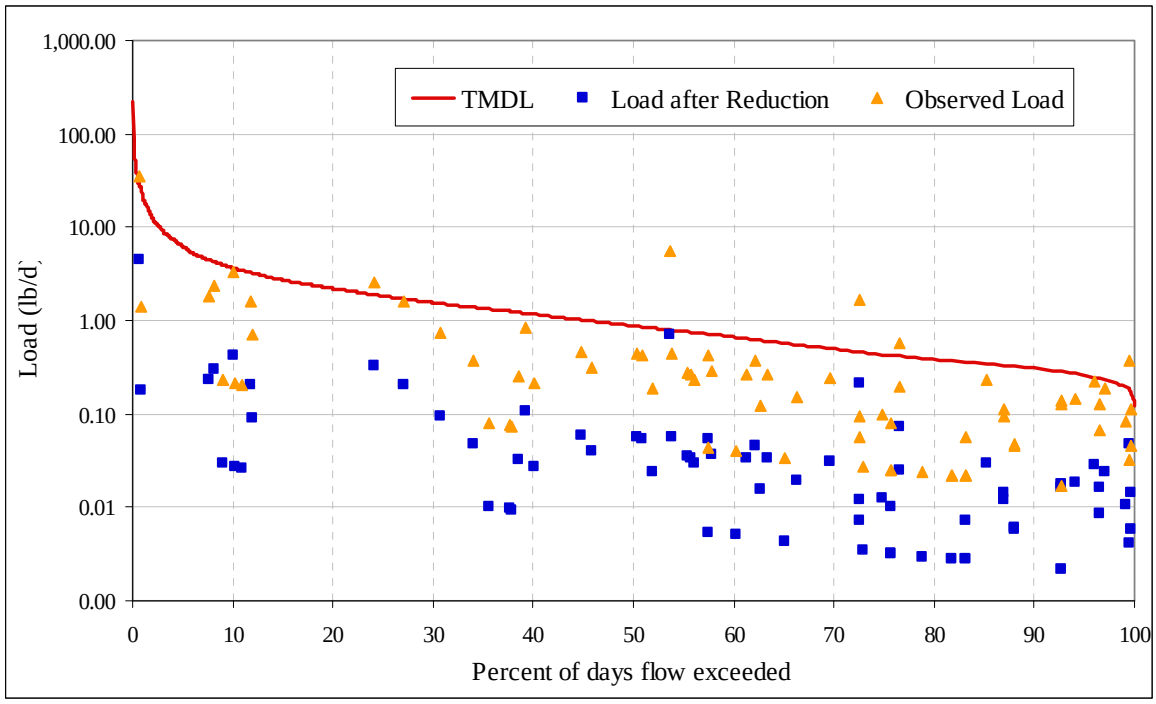

Figure G-2. Copper load duration curve for station OUA0044 for South Fork Caddo River (HUC-reach 08040102-023)

Table G-3. Allowable copper load for station OUA0044 for South Fork Caddo River (HUC-reach 08040102-023)

Date	Observed flow (cfs)	Percent exceedance for observed flow	Adjusted flow for entire basin (cfs)	Width for area under curves (%)	Allowable load to meet standard (lb/day)	Area under TMDL curve (lb/day)
						2.01
08/19/06	16	100	5.46	0.00	0.12	0.00
08/11/06	17	100	5.80	0.00	0.13	0.00
08/18/06	17	100	5.80	0.00	0.13	0.00
08/20/06	17	100	5.80	0.00	0.13	0.00
09/11/06	17	100	5.80	0.00	0.13	0.00
09/16/06	17	100	5.80	0.00	0.13	0.00
08/03/06	18	100	6.14	0.00	0.14	0.00
08/21/06	18	100	6.14	0.00	0.14	0.00
09/09/06	18	100	6.14	0.00	0.14	0.00
09/10/06	18	100	6.14	0.00	0.14	0.00
09/15/06	18	100	6.14	0.00	0.14	0.00
09/17/06	18	100	6.14	0.10	0.14	0.00
Fro brevity, most cells have been hidden.						
03/18/04	8210	0.1	2,799.25	0.00	63.41	0.00
03/20/06	8660	0.1	2,952.68	0.00	66.89	0.00
11/24/96	10500	0.1	3,580.04	0.00	81.10	0.00
02/16/01	10500	0.1	3,580.04	0.00	81.10	0.00
03/08/90	11600	0.1	3,955.09	0.10	89.60	0.09
12/03/93	28600	0	9,751.34	0.00	220.91	0.00

Table G-4. Existing load station OUA0044 for South Fork Caddo River (HUC-reach 08040102-023)

Date	Observed Concentration (mg/L)	Flow/unit area on sampling day (cfs)	Percent exceedance for flow on sampling day	Current load (lbs/day)	Reduced load (lbs/day)	Allowable load with MOS incorporated (lbs/day)	Reduced load less than or equal to allow load?
03/18/03	0.0297	35.12	53.6	5.63	0.72	0.72	Yes
01/28/03	0.0154	20.46	72.5	1.70	0.22	0.42	Yes
08/07/06	0.00831	8.18	99.5	0.37	0.05	0.17	Yes
03/11/97	0.0058	83.19	24.1	2.60	0.33	1.70	Yes
11/19/02	0.00571	18.41	76.5	0.57	0.07	0.38	Yes
01/04/05	0.00498	1,309.27	0.7	35.17	4.48	26.69	Yes
11/09/04	0.00402	75.35	27.1	1.63	0.21	1.54	Yes
05/14/02	0.00388	160.25	10.1	3.35	0.43	3.27	Yes
07/05/05	0.0038	10.91	96	0.22	0.03	0.22	Yes
07/18/06	0.00337	10.23	97	0.19	0.02	0.21	Yes
05/16/06	0.0029	52.85	39.3	0.83	0.11	1.08	Yes
07/09/02	0.00287	15.34	85.2	0.24	0.03	0.31	Yes
09/12/06	0.00285	7.16	99.7	0.11	0.01	0.15	Yes
05/30/95	0.00249	31.71	57.4	0.43	0.05	0.65	Yes
05/03/05	0.00245	27.62	62.1	0.36	0.05	0.56	Yes
05/27/03	0.00235	34.78	53.8	0.44	0.06	0.71	Yes
01/02/96	0.0023	187.87	8.2	2.33	0.30	3.83	Yes
09/10/02	0.00221	10.57	96.5	0.13	0.02	0.22	Yes
09/07/04	0.00221	11.93	94.1	0.14	0.02	0.24	Yes
03/14/06	0.00216	38.53	50.3	0.45	0.06	0.79	Yes
04/16/96	0.0021	144.22	11.8	1.63	0.21	2.94	Yes
01/19/99	0.00209	37.85	50.8	0.43	0.05	0.77	Yes
06/27/05	0.00207	12.62	92.7	0.14	0.02	0.26	Yes
06/13/95	0.00202	67.51	30.7	0.74	0.09	1.38	Yes
02/06/96	0.002	22.16	69.7	0.24	0.03	0.45	Yes
07/08/03	0.00198	18.41	76.5	0.20	0.03	0.38	Yes
03/02/04	0.00193	45.01	44.8	0.47	0.06	0.92	Yes
11/08/05	0.00185	12.62	92.7	0.13	0.02	0.26	Yes
09/13/05	0.00184	8.52	99.2	0.08	0.01	0.17	Yes
09/16/03	0.00183	26.59	63.4	0.26	0.03	0.54	Yes
11/03/98	0.00171	28.30	61.3	0.26	0.03	0.58	Yes
09/15/98	0.0017	197.07	7.7	1.81	0.23	4.02	Yes
03/15/05	0.00168	31.37	57.8	0.28	0.04	0.64	Yes
03/02/99	0.00154	33.41	55.4	0.28	0.04	0.68	Yes
07/05/00	0.0015	33.07	55.7	0.27	0.03	0.67	Yes
11/06/01	0.0014	14.66	86.9	0.11	0.01	0.30	Yes
03/13/06	0.00133	43.64	45.8	0.31	0.04	0.89	Yes
05/01/01	0.0013	32.73	56.1	0.23	0.03	0.67	Yes
11/04/03	0.00119	14.66	86.9	0.09	0.01	0.30	Yes
05/08/00	0.00118	24.21	66.4	0.15	0.02	0.49	Yes
08/01/06	0.00118	7.16	99.7	0.05	0.01	0.15	Yes
09/07/99	0.00117	10.57	96.5	0.07	0.01	0.22	Yes
03/07/00	0.00115	61.37	34.1	0.38	0.05	1.25	Yes
01/08/02	0.00095	36.82	51.9	0.19	0.02	0.75	Yes
07/03/01	0.00094	19.09	74.9	0.10	0.01	0.39	Yes
03/06/01	0.00091	143.20	11.9	0.70	0.09	2.92	Yes
05/08/06	0.00088	54.21	38.5	0.26	0.03	1.11	Yes
05/17/05	0.00086	20.46	72.5	0.09	0.01	0.42	Yes
05/02/05	0.00084	27.28	62.6	0.12	0.02	0.56	Yes
07/13/98	0.00079	18.75	75.7	0.08	0.01	0.38	Yes
11/02/99	0.00077	51.83	40.1	0.22	0.03	1.06	Yes
09/05/00	0.00074	8.18	99.5	0.03	0.00	0.17	Yes
07/06/99	0.00066	16.02	83.2	0.06	0.01	0.33	Yes
09/04/01	0.00061	14.32	88.1	0.05	0.01	0.29	Yes
10/31/00	0.0006	14.32	88.1	0.05	0.01	0.29	Yes
05/17/05	0.00051	20.46	72.5	0.06	0.01	0.42	Yes
01/17/95	0.00025	152.41	10.9	0.21	0.03	3.11	Yes
02/14/95	0.00025	31.71	57.4	0.04	0.01	0.65	Yes
03/21/95	0.00025	55.58	37.7	0.07	0.01	1.13	Yes
04/04/95	0.00025	159.23	10.2	0.21	0.03	3.25	Yes
08/01/95	0.00025	20.12	72.9	0.03	0.00	0.41	Yes
08/22/95	0.00025	16.37	81.8	0.02	0.00	0.33	Yes

Table G-4 Continued.

09/19/95	0.00025	25.23	65.1	0.03	0.00	0.51	Yes
10/17/95	0.00025	12.62	92.7	0.02	0.00	0.26	Yes
11/20/95	0.00025	16.37	81.8	0.02	0.00	0.33	Yes
11/28/95	0.00025	16.02	83.2	0.02	0.00	0.33	Yes
03/12/96	0.00025	29.32	60.3	0.04	0.01	0.60	Yes
05/07/96	0.00025	1,036.51	0.9	1.40	0.18	21.13	Yes
06/25/96	0.00025	18.75	75.7	0.03	0.00	0.38	Yes
07/30/96	0.00025	16.02	83.2	0.02	0.00	0.33	Yes
09/17/96	0.00025	18.75	75.7	0.03	0.00	0.38	Yes
11/19/96	0.00025	175.93	9.1	0.24	0.03	3.59	Yes
01/21/97	0.00025	58.64	35.6	0.08	0.01	1.20	Yes
05/04/99	0.00025	55.23	37.8	0.07	0.01	1.13	Yes
01/17/06	0.00025	17.39	78.8	0.02	0.00	0.35	Yes

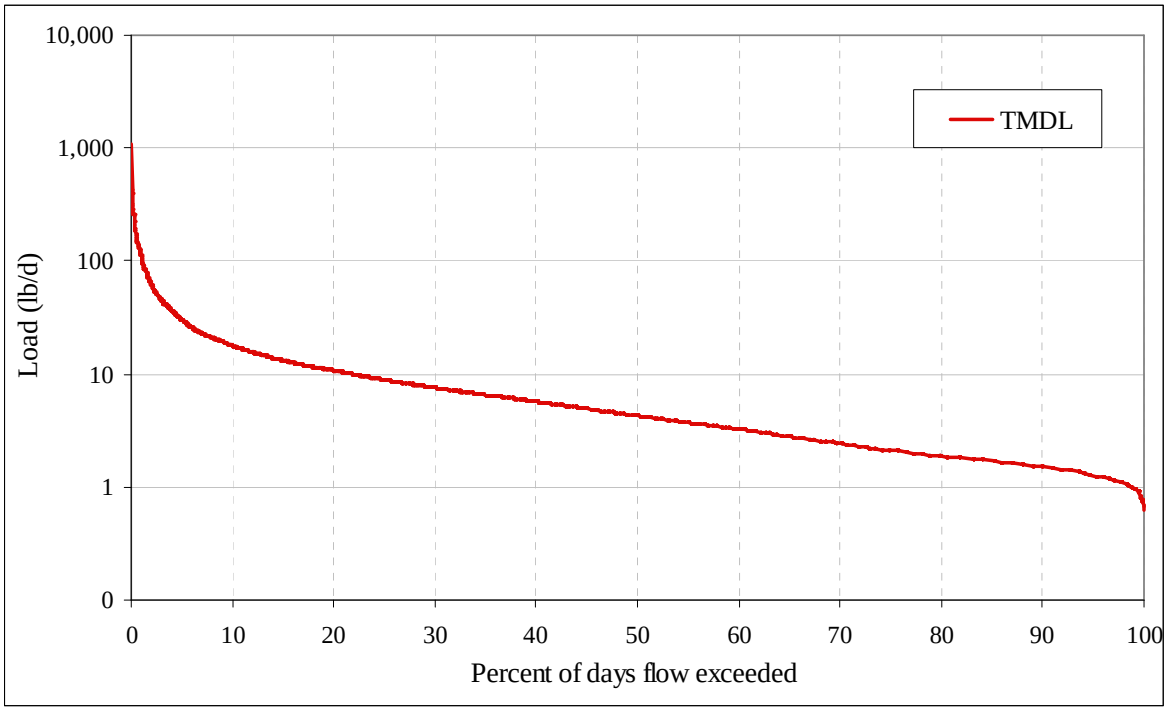

Figure G-3 Copper load duration curve for Caddo River (HUC-reach 08040102-018)

Table G-5. Allowable copper load for Caddo River (HUC-reach 08040102-018)

Date	Observed flow (cfs)	Percent exceedance for observed flow	Adjusted flow for entire basin (cfs)	Width for area under curves (%)	Allowable load to meet standard (lb/day)	Area under TMDL curve (lb/day)
						9.67
08/19/06	16	100	26.28	0.00	0.60	0.00
08/11/06	17	100	27.93	0.00	0.63	0.00
08/18/06	17	100	27.93	0.00	0.63	0.00
08/20/06	17	100	27.93	0.00	0.63	0.00
09/11/06	17	100	27.93	0.00	0.63	0.00
09/16/06	17	100	27.93	0.00	0.63	0.00
08/03/06	18	100	29.57	0.00	0.67	0.00
08/21/06	18	100	29.57	0.00	0.67	0.00
09/09/06	18	100	29.57	0.00	0.67	0.00
09/10/06	18	100	29.57	0.00	0.67	0.00
09/15/06	18	100	29.57	0.00	0.67	0.00
09/17/06	18	100	29.57	0.10	0.67	0.00
Fro brevity, most cells have been hidden.						
03/20/06	8660	0.1	14,225.32	0.00	322.26	0.00
11/24/96	10500	0.1	17,247.79	0.00	390.73	0.00
02/16/01	10500	0.1	17,247.79	0.00	390.73	0.00
03/08/90	11600	0.1	19,054.71	0.10	431.66	0.43
12/03/93	28600	0	46,979.71	0.00	1,064.27	0.00

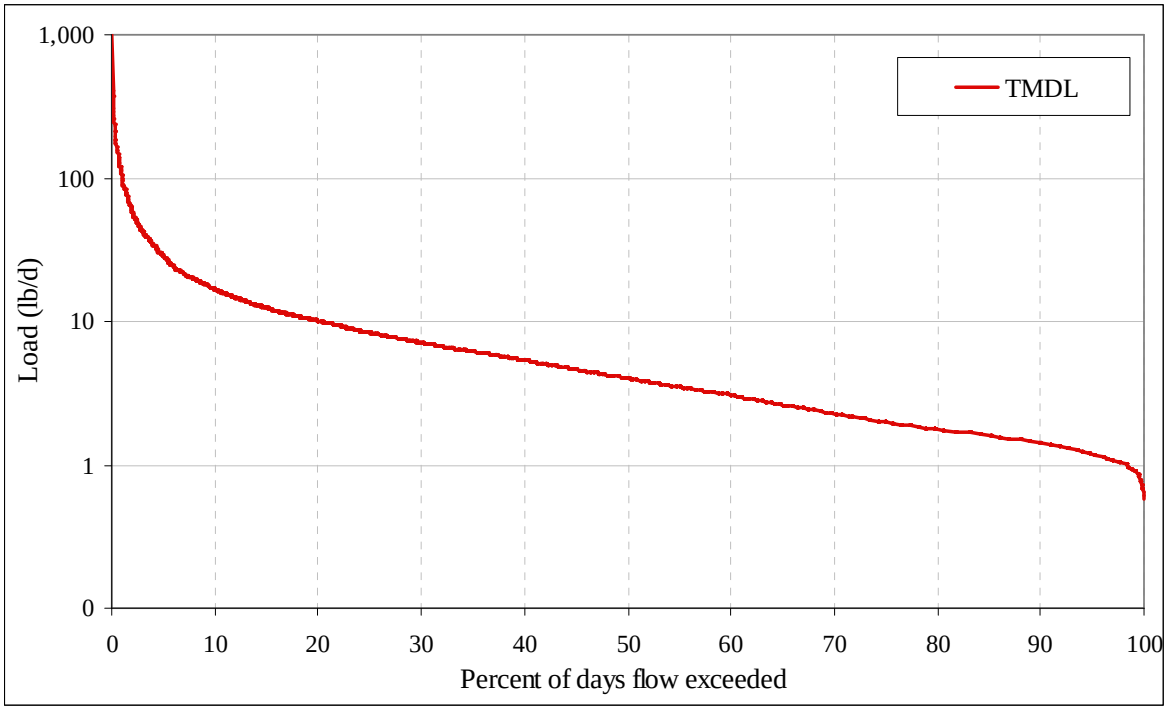

Figure G-4 Copper load duration curve for Caddo River (HUC-reach 08040102-019)

Table G-6. Allowable copper load for Caddo River (HUC-reach 08040102-019)

Date	Observed flow (cfs)	Percent exceedance for observed flow	Adjusted flow for entire basin (cfs)	Width for area under curves (%)	Allowable load to meet standard (lb/day)	Area under TMDL curve (lb/day)
						9.09
08/19/06	16	100	24.69	0.00	0.56	0.00
08/11/06	17	100	26.23	0.00	0.59	0.00
08/18/06	17	100	26.23	0.00	0.59	0.00
08/20/06	17	100	26.23	0.00	0.59	0.00
09/11/06	17	100	26.23	0.00	0.59	0.00
09/16/06	17	100	26.23	0.00	0.59	0.00
08/03/06	18	100	27.78	0.00	0.63	0.00
08/21/06	18	100	27.78	0.00	0.63	0.00
09/09/06	18	100	27.78	0.00	0.63	0.00
09/10/06	18	100	27.78	0.00	0.63	0.00
09/15/06	18	100	27.78	0.00	0.63	0.00
09/17/06	18	100	27.78	0.10	0.63	0.00
Fro brevity, most cells have been hidden.						
03/18/04	8210	0.1	12,669.36	0.00	287.01	0.00
03/20/06	8660	0.1	13,363.78	0.00	302.74	0.00
11/24/96	10500	0.1	16,203.20	0.00	367.06	0.00
02/16/01	10500	0.1	16,203.20	0.00	367.06	0.00
03/08/90	11600	0.1	17,900.68	0.10	405.52	0.41
12/03/93	28600	0	44,134.43	0.00	999.82	0.00

Appendix H
Load Duration Curve Summaries and Plots for Zinc

Figure H-1. Zinc load duration curve for station OUA0023 for Caddo River (HUC-reach 08040102-016) 2
Figure H-2. Zinc load duration curve for station OUA0044 for South Fork Caddo River (HUC-reach 08040102-023) 4
Figure H-3 Zinc load duration curve for Caddo River (HUC-reach 08040102-018) 8
Figure H-4 Zinc load duration curve for Caddo River (HUC-reach 08040102-019) 9

Table H-1. Allowable zinc load for station OUA0023 for Caddo River (HUC-reach 08040102-016) 2
Table H-2. Existing load for station OUA0023 for zinc for Caddo River (HUC-reach 08040102-016) 3
Table H-3. Allowable zinc load for station OUA0044 for South Fork Caddo River (HUC-reach 08040102-023) 5
Table H-4. Existing load for zinc for station OUA0044 for South Fork Caddo River (HUC-reach 08040102-023) 6
Table H-5. Allowable Zinc load for Caddo River (HUC-reach 08040102-018) 8
Table H-6. Allowable Zinc load for Caddo River (HUC-reach 08040102-019) 9

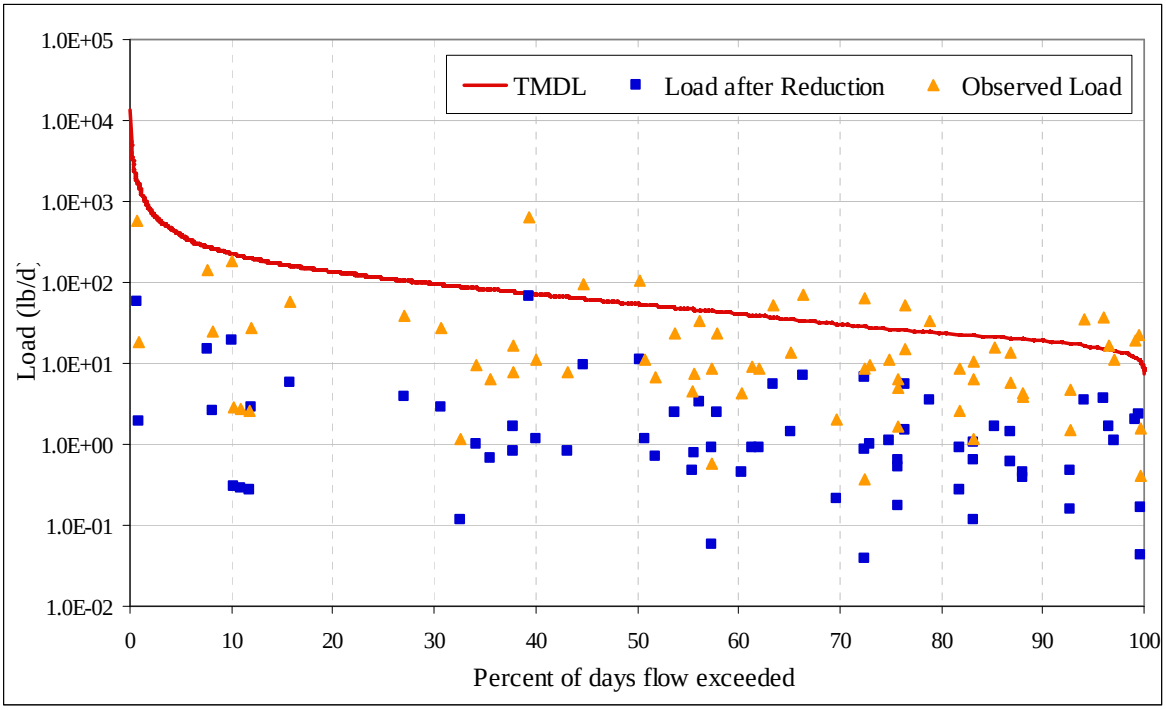

Figure H-1. Zinc load duration curve for station OUA0023 for Caddo River (HUC-reach 08040102-016)

Table H-1. Allowable zinc load for station OUA0023 for Caddo River (HUC-reach 08040102-016)

Date	Observed flow (cfs)	Percent exceedance for observed flow	Adjusted flow for entire basin (cfs)	Width for area under curves (%)	Allowable load to meet standard (lb/day)	Area under TMDL curve (lb/day)
						122.5
8/19/2006	16	100.000	36.133	0.00	7.5424	0.00E+00
8/11/2006	17	100.000	38.391	0.00	8.0138	0.00E+00
8/18/2006	17	100.000	38.391	0.00	8.0138	0.00E+00
8/20/2006	17	100.000	38.391	0.00	8.0138	0.00E+00
9/11/2006	17	100.000	38.391	0.00	8.0138	0.00E+00
9/16/2006	17	100.000	38.391	0.00	8.0138	0.00E+00
8/3/2006	18	100.000	40.650	0.00	8.4852	0.00E+00
8/21/2006	18	100.000	40.650	0.00	8.4852	0.00E+00
For brevity, most cells in this spreadsheet have been hidden						
1/26/1994	7320	0.200	16530.821	0.00	3450.6292	0.00E+00
5/20/1990	7510	0.200	16959.899	0.00	3540.1947	0.00E+00
12/17/2001	7520	0.200	16982.482	0.00	3544.9087	0.00E+00
12/16/2001	7580	0.200	17117.981	0.10	3573.1925	3.57E+00
11/19/1991	7740	0.100	17479.310	0.00	3648.6161	0.00E+00
3/18/2004	8210	0.100	18540.715	0.00	3870.1729	0.00E+00
3/20/2006	8660	0.100	19556.954	0.00	4082.3017	0.00E+00
11/24/1996	10500	0.100	23712.243	0.00	4949.6730	0.00E+00
2/16/2001	10500	0.100	23712.243	0.00	4949.6730	0.00E+00
3/8/1990	11600	0.100	26196.382	0.10	5468.2102	5.47E+00
12/3/1993	28600	0.000	64587.632	0.00	13481.9665	0.00E+00

Table H-2. Existing load for station OUA0023 for zinc for Caddo River (HUC-reach 08040102-016)

Date	Observed Concentration (mg/L)	Flow/unit area on sampling day (cfs)	Percent exceedance for flow on sampling day	Current load (lbs/day)	Reduced load (lbs/day)	Allowable load with MOS incorporated (lbs/day)	Reduced load less than or equal to allow load?
5/16/2006	0.335	350.038	39.3	6.325E+02	6.576E+01	6.576E+01	Yes
7/5/2005	0.0926	72.266	96	3.609E+01	3.753E+00	1.358E+01	Yes
1/28/2003	0.0887	135.499	72.5	6.483E+01	6.740E+00	2.546E+01	Yes
9/7/2004	0.0808	79.041	94.1	3.445E+01	3.581E+00	1.485E+01	Yes
11/19/2002	0.0806	121.949	76.5	5.302E+01	5.512E+00	2.291E+01	Yes
5/8/2000	0.0798	160.340	66.4	6.901E+01	7.175E+00	3.012E+01	Yes
3/14/2006	0.0763	255.189	50.3	1.050E+02	1.092E+01	4.794E+01	Yes
9/5/2000	0.07539	54.199	99.5	2.204E+01	2.291E+00	1.018E+01	Yes
9/13/2005	0.0634	56.458	99.2	1.931E+01	2.007E+00	1.061E+01	Yes
3/2/2004	0.0581	298.097	44.8	9.342E+01	9.713E+00	5.600E+01	Yes
9/16/2003	0.0561	176.148	63.4	5.330E+01	5.542E+00	3.309E+01	Yes
1/17/2006	0.0538	115.174	78.8	3.342E+01	3.475E+00	2.164E+01	Yes
9/10/2002	0.043	70.008	96.5	1.624E+01	1.688E+00	1.315E+01	Yes
5/14/2002	0.0325	1,061.405	10.1	1.861E+02	1.934E+01	1.994E+02	Yes
7/18/2006	0.0298	67.749	97	1.089E+01	1.132E+00	1.273E+01	Yes
7/9/2002	0.0285	101.624	85.2	1.562E+01	1.624E+00	1.909E+01	Yes
5/1/2001	0.028	216.798	56.1	3.274E+01	3.404E+00	4.073E+01	Yes
11/4/2003	0.0255	97.107	86.9	1.336E+01	1.389E+00	1.824E+01	Yes
7/8/2003	0.0222	121.949	76.5	1.460E+01	1.518E+00	2.291E+01	Yes
3/15/2005	0.0207	207.764	57.8	2.320E+01	2.412E+00	3.903E+01	Yes
9/15/1998	0.0202	1,305.303	7.7	1.422E+02	1.479E+01	2.452E+02	Yes
5/27/2003	0.0191	230.348	53.8	2.373E+01	2.467E+00	4.327E+01	Yes
7/30/1996	0.018	106.141	83.2	1.030E+01	1.071E+00	1.994E+01	Yes
7/3/2001	0.0159	126.465	74.9	1.085E+01	1.128E+00	2.376E+01	Yes
9/19/1995	0.0149	167.115	65.1	1.343E+01	1.396E+00	3.140E+01	Yes
8/22/1995	0.0147	108.399	81.8	8.595E+00	8.936E-01	2.036E+01	Yes
11/9/2004	0.0141	499.086	27.1	3.796E+01	3.946E+00	9.376E+01	Yes
1/9/2001	0.0137	767.825	15.7	5.674E+01	5.899E+00	1.442E+02	Yes
8/1/1995	0.0133	133.240	72.9	9.558E+00	9.938E-01	2.503E+01	Yes
1/4/2005	0.0121	8,671.906	0.7	5.660E+02	5.884E+01	1.629E+03	Yes
5/17/2005	0.0116	135.499	72.5	8.478E+00	8.814E-01	2.546E+01	Yes
6/13/1995	0.0113	447.145	30.7	2.725E+01	2.834E+00	8.400E+01	Yes
11/6/2001	0.0111	97.107	86.9	5.814E+00	6.045E-01	1.824E+01	Yes
7/6/1999	0.0109	106.141	83.2	6.240E+00	6.488E-01	1.994E+01	Yes
11/8/2005	0.0103	83.557	92.7	4.642E+00	4.826E-01	1.570E+01	Yes
7/13/1998	0.0093	124.207	75.7	6.230E+00	6.478E-01	2.333E+01	Yes
11/3/1998	0.0088	187.440	61.3	8.897E+00	9.250E-01	3.521E+01	Yes
5/3/2005	0.00872	182.923	62.1	8.604E+00	8.945E-01	3.436E+01	Yes
9/4/2001	0.0085	94.849	88.1	4.349E+00	4.521E-01	1.782E+01	Yes
1/19/1999	0.0082	250.672	50.8	1.109E+01	1.153E+00	4.709E+01	Yes
5/4/1999	0.0082	365.846	37.8	1.618E+01	1.682E+00	6.873E+01	Yes
5/30/1995	0.00752	210.023	57.4	8.519E+00	8.857E-01	3.946E+01	Yes
9/17/1996	0.0074	124.207	75.7	4.958E+00	5.154E-01	2.333E+01	Yes
10/31/2000	0.0074	94.849	88.1	3.786E+00	3.936E-01	1.782E+01	Yes
7/5/2000	0.0064	219.056	55.7	7.562E+00	7.862E-01	4.115E+01	Yes
11/2/1999	0.0061	343.263	40.1	1.129E+01	1.174E+00	6.449E+01	Yes
9/12/2006	0.00607	47.424	99.7	1.553E+00	1.614E-01	8.909E+00	Yes
3/6/2001	0.0054	948.490	11.9	2.763E+01	2.872E+00	1.782E+02	Yes
1/8/2002	0.0052	243.897	51.9	6.841E+00	7.112E-01	4.582E+01	Yes
6/5/2001	0.0047	313.905	43.1	7.958E+00	8.274E-01	5.897E+01	Yes
11/20/1995	0.0045	108.399	81.8	2.631E+00	2.736E-01	2.036E+01	Yes
3/7/2000	0.0044	406.496	34.1	9.647E+00	1.003E+00	7.637E+01	Yes
3/12/1996	0.0041	194.215	60.3	4.295E+00	4.465E-01	3.649E+01	Yes
3/21/1995	0.0039	368.104	37.7	7.743E+00	8.051E-01	6.915E+01	Yes
3/2/1999	0.0038	221.314	55.4	4.536E+00	4.716E-01	4.158E+01	Yes
1/2/1996	0.0037	1,244.328	8.2	2.483E+01	2.582E+00	2.338E+02	Yes
10/17/1995	0.0033	83.557	92.7	1.487E+00	1.546E-01	1.570E+01	Yes
1/21/1997	0.0031	388.429	35.6	6.495E+00	6.753E-01	7.297E+01	Yes
2/6/1996	0.0026	146.790	69.7	2.059E+00	2.140E-01	2.758E+01	Yes
6/25/1996	0.0025	124.207	75.7	1.675E+00	1.741E-01	2.333E+01	Yes
11/28/1995	0.002	106.141	83.2	1.145E+00	1.190E-01	1.994E+01	Yes
8/1/2006	0.00161	47.424	99.7	4.118E-01	4.282E-02	8.909E+00	Yes
1/17/1995	0.0005	1,009.464	10.9	2.722E+00	2.830E-01	1.896E+02	Yes

Table H-2 Continued.

2/14/1995	0.0005	210.023	57.4	5.664E-01	5.889E-02	3.946E+01	Yes
4/4/1995	0.0005	1,054.630	10.2	2.844E+00	2.957E-01	1.981E+02	Yes
4/16/1996	0.0005	955.265	11.8	2.576E+00	2.679E-01	1.795E+02	Yes
5/7/1996	0.0005	6,865.259	0.9	1.851E+01	1.925E+00	1.290E+03	Yes
11/5/1996	0.0005	422.304	32.5	1.139E+00	1.184E-01	7.934E+01	Yes
5/17/2005	0.0005	135.499	72.5	3.654E-01	3.799E-02	2.546E+01	Yes

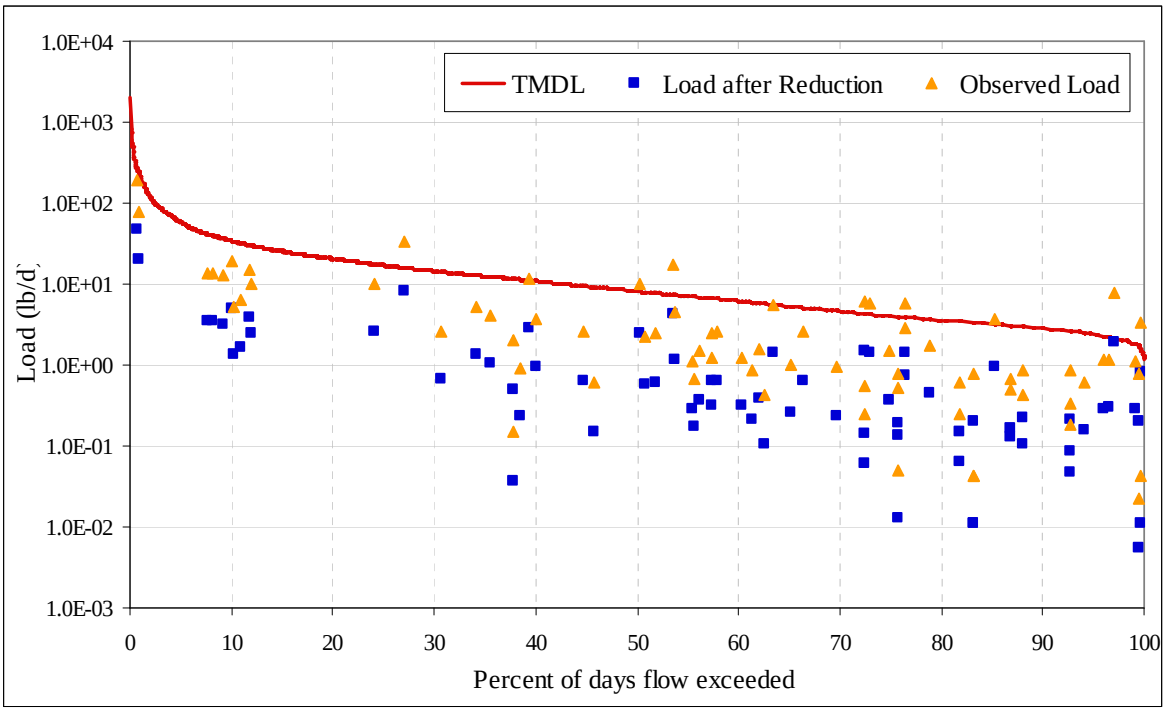

Figure H-2. Zinc load duration curve for station OUA0044 for South Fork Caddo River (HUC-reach 08040102-023)

Table H-3. Allowable zinc load for station OUA0044 for South Fork Caddo River (HUC-reach 08040102-023)

Date	Observed flow (cfs)	Percent exceedance for observed flow	Adjusted flow for entire basin (cfs)	Width for area under curves (%)	Allowable load to meet standard (lb/day)	Area under TMDL curve (lb/day)
						18.5
8/19/2006	16	100.000	5.455	0.00	1.1387	0.00E+00
8/11/2006	17	100.000	5.796	0.00	1.2099	0.00E+00
8/18/2006	17	100.000	5.796	0.00	1.2099	0.00E+00
8/20/2006	17	100.000	5.796	0.00	1.2099	0.00E+00
9/11/2006	17	100.000	5.796	0.00	1.2099	0.00E+00
9/16/2006	17	100.000	5.796	0.00	1.2099	0.00E+00
8/3/2006	18	100.000	6.137	0.00	1.2811	0.00E+00
8/21/2006	18	100.000	6.137	0.00	1.2811	0.00E+00
For brevity, most of the cells in this spreadsheet have been hidden						
1/26/1994	7320	0.200	2495.797	0.00	520.9705	0.00E+00
5/20/1990	7510	0.200	2560.579	0.00	534.4930	0.00E+00
12/17/2001	7520	0.200	2563.988	0.00	535.2047	0.00E+00
12/16/2001	7580	0.200	2584.446	0.10	539.4749	5.39E-01
11/19/1991	7740	0.100	2638.999	0.00	550.8623	0.00E+00
3/18/2004	8210	0.100	2799.248	0.00	584.3126	0.00E+00
3/20/2006	8660	0.100	2952.678	0.00	616.3394	0.00E+00
11/24/1996	10500	0.100	3580.037	0.00	747.2938	0.00E+00
2/16/2001	10500	0.100	3580.037	0.00	747.2938	0.00E+00
3/8/1990	11600	0.100	3955.088	0.10	825.5817	8.26E-01
12/3/1993	28600	0.000	9751.338	0.00	2035.4859	0.00E+00

Table H-4. Existing load for zinc for station OUA0044 for South Fork Caddo River (HUC-reach 08040102-023)

Date	Observed Concentration (mg/L)	Flow/unit area on sampling day (cfs)	Percent exceedance for flow on sampling day	Current load (lbs/day)	Reduced load (lbs/day)	Allowable load with MOS incorporated (lbs/day)	Reduced load less than or equal to allow load?
7/18/2006	0.138	10.229	97	7.614E+00	1.922E+00	1.922E+00	Yes
3/18/2003	0.0902	35.118	53.6	1.709E+01	4.312E+00	6.598E+00	Yes
9/12/2006	0.0858	7.160	99.7	3.314E+00	8.363E-01	1.345E+00	Yes
11/9/2004	0.0815	75.351	27.1	3.312E+01	8.360E+00	1.416E+01	Yes
11/19/2002	0.0573	18.412	76.5	5.690E+00	1.436E+00	3.459E+00	Yes
1/28/2003	0.0547	20.457	72.5	6.036E+00	1.523E+00	3.843E+00	Yes
8/1/1995	0.0528	20.116	72.9	5.729E+00	1.446E+00	3.779E+00	Yes
3/14/2006	0.0474	38.528	50.3	9.850E+00	2.486E+00	7.238E+00	Yes
7/9/2002	0.0453	15.343	85.2	3.749E+00	9.462E-01	2.882E+00	Yes
5/16/2006	0.0399	52.848	39.3	1.137E+01	2.871E+00	9.928E+00	Yes
9/16/2003	0.0392	26.595	63.4	5.623E+00	1.419E+00	4.996E+00	Yes
7/8/2003	0.0292	18.412	76.5	2.900E+00	7.319E-01	3.459E+00	Yes
1/4/2005	0.0267	1,309.271	0.7	1.886E+02	4.759E+01	2.460E+02	Yes
9/13/2005	0.0245	8.524	99.2	1.126E+00	2.843E-01	1.601E+00	Yes
5/27/2003	0.0244	34.778	53.8	4.577E+00	1.155E+00	6.533E+00	Yes
5/14/2002	0.0226	160.249	10.1	1.953E+01	4.930E+00	3.011E+01	Yes
3/11/1997	0.0225	83.193	24.1	1.010E+01	2.548E+00	1.563E+01	Yes
9/10/2002	0.0208	10.570	96.5	1.186E+00	2.993E-01	1.986E+00	Yes
5/8/2000	0.0198	24.208	66.4	2.585E+00	6.525E-01	4.548E+00	Yes
4/16/1996	0.0195	144.224	11.8	1.517E+01	3.829E+00	2.709E+01	Yes
7/5/2005	0.0193	10.911	96	1.136E+00	2.867E-01	2.050E+00	Yes
1/17/2006	0.0186	17.389	78.8	1.745E+00	4.403E-01	3.267E+00	Yes
9/5/2000	0.01808	8.183	99.5	7.980E-01	2.014E-01	1.537E+00	Yes
3/7/2000	0.016	61.372	34.1	5.296E+00	1.337E+00	1.153E+01	Yes
3/15/2005	0.015	31.368	57.8	2.538E+00	6.405E-01	5.893E+00	Yes
5/30/1995	0.0146	31.709	57.4	2.497E+00	6.302E-01	5.957E+00	Yes
7/3/2001	0.0144	19.094	74.9	1.483E+00	3.743E-01	3.587E+00	Yes
5/7/1996	0.0141	1,036.506	0.9	7.883E+01	1.990E+01	1.947E+02	Yes
1/2/1996	0.0135	187.867	8.2	1.368E+01	3.453E+00	3.529E+01	Yes
11/19/1996	0.0133	175.933	9.1	1.262E+01	3.185E+00	3.305E+01	Yes
11/2/1999	0.0132	51.825	40.1	3.690E+00	9.313E-01	9.736E+00	Yes
1/21/1997	0.013	58.644	35.6	4.112E+00	1.038E+00	1.102E+01	Yes
3/6/2001	0.0129	143.201	11.9	9.964E+00	2.515E+00	2.690E+01	Yes
9/15/1998	0.0128	197.073	7.7	1.361E+01	3.434E+00	3.702E+01	Yes
11/8/2005	0.0125	12.615	92.7	8.506E-01	2.147E-01	2.370E+00	Yes
1/8/2002	0.0121	36.823	51.9	2.403E+00	6.066E-01	6.918E+00	Yes
10/31/2000	0.0114	14.320	88.1	8.805E-01	2.222E-01	2.690E+00	Yes
1/19/1999	0.011	37.846	50.8	2.245E+00	5.667E-01	7.110E+00	Yes
3/2/2004	0.0106	45.006	44.8	2.573E+00	6.494E-01	8.455E+00	Yes
5/3/2005	0.0105	27.617	62.1	1.564E+00	3.948E-01	5.188E+00	Yes
9/7/2004	0.00952	11.933	94.1	6.128E-01	1.547E-01	2.242E+00	Yes
7/6/1999	0.0091	16.025	83.2	7.866E-01	1.985E-01	3.011E+00	Yes
11/4/2003	0.00843	14.661	86.9	6.666E-01	1.683E-01	2.754E+00	Yes
5/1/2001	0.0084	32.732	56.1	1.483E+00	3.743E-01	6.149E+00	Yes
3/12/1996	0.0079	29.322	60.3	1.249E+00	3.153E-01	5.509E+00	Yes
1/17/1995	0.00787	152.407	10.9	6.470E+00	1.633E+00	2.863E+01	Yes
2/6/1996	0.0078	22.162	69.7	9.324E-01	2.353E-01	4.163E+00	Yes
6/25/1996	0.0076	18.753	75.7	7.687E-01	1.940E-01	3.523E+00	Yes
9/19/1995	0.0075	25.231	65.1	1.021E+00	2.576E-01	4.740E+00	Yes
2/14/1995	0.00716	31.709	57.4	1.225E+00	3.091E-01	5.957E+00	Yes
6/13/1995	0.00714	67.509	30.7	2.600E+00	6.562E-01	1.268E+01	Yes
8/22/1995	0.0067	16.366	81.8	5.914E-01	1.493E-01	3.075E+00	Yes
3/21/1995	0.0066	55.576	37.7	1.978E+00	4.993E-01	1.044E+01	Yes
11/6/2001	0.0064	14.661	86.9	5.061E-01	1.277E-01	2.754E+00	Yes
4/4/1995	0.0062	159.226	10.2	5.325E+00	1.344E+00	2.991E+01	Yes
3/2/1999	0.0062	33.414	55.4	1.117E+00	2.820E-01	6.277E+00	Yes
11/3/1998	0.0056	28.299	61.3	8.548E-01	2.157E-01	5.316E+00	Yes
9/4/2001	0.0054	14.320	88.1	4.171E-01	1.053E-01	2.690E+00	Yes
7/13/1998	0.0052	18.753	75.7	5.260E-01	1.327E-01	3.523E+00	Yes
5/17/2005	0.00505	20.457	72.5	5.572E-01	1.406E-01	3.843E+00	Yes
10/17/1995	0.0049	12.615	92.7	3.334E-01	8.415E-02	2.370E+00	Yes
7/5/2000	0.0038	33.073	55.7	6.779E-01	1.711E-01	6.213E+00	Yes
5/8/2006	0.00315	54.212	38.5	9.211E-01	2.325E-01	1.018E+01	Yes

Table H-4 Continued.

5/2/2005	0.00287	27.276	62.6	4.222E-01	1.066E-01	5.124E+00	Yes
11/20/1995	0.0028	16.366	81.8	2.472E-01	6.238E-02	3.075E+00	Yes
6/27/2005	0.00271	12.615	92.7	1.844E-01	4.654E-02	2.370E+00	Yes
3/13/2006	0.00255	43.642	45.8	6.003E-01	1.515E-01	8.199E+00	Yes
5/17/2005	0.00222	20.457	72.5	2.450E-01	6.183E-02	3.843E+00	Yes
8/1/2006	0.00112	7.160	99.7	4.325E-02	1.092E-02	1.345E+00	Yes
11/28/1995	0.0005	16.025	83.2	4.322E-02	1.091E-02	3.011E+00	Yes
7/30/1996	0.0005	16.025	83.2	4.322E-02	1.091E-02	3.011E+00	Yes
9/17/1996	0.0005	18.753	75.7	5.057E-02	1.276E-02	3.523E+00	Yes
5/4/1999	0.0005	55.235	37.8	1.490E-01	3.760E-02	1.038E+01	Yes
8/7/2006	0.0005	8.183	99.5	2.207E-02	5.570E-03	1.537E+00	Yes

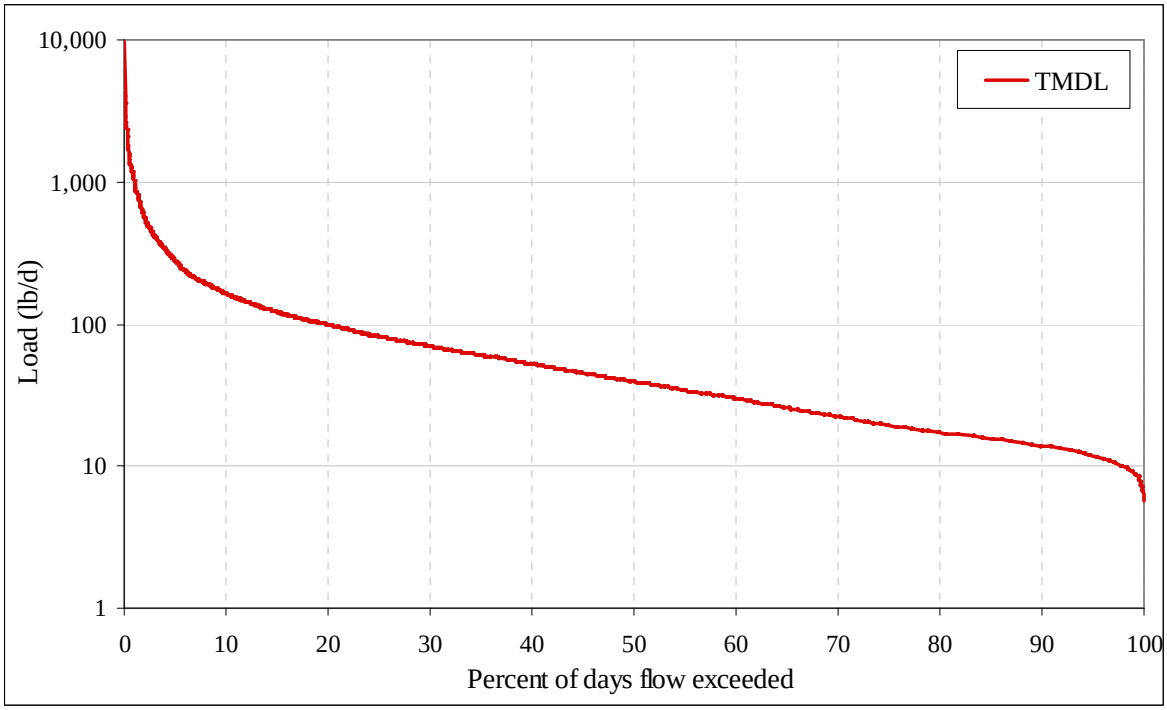

Figure H-3 Zinc load duration curve for Caddo River (HUC-reach 08040102-018)

Table H-5. Allowable Zinc load for Caddo River (HUC-reach 08040102-018)

Date	Observed flow (cfs)	Percent exceedance for observed flow	Adjusted flow for entire basin (cfs)	Width for area under curves (%)	Allowable load to meet standard (lb/day)	Area under TMDL curve (lb/day)
						89.11
08/19/06	16	100	26.28	0.00	5.49	0.00
08/11/06	17	100	27.93	0.00	5.83	0.00
08/18/06	17	100	27.93	0.00	5.83	0.00
08/20/06	17	100	27.93	0.00	5.83	0.00
09/11/06	17	100	27.93	0.00	5.83	0.00
09/16/06	17	100	27.93	0.00	5.83	0.00
08/03/06	18	100	29.57	0.00	6.17	0.00
08/21/06	18	100	29.57	0.00	6.17	0.00
09/09/06	18	100	29.57	0.00	6.17	0.00
09/10/06	18	100	29.57	0.00	6.17	0.00
09/15/06	18	100	29.57	0.00	6.17	0.00
09/17/06	18	100	29.57	0.10	6.17	0.01
Fro brevity, most cells have been hidden.						
11/19/91	7740	0.1	12,714.09	0.00	2,653.93	0.00
03/18/04	8210	0.1	13,486.13	0.00	2,815.08	0.00
03/20/06	8660	0.1	14,225.32	0.00	2,969.38	0.00
11/24/96	10500	0.1	17,247.79	0.00	3,600.29	0.00
02/16/01	10500	0.1	17,247.79	0.00	3,600.29	0.00
03/08/90	11600	0.1	19,054.71	0.10	3,977.46	3.98
12/03/93	28600	0	46,979.71	0.00	9,806.50	0.00

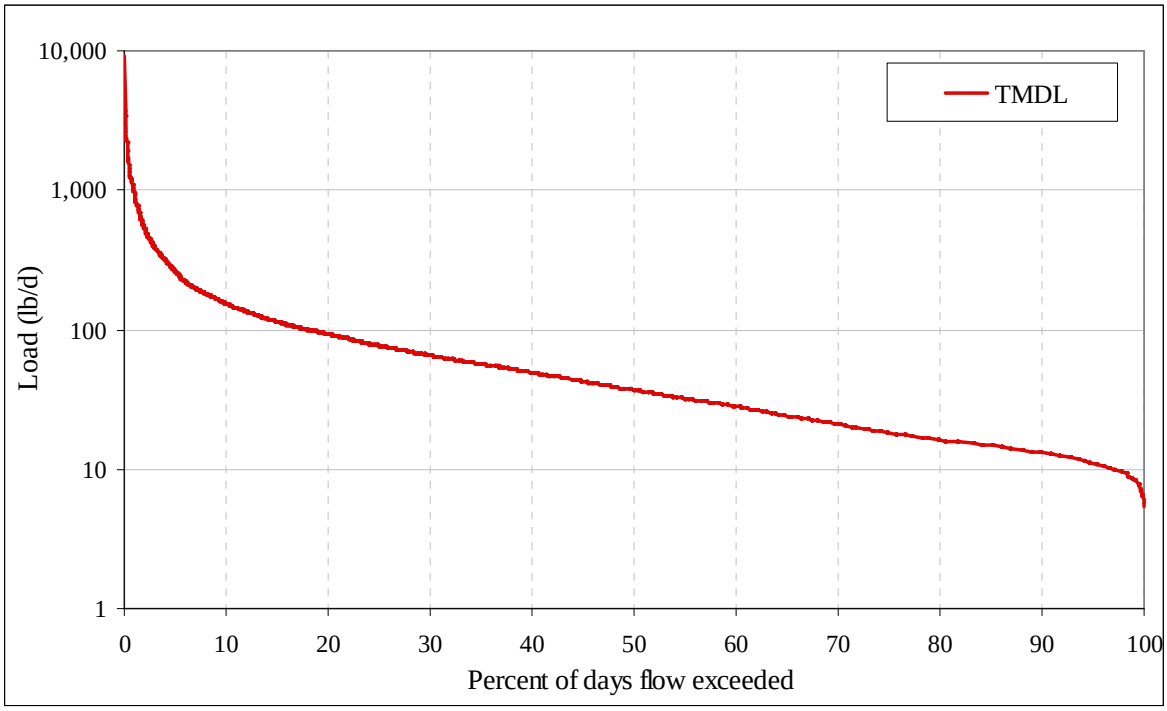

Figure H-4 Zinc load duration curve for Caddo River (HUC-reach 08040102-019)

Table H-6. Allowable Zinc load for Caddo River (HUC-reach 08040102-019)

Date	Observed flow (cfs)	Percent exceedance for observed flow	Adjusted flow for entire basin (cfs)	Width for area under curves (%)	Allowable load to meet standard (lb/day)	Area under TMDL curve (lb/day)
						83.71
08/19/06	16	100	24.69	0.00	5.15	0.00
08/11/06	17	100	26.23	0.00	5.48	0.00
08/18/06	17	100	26.23	0.00	5.48	0.00
08/20/06	17	100	26.23	0.00	5.48	0.00
09/11/06	17	100	26.23	0.00	5.48	0.00
09/16/06	17	100	26.23	0.00	5.48	0.00
08/03/06	18	100	27.78	0.00	5.80	0.00
08/21/06	18	100	27.78	0.00	5.80	0.00
09/09/06	18	100	27.78	0.00	5.80	0.00
09/10/06	18	100	27.78	0.00	5.80	0.00
09/15/06	18	100	27.78	0.00	5.80	0.00
09/17/06	18	100	27.78	0.10	5.80	0.01
Fro brevity, most cells have been hidden.						
03/18/04	8210	0.1	12,669.36	0.00	2,644.59	0.00
03/20/06	8660	0.1	13,363.78	0.00	2,789.54	0.00
11/24/96	10500	0.1	16,203.20	0.00	3,382.24	0.00
02/16/01	10500	0.1	16,203.20	0.00	3,382.24	0.00
03/08/90	11600	0.1	17,900.68	0.10	3,736.57	3.74
12/03/93	28600	0	44,134.43	0.00	9,212.58	0.00