TMDLS FOR ZINC, COPPER, AND NITRATE IN THE LOWER OUACHITA RIVER BASIN, ARKANSAS

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EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to identify water bodies that are not meeting water quality standards, and to develop total maximum daily pollutant loads (TMDL) for those water bodies. A TMDL is the amount of pollutant that a water body can assimilate without exceeding the established water quality standard for that pollutant. Through a TMDL, pollutant loads can be allocated to point sources and nonpoint sources discharging to the water body. This report presents TMDLs that have been developed for zinc and copper for six stream reaches in the lower Ouachita River basin and a TMDL for nitrate for one reach in the lower Ouachita River basin. These stream reaches and associated general information are listed in Table ES.1.

Table ES.1. General information for stream reaches addressed in this report.

Reach number	Stream name	Planning segment	Drainage area at downstream end (square miles)	Parameters for which TMDLs were developed
08040201-005	Ouachita River	2D	5,826	Zinc, Copper
08040201-006	Smackover Creek	2D	541	Zinc, Copper
08040201-007	Smackover Creek	2D	338	Zinc, Copper
08040201-606	El Dorado Chemical Company Tributary	2D	22.6	Zinc, Copper, Nitrate
08040202-002	Ouachita River	2D	10,886	Zinc, Copper
08040202-004	Ouachita River	2D	7,285	Zinc, Copper

The study area for this report is the watersheds of the stream reaches listed in Table ES.1 (excluding the Ouachita River drainage area upstream of the Little Missouri River). The study area is located in southern Arkansas and covers parts of Calhoun, Bradley, Dallas, Ouachita, Union, Ashley, Cleveland, Columbia, and Nevada Counties. The primary cities and towns within the study area are El Dorado, Camden, Fordyce, Warren, and Crossett. The study area is located in the Gulf Coastal Plain ecoregion and is predominantly forested.

All six stream reaches in Table ES.1 were included on the final 2004 Arkansas 303(d) list as being impaired due to zinc. One reach of the Ouachita River was also listed as impaired due to copper and the El Dorado Chemical Company Tributary was also listed as impaired due to

copper and nitrate. The 2004 Integrated Report for Arkansas lists the suspected sources of these contaminants as unknown for the Ouachita River, resource extraction for Smackover Creek, and an industrial point source for the El Dorado Chemical Company Tributary.

The designated uses for these six stream reaches are primary contact recreation (where drainage areas exceed 10 square miles); secondary contact recreation; domestic, industrial and agricultural water supply; and perennial Gulf Coastal Plain fishery. The Arkansas Department of Environmental Quality (ADEQ) recently approved a Use Attainability Analysis (UAA) requesting removal of the domestic water supply designated use for the El Dorado Chemical Company Tributary, but the current version of the Arkansas water quality standards does not show the domestic water supply use removed.

ADEQ historical water quality data that were collected in the study area were analyzed for basic statistics, seasonal patterns, and relationships between concentration and flow. Seasonal TMDLs were not prepared because the results of these analyses did not indicate a need for seasonal TMDLs.

All the TMDLs in this report 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 this methodology for the TMDLs in this report were:

1. Developing a flow duration curve;
2. Converting the flow duration curve to load duration curves;
3. Plotting observed loads with load duration curves;
4. Calculating the TMDL components; and
5. Calculating percent reductions.

The zinc and copper load duration curves were developed using numeric criteria in the water quality standards for protection of aquatic life from chronic toxicity. The nitrate load duration curve was developed using a target concentration of 10 mg/L. This nitrate concentration (10 mg/L) is EPA's maximum contaminant level for drinking water and it is the concentration used by ADEQ for assessing waterbodies with the designated use of domestic water supply.

Each TMDL was calculated as the total loading represented by the area under the load duration curve (i.e., the total loading over all flows). An explicit margin of safety (MOS) was

established as 10% of each TMDL. Wasteload allocations (WLAs) were calculated for point source discharges that have a known or expected source of zinc, copper, or nitrate.

The zinc and copper WLAs were calculated based on monthly average limits from existing permits. No reductions were needed for existing permit limits for copper or zinc because the limits were already calculated by ADEQ so that the discharges would not cause exceedances of the numeric criteria in the receiving stream under critical conditions.

The nitrate WLAs for the El Dorado Chemical Company Tributary were calculated using an effluent concentration equal to the target concentration of 10 mg/L because there was evidence suggesting that each of the discharges could occur during critical low flow conditions when there would be no upstream dilution water in the receiving stream. The only discharges with existing permit limits for nitrate were outfalls 001 and 002 for El Dorado Chemical Company. The existing limit for these two outfalls (26.3 mg/L) had to be reduced to 10 mg/L in the WLA calculations in order to be protective of the domestic water supply designated use. .

Each load allocation (LA) for nonpoint sources was calculated as the TMDL minus the MOS and WLA.

A percent reduction for nonpoint sources was calculated for each TMDL by applying a uniform percent reduction factor to the actual loads until the number of loads exceeding the allowable loads was less than or equal to an acceptable number based on ADEQ's assessment methodology and water quality standards.

The results of the TMDL calculations and percent reduction calculations are summarized in Tables ES.2 through ES.4. The effluent flows and concentrations that were used in the TMDL calculations are listed in Table ES.5

Table ES.2. Summary of TMDLs for zinc.

Reach Number	Stream Name	Loads (lbs/day of dissolved zinc)				Percent Reduction Needed
		WLA	LA	MOS	TMDL	
08040201-005	Ouachita River	0.5	1,292.7	143.7	1,436.9	46%
08040201-006	Smackover Creek	0	112.8	12.5	125.3	38%
08040201-007	Smackover Creek	0	70.4	7.8	78.2	
08040201-606	El Dorado Chemical Company Tributary	0.76	3.95	0.52	5.23	25%
08040202-002	Ouachita River	0	240,039	26,671	266,710	18%
08040202-004	Ouachita River	2.4	1,526.2	169.9	1,698.5	49%

Table ES.3. Summary of TMDLs for copper.

Reach Number	Stream Name	Loads (lbs/day of dissolved copper)				Percent Reduction Needed
		WLA	LA	MOS	TMDL	
08040201-005	Ouachita River	4.0	136.1	15.6	155.7	8%
08040201-006	Smackover Creek	0	12.2	1.4	13.6	15%
08040201-007	Smackover Creek	0	7.6	0.9	8.5	
08040201-606	El Dorado Chemical Company Tributary	0.09	0.42	0.06	0.57	63%
08040202-002	Ouachita River	0	25,694	2,855	28,549	0%
08040202-004	Ouachita River	0	165.6	18.4	184.0	7%

Table ES.4. Summary of TMDL for nitrate.

Reach Number	Stream Name	Loads (lbs/day of nitrate)				Percent Reduction Needed
		WLA	LA	MOS	TMDL	
08040201-606	El Dorado Chemical Company Tributary	221	995	135	1,351	89%

Table ES.5. Point source flows and concentrations used in TMDLs.

Permit Number	Facility Name	Outfall	Flow (MGD)	Effluent concentrations		
				Total zinc (µg/L)	Total copper (µg/L)	Nitrate (mg/L)
AR0000752	El Dorado Chemical Company	001	1.845	115.62	12.2	10
		002	0.50	115.62	12.2	10
		003	0.017	--	--	10
		004	0*	--	--	--
		005	0.002	115.62	--	10
		006	0.028	115.62	--	10
		007	0.046	115.62	--	10
AR0000841	Arkansas Electric Cooperative McClellan Generating Station	001	99.6	--	12.5	--
AR0034363	Shumaker Public Service Corp.	001	1.5	120.56	13.26	--
AR0035653	City of Norphlet	001	0.18	--	--	10
AR0044733	Cedarwood Leisure Park	001	0.031	--	--	10
AR0049140	Union Power Partners	01C	0.90	1000	--	--

*Not expected to discharge except during very large storms

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF APPENDICES

LIST OF TABLES

1.0 INTRODUCTION

This report presents total maximum daily loads (TMDLs) for copper and zinc for six reaches in the lower Ouachita River basin in southern Arkansas, as well as nitrate for one reach. These stream reaches were included on the draft and final versions of the 2004 303(d) list for Arkansas as not supporting their designated use of aquatic life (Arkansas Department of Environmental Quality (ADEQ) 2005a; Environmental Protection Agency (EPA) 2006). Suspected sources of contamination, suspected causes of impairment, and priority rankings from the 2004 Integrated Report (ADEQ 2005b) are shown in Table 1.1. The TMDLs in this report were developed in accordance with Section 303(d) of the Federal Clean Water Act and EPA regulations in 40 CFR 130.7.

Table 1.1. Information from the 2004 Integrated Report for TMDLs in this report.

Reach Number	Stream Name	Impaired Uses	Suspected Causes	Suspected Sources	Priority	Category
08040201-005	Ouachita River	Aquatic Life	Zinc, Copper	Unknown	Medium	5d
08040201-006	Smackover Creek	Aquatic Life	Zinc	Resource Extraction	Medium	5d
08040201-007	Smackover Creek	Aquatic Life	Zinc	Resource Extraction	Medium	5d
08040201-606	El Dorado Chemical Company Tributary	Aquatic Life, Drinking Water	Zinc, Copper, Nitrate	Industrial Point Source	High	5a
08040202-002	Ouachita River	Aquatic Life	Zinc	Unknown	Medium	5d
08040202-004	Ouachita River	Aquatic Life	Zinc	Unknown	Medium	5d

*Note: Only parameters cited on the 303(d) list as causes of impairment are shown in this table. At EPA's direction, TMDLs in this report were developed for copper for all six reaches, including the four reaches that are not impaired for copper.

The purpose of a TMDL is to determine the pollutant loading that a waterbody can assimilate without exceeding the water quality standard for that pollutant and to establish the load reduction that is necessary to meet the standard in a waterbody. The TMDL is the sum of

the wasteload allocation (WLA), the load allocation (LA), and a margin of safety (MOS). The WLA is the load allocated to point sources of the pollutant of concern. The LA is the load allocated to nonpoint sources, including natural background. The MOS is a percentage of the TMDL that takes into account any lack of knowledge concerning the relationship between pollutant loadings and water quality.

2.0 BACKGROUND INFORMATION

2.1 General Information

The study area for this report consists of the watersheds for the six stream reaches listed in Table 1.1 (excluding the Ouachita River drainage area upstream of the Little Missouri River). These reaches are located in the lower Ouachita River basin in southern Arkansas as shown on Figure A.1 in Appendix A. The portion of the lower Ouachita River basin that is included in the study area is within the Gulf Coastal Plain ecoregion. The lower Ouachita River basin lies in United States Geological Survey (USGS) Hydrologic Units 08040201 and 08040202 and is part of ADEQ Planning Segment 2D. The study area includes all of Calhoun County, large portions of Bradley, Dallas, Ouachita, and Union Counties and smaller areas of Ashley, Cleveland, Columbia, and Nevada Counties. Towns and cities within the study area include Camden, El Dorado, Fordyce, Crossett, Smackover, and a portion of Warren.

2.2 Land Use

Land use data for the study area were obtained from the GEOSTOR database, which is maintained by the Center for Advanced Spatial Technology (CAST) at the University of Arkansas in Fayetteville. These data were based on satellite imagery from 2004. The spatial distribution of these land uses is shown on Figure A.2 (located in Appendix A) and land use percentages are shown in Table 2.1. These data indicate that the study area is predominantly forested.

Table 2.1. Land use percentages for the study area (CAST 2005).

Land Use Category	Percentage of Study Area
Urban	1.2%
Barren or Bare Soil	0.1%
Water	1.6%
Forest	91.0%
Soybeans	0.0%
Rice	0.0%
Other Crops	0.0%
Cotton	0.0%
Pasture/Forages	6.1%
TOTAL	**100.0%**

2.3 Description of Hydrology

The TMDLs in this report were developed using USGS stream flow data from two gaging stations, Ouachita River at Camden (07362000) and Smackover Creek near Smackover (07362100). Selected information for these two gages is summarized in Table 2.2. The locations of the two gages are shown on Figure A.1 in Appendix A.

Table 2.2. Information for USGS stream flow gaging stations (USGS 2006).

Gage number:	07362000	07362100
Descriptive location:	AR Hwy 7 northeast of Camden, AR	AR Hwy 7 northwest of Smackover, AR
Gage name:	Ouachita River at Camden	Smackover Creek near Smackover
Period of record:	October 1928 – present	October 1961 – present
Drainage area:	5,357 square miles	385 square miles
Mean flow:	7,645 cfs	424.4 cfs

2.4 Water Quality Standards

Water quality standards for Arkansas waterbodies are listed in Regulation No. 2 (Arkansas Pollution Control and Ecology Commission (APCEC) 2007). The study area lies within the Gulf Coastal Plain ecoregion. Designated uses for all six stream reaches addressed in this report are primary and secondary contact recreation; domestic, industrial and agricultural water supply; and perennial Gulf Coastal Plains fishery. The perennial fishery designated use applies to the entire length of the El Dorado Chemical Company Tributary downstream of the El Dorado Chemical Company discharge (including portions of the stream where the drainage area

is less than 10 square miles) because the design flow of the discharge exceeds 1 cfs (FTN 1991; ADEQ 1998; FTN 2002). A Use Attainability Analysis (UAA) requesting removal of the drinking water designated use for the El Dorado Chemical Company Tributary was recently approved by ADEQ (GBMc & Associates 2006), but the current version of Regulation No. 2 does not show the drinking water use removed. Section 2.508 of Regulation No. 2 includes narrative and numeric criteria for dissolved metals, including zinc and copper. The following narrative criterion for toxic substances applies to dissolved metals:

> "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."

The numeric criteria for dissolved zinc and dissolved copper to protect from chronic toxicity are expressed as the following equations in Regulation No. 2:

Zinc: $0.986 * \exp[0.8473 * \ln(\text{hardness}) + 0.7614]$
Copper: $0.960 * \exp[0.8545 * \ln(\text{hardness}) - 1.465]$

The hardness used by ADEQ in these equations is the mean hardness for the ecoregion (for Smackover Creek) or the mean hardness for a specific stream (Ouachita River). Attachment VI of the State of Arkansas Continuing Planning Process (CPP) states that the mean hardness for the Gulf Coastal Plain ecoregion is 31 mg/L and the mean hardness for the Ouachita River is 28 mg/L (ADEQ 2000).

An alternative to using the mean hardness values in the CPP is to use site-specific hardness values. Measured hardness values were downloaded from the ADEQ web site for the five water quality stations that are located on the stream reaches being addressed in this report (see Tables C.1 – C.5 in Appendix C). Averages of these site-specific hardness data are shown in Table 2.3 along with numeric criteria that were calculated using the lower of the hardness from the CPP or the site-specific average hardness. Criteria for Ouachita River reaches 08040201-005 and 08040202-004 were calculated using a hardness value of 25 mg/L because the site-specific average hardness values were below 25 mg/L and federal regulations at 40 CFR 131(c)(4)(i)

specify 25 mg/L as the minimum hardness for calculating metals criteria (ADEQ 2000). Lower hardness values yield lower (i.e., more stringent) criteria for zinc and copper.

Table 2.3. Hardness values and dissolved metals criteria.

Reach number	Stream name	Water quality station	Average site-specific hardness	Applicable hardness from CPP	Dissolved zinc criterion	Dissolved copper criterion
08040201-005	Ouachita River	OUA0037	21.9 mg/L	28 mg/L	32.3 µg/L	3.5 µg/L
08040201-006	Smackover Creek	OUA0027	39.9 mg/L	31 mg/L	38.7 µg/L	4.2 µg/L
08040201-007	Smackover Creek	none	--	31 mg/L	38.7 µg/L	4.2 µg/L
08040201-606	El Dorado Chemical Company Tributary	OUA0137A OUA0137B	55.3 mg/L 37.2 mg/L	31 mg/L	38.7 µg/L	4.2 µg/L
08040202-002	Ouachita River	OUA0008B	29.7 mg/L	28 mg/L	35.5 µg/L	3.8 µg/L
08040202-004	Ouachita River	OUA0124B	24.5 mg/L	28 mg/L	32.3 µg/L	3.5 µg/L

Section 2.509 of Regulation No. 2 includes a narrative standard for nutrients (which includes nitrate):

> "Materials stimulating algal growth shall not be present in concentrations sufficient to cause objectionable algal densities or other nuisance aquatic vegetation or otherwise impair any designated use of the waterbody."

Regulation No. 2 does not include numeric criteria for nitrate. A nitrate concentration of 10 mg/L is used by ADEQ for assessing waterbodies with the designated use of drinking water (ADEQ 2005b). This value (10 mg/L) is EPA's maximum contaminant level for drinking water.

As specified in EPA's regulations at 40 CFR 130.7 (b)(2), applicable water quality standards include antidegradation requirements. Arkansas' antidegradation policy is listed in Sections 2.201-2.204 of Regulation No. 2. These sections impose the following requirements:

- Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.
- Water quality that exceeds standards shall be maintained and protected unless allowing lower water quality is necessary to accommodate important economic or social development, although water quality must still be adequate to fully protect existing uses.
- For outstanding state or national resource waters, those uses and water quality for which the outstanding waterbody was designated shall be protected.
- For potential water quality impairments associated with a thermal discharge, the antidegradation policy and implementing method shall be consistent with Section 316 of the Clean Water Act

2.5 Point Sources

Information for point source discharges in the study area was obtained by searching the Permit Compliance System (PCS) on the EPA website, reviewing ADEQ files, and reviewing information found in the Integrated Report (ADEQ 2005b). The search yielded 18 facilities with point source discharges. Selected information for these facilities is included as Table B.1 (located in Appendix B). Locations of the permitted facilities are shown on Figure A.3 (located in Appendix A). The discharge from the El Dorado Chemical Company plant is identified as the suspected source of water quality impairments of the El Dorado Chemical Company Tributary in the Integrated Report (ADEQ 2005b). There are no Municipal Separate Storm Sewer System (MS4) permits in the study area.

2.6 Nonpoint Sources

Nonpoint sources of pollution in the study area have been discussed in the Integrated Report (ADEQ 2005b):

> "The oil, brine and bromine extraction industry has contributed nonpoint source contamination to waters in this [planning] segment for many years. Recent water quality improvements are likely a result of clean up of the extraction sites; improved storage, such as phasing out open pits; and better maintenance of transmission lines, e.g., repair and replacement of broken and leaking pipelines."

2.7 Previous Water Quality Studies

Following is a list of previous water quality studies that were identified for the study area:

1. "Section 2.306 Site Specific Water Quality Study for Chloride, Sulfate, and TDS" prepared for El Dorado Chemical Company by GBMc & Associates (2006). This study was used to justify increases to the numeric criteria for chloride, sulfate, and total dissolved solids (TDS) in the El Dorado Chemical Company Tributary.
2. "Water Quality Data Assessment for the Ouachita River Between Felsenthal Reservoir Lock and Dam, Arkansas and Sterlington, Louisiana," prepared for EPA Region 6 by Parsons (2003). This report summarizes available data to assess attainment of narrative and numeric water quality standards in the Ouachita River between Felsenthal Dam and Sterlington, Louisiana.
3. "TMDL Investigation of Water Quality Impairments to Unnamed Tributary to Flat Creek, Union County, Arkansas" prepared by ADEQ (1998). This study presents and analyzes field data for the El Dorado Chemical Company Tributary for a wide range of water quality parameters including minerals, nutrients, and metals, as well as toxicity and macroinvertebrate and fish communities.
4. "TMDLs for Chlorides, Sulfate, TDS, and Ammonia in the El Dorado Chemical Company Tributary, Arkansas" prepared for EPA Region 6 by FTN (2002).

3.0 EXISTING WATER QUALITY DATA

3.1 General Description of Data

Data for zinc, copper, and nitrate have been collected by ADEQ at three sites along the Ouachita River (OUA0037, OUA0124B, and OUA0008B), one site along Smackover Creek (OUA0027), and two (metals) to five (nitrate) sites in the El Dorado Chemical Company Tributary watershed. The locations of these sampling sites are shown on Figure A.1 (Appendix A). Individual values of zinc, copper, and nitrate collected by ADEQ in the study area are listed in Tables C.1 through C.6 in Appendix C and presented as time series plots on Figures C.1 through C.11 in Appendix C. Tables 3.1 through 3.3 show summaries of these data. The zinc and copper data are reported by ADEQ as dissolved concentrations, not total concentrations.

Table 3.1. Summary of dissolved zinc data for reaches addressed in this TMDL.

	Ouachita River at Felsenthal Lock & Dam OUA0008B	**Ouachita River below Pigeon Hill Access OUA0124B**	**Ouachita River below Camden OUA0037**	**Smackover Creek near Smackover OUA0027**	**El Dorado Chemical Company Tributary at Hwy 7 Spur Bridge OUA0137A**	**El Dorado Chemical Company Tributary at O'Rear Rd OUA0137B**
Period of Record	2/20/96-3/13/07	1/10/95-1/2/07	1/9/95-3/13/07	1/9/95-3/13/07	4/4/95-12/4/01	4/4/95-9/19/00
No. of Values	57	64	74	68	7	6
Minimum (µg/L)	3.40	2.30	0.50	0.50	15.9	6.3
Maximum (µg/L)	273.0	155.0	273.0	123.0	133.8	48.3
Median (µg/L)	17.60	17.50	13.90	23.75	25.3	23.9

Table 3.2. Summary of dissolved copper data for reaches addressed in this TMDL.

	Ouachita River at Felsental Lock & Dam OUA0008B	Ouachita River below Pigeon Hill access OUA0124B	Ouachita River below Camden OUA0037	Smackover Creek near Smackover OUA0027	El Dorado Chemical Company Tributary at Hwy 7 spur bridge OUA0137A	El Dorado Chemical Company Tributary at O'Rear Rd OUA0137B
Period of Record	2/20/96-3/13/07	1/10/95-1/2/07	1/9/95 – 3/13/07	1/9/95 - 3/13/07	4/4/95 – 12/4/01	4/4/95 – 9/19/00
No. of Values	59	66	75	70	7	6
Minimum (µg/L)	0.25	0.25	0.25	0.25	3.83	7.42
Maximum (µg/L)	8.38	19.0	24.65	60.20	14.1	10.0
Median (µg/L)	1.37	1.17	1.55	1.67	5.93	8.49

Table 3.3. Summary of nitrate data in El Dorado Chemical Company Tributary watershed.

	El Dorado Chemical Company Tributary at Hwy 7 Spur Bridge OUA0137A	El Dorado Chemical Company Tributary at O'Rear Rd OUA0137B	El Dorado Chemical Company Tributary at 19th Street, upstream of Outfall 001 OUA0137E	El Dorado Chemical Company Tributary 1000 ft upstream of Hwy 7 Spur Bridge OUA0137F	Unnamed Tributary downstream of El Dorado Chemical Company stormwater discharge OUA0137G
Period of Record	5/17/94 – 12/4/01	5/17/94 – 9/19/00	3/10/97 – 12/4/01	3/10/97 – 12/1/97	3/10/97 – 12/1/97
No. of Values	21	20	5	4	4
Minimum (mg/L)	2.64	2.62	0.037	22.2	4.3
Maximum (mg/L)	211	96	0.214	105	40.8
Median (mg/L)	24.5	17.3	0.078	64.5	10.8
No. of Values > 10 mg/L	16	16	0	4	2
Percent of Values > 10 mg/L	76%	80%	0%	100%	50%

3.2 Seasonal Patterns

The zinc, copper and nitrate data do exhibit some seasonal variability, but consistent seasonal patterns were not visually apparent in the plots of the data by day of the year (Figures C.12 through C.22 in Appendix C).

3.3 Relationship with Flow

Plots of zinc and copper versus estimated stream flow were also developed to examine any correlation between concentration and flow. At the Ouachita River stations, the highest zinc and copper concentrations occurred at low flows, so there may be inverse relationships between flow and concentration (Figures C.23 through C.28). Additional flow data would be needed to confirm these relationships. Strong relationships between flow and concentration were not visually apparent for Smackover Creek (Figures C.29 and C.30) and the El Dorado Chemical Company Tributary (Figures C.31 through C.33).

4.0 TMDL DEVELOPMENT

4.1 Seasonality and Critical Conditions

EPA's regulations at 40 CFR 130.7 require the determination of TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Also, both Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 require TMDLs to consider seasonal variations for meeting water quality standards. Therefore, the historical data and analyses discussed in Sections 3.0 were used to evaluate whether there were certain flow conditions or certain periods of the year that could be used to characterize critical conditions. Based on these analyses, the TMDLs in this report were not developed on a seasonal basis. The methodology used to develop these TMDLs (load duration curve) addresses a wide range of flow conditions.

4.2 TMDL Endpoints

No water quality targets needed to be established as endpoints for the zinc and copper TMDLs because numeric criteria exist for these parameters. The criteria for dissolved zinc and dissolved copper (shown in Table 2.3) were calculated using hardness values as explained in Section 2.4 and equations from the state water quality standards for chronic toxicity criteria. A water quality target of 10 mg/L was established as the endpoint for the nitrate TMDL. This value is EPA's maximum contaminant level for drinking water and ADEQ's maximum allowable concentration for assessment of waterbodies with the designated use of drinking water (Section 2.4). Zinc, copper, and nitrate can easily be expressed as mass, so there was no need to use surrogate parameters.

4.3 Methodology for TMDL Calculations

The methodology used for all of the TMDLs in the report 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 fixed at a single value. The basic elements of this procedure are documented on the Kansas Department of Health

and Environment web site (KDHE 2007). This method was used to illustrate allowable loading at a wide range of flows. The steps for how this methodology was applied for the TMDLs in this report can be summarized as follows:

1. Develop a flow duration curve (Section 4.4).
2. Convert the flow duration curve to load duration curves (Section 4.5).
3. Plot observed loads with load duration curves (Section 4.6).
4. Calculate TMDL, MOS, WLA, and LA (Sections 4.7 through 4.10).
5. Calculate percent reductions required to meet assessment criteria (Section 4.11).

4.4 Flow Duration Curves

Daily stream flow values were estimated for the downstream end of each reach using USGS daily stream flow measurements and drainage areas as described in Table 4.1. Each USGS flow gage that was used had a period of record that was long and overlapped the period when observed water quality data were collected. A unique flow duration curve was developed for each reach by sorting each set of estimated flows in increasing order and calculating the percentile ranking of each flow. The flow duration curves are plotted in the appendices as follows:

Appendix D	(Figure D.1):	flow duration for reach 08040201-005
Appendix E	(Figure E.1):	flow duration for reach 08040201-006
Appendix F	(Figure F.1):	flow duration for reach 08040201-007
Appendix G	(Figure G.1):	flow duration for reach 08040201-606
Appendix H	(Figure H.1):	flow duration for reach 08040202-002
Appendix I	(Figure I.1):	flow duration for reach 08040202-004

Table 4.1. Methods for estimating daily stream flows for each reach.

Reach number and stream name	Method for estimating daily flows at downstream end of the reach
08040201-005 Ouachita River	Multiply flows from Ouachita River at Camden (gage no. 07362000) times ratio of drainage area at downstream end of reach (5,826 square miles) to drainage area at gage (5,357 square miles).
08040201-006 Smackover Creek	Multiply flows from Smackover Creek at Smackover (gage no. 07362100) times ratio of drainage area at downstream end of reach (541 square miles) to drainage area at gage (385 square miles).
08040201-007 Smackover Creek	Multiply flows from Smackover Creek at Smackover (gage no. 07362100) times ratio of drainage area at downstream end of reach (338 square miles) to drainage area at gage (385 square miles).
08040201-606 El Dorado Chemical Co. Tributary	Multiply flows from Smackover Creek at Smackover (gage no. 07362100) times ratio of drainage area at downstream end of reach (22.6 square miles) to drainage area at gage (385 square miles).
08040202-002 Ouachita River	Add flows from Ouachita River at Camden (gage no. 07362000), Saline River at Rye (gage no. 07363500), and local inflows downstream of those two gages. Estimate local inflows as flows from Smackover Creek at Smackover (gage no. 07362100) multiplied times ratio of local drainage area (3,427 square miles) to drainage area at Smackover gage (385 square miles). Calculations are shown in Table H.1.
08040202-004 Ouachita River	Add flows from Ouachita River at Camden (gage no. 07362000) and local inflows downstream of that gage. Estimate local inflows as flows from Smackover Creek at Smackover (gage no. 07362100) multiplied times ratio of local drainage area (1,928 square miles) to drainage area at Smackover gage (385 square miles). Calculations are shown in Table I.1.

4.5 Load Duration Curves

The flows from each flow duration curve were multiplied by the appropriate numeric criterion for zinc or copper or the target concentration for nitrate to calculate an allowable load duration curve. Each load duration curve is a plot of pounds per day versus the percent exceedances from the flow duration curve. The load duration curves and the associated calculations are presented in Appendices D through I.

The load duration curve is beneficial when analyzing monitoring data with its corresponding flow information plotted as a load. This allows the monitoring data to be plotted in relation to its place in the flow continuum. Assumptions of the probable source or sources of the impairment can often 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 will allow analysis of load cases in the future for different flow regimes.

4.6 Observed Loads

Observed loads were calculated for each sampling station by multiplying each observed concentration of the parameters of interest by the flow on the sampling day. These observed loads were then plotted versus the percent exceedances of the flow on the sampling day and placed on the same plot as the load duration curve. These plots are shown in Appendices D through I of this report.

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 where observed loads exceed the loads corresponding to the numeric criterion for zinc or copper or the target concentration for nitrate. Observed loads below the load duration curve represent conditions where observed loads were less than loads corresponding to the numeric criterion or target concentration (i.e., not violating water quality standards).

4.7 TMDL and MOS

Each TMDL was calculated as the area under the load duration curve. The TMDL calculations are shown in Appendices D through I. The TMDLs are summarized in Tables 4.2 through 4.4.

Both Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 require TMDLs to include a MOS to account for any lack of knowledge concerning the relationship between pollutant loadings and water quality. The MOS may be expressed explicitly as unallocated assimilative capacity or implicitly through conservative assumptions used in establishing the TMDL. An explicit MOS was established as 10% of each TMDL in this report.

Table 4.2. Summary of TMDLs for zinc.

Reach Number	Stream Name	Loads (lbs/day of dissolved zinc)				Percent Reduction Needed
		WLA	LA	MOS	TMDL	
08040201-005	Ouachita River	0.5	1,292.7	143.7	1,436.9	46%
08040201-006	Smackover Creek	0	112.8	12.5	125.3	38%
08040201-007	Smackover Creek	0	70.4	7.8	78.2	
08040201-606	El Dorado Chemical Company Tributary	0.76	3.95	0.52	5.23	25%
08040202-002	Ouachita River	0	240,039	26,671	266,710	18%
08040202-004	Ouachita River	2.4	1,526.2	169.9	1,698.5	49%

Table 4.3. Summary of TMDLs for copper.

Reach Number	Stream Name	Loads (lbs/day of dissolved copper)				Percent Reduction Needed
		WLA	LA	MOS	TMDL	
08040201-005	Ouachita River	4.0	136.1	15.6	155.7	8%
08040201-006	Smackover Creek	0	12.2	1.4	13.6	15%
08040201-007	Smackover Creek	0	7.6	0.9	8.5	
08040201-606	El Dorado Chemical Company Tributary	0.09	0.42	0.06	0.57	63%
08040202-002	Ouachita River	0	25,694	2,855	28,549	0%
08040202-004	Ouachita River	0	165.6	18.4	184.0	7%

Table 4.4. Summary of TMDL for nitrate.

Reach Number	Stream Name	Loads (lbs/day of nitrate)				Percent Reduction Needed
		WLA	LA	MOS	TMDL	
08040201-606	El Dorado Chemical Company Tributary	221	995	135	1,351	89%

4.8 Point Source Loads for Zinc and Copper

Zinc and copper WLAs were calculated for those discharges with zinc or copper permit limits. These discharges were from El Dorado Chemical Company, Shumaker Public Service Corporation, Union Power Partners (zinc only), and Arkansas Electric Cooperative (copper only). No other discharges were assumed to have sources of zinc or copper. Each WLA was

calculated as the design flow or highest 30-day average flow multiplied times the monthly average concentration limit from the current permit and a conversion factor. The point source loads for zinc and copper did not need to be reduced below existing permit limits because the permit limits were developed so that the discharges would not cause or contribute to any violations of water quality standards in the receiving streams under critical conditions. Calculations for the zinc and copper WLAs are shown in Tables J.1 and J.2 in Appendix J.

Permit limits for metals are specified as total recoverable metals, while the ambient water quality criteria are specified as dissolved metals. Calculating the WLAs for these zinc and copper TMDLs involved converting the total metals concentrations from the permits to dissolved metals concentrations. This was done using dissolved to total ratios (0.3242 for zinc and 0.3817 for copper) calculated from information in Attachment VI of the State of Arkansas CPP (ADEQ 2000). The information from the CPP that was used to calculate the dissolved to total ratios included the partition coefficients for zinc ($K_{PO} = 1.25 \times 10^6$ and a = -0.70) and copper ($K_{PO} = 1.04 \times 10^6$ and a = -0.74) and the TSS value for the Gulf Coastal ecoregion (5.5 mg/L). The dissolved metal equivalents for the total zinc and total copper permit limits are shown in Tables J.1 and J.2 in Appendix J.

Future growth for any existing or new point sources in the study area is not limited by these zinc and copper TMDLs if the effluent concentrations of zinc and copper are less than the instream criteria in the water quality standards. If effluent concentrations exceed the instream criteria, future growth can still occur if it can be shown that sufficient dilution exists at the location of the discharge during the time periods when discharges will occur, such that the discharge will not cause or contribute to exceedances of criteria in the stream.

4.9 Point Source Loads for Nitrate

The nitrate WLAs were calculated for discharges that have a known or expected source of nitrate and are located in the El Dorado Chemical Company Tributary watershed. These discharges were from El Dorado Chemical Company, City of Norphlet, and Cedarwood Leisure Park (formerly Wildwood Trailer Park). Calculations for the nitrate WLAs are presented in Table J.3 in Appendix J.

The only discharges with effluent limits for nitrate were El Dorado Chemical Company Outfalls 001 and 002. The monthly average nitrate limit for these two outfalls (26.3 mg/L) is a technology-based limit rather than a water quality based limit to protect the drinking water use. A nitrate concentration of 10 mg/L was used in the WLAs for these two outfalls because both outfalls can discharge during critical low flow periods when there is no dilution water in the receiving stream and the target concentration must be met "at the end of the pipe". A nitrate concentration of 10 mg/L was also used in the WLAs for the discharges of treated sanitary wastewater (El Dorado Chemical Company Outfall 003, City of Norphlet, and Cedarwood Leisure Park) because each of these discharges can occur during critical low flow conditions. The WLAs for the El Dorado Chemical Company stormwater outfalls (005, 006, and 007) were calculated using a nitrate concentration of 10 mg/L because the permit limits for zinc and the permit requirements for toxicity testing for these three outfalls assumed no dilution water in the stream. The currently effective permit and the latest application submitted by El Dorado Chemical Company (dated December 2006) were reviewed and no documentation was found for quantifying the amount of upstream dilution water that would occur during discharges from these three stormwater outfalls.

The WLA and TMDL calculations for nitrate do not consider nitrate that is generated by ammonia being nitrified in the stream. The concentrations of ammonia in the stream should be relatively low if discharges from point sources are not causing exceedances of the applicable ammonia criteria (2.43 mg/L during summer and 4.17 mg/L during winter; FTN 2002). The percentage of ammonia discharged by El Dorado Chemical Company that is nitrified prior to reaching the downstream end of the El Dorado Chemical Company Tributary (confluence with Flat Creek) is approximately 27% during the summer and 15% during the winter. These percentages were calculated using output from computer simulations of ammonia, dissolved oxygen, and related parameters in the El Dorado Chemical Company Tributary (FTN 1991). The expected amount of ammonia that would be nitrified (converted to nitrate) would be about 0.6 to 0.7 mg/L (2.43 mg/L × 27% during the summer and 4.17 mg/L × 15% during winter). This assumes that the ammonia criteria are being maintained in the stream. Effluent data submitted in El Dorado Chemical Company's December 2006 application showed average ammonia

concentrations of 105 mg/L for outfall 006 and 54 mg/L for outfall 007 during 2004 through 2006. The instream ammonia and nitrate concentrations that have occurred as a result of these stormwater discharges during recent years are unknown. The latest available instream data for ammonia were collected in 2001.

Future growth for any existing or new point sources in the study area is not limited by this nitrate TMDL if the effluent concentrations of nitrate are less than the target concentration (10 mg/L). If effluent concentrations exceed the target concentration, future growth can still occur if it can be shown that sufficient dilution exists at the location of the discharge during the time periods when discharges will occur, such that the discharge will not cause or contribute to exceedances in the stream.

4.10 Nonpoint Source Loads

The LA for nonpoint sources for each TMDL was set equal to the TMDL minus the MOS and the WLA. Calculations for the LAs are shown in Appendices D through I of this report.

4.11 Percent Reductions

In addition to calculating allowable loads, estimates were made for nonpoint source percent reductions that are needed in order for TMDLs to be attained in the streams. The calculated loads identified as TMDLs are the approved descriptor of this document. The percent reductions are shown for informational purposes only. They may assist in the preparation of an implementation plan for this TMDL package.

Each percent reduction was determined by applying a uniform percent reduction factor to the observed loads (see Section 4.6) until the number of loads exceeding the allowable loads was less than or equal to an acceptable number. The allowable loads were defined as the loads represented by the line labeled “TMDL” on the load duration plots. The acceptable number of exceedances was set to 10% of the total number of observed loads based on the ADEQ assessment methodology (ADEQ 2005b). If the percentage multiplied by the number of observed values yielded a fractional number (e.g., 25% × 38 = 9.5), the allowable number of exceedances was rounded up to the next whole number (e.g., 9.5 rounded up to 10) in accordance with the

ADEQ assessment methodology (ADEQ 2005b). The percent reduction calculations are shown in Appendices D through I, and the resulting percent reductions are shown in Tables 4.2 through 4.4.

5.0 OTHER RELEVANT INFORMATION

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, utilizing appropriate sampling methods and procedures for ensuring the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term data base for long term trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program is used to develop the state's biennial 305(b) report (*Water Quality Inventory*) and the 303(d) list of impaired waters, which are issued as a single document titled Arkansas Integrated Water Quality Monitoring and Assessment Report.

6.0 PUBLIC PARTICIPATION

When EPA establishes a TMDL, federal regulations require EPA to give public notice and seek comment concerning the TMDL. The TMDLs in this report were prepared under contract to EPA. EPA is seeking comments, information, and data from the general and affected public concerning these draft TMDLs. If comments, data, or information are submitted during the public comment period, EPA will address the comments and revise these TMDLs accordingly. EPA will then transmit the final TMDLs to ADEQ for implementation and for incorporation into ADEQ current water quality management plan.

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