United States Environmental Protection Agency
Region 7
Total Maximum Daily Load
For Low Dissolved Oxygen

West Fork Niangua River (MO_1175)
Webster County, Missouri

Karen A. Flournoy for William A. Spratlin
Director
Water, Wetlands and Pesticides Division

12-23-10
Date

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William A. Spratlin Date
Director
Water, Wetlands and Pesticides Division

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Total Maximum Daily Loads (TMDL)
For West Fork Niangua River
Pollutant: Low Dissolved Oxygen (DO)

Name: West Fork Niangua River near Marshfield, Missouri

Location: Webster County, Missouri (MO)

Hydrologic Unit Code (HUC): 1029011001

Water Body Identification (WBID): 1175

Missouri Stream Classification: Class P[1]

Designated Beneficial Uses:

- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Human Health Protection (Fish Consumption)
- Whole Body Contact Recreation – Category B (CSR, 2009)

Size of Impaired Segment: 7 miles

Location of Impaired Segment: Section 33, Township 32N, Range 18W to Section 33, Township 31N, Range 18W

Use that is Impaired: Protection of Warm Water Aquatic Life

Pollutant: Low Dissolved Oxygen

Identified Source on 303(d) List: None Listed

TMDL Priority Ranking: High[2]

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[1] Streams that maintain permanent flow even in drought periods. See Missouri Water Quality Standards (WQS) 10 Code of State Regulations (CSR) 20-7.031 (1)(F).
[2] According to the 1998 Missouri 303(d) List.

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ACRONYMS AND ABBREVIATIONS

µg N/L	Micrograms of Nitrogen per Liter
µg P/L	Micrograms of Phosphorus per Liter
µmhos	Micro Siemens
ASL	Above Sea Level
BOD	Biochemical Oxygen Demand
CAFO	Concentrated Animal Feeding Operation
CBOD	Carbonaceous Biochemical Oxygen Demand
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
cms	Cubic Meters per Second
CSR	Code of State Regulations
CWA	Clean Water Act
DO	Dissolved Oxygen
EDU	Ecological Drainage Unit
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System
HUC	Hydrologic Unit Code
LA	Load Allocation
lbs/day	Pounds per Day
LC	Loading Capacity
LDC	Load Duration Curve
MDC	Missouri Department of Conservation
MDNR	Missouri Department of Natural Resources
mg $CaCO_3$/L	Milligrams Calcium Carbonate per Liter
mg O_2/L	Milligrams of Oxygen per Liter
mg/L	Milligrams per Liter
MGD	Million Gallons per Day
mi^2	Square Miles
MO	Missouri
MoRAP	Missouri Resource Assessment Partnership
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
MSDIS	Missouri Spatial Data Information Service
MSOPS	Missouri State Operating Permit System
NA	Not Applicable
NASS	National Agricultural Statistics Service
$NBOD_{ult}$	Ultimate Nitrogenous Biochemical Oxygen Demand

NH_3	Ammonia
NO_3+NO_2	Nitrate plus Nitrite Nitrogen
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
SOD	Sediment Oxygen Demand
STEPL	Spreadsheet Tool for Estimating Pollutant Load
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USGS	U.S. Geological Survey
WBID	Water body Identification
WLA	Wasteload Allocation
WQBELs	Water Quality–Based Effluent Limitations
WQS	Water Quality Standards
WWTP	Wastewater Treatment Plant

1 INTRODUCTION

The West Fork Niangua River Total Maximum Daily Load (TMDL) is being established in accordance with Section 303(d) of the Clean Water Act (CWA). The water quality limited segment is included on the U.S. Environmental Protection Agency (EPA) approved 2008 Missouri 303(d) List. The West Fork Niangua River is identified as impaired due to low dissolved oxygen (DO) from unlisted sources; however, past versions of Missouri's 303(d) List included the city of Marshfield Wastewater Treatment Plant (WWTP) as a listed source. Data analyses and field investigations to support the listing and TMDL development for the West Fork Niangua River have indicated low DO as a contributor to the impairment, which can be linked to the impaired Protection of Warm Water Aquatic Life designated beneficial use of the water body. This report addresses the West Fork Niangua River impairment by establishing TMDLs associated with low DO levels, in accordance with Section 303(d) of the CWA. EPA is establishing this TMDL to meet the milestones of the 2001 Consent Decree, *American Canoe Association, et al. v. EPA*, No. 98-1195-CV-W, in consolidation with No. 98-4282-CV-W, February 27, 2001.

Section 303(d) of the CWA and Federal Chapter 40 of the Code of Federal Regulations (CFR) Part 130 requires states to develop TMDLs for waters not meeting designated beneficial uses. The TMDL process quantitatively assesses impairment factors so that states can establish water-quality based controls to reduce pollutants and restore and protect the quality of their water resources. The purpose of a TMDL is to determine the maximum amount of a pollutant (the load) that a water body can assimilate without causing exceedances of the water quality standards (WQS). WQS are benchmarks used to assess the water quality of rivers and lakes. The TMDL also establishes the pollutant loading capacity (LC) (i.e., amount) necessary to meet the Missouri WQS established for each water body based on the relationship between pollutant sources and instream water quality conditions. The TMDL consists of a wasteload allocation (WLA), a load allocation (LA) and a margin of safety (MOS). The WLA is the portion of the allowable load that is allocated to point sources, the LA is the portion of the allowable load that is allocated to nonpoint sources and the MOS accounts for the uncertainty associated with linking pollutant loads to receiving-water impacts. The uncertainty is often associated with model assumption and data limitations.

The goal of EPA's TMDL program is to restore impaired designated beneficial uses to water bodies. In addition to establishing TMDLs for the West Fork Niangua River, this report provides a summary of information, results and recommendations related to the impairment based on a broad analysis of watershed information, analysis of water quality data and computer modeling to support TMDL development. The sections of this report are organized as follows:

- Section 2 provides background information on the West Fork Niangua River watershed;
- Section 3 describes potential sources of concern;
- Section 4 presents the applicable WQS;
- Section 5 describes the modeling that was done to support the TMDL;
- Sections 6 to 10 present the required TMDL elements (e.g., LC, WLA, LA, MOS, seasonal variation);

- Sections 11 to 13 summarize the follow-up monitoring plan, reasonable assurances and public participation, and;
- Section 14 presents a summary of the administrative record.

2 BACKGROUND

This section of the report provides background information on the West Fork Niangua River and its watershed.

2.1 THE SETTING

The West Fork Niangua River is a rural water body that flows north to join with the East Fork Niangua River and form the Niangua River, which is a tributary of the Osage River. The West Fork Niangua River is located in the Ozark/Osage River Ecological Drainage Unit (EDU) and its watershed covers an area of approximately 27.6 square miles (mi^2) with a river distance of approximately 7 miles. The topographic relief along the impaired segment of the West Fork Niangua River has an approximate elevation of 1,269 feet above sea level (ASL) upstream and gradually slopes down to approximately 1,129 to 1,140 feet ASL downstream. The West Fork Niangua River watershed was defined using the 10-digit watershed Hydrologic Unit Code (HUC) labeled the Upper Niangua Subwatershed (1029011001) and was further delineated using contours based off U. S. Geological Survey (USGS) topographic maps and national hydrography dataset stream coverage.

EPA placed the West Fork Niangua River on the 303(d) List in 1994 because of low levels of DO that impaired the Protection of Warm Water Aquatic Life designated use. The basis for this listing was supported by data from the Missouri Department of Natural Resources (MDNR) collected upstream and downstream of the city of Marshfield WWTP from 1985–2000. During approximately 30 sampling events, DO levels were routinely below the Missouri WQS numeric criteria for the Protection of Warm Water Aquatic Life, which is a minimum of 5 milligrams per liter (mg/L). In Missouri's 1998 303(d) List, the Marshfield WWTP was listed as a pollutant source contributing to the low DO levels in the West Fork Niangua River. One additional sampling location near Bermott, Missouri, was sampled by the USGS from 1991–1995 as part of a collection of water quality data for the Niangua River Basin Project.

Land use in the prairie portions of the watershed and municipal discharges are possible reasons why the West Fork Niangua River has a reduced ability to support aquatic life. The major water quality problem is low DO, possibly due to runoff or drainage from agricultural land dominating the watershed and permitted point sources from municipal facilities, such as the Marshfield WWTP. Contributing nonpoint sources could include runoff from urban areas and failing onsite wastewater systems (e.g., septic tanks). To address the water quality deficiencies exhibited by West Fork Niangua River, the TMDL targets contributors to low DO levels, such as elevated total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS), along with carbonaceous biochemical oxygen demand (CBOD).

2.2 PHYSIOGRAPHIC LOCATION, GEOLOGY AND SOILS

The West Fork Niangua watershed (a small portion of the larger Niangua River watershed) lies in the Salem Plateau subdivision of the Ozark Plateau physiographic region. The watershed is underlain with several hundred feet of Ordovician and Cambrian rock, largely dolomite (Harvey et al., 1983). The upland edges of the watershed lie in Jefferson City-Cotter dolomite, while the waterways cut into progressively older Roubidoux, Gasconade and Eminence formations (MDNR, 1984). There is considerable subsurface movement of water in the watershed through channels in the fractured and jointed dolomite. As a result, karst features, such as caves, sinkholes, losing streams and springs, are abundant. Streams that incise into the middle or lower Gasconade have well-sustained base flows, even during dry periods, due to ample groundwater supplies (MDNR, 1984). Streams that incise into the Roubidoux formation are frequently losing streams and sinkholes are common (Harvey et al., 1983).

Soils in the watershed are classified as residual, alluvial, colluvial and loess (Harvey et al., 1983; MDC, 2010). Residual soils consist primarily of material weathered from dolomite and sandstone and occur on the surface of steep slopes. Colluvial soils are soils deposited on lower valley slopes by erosion from more elevated sites and are limited in abundance. Alluvial soils are soils that range in size from silt to gravel that are transported by streams and deposited on level or gently sloping areas in flood plains. Loess soils are silty, windblown material that commonly occurs on ridge tops (MDC, 2010). Table 1 provides a summary of the soil types in the impaired West Fork Niangua River watershed.

A soil's Hydrologic Soil Group relates to the rate at which water enters the soil profile, which in turn affects the amount of water that enters the stream as direct runoff. The dominant soil type, Group C, covers approximately 80.83 percent of the watershed and includes sandy and silty loam soils that have a moderately fine to fine structure. These soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water. Only 4.23 percent of soils in the impaired watershed are categorized as Group D. These soils include silty loams and complexes that have the highest runoff potential. Group D soils have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils, soils with a permanent high water table and soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material. The remaining 14.56 percent of soils in the West Fork Niangua River watershed are composed of Group B soils. These soils are gravelly silt and silt loams with a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures (Purdue Research Foundation, 2009).

Table 1. Soils Summary for the West Fork Niangua River Watershed (NRCS, 2010)

Soil Name	Hydrologic Soil Group	Watershed Area		Percent (%)
		Acre	Square Miles	
Cedargap gravelly silt loam	B	685.76	1.072	3.88
Dameron silt loam	B	1,106.01	1.728	6.26
Jamesfin silt loam	B	46.19	0.072	0.26
Noark very gravelly silt loam	B	6.83	0.011	0.04
Peridge silt loam	B	102.90	0.161	0.58
Pomme silt loam	B	625.97	0.978	3.54
Subtotal		**2,573.66**	**4.022**	**14.56**
Alred-Gatewood complex	C	5.51	0.009	0.03
Alsup gravelly silt loam	C	113.18	0.177	0.64
Alsup-Noark complex	C	70.73	0.111	0.40
Basehor fine sandy loam	C	341.05	0.533	1.93
Goss-Wilderness complex	C	3,837.53	5.996	21.71
Hobson loam	C	1,733.40	2.708	9.81
Mano-Ocie complex	C	4,052.55	6.332	22.93
Ocie-Gatewood complex	C	1,382.75	2.161	7.82
Plato silt loam	C	265.65	0.415	1.50
Scholten-Noark complex	C	27.24	0.043	0.15
Tonti silt loam	C	11.06	0.017	0.06
Viraton silt loam	C	2,448.62	3.826	13.85
Subtotal		**14,289.27**	**22.328**	**80.83**
Moniteau silt loam	C/D	44.28	0.069	0.25
Subtotal		**44.28**	**0.069**	**0.25**
Bado silt loam	D	27.90	0.044	0.16
Gatewood-Moko complex	D	368.55	0.576	2.08
Hartville silt loam	D	316.97	0.495	1.79
Moko-Rock outcrop complex	D	19.54	0.031	0.11
Udorthents	D	16.17	0.025	0.09
Subtotal		**749.13**	**1.171**	**4.23**
Water		20.72	0.032	0.12
Subtotal		**20.72**	**0.032**	**0.12**
Total		**17,677.04**	**27.62**	**100**

2.3 RAINFALL AND CLIMATE

Two weather stations are located near the West Fork Niangua River watershed (Figure 1): Station 235307 (Marshfield, Missouri) and Station 237976 (Springfield Regional Airport, Missouri). These stations record daily precipitation, maximum and minimum temperatures, snowfall and snow depth. Figure 2 provides a summary of rainfall and climate data for these stations, based on 30-year totals (1971–2000) (NOAA, 2010). The annual average precipitation, maximum daily temperature and minimum daily temperature for the Marshfield, Missouri, station over the 30-year period is 43.44 inches, 67.3 degrees Fahrenheit and 45.3 degrees Fahrenheit, respectively. The annual average precipitation, maximum daily temperature and minimum daily temperature over the 30-year period for the Springfield, Missouri station is 44.97 inches, 67.4 degrees Fahrenheit and 45.0 degrees Fahrenheit, respectively. These nearby weather stations provide useful information for simulating stream temperature, which impacts the decay of CBOD, transformation of nutrients and solubility of DO.

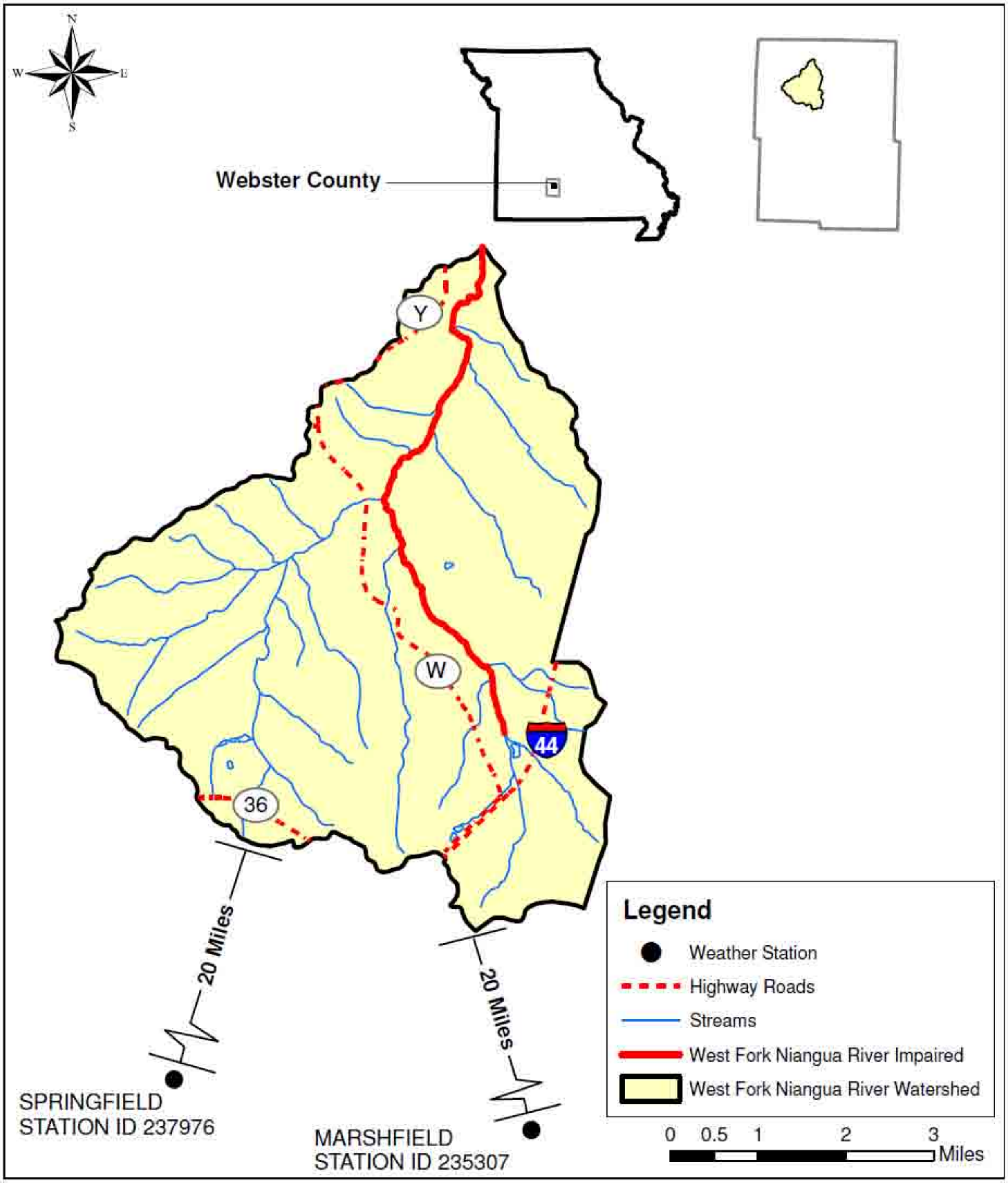

Figure 1. Location of West Fork Niangua River Watershed with Weather Stations

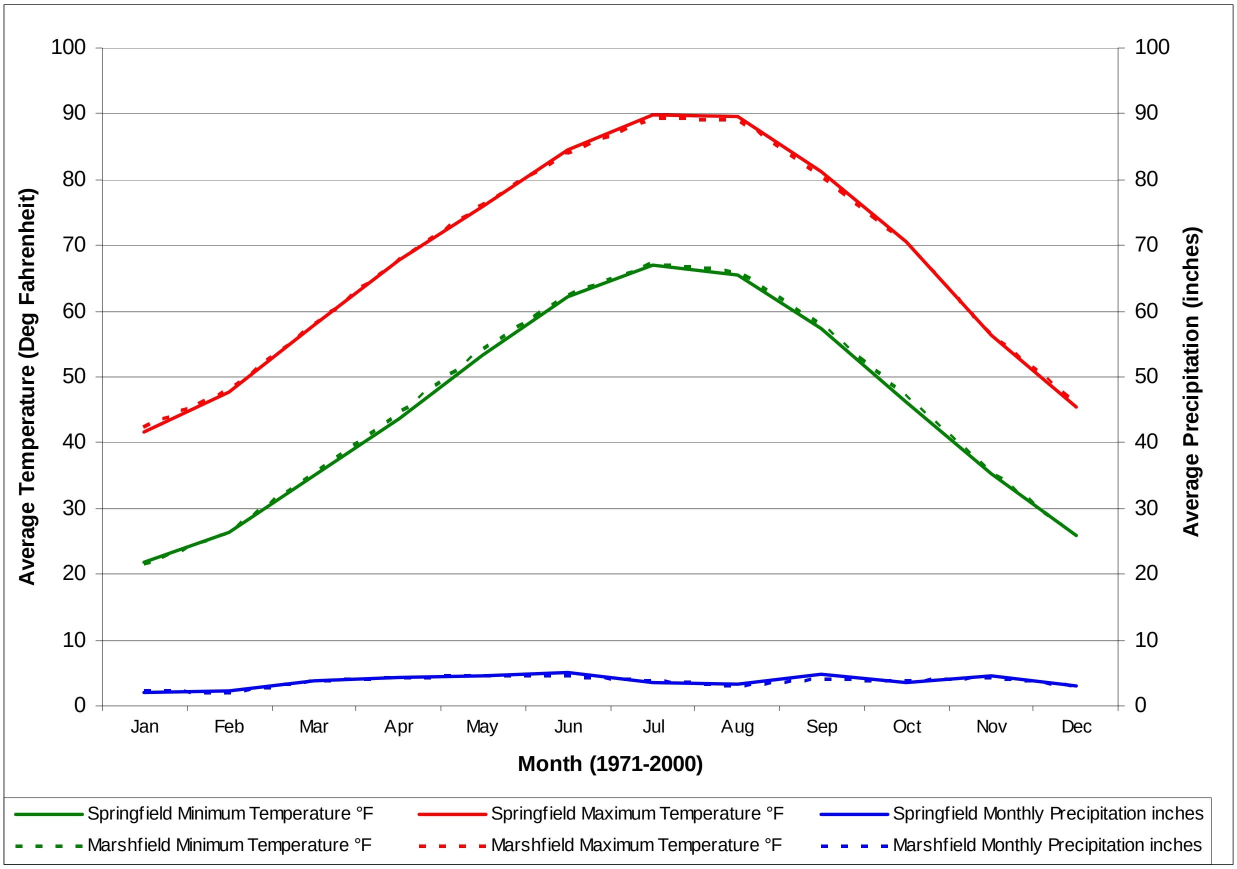

Figure 2. Thirty-year Monthly Averages for Station 235307 (Marshfield, Missouri) and Station 237976 (Springfield Regional Airport, Missouri) (NOAA, 2010)

2.4 POPULATION

The population of the West Fork Niangua River watershed is not directly available; however, the census reports that the 2000 population for Webster County, Missouri, was 31,045 (U.S. Census Bureau, 2000). The West Fork Niangua River watershed population was estimated to be 4,443 persons. This estimation was calculated using geographic information system (GIS) analyses by selecting the census block points located within the watershed area (27.62 mi^2). Based on the watershed population calculation, an estimated overall population density for the West Fork Niangua River watershed was calculated to be approximately 160 persons per square mile (4,443 persons divided by 27.62 mi^2).

2.5 LAND USE AND LAND COVER

The land use and land cover of the West Fork Niangua River watershed is shown in Figure 3 and summarized in Table 2 (MoRAP, 2005). The primary land uses/land covers are grassland (55.66 percent) and forest (31.72 percent). The classifications for the remaining 12.62 percent of the watershed area are wetlands, impervious, high-intensity urban, low-intensity urban, barren, open water and cropland.

Table 2. Land Use/Land Cover in the West Fork Niangua River Watershed (MoRAP, 2005)

Land Use/Land Cover	Watershed Area		Percent (%)
	Acres	Square Miles	
Impervious[1]	411.35	0.64	2.33
High-intensity Urban	11.81	0.02	0.07
Low-intensity Urban	867.51	1.36	4.91
Barren or Sparsely Vegetated	128.38	0.20	0.73
Cropland	688.26	1.08	3.89
Grassland	9,839.24	15.37	55.66
Forest	5,607.62	8.76	31.72
Wetland	5.89	0.01	0.03
Open Water	116.97	0.18	0.66
Total	**17,677.03**	**27.62**	**100**

[1] Impervious land uses include non-vegetated, impervious surfaces, such as areas dominated by streets, parking lots and buildings (MoRAP, 2005).

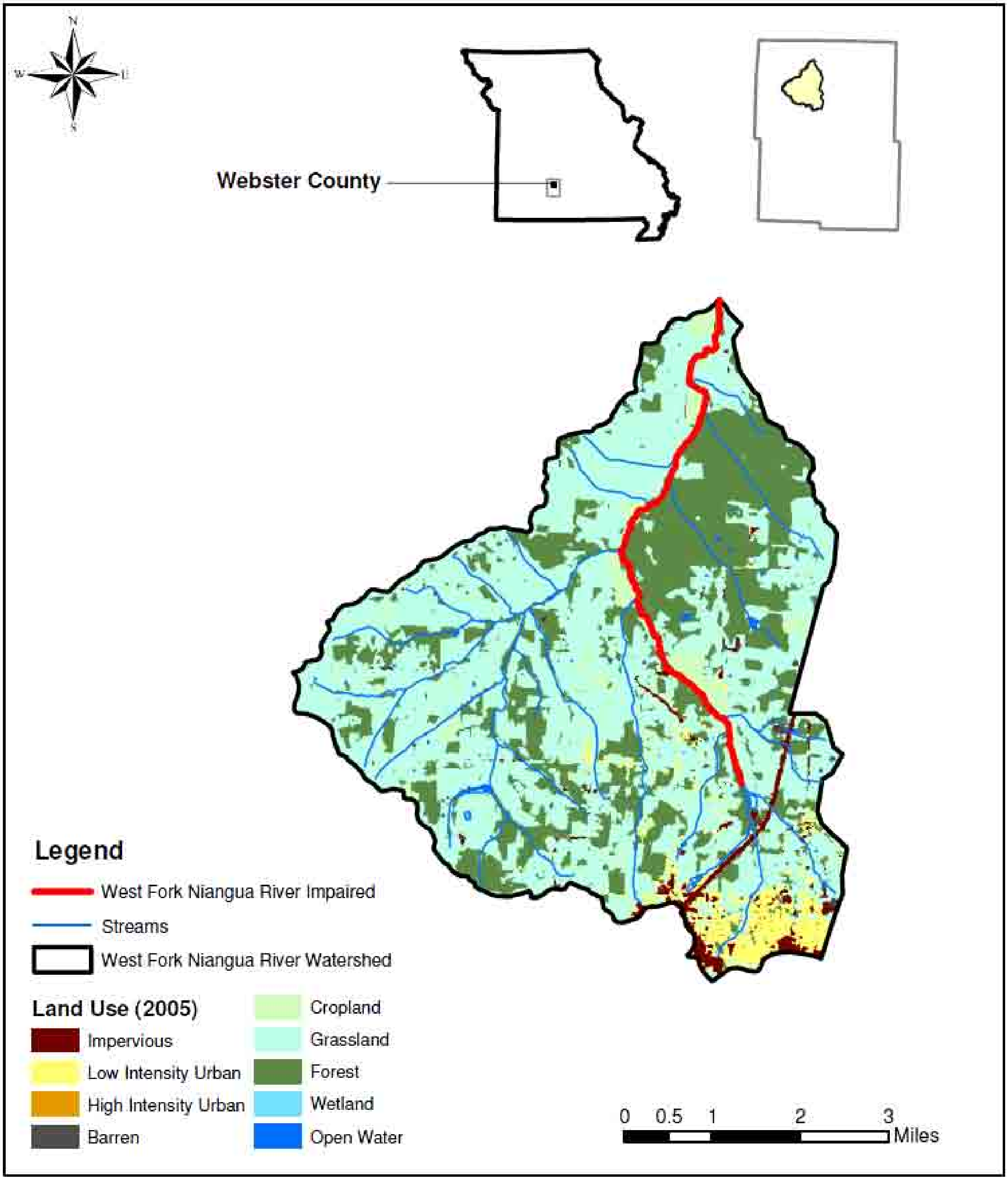

Figure 3. Land Use/Land Cover in the West Fork Niangua River Watershed (MoRAP, 2005)

2.6 DEFINING THE PROBLEM

The West Fork Niangua River is impaired due to exceedances of Missouri's minimum DO water quality criterion for the Protection of Aquatic Life (10 CSR 20-7.031). Historical water quality data collected by MDNR from June 1985 through 2000 show DO concentrations below
5 mg/L in 10 of 29 samples collected at locations upstream and downstream of the Marshfield WWTP (see Appendix A). The Missouri WQS for DO in warm water fisheries is a minimum of 5 mg/L; consequently, the West Fork Niangua River is not in compliance with Missouri WQS. Missouri's 2008 303(d) List has no specific pollutant source listed; however, the 1998 303(d) List identified the Marshfield WWTP as a potential source of the impairment. Table 3 and Table 4 summarize the DO data collected by the MDNR by year and sampling location. The DO levels for the West Fork Niangua River were in exceedance of the Missouri WQS (5 mg/L) minimum criterion approximately 34 percent of the time. Sixty percent of the DO exceedances occurred in 1998 and 80 percent occurred one mile or more downstream of the Marshfield WWTP.

Table 3. MDNR Annual DO Data for the West Fork Niangua River (MDNR, 2000)

Year	Number of Samples	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Lower Quartile (mg/L)	Upper Quartile (mg/L)	Number of Exceedances[1]
1985	3	7.0	4.0	10.0	4.0	10.0	1
1998	18	8.3	3.4	14.6	4.2	10.8	6
1993	2	5.1	4.2	6.0	NA	NA	1
1998	2	10	9.3	10.7	NA	NA	0
2000	4	6.2	3.2	9.4	3.6	8.9	2
All Years	**29**	**7.8**	**3.2**	**14.6**	**4.2**	**10.2**	**10**

[1] Missouri WQS numeric criterion is a minimum 5 mg/L for DO
NA = Not Applicable

Table 4. MDNR Site-Specific DO Data for the West Fork Niangua River (MDNR, 2000)

Location	Number of Samples	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Lower Quartile (mg/L)	Upper Quartile (mg/L)	Number of Exceedances[1]
0.1 miles upstream of Marshfield WWTP	2	7.0	4.0	10.0	NA	NA	1
0.6 miles downstream of Marshfield WWTP	2	6.8	4.2	9.3	NA	NA	1
1.0 miles downstream of Marshfield WWTP	9	8.0	3.2	14.6	3.7	12.8	3
2.0 miles downstream of Marshfield WWTP	11	7.9	3.4	14.1	4.6	10.0	3
3.3 miles downstream of Marshfield WWTP	5	7.9	4.2	10.6	4.2	10.4	2

[1] Missouri WQS numeric criteria is 5.0 mg/L for DO
NA = Not Applicable

DO levels in streams are affected by several factors, including the water temperature, amount of decaying matter (i.e., organic sediment) in the stream, turbulence at the air–water interface and amount of photosynthesis occurring in plants within the stream. Excessive nitrogen and phosphorus loading to water bodies can also contribute to DO problems because high nutrient levels can accelerate algal growth. Rapid algal growth, decay and decomposition can lead to excessive bottom deposits which can become a source of oxygen-consuming substances. A water quality study performed by the USGS as part of the Niangua River Basin Project had a sampling location in the West Fork Niangua River near Bermott, Missouri. Table 5 summarizes the results from that study, which includes data for DO and nutrients that impact DO levels, such as TN and TP. Missouri currently does not have a numeric criteria for TN and TP in freshwater streams in its WQS; therefore, targets and LCs are based on EPA-recommended Ecoregion 39 criteria and water quality observations at locations throughout the ecoregion (EPA, 2000). To address nutrient levels, the EPA nutrient ecoregion reference concentrations were used. For Ecoregion 39, where the West Fork Niangua River is located, the reference concentration for TN is 0.289 mg/L and the reference concentration for TP is 0.007 mg/L (EPA, 2000). Although no USGS sampling events recorded low DO levels, TN was elevated for approximately 64 percent of the sampling events and TP was elevated for approximately 43 percent of the sampling events.

It should be noted that the TP detection limit for this study was greater than the ecoregion criterion; thus, the samples reported as below the detection limit may be in excess of the criterion. Therefore, 43 percent is a potentially low estimate of samples reporting TP in excess of the ecoregion criterion.

Table 5. Water Quality Data for the West Fork Niangua River (U.S. DOI, 1995)

Sample Date	DO (mg/L)	TN (mg/L)	TP (mg/L)	Exceeded Parameters[1]
11/21/91	11.7	0.49	0.01	TN, TP
1/16/92	13.8	0.74	< 0.01	TN
5/12/92	8.8	0.35	0.05	TN, TP
7/21/92	8.3	0.28	< 0.01	-
11/05/92	8.5	0.19	0.01	TP
1/26/93	13.8	0.42	< 0.02	TN
5/12/93	9.5	0.37	0.02	TN, TP
7/07/93	8.0	0.23	< 0.02	-
11/04/93	10.2	0.17	0.04	TP
2/01/94	13.5	0.49	< 0.02	TN
5/10/94	10.2	0.32	< 0.02	TN
8/21/94	7.6	0.36	0.02	TN, TP
10/25/94	9.9	0.11	< 0.02	-
2/06/95	12.9	0.41	< 0.02	TN
Average	**10.48**	**0.35**	**0.02**	

[1] Ecoregion reference concentrations: TN = 0.289 mg/L and TP = 0.007 mg/L

Organic sediments can also contribute to fluctuating DO concentrations. Decaying matter can come from wastewater effluent, as well as agricultural and urban runoff, and is typically measured instream as biochemical oxygen demand (BOD). Decaying matter can also accumulate on the bottom of a stream and cause sediment oxygen demand (SOD). SOD is a combination of all of the oxygen-consuming processes that occur at or just below the sediment/water interface. SOD is partly due to biological processes and partly due to chemical processes. Most of the SOD at the surface of the sediment is due to the biological decomposition of organic material and the bacterially facilitated nitrification of ammonia, while SOD found several centimeters into the sediment is often dominated by the chemical oxidation of species such as iron, manganese and sulfide (Wang, 1980; Walker and Snodgrass, 1986). Organic sediment can also settle out of the water column and smother aquatic invertebrates and fish eggs and cause offensive odors and unsightliness.

3 SOURCE INVENTORY

A source assessment is used to identify and characterize the known and suspected pollutant sources contributing to the impairment in West Fork Niangua River. For the purpose of this report, sources have been divided into two broad categories: point sources and nonpoint sources. Point sources can be defined as sources, either constant or time transient, which occur at a fixed location in a watershed. Nonpoint sources are generally accepted to be diffuse sources not entering a water body at a specific location. Nutrients and oxygen-consuming substances from both point and nonpoint sources are considered to be the primary contributors to impairment in the West Fork Niangua River.

3.1 POINT SOURCES

The term “point source” refers to any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel or conduit, by which pollutants are transported to a water body. For the purposes of TMDL development, point sources are defined as sources regulated through the National Pollutant Discharge Elimination System (NPDES) program. Missouri has its own program for administering the NPDES program, referred to as the Missouri State Operating Permit System (MSOPS). Because the NPDES and MSOPS programs are the same, for the purposes of this document, the term NPDES will be used.

The following NPDES-regulated entities are included in this source category:

- Municipal and industrial wastewater treatment facilities (e.g., WWTP);
- Concentrated animal feeding operations (CAFO);
- Storm water runoff from Municipal Separate Storm Sewer Systems (MS4); and
- General permitted facilities (e.g., including storm water runoff from construction and industrial sites).

General permits (as opposed to site specific permits) are issued to activities that are similar enough to be covered by a single set of requirements. Storm water permits are issued to activities that discharge only in response to precipitation events. Point sources in the West Fork Niangua River watershed were identified by consulting EPA’s Permit Compliance System website[3] (EPA, 2010a) and the MDNR’s GIS inventory[4] of NPDES-permitted facilities covered under storm water or general permits.

The point sources for West Fork Niangua River are listed in Table 6 and shown on Figure 4. There are two storm water permits issued to the Niangua Ranch Subdivision and one general wastewater permit issued to the Hoerman Meat Company, which has no reported discharges. These facilities and their outfalls are unlikely to contribute nutrients or oxygen-consuming substances to the West Fork Niangua River.

The WWTPs of two mobile home parks have the potential to be minor contributors of nutrients and oxygen-consuming substances to the watershed. The Gaslight Village Mobile

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[3] www.epa.gov/enviro/html/pcs/index.html
[4] http://msdis.missouri.edu/datasearch/ThemeList.jsp; GIS layers updated May 2009 and June 2009 (MSDIS, 2010)

Home Park and the Fountain Plaza Mobile Home Park have NPDES permits to discharge wastewater from their lagoons; however, the discharges are only 5,200 and 7,350 gallons per day, respectively. The effluent limitations for BOD for these discharges are a weekly average of 65 mg/L and a monthly average of 45 mg/L. These small WWTPs most likely contribute some nutrients and oxygen-consuming substances to the West Fork Niangua River; however, compared to the discharge of large WWTPs, these discharges are minor due to the flow rate.

One major contributor of nutrients and oxygen-consuming substances to the West Fork Niangua River is the Marshfield WWTP, which was named as a pollutant source in previous versions of the 303(d) list. The NPDES permit allows the Marshfield WWTP to discharge through three outfalls. Two outfalls (outfalls #001 and #003) are designated for storm water discharge from a storm water clarifier and can discharge up to 3.92 million gallons per day (MGD) during storm events where influent flow exceeds wet weather treatment capacity of the WWTP. Discharges from these storm water outfalls cannot exceed weekly averages of 45 mg/L for BOD. As of July 2010, the permit for the Marshfield WWTP has expired and is expected to be rewritten to exclude discharge from the storm water clarifier. Therefore, the TMDL modeling does not include storm water discharge from this source. Previous operating permits in Missouri authorized discharges of bypassed wastewater at some facilities during peak flow conditions. These discharges were required to meet effluent limitations, but these limitations were not as stringent as those for the main facility discharge. Changes to MDNR regulations have removed this authorization, and permits are now issued without bypass discharges being authorized. Discharges resulting from emergency diversion shall be considered an unauthorized bypass pursuant to 40 CFR 122.41(m) and shall be reported, pursuant to 40 CFR 122.41(m).

Outfall #002 is the main facility outfall and designated to discharge wastewater from processes involving extended aeration, secondary clarifiers, tertiary clarifiers, chlorination, sludge storage basins and the land application of sludge. This outfall averages a discharge of 1.5 MGD and has effluent limitations of 15 mg/L weekly average and 10 mg/L monthly average for BOD. The Marshfield WWTP discharges large amounts of wastewater into the West Fork Niangua River and is a major contributor of the pollutants of concern to the impaired segment.

Illicit straight pipe discharges of household waste are also potential point sources in rural areas. These are discharges directly into streams or land areas and are different than illicitly connected sewers. There is no specific information on the number of illicit straight pipe discharges of household wastes in the West Fork Niangua River watershed and since a WWTP is located within the watershed, it is assumed that illicit straight pipe discharges are an insignificant load to the stream.

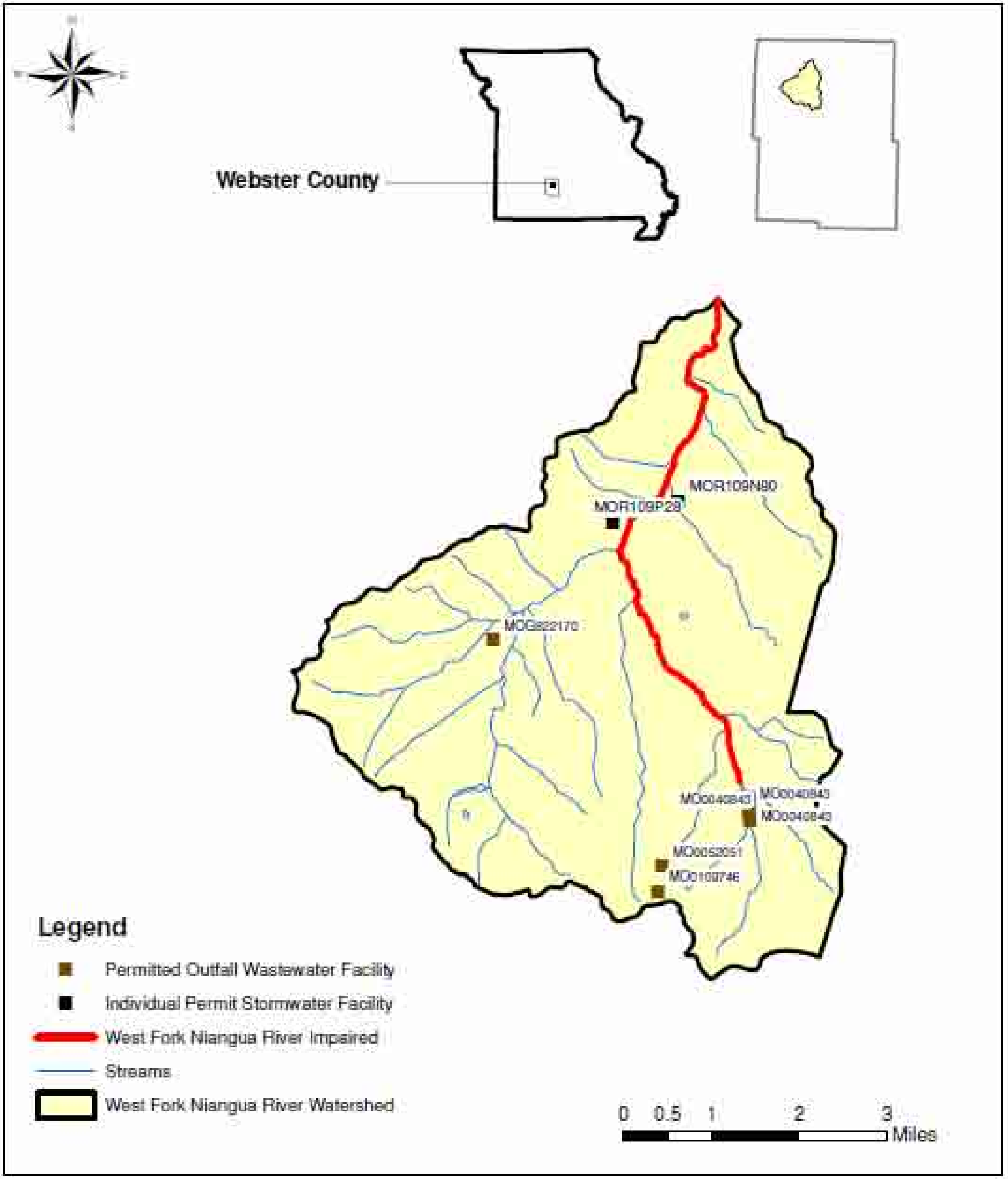

Figure 4. Location of Permitted Facilities in the West Fork Niangua River Watershed

Table 6. Permitted Facilities in the West Fork Niangua River Watershed

WASTEWATER						
Facility ID	**Facility Name**	**No. of Outfalls**	**Designed Flow Rate (MGD)**	**Receiving Stream**	**Facility Type**	**Permit Expiration Date**
MO0109746	Fountain Plaza Mobile Home Park WWTP	1	0.007	Tributary of West Fork Niangua River	Non-Municipal	2/25/2012
MO0052051	Gaslight Village Mobile Home Park WWTP	1	0.005	Tributary of West Fork Niangua River	Non-Municipal	1/25/2011
MO0040843	city of Marshfield WWTP	3	1.5 (Average Daily Flow)	Tributary of West Fork Niangua River	Municipal	9/20/2006
MOG822170	Hoerman Meat Company	1	No Flow Facility	Tributary of Greer Creek	Non-Municipal	6/8/2011
MOG350272	MFA Oil Company - Marshfield	1	No Flow Facility	Tributary to Turnbo Creek	Non-Municipal	06/14/2012
STORM WATER						
Facility ID	**Facility Name**	**City**	**Status**	**Receiving Stream**	**Permit Issue Date**	**Permit Expiration**
MOR109P28	Niangua Ranch Subdivision	Niangua	Active	Tributary of West Fork Niangua River	4/26/2007	3/7/2012
MOR109N80	Niangua Ranch Subdivision	Niangua	Active	Tributary of West Fork Niangua River	4/26/2007	3/7/2012
MOR203310	SRG Power Systems Inc.	Marshfield	Active	Tributary to West Fork Niangua River	9/18/2009	6/14/2014
MOR10B099	Greyhawk Estates	Marshfield	Active	Tributary to West Fork Niangua River	9/13/2007	2/7/2012
MOR109FJ0	Webster Elementary	Marshfield	Active	Tributary to West Fork Niangua River	9/9/2010	3/7/2012
MOR109FC9	Days Floor Company	Marshfield	Active	Tributary to West Fork Niangua River	6/14/2010	3/7/2012

3.2 NONPOINT SOURCES

Nonpoint sources include all other categories of pollutant sources not classified as point sources. Potential nonpoint sources contributing to low DO levels in the West Fork Niangua River watershed include runoff from agricultural areas, runoff from urban areas, onsite wastewater treatment systems and various sources associated with riparian habitat conditions. Each of these sources is discussed further in the following sections.

In the absence of an NPDES permit, discharges associated with sources were applied to the LA, as opposed to the WLA for purposes of this TMDL. The decision to allocate these sources to the LA does not reflect any determination by EPA as to whether these discharges are, in fact, unpermitted point source discharges within this watershed. In addition, by establishing these TMDLs with some sources treated as LAs, EPA is not determining that these discharges are exempt from NPDES permitting requirements. If sources of the allocated pollutants in this TMDL are found to be or become, NPDES-regulated discharges, their loads must be considered as part of the calculated sum of the WLAs in this TMDL. WLA in addition to that allocated here is not available.

3.2.1 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (e.g., septic systems) that are properly designed and maintained generally do not serve as a source of contamination to surface waters; however, these systems can fail for a variety of reasons. When these systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration), there can be adverse effects to surface waters (Horsley and Witten, 1996). Failing septic systems are sources of nutrients and pathogens that can reach nearby streams through both runoff and subsurface flows.

The exact number of onsite wastewater treatment systems in the West Fork Niangua River watershed is unknown. However, the EPA's Spreadsheet Tool for Estimating Pollutant Load (STEPL)[5] reports there are 13,157 septic systems within the Niangua River watershed, which is the eight digit HUC watershed that contains the West Fork Niangua River watershed. The Niangua River watershed has an average population per septic system of 1.61. As discussed in Section 2.4, the estimated rural population of the West Fork Niangua River watershed is approximately 4,443 persons. Based on this population and an average density of 1.61 persons per septic system, an estimate of approximately 2,760 systems in the watershed is obtained. While onsite wastewater treatment (i.e., septic) systems can also be viewed as nonpoint pollutant sources, their impacts can be factored into a load analysis when the locations of failing septic systems are known. An EPA study reports that the estimated failure rate of onsite wastewater treatment systems in Missouri is 30 percent to 50 percent (EPA, 2010b). At this failure rate, there would be approximately 828 to 1,380 failing systems in the West Fork Niangua River watershed. Although there are no data that suggest that failing onsite wastewater treatment systems are a significant problem in the West Fork Niangua River watershed, these systems could be a potential contributor of nutrients (e.g., TN, TP) that would result in low DO levels. However, failing septic systems would only be a small source of nutrients to the West Fork Niangua River watershed and would not be the primary pollutant source.

[5] http://bering.tetratech-ffx.com/website/stepl/viewer.htm

3.2.2 Runoff from Agricultural Areas

Lands used for agricultural and grazing purposes can be a source of nutrients and oxygen-consuming substances. Accumulation of nitrogen and phosphorus on cropland occurs from decomposition of residual crop material, fertilization with chemical and manure fertilizers, atmospheric deposition, wildlife excreta, irrigation water and livestock excreta. The 2005 land use/land cover data (MoRAP, 2005) indicate approximately 688 cropland acres (3.89 percent) and approximately 9,839 grassland acres (55.66 percent) grassland acres in the West Fork Niangua River watershed (see Table 2). Additionally, cropland comprises approximately 8.07 percent of the watershed's riparian buffer, while 42.93 percent of the buffer is classified as grassland (Table 7). County-wide data from the National Agricultural Statistics Service (NASS) (USDA, 2010) were combined with the land cover data for the West Fork Niangua River watershed to estimate approximately 3,537 cattle in the watershed[6]. The cattle are most likely located on the approximately 15.37 mi^2 of grassland/pastureland in the watershed. Runoff from these areas can be potential sources of nutrients and oxygen-consuming substances. Animals grazing in pasture areas deposit manure directly upon the land surface and even though a pasture may be relatively large and animal densities low, the manure will often be concentrated near the feeding and watering areas in the field. These areas can quickly become barren of plant cover, increasing the possibility of erosion and contaminated runoff during a storm event. In addition, when pasture land is not fenced off from the stream, cattle or other livestock may contribute nutrients to the stream while walking in or adjacent to the water body. The density of cattle in the West Fork Niangua River watershed (230 cattle per mi^2 or 3,537 cattle in the entire watershed) suggests they could be a potential source of pollutants.

No permitted CAFOs were identified in this TMDL. At this time, Animal Feeding Operations (AFOs) and unpermitted CAFOs are considered under the LA because there is currently not enough detailed information to know whether these facilities are required to obtain NPDES permits. This TMDL does not reflect a determination by EPA that such a facility does not meet the definition of a CAFO, nor that the facility does not need to obtain a permit. To the contrary, a CAFO that discharges or proposes to discharge has a duty to obtain a permit. If it is determined that any such operation is an AFO or CAFO that discharges, any future WLA assigned to the facility must not result in an exceedance of the sum of the WLAs in this TMDL as approved.

Any CAFO that does not obtain an NPDES permit must operate as a no discharge operation. Any discharge from an unpermitted CAFO is a violation of Section 301. It is EPA's position that all CAFOs should obtain an NPDES permit because it provides clarity of compliance requirements and authorization to discharge when the discharges are the result of large precipitation events (e.g., in excess of 25-year and 24-hour frequency/duration) or are from a man-made conveyance.

[6] According to the NASS, there are approximately 73,400 head of cattle in Webster County, Missouri (USDA, 2010). According to the 2005 Missouri Resource Assessment Partnership (MoRAP), there are 319 square miles of grasslands in Webster County (MoRAP, 2005). These two values result in a cattle density of approximately 230 cattle per square mile of grasslands. This density was multiplied by the number of grassland square miles in the West Fork Niangua River Watershed to estimate the number of cattle in the watershed.

3.2.3 Runoff from Urban Areas

Storm water runoff from urban areas can also be a significant source of nutrients and oxygen-consuming substances. Lawn fertilization can lead to high nutrient loads and pet wastes can contribute both nutrient loads and oxygen-consuming substances. Phosphorus loads from residential areas can be comparable to or higher than loading rates from agricultural areas (Reckhow et al., 1980; Athayde et al., 1983). Leaking or illicitly connected sewers can also be a significant source of pollutant loads within urban areas. Storm water runoff from urban areas such as parking lots and buildings is also warmer than runoff from grassy and woodland areas, which can lead to higher temperatures that lower the DO saturation capacity of the river. Since only approximately 7.31 percent of the West Fork Niangua River watershed is classified as impervious, high-intensity urban or low-intensity urban, urban runoff is unlikely to be a major contributor of the pollutants of concern to the watershed.

3.2.4 Riparian Habitat Conditions

Riparian[7] (i.e., streamside) habitat conditions can have a strong influence on instream DO levels. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the detention, removal and assimilation of nutrients from or by the water column. Therefore, a stream with good riparian habitat is better able to moderate the impacts of high nutrient loads than a stream with poor habitat. Wooded riparian buffers can also provide shading that reduces stream temperatures and increases the DO saturation capacity of the stream.

Riparian buffers can also be sources of natural background material that contributes nutrients to the creek. For example, leaf fall from vegetation near the water's edge, aquatic plants, and drainage from organically rich areas like swamps and bogs are all natural sources of organic material.

As indicated in Table 7, the majority of the land in the West Fork Niangua River 30-meter riparian corridor is classified as grassland (42.93 percent) and forest (41.74 percent) (MoRAP, 2005). The remaining 15.33 percent of the riparian corridor is comprised of cropland, open water, wetlands, impervious surfaces and low-intensity urban. Compared to wooded areas, grasslands and cropland have the potential to provide much less shading and higher nutrient loads, due to livestock activity and fertilization. Over half of the riparian corridor of the West Fork Niangua River watershed is comprised of cropland and grassland. Since these land types are associated with high nutrient loads, their presence near the West Fork Niangua River indicates that the transport of pollutants from these areas is more likely to occur compared to other land uses further from this receiving water.

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[7] A riparian corridor (or zone or area) is the linear strip of land running adjacent to a stream bank.

Table 7. Percentage Land Use/Land Cover within West Fork Niangua River Watershed Riparian Buffer, 30-Meter (MoRAP, 2005)

Land Use/Land Cover	Acres	Square Miles	Percent (%)
Grassland	35.23	0.06	42.93
Forest	34.25	0.05	41.74
Cropland	6.62	0.01	8.07
Open Water	3.77	0.006	4.59
Wetlands	0.22	0.0003	0.27
Impervious[1]	0.18	0.0003	0.22
Low-intensity Urban	1.79	0.003	2.18
Total	**82.06**	**0.13**	**100**

[1] Impervious land uses include non-vegetated, impervious surfaces, such as areas dominated by streets, parking lots and buildings (MoRAP, 2005).

4 APPLICABLE WATER QUALITY STANDARDS AND NUMERIC WATER QUALITY TARGETS

Section 303(d) of the CWA and Chapter 40 of the CFR Part 130 require states to develop TMDLs for waters not meeting designated uses. The purpose of developing a TMDL is to identify the maximum amount of a pollutant load that a water body can receive and still achieve WQS. The TMDL process quantitatively assesses the impairment factors so that states can establish water-quality based controls to reduce pollutants of concern from both point and nonpoint sources and work to restore and protect the quality of their water resources. The water-quality–based approach allows the pollutants entering the water body to be set at a level protective of its designated beneficial uses.

Under the CWA, every state must adopt WQS to protect, maintain and improve the quality of the nation's surface waters (U.S. Code Title 33, Chapter 26, Subchapter III [available at http://www.law.cornell.edu/uscode/html/uscode33/usc_sup_01_33_10_26.html]). These standards represent a level of water quality that will support the CWA's goal of "fishable/swimmable" waters. Missouri's WQS (10 Code of State Regulations [CSR, 2009] 20-7.031) consist of three components: designated uses, criteria (i.e., general and numeric) to protect these uses and an antidegradation policy.

Beneficial or designated uses for Missouri streams are found in the WQS at 10 CSR 20-7.031(1)(C), (1)(F) and Table H (CSR, 2009). Criteria for designated uses are found at 10 CSR 20-7.031, Tables A and B (CSR, 2009). Missouri's antidegradation policy is outlined at 10 CSR 20-7.031(2) (CSR, 2009).

4.1 DESIGNATED BENEFICIAL USES

The impaired portion of the West Fork Niangua River (WBID 1175) is 7 miles in length and is classified as a stream that maintains permanent flow during drought conditions (P). Designated beneficial uses include:

- Protection of Warm Water Aquatic Life,
- Whole Body Contact Recreation – Category B (Swimming),
- Livestock and Wildlife Watering, and
- Protection of Human Health (Fish Consumption).

The designated beneficial use that is impaired is the Protection of Warm Water Aquatic Life.

4.2 CRITERIA

On the 2008 Missouri 303(d) List, the West Fork Niangua River is listed as impaired due to low DO levels. Previous versions of the 303(d) list listed the river as impaired for elevated BOD and non-filterable residue. Water quality monitoring has revealed specific exceedances of the DO minimum criterion in the West Fork Niangua River. DO concentrations were routinely below the 5 mg/L minimum numeric criterion for the Protection of Warm Water Aquatic Life. Additionally, all water bodies in Missouri are protected by the general criteria contained in Missouri's WQS at, 10 CSR 20-7.031(3). These criteria are also called narrative criteria because they do not contain specific numerical limits. The narrative criteria not being met in the West Fork Niangua River are (3)(A),(C), (D) and (G), as follows:

- Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly or harmful bottom deposits or prevent full maintenance of beneficial uses.
- Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor or prevent full maintenance of beneficial uses.
- Waters shall be free from substances or conditions in sufficient amounts to result in toxicity to human, animal or aquatic life.
- Waters shall be free from physical, chemical or hydrologic changes that would impair the natural biological community.

In the absence of Missouri numeric criteria for nutrients in freshwater streams, ambient water quality criteria recommendations provided by the EPA (2000) are used to quantify TN and TP LCs in Ecoregion 39 and West Fork Niangua River. Reference conditions for TN and TP in level III Ecoregion 39 streams are as follows: TN = 0.289 milligrams per liter (mg/L) and TP = 0.007 mg/L. For this TMDL, recommended TN and TP criteria are used directly in developing LCs for TN and TP. The LCs related to DO include the aforementioned TN and TP targets plus BOD. The BOD loads were set so that the instream criteria for DO met the minimum 5 mg/L water quality criterion established for Protection of Warm Water Aquatic Life. There are many quantitative indicators of sediment, such as TSS, turbidity and bedload sediment, which are appropriate to describe sediment in rivers and streams (EPA, 2006). A concentration of TSS was selected to represent the numeric target for this TMDL because it enables the use of the highest quality available data and is included in monitoring data. Additional discussion on watershed-specific targets used to develop LCs for TSS, TN, TP and DO is provided in Section 5.1 and 5.2 of this document.

4.2.1 Dissolved Oxygen

The amount of DO in water is one of the most commonly used indicators of river and stream health. Under extended hypoxic (low DO levels) or anoxic (no DO) conditions, many higher forms of life are driven off or die. Fish, mussels, macroinvertebrates and all other aquatic life utilize DO to create energy and metabolize food. The WQS for all classified Missouri streams, except cold water fisheries, require a daily minimum of 5 mg/L DO according to 10 CSR 20-7.031, Table A.

4.3 ANTIDEGRADATION POLICY

Missouri's WQS include EPA's "three-tiered" approach to antidegradation, which can be found at 10 CSR 20-7.031(2) (CSR, 2009) and is summarized as follows:

- Tier 1—Protects existing uses and a level of water quality necessary to maintain and protect those uses. Tier 1 provides the absolute floor of water quality for all waters of the United States. Existing instream water uses are those uses that were attained on or after November 28, 1975, the date of EPA's first WQS Regulation.
- Tier 2—Protects and maintains the existing level of water quality where it is better than applicable water quality criteria. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: 1) a finding that it is necessary to accommodate important economic and social development in the area where the waters are located; 2) full satisfaction of all intergovernmental coordination and public participation provisions; and 3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.
- Tier 3—Protects the quality of outstanding national and state resource waters, such as waters of national and state parks, wildlife refuges and waters of exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality.

5 MODELING APPROACH

The low DO levels in West Fork Niangua River could be due to one or more of the following conditions:

- Excessive loads of biodegradable matter, as measured by CBOD
- Excessive algae in the stream as a result of high nutrient loading
- High consumption of oxygen from decaying organic matter on the streambed
- Chemical oxygen demand from ammonia and other substances.

DO in streams is determined by the factors of photosynthetic productivity, respiration (autotrophic and heterotrophic), reaeration and temperature. These factors are influenced by natural and anthropogenic conditions within a watershed. Generally, reaeration is based on the physical properties of the stream and on the capacity of water to hold DO. This capacity is mainly determined by water temperature with colder water having a higher saturation concentration for DO. In a review of variables and their importance in DO modeling, Nijboer and Verdonschot (2004) categorized the impact of a number of variables on oxygen depletion. For this TMDL, the effects of temperature and the physical aspects of the stream itself were discounted. Even though the hydrologic regime of historic alluvial streams have been modified by changes in land cover and channelization, manipulation of these parameters does not address a pollutant and so is not the goal of a TMDL. Pollutants which result in oxygen concentrations below saturation are:

- fine particle size of bottom sediment
- high nutrient levels (nitrogen and phosphorus)
- turbidity

Because the influence of these three pollutants on DO varies to a large extent based on anthropogenic factors, they are appropriate targets for a TMDL written to address an impairment of low DO.

An essential component of developing a TMDL is establishing a relationship between the source loadings and the resulting water quality. For this TMDL, two modeling approaches are used. The load duration curve method is used to develop TMDLs for TSS, TN and TP under all flow conditions and the QUAL2K model is used to assess DO under low flow conditions (see Appendix B). The relationship between the source loadings of CBOD, nutrients (ammonia [NH_3], TN and TP) and algal dynamics on DO is generated by the water quality model QUAL2K (Chapra et al., 2008) under steady-state low-flow conditions.

Since fine particle sized sediment and turbidity are derived from similar loading conditions of terrestrial and stream bank erosion, this TMDL establishes an allocation for TSS (see Appendix C for discussion of development of TSS targets). This target was derived based on a reference approach by targeting the 25th percentile of TSS measurements (USGS, non-filterable residue) in the geographic region in which the West Fork Niangua River is located. To address nutrient levels, the EPA nutrient ecoregion reference concentrations were used. For the ecoregion where West Fork Niangua River is located, the reference concentration for TN is 0.289 mg/L and the reference concentration for TP is 0.007 mg/L (EPA, 2001a and EPA, 2001b). This TMDL will not specifically target chlorophyll-*a* as a WLA, but will use a linkage between nutrient concentrations and chlorophyll response to achieve the ecoregion reference concentrations.

5.1 LOAD DURATION CURVES

The sediment target for this TMDL was derived using a reference approach by targeting the 25th percentile of TSS measurements (USGS, non-filterable residue) in the geographic region in which West Fork Niangua River is located (see Appendix C for a list of sites and data). In this approach, the target for pollutant loading is the 25th percentile of the current EDU condition calculated from all data available within the EDU in which the water body is located. Therefore, the 25th percentile is targeted as the TMDL LDC.

To develop LDCs for TN and TP, a method similar to that used for TSS was employed. First, TN and TP measurements were collected from USGS sites in the vicinity of the impaired stream. These data were adjusted such that the median of the measured data was equal to the ecoregion reference concentration. This was accomplished by subtracting the difference of the data median and the reference concentration. Where this would result in a negative concentration, the data point in question was replaced with the minimum concentration seen in the measured data. This resulted in a modeled data set which retained much of the original variability seen in the measured data. This modeled data was then regressed as instantaneous load versus flow. The resultant regression equation was used to develop the load duration curve. Allowable pollutant loads were calculated for all flow conditions by multiplying flow by either the EPA-recommended ecoregion reference concentration or the concentration established using the regional streams, whichever concentration is higher.

To develop the TMDL expression of maximum daily loads, the background discharge at the stream outlet was modified from the traditional approach using synthetic flow estimation. Since the design flow from permitted facilities would overwhelm the background natural low flow, the sum of permitted volumes was added to the derived stream discharge at all percentiles of flow to take into account the increases in flow volume as well as pollutant load. The TMDL LDCs flatten at low flow because at these lower flows the TMDL target is dominated by the point source flow.

5.2 QUAL2K

QUAL2K and its predecessor models have been used extensively for permitting of wastewater treatment discharges and TMDL development across the country. QUAL2K is supported by EPA and is well accepted within the scientific community because of its proven ability to simulate the processes important to DO conditions within streams. QUAL2K is suitable for simulating the hydraulics and water quality conditions of a small river. It is a one-dimensional model with the assumption of a completely mixed system for each computational cell. QUAL2K assumes that the major pollutant transport mechanisms, advection and dispersion, are significant only along the longitudinal direction of flow. The model allows for multiple waste discharges, water withdrawals, tributary flows and incremental inflows and outflows. The processes employed in QUAL2K address nutrient cycles, algal growth and DO dynamics. QUAL2K links plant respiration and photosynthesis, as well as other oxygen demanding substances such as CBOD, the nitrification process (which uses oxygen to reduce organic nitrogen to NH_3 and then to nitrate plus nitrite nitrogen [NO_3+NO_2]) and sediment demands of organic substances to instream DO levels.

Flow, depth, stream velocity and water quality data, suitable for computer modeling, were collected on October 19, 2004 and July 12, 2000. Because more data was available for the October 19, 2004 sampling event, it was used as the primary calibration period. The July 12, 2000, event was used as a second calibration period given that flow data for this event was visually estimated by MDNR. It was not considered a validation period due to the limited data set. These events were used to calibrate the QUAL2K model for the West Fork Niangua River

TMDL. The QUAL2K model was set up and calibrated for West Fork Niangua River and a series of scenarios were run to evaluate the pollutant load reductions needed to achieve the minimum DO criterion. These results are summarized in Sections 6 and 7, and a detailed discussion of the QUAL2K model is included in Appendix B.

6 CALCULATION OF LOADING CAPACITY

LC is defined as the greatest amount of a pollutant that a water body can assimilate without violating WQS. This load is then divided among the point source (WLA) and nonpoint source (LA) pollutant contributions to the stream, with an allowance for an explicit MOS. The MOS accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition is represented by the equation:

$$LC = \Sigma\ WLAs + \Sigma\ LAs + MOS$$ **Equation 1**

Where:

LC = Loading Capacity

WLA = Wasteload Allocations (point source)

LA = Load Allocations (non point source)

MOS = Margin of Safety (may be implicit and factored into a conservative WLA or LA or explicit)

The objective of the TMDL is to estimate allowable pollutant loads and to allocate these loads to known pollutant sources within the watershed so that appropriate control measures can be implemented and the WQS achieved. The WLA and LA are calculated by multiplying the appropriate flow in cubic feet per second (cfs) by the appropriate pollutant concentration in milligrams per liter (mg/L). A conversion factor of 5.395 is used to convert to pounds per day (lbs/day).

Critical conditions were considered when the LC was calculated. DO levels that threaten the integrity of aquatic communities generally occur during low flow periods; these periods are considered the critical condition. For Class P streams mixing zones are applicable to all pollutants (with the exception of bacteria) that have specific criteria. Mixing zones are typically based on the 7-day average low flow of a stream with a recurrence interval of 10 years (7Q10) to account for critical low-flow conditions.

In the case of West Fork Niangua River, a mixing zone of one-quarter (1/4) of the stream width, cross-sectional area or volume of flow and a length of 1/4 mile is allowed. For modeling purposes, 1/4 of the 7Q10 flow was used. The default 7Q10 for Class P streams is 0.1 cfs; thus a mixing zone flow of 0.025 cfs is appropriate for West Fork Niangua River upstream of the facility. For DO targeting purposes, the 5 mg/L minimum DO criterion must be met at one-quarter mile below the facility outfall at 25 percent of the 7Q10 low flow to meet the mixing zone requirements. The applicable mixing zone regulation can be found at 10 CSR 20-7.031(4)(A)4.B.(II). The rationale for limiting the size of mixing zones is three-fold. First, the assumption of rapid and complete mixing is not a conservative assumption. Meaning, many times effluent plumes exist and cause areas of chronically toxic conditions that can extend laterally and longitudinally downstream. Second, a zone of passage should be provided so that aquatic organisms may pass by facility outfalls without becoming adversely affected. Third, for antidegradation purposes, the entire assimilative capacity of the water body cannot be allocated to a single discharger.

The mixing zone extends one-quarter mile downstream of the facility outfall and the LC must meet the DO target at the end of this section of the impaired segment. Further downstream the 7Q10 is the critical flow condition. For modeling purposes, model runs were conducted at one-quarter of the 7Q10 to assess compliance of the LC one-quarter mile downstream of the city of Marshfield WWTP. The 7Q10 low flow was used at distances further than a quarter mile from the city of Marshfield WWTP. The QUAL2K models predicted that the minimum DO concentration occurs within a quarter mile of the WWTP; thus, critical conditions are controlled by the one-quarter 7Q10 flow or mixing zone conditions.

The QUAL2K model was calibrated using data collected on October 19, 2004 and July 12, 2000. The July 2000 model, was used to identify the LC since this period represented more critical conditions (i.e., reduced DO and lower flows) than those present during the October 2004 monitoring events. The following steps were taken during the modeling process:

- Step 1: Application of the Model to Existing Conditions

  This application forms the current condition that is used to evaluate the magnitude of load reductions that are needed to meet WQS. Nonpoint source loads are set equal to the calibrated conditions.

- Step 2: Application of the Model to Existing Conditions with Point Sources at Permit Limits

  This application forms the baseline condition that will be reduced to meet the allowable load. The Marshfield WWTP was set at its permit limits using the permitted flow and mean daily concentration allowed for in the permit. For pollutants not included in the permit, the observed effluent data were used.

- Step 3: Develop and Test Allocation Scenarios

  Working from the baseline condition and considering the primary pollutant sources, sample allocation scenarios were developed and applied. For example, if existing BOD or nutrient effluent limits for the Marshfield WWTP in Step 2 are not protective of the instream DO WQS, the QUAL2K model is iteratively run at reduced BOD and nutrient concentrations until compliance with the WQS is met. The difference between the baseline condition and BOD and nutrient WLA required to achieve the standard is the percent reduction needed at the facility.

The predicted DO levels for the critical flow conditions are shown in Figure 5, based the mixing zone conditions (i.e. one-quarter 7Q10), and their associated nutrient loads are summarized in Table 8. As indicated in Figure 5, although the critical DO condition occurs within one-quarter mile downstream of the Marshfield WWTP, its DO levels and downstream DO concentrations are all above the 5 mg/L. These modeling results suggest that aquatic life in West Fork Niangua River can be protected if the nutrient conditions of this TMDL are fully achieved.

The modeling analysis indicates an 81 percent reduction in NH_3, and a 22 percent reduction in BOD_5 load, based on a 27 percent reduction in SOD. At these load reductions and effluent DO concentration of 6.2 mg/L a minimum DO of 5 mg/L will be achieved throughout and downstream of the mixing zone.

BOD reductions are deemed necessary to achieve the SOD reduction because most of the SOD at the surface of the sediment is likely due to the biological decomposition of particulate organic material (including algae) discharged by the WWTP that settles downstream of the outfall. Bacterially facilitated nitrification of NH_3 is also a likely contributor to SOD.

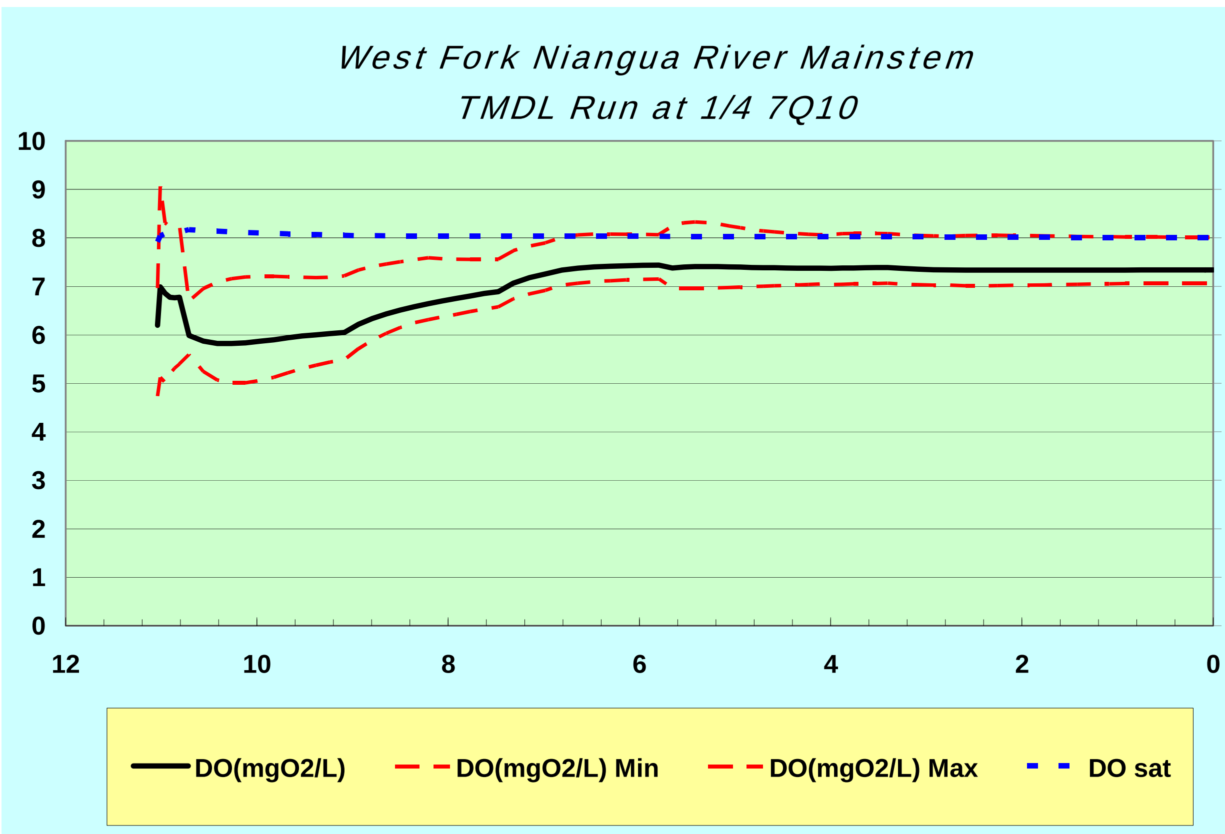

Figure 5. Predicted DO concentrations under TMDL conditions for West Fork Niangua River

To meet the targeted nutrient and TSS critical condition targets outlined in this TMDL, the sum of the WLA was calculated by using nutrient ecoregion reference concentrations, the 25th percentile EDU TSS concentrations (5 mg/L) and the sum of the design flows of all permitted facilities in the watershed (with the exception of storm water flows). The nonpoint source or LA TMDL targets for TSS, TN and TP were calculated using nutrient ecoregion reference concentrations, 25th percentile EDU TSS concentrations and the sum of the headwater and tributary flows. TN and TP nonpoint source baseline flow conditions were obtained using loads estimated for the July 12, 2000, modeling period. The LDCs for the targeted pollutants are depicted in Figures 6 - 8, where the TMDL line represents the total LC of all point and nonpoint sources of pollutants. In these figures, the “Continuous WLA” includes the combined allocation for all four WWTPs that have a permitted design flow (city of Marshfield WWTP, Fountain Plaza Mobile Home Park WWTP, Gaslight Village Mobile Home Park WWTP and Hoerman Meat Company WWTP). The pollutant allocations under a range of flow conditions are presented in Figures 6 – 8, and the corresponding allocations for these figures are summarized in Tables 9 – 11.

Table 8. TMDL Summary for West Fork Niangua River at Critical Low Flows

Pollutant		Baseline Conditions (based on monthly average limits and design flow)			TMDL			WLA Percent Reduction	LA Percent Reduction
		Point Sources	Nonpoint Sources	Total	Point Sources (WLA)	Nonpoint Sources (LA)	Total		
Flow (cubic meters per second [cms])		2.33	0.600	2.931	2.33	0.600	2.931	0	0
BOD_5	(lb/day)	125.7	5.1	130.8	98.6	4.4	103.0	22	14
	(mg/L)	10.00	1.57	8.27	7.8	1.1	6.5		
$NBOD_{ult}$	(lbs/day)	No limit	2.5	Not applicable	16.6	0.73	17.3	Not applicable	71
	(mg/L)	No limit	0.772	Not applicable	1.32	0.229	1.1		
NH_3	(lb/day)	17.6	0.30	17.8	3.3	0.08	3.4	81	73
	(mg/L)	1.400	0.093	1.126	0.264	0.025	0.22		
TSS	(lbs/day)	188.6	Not applicable	Not applicable	63.0	16.2	79.2	67	See LDC
	(mg/L)	15.0	Not applicable	Not applicable	5.0	5.0	5.0		
TN	(lbs/day)	No limit	1.9	Not applicable	3.6	0.9	4.5	Not applicable	53
	(mg/L)	No limit	0.59	Not applicable	0.289	0.289	0.289		
TP	(lbs/day)	No limit	0.14	Not applicable	0.1	0.05	0.15	Not applicable	64
	(mg/L)	No limit	0.0432	Not applicable	0.007	0.007	0.007		

Note: The WLA and LA specified in Table 8 results in a minimum DO of 5.0 mg/L and the effluent is aerated to at least 6.2 mg/L DO. Tributary and headwater nutrient concentrations are set to ecoregion criteria (TN = 0.289 mg/L and TP = 0.007 mg/L). Monthly average permit limits were used for baseline conditions. No TSS data is available in West Fork Niangua River to calculate a baseline condition for nonpoint sources. Point and nonpoint baseline conditions for flow, BOD_5, Ultimate Nitrogenous Biological Oxygen Demand ($NBOD_{ult}$), NH_3, TN and TP are based on QUAL2K modeling results. The point source baseline condition for TSS is based on permitted flow and TSS concentration limits at the WWTPs. Point and nonpoint source TMDL limits for BOD_5, $NBOD_{ult}$ and NH_3 were obtained from QUAL2K model results. Point and nonpoint source TMDL limits for TSS, TN and TP were obtained using the EDU and ecoregion criteria.

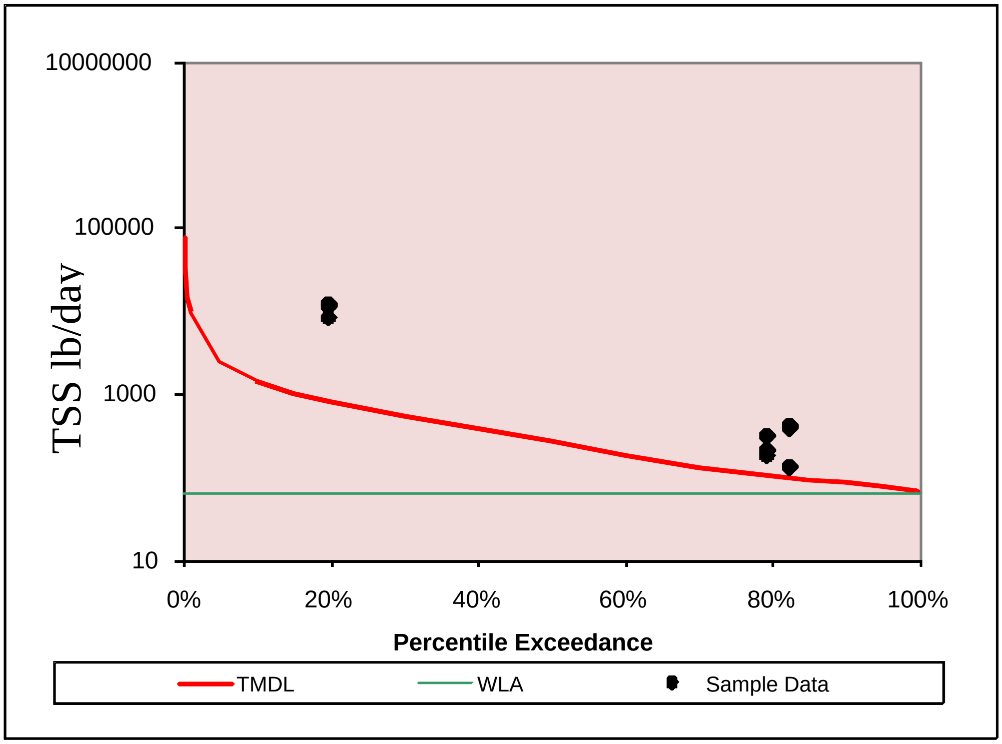

Figure 6. TSS LDC for West Fork Niangua River

Table 9. TSS TMDL Under a Range of Flow Conditions in West Fork Niangua River

Percent Flow Exceedance	Estimated Flow (cfs)	TMDL (mg/L)	TMDL (lbs/day)	MOS[1] (lbs/day)	LA (lbs/day)	WLA (lbs/day)
95%	3.0	5.0	80	NA	17	63.0
90%	3.2	5.0	87	NA	24	63.0
70%	4.9	5.0	132	NA	69	63.0
50%	10.3	5.0	279	NA	216	63.0
30%	20.7	5.0	556	NA	493	63.0
10%	53.1	5.0	1431	NA	1368	63.0
5%	88.3	5.1	2422	NA	2359	63.0

[1] The TSS MOS is implicit; NA = not applicable

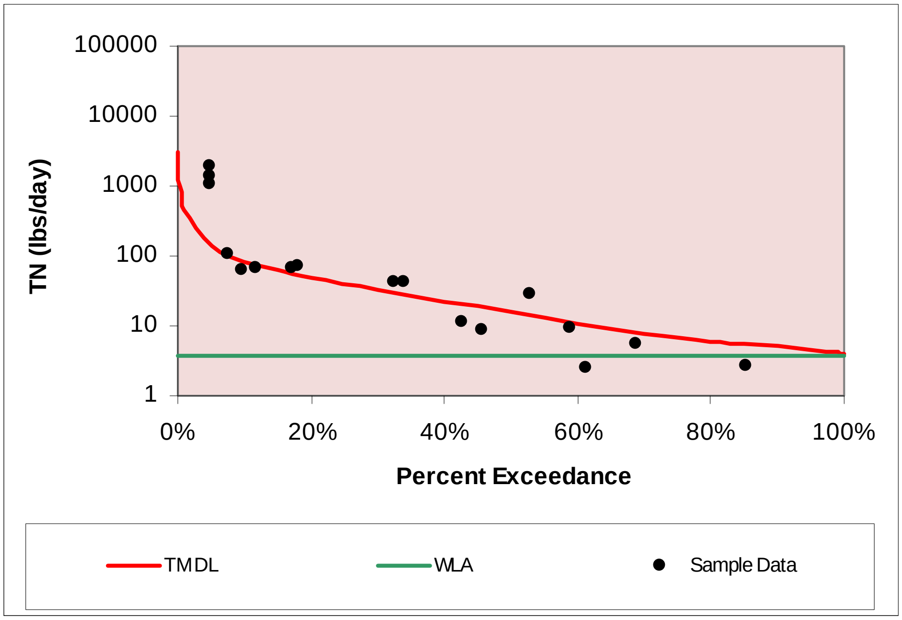

Figure 7. TN LDC for West Fork Niangua River

Table 10. TN TMDL Under a Range of Flow Conditions in West Fork Niangua River

Percent Flow Exceedance	Estimated Flow (cfs)	TMDL (lbs/day)	MOS[1] (lbs/day)	LA (lbs/day)	WLA (lbs/day)
95%	3.0	4.65	NA	1.00	3.65
90%	3.2	5.03	NA	1.38	3.65
70%	4.9	7.66	NA	4.01	3.65
50%	10.3	16.13	NA	12.48	3.65
30%	20.7	32.21	NA	28.56	3.65
10%	53.1	82.86	NA	79.21	3.65
5%	88.3	137.64	NA	133.99	3.65

[1] The TN MOS is implicit; NA = not applicable

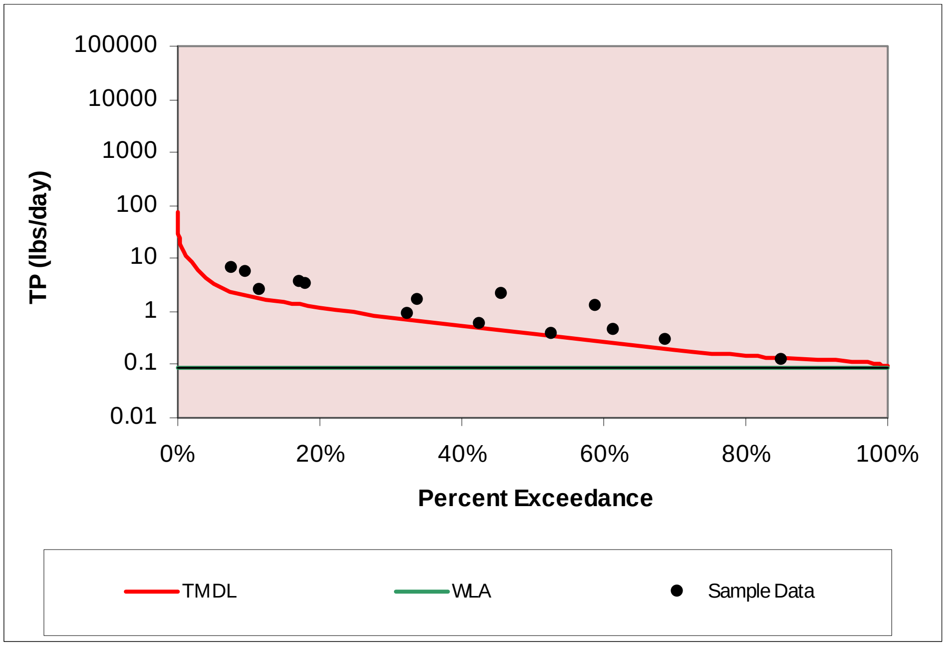

Figure 8. TP LDC for West Fork Niangua River

Table 11. TP TMDL Under a Range of Flow Conditions in West Fork Niangua River

Percent Flow Exceedance	Estimated Flow (cfs)	TMDL (lbs/day)	MOS[1] (lbs/day)	LA (lbs/day)	WLA WWTP (lbs/day)
95%	3.0	0.11	NA	0.02	0.09
90%	3.2	0.12	NA	0.03	0.09
70%	4.9	0.19	NA	0.10	0.09
50%	10.3	0.39	NA	0.30	0.09
30%	20.7	0.78	NA	0.69	0.09
10%	53.1	2.01	NA	1.92	0.09
5%	88.3	3.33	NA	3.24	0.09

[1] The TP MOS is implicit; NA = not applicable

7 WASTELOAD ALLOCATION (POINT SOURCE LOADS)

The WLA is the portion of the LC that is allocated to existing and/or future point sources of pollutants. The sum of design flows of all site specific dischargers with NPDES permits (see Table 6) in the West Fork Niangua River watershed, excluding permitted storm water flows, is 1.5 MGD.

New WLAs for the city of Marshfield WWTP (outfall #002) were calculated through the modeling process and are shown in Table 12. The WLA for $CBOD_5$ and NH_3 were derived from the QUAL2K modeling that resulted in meeting WQS at the end of the regulatory mixing zone.

The WLAs for TN, TP and TSS were derived from the LDCs at low flow, when inputs are set at the facility design flow of 2.3 cfs (1.5 MGD). The other permitted facilities in the watershed each discharge an insignificant volume of effluent compared to the city of Marshfield WWTP and are unlikely to discharge during critical low flow periods. The WLAs for these facilities remain equal to existing permit limits which are summarized in Table 13, for the facilities with individual, site specific permits.

Table 12. WLAs for City of Marshfield WWTF Outfall #002 (MO0040843)

Effluent Parameter	Design Flow (MGD)	Existing Permit Limit		WLA at Design Flow based on QUAL2K modeling		Percent Reduction
		Concentration (mg/L)	Load (lbs/day)	Concentration (mg/L)	Load (lbs/day)	
$CBOD_5$	1.5	No limit	No limit	6.05	75.9	Not applicable
$NBOD_5$		No limit	No limit	1.75	22	Not applicable
TN		No limit	No limit	0.289	3.63	Not applicable
TP		No limit	No limit	0.007	0.09	Not applicable
NH_3		1.4	17.5	0.264	3.3	81
TSS		15	187.7	5.0	62.8	67
DO		No limit	No limit	6.2	Not applicable	Not applicable

Notes: $CBOD_5$ is calculated using simulated BOD_5 divided by 1.29, based on 1998 EPA modeling guidance for NH3 toxicity and DO modeling. $NBOD_5$ is the difference between BOD_5 and $CBOD_5$. TN target loading for point sources was based on 289 µgN/L, Ecoregion 39 TN value. TP target loading for point sources was based on 7 µgP/L, Ecoregion 39 TP value.

Table 13. Existing TSS Permit Limits for WWTPs in the West Fork Niangua River Watershed

Permit Number	Facility Name	Design Flow (MGD)[1]	Existing TSS Permit Limits	
			Concentration (mg/L)	Load (lbs/day)[2]
MO0040843	Marshfield WWTP (daily average flow)	1.5	15	187.7
MO0052051	Gaslight Village Mobile Home Park WWTP	0.0052	70	3.0
MO0109746	Fountain Plaza Mobile Home Park WWTP	0.00735	120	5.2

[1] MGD = Million Gallons per Day
[2] Existing TSS permit limit loads (lbs/day) are based on existing design flow and monthly or weekly average limits

8 LOAD ALLOCATION (NONPOINT SOURCE LOADS)

The LA includes all existing and future nonpoint sources and natural background contributions (40 CFR § 130.2(g)) of the pollutants of concern. The LA for the West Fork Niangua River TMDL is for all nonpoint sources of $CBOD_5$, NBOD, TSS, TP and TN, which could include loads from agricultural lands, runoff from urban areas, livestock and failing onsite wastewater treatment systems. The LA also includes runoff from the city of Marshfield, Missouri. The LAs provided in Tables 8 - 11 were calculated based on the total of all headwater and lateral inflow loads used in the QUAL2K model for the allocation scenario model run and LDCs. The LA is intended to allow the DO target to be met at all locations within the stream.

9 MARGIN OF SAFETY

A MOS is required in the TMDL calculation to account for uncertainties in scientific and technical understanding of water quality in natural systems. The MOS is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the MOS can be achieved through one of two approaches:

1) Explicit - Reserve a numeric portion of the LC as a separate term in the TMDL.
2) Implicit - Incorporate the MOS as part of the critical conditions for the WLA and LA calculations by making conservative assumptions in the analysis.

An implicit MOS was incorporated into the CBOD and NBOD TMDLs by identifying a LC that achieves a minimum DO concentration of 5 mg/L at the 7Q10 low flow by using conservative modeling assumptions within QUAL2K. The conservative modeling assumptions used for the implicit MOS in the QUAL2K model calibration focused on measured low DO concentrations, critical low flow conditions and DO concentrations under critical low flow conditions in deriving applicable BOD, CBOD, NBOD, NH3 and TSS targets for the city of Marshfield WWTP.

For TSS, TN and TP, an implicit MOS was incorporated into the TMDL based on conservative assumptions used in the development of the TMDL LDCs. Among the conservative approaches used was to calculate WLAs by targeting the 25th percentile of TSS concentrations in the geographic region in which West Fork Niangua River is located. Another conservative approach was to establish WLAs for the city of Marshfield WWTP under critical low flow conditions when discharge from this facility will dominate the stream flow. The TN and TP targets for this TMDL are also conservative because they are based on the 25th percentile of all TN and TP data gathered from the Subecoregion 39 of Aggregate Nutrient Ecoregion XI. These targets were derived by EPA to represent conditions of surface waters that are minimally impacted by human activities and protective of aquatic life and recreational uses (EPA, 2000). The 25th percentile is considered a surrogate for establishing a reference population of the pristine systems (EPA, 2000).

10 CRITICAL CONDITIONS AND SEASONAL VARIATION

A TMDL must consider seasonal variation in the derivation of the allocations. DO levels that threaten the integrity of aquatic communities generally occur during low flow periods and warm temperatures, so these periods are considered the critical condition for the DO target. Annual low-flow conditions in Missouri typically occur between July 1 and September 15. In this TMDL, summer low flow is defined as a 7-day average flow with a 10-year return frequency (7Q10) dry-weather condition. This TMDL addresses seasonal variation and critical conditions by identifying a LC that would be protective of the DO target during the 7Q10 low flow period. TMDL development for low DO at critical low-flow conditions is expected to be protective year round. LCs protective of WQS during critical low flow conditions can also be expected to be protective year round.

Dissolved oxygen in streams is affected by several factors including water temperature, the amount of decaying matter (i.e., organic sediment) in the stream, turbulence at the air-water interface and the amount of photosynthesis occurring in plants within the stream. Organic sediments and SOD can also contribute to fluctuating DO concentrations in the water column. The effects of high nutrient and BOD concentrations on DO swings and low DO conditions (discussed in Section 5.2) are typically amplified under circumstances in which flow is low and water temperature is relatively high (for example, summer months). Developing LCs that will be protective of DO during these conditions should ensure the LCs are protective of water quality year round.

The TMDL LDCs for TSS, TN and TP represent flow under all conditions. Because the WLA, LA and TMDL are applicable at all flow conditions, they are also applicable and protective over all seasons. One advantage of the LDC approach is that all flow conditions are considered and the constraints associated with using a single-flow critical condition are avoided.

11 MONITORING PLANS

In general, future stream monitoring is scheduled and conducted by MDNR approximately three years after the approval of a TMDL or in a reasonable time frame following the completion of permit compliance schedules and/or the application of new effluent limits. MDNR will also routinely examine stream habitat, water quality, invertebrate and fish community data collected by the Resource Assessment and Monitoring Program of the Missouri Department of Conservation. This program randomly samples streams across Missouri on a five to six year rotating schedule.

12 REASONABLE ASSURANCES

MDNR has the authority to issue and enforce Missouri State Operating Permits.

Inclusion of effluent limits into a state operating permit and requiring that effluent and instream monitoring be reported to MDNR should provide reasonable assurance that instream WQS will be met. Section 301(b)(1)(C) requires that point source permits have effluent limits as stringent as necessary to meet WQS. However, for WLAs to serve that purpose, they must themselves be stringent enough so that in conjunction with the water body's other loadings they meet WQS. This generally occurs when the TMDL's combined nonpoint source LAs and point source WLAs do not exceed the WQS-based LC and there is reasonable assurance that the TMDL's allocations can be achieved. Any discussion of reduction efforts relating to nonpoint sources would be found in the implementation section of the TMDL. EPA believes that point source permitting authority and nonpoint source measures discussed in the supplemental implementation plan (see Appendix F) provides reasonable assurances that the TMDL allocations can be achieved.

13 PUBLIC PARTICIPATION

EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). EPA is providing public notice of this draft TMDL for West Fork Niangua River on the EPA, Region 7, TMDL website: http://www.epa.gov/region07/water/tmdl_public_notice.htm. The response to comments and final TMDL will be available at: http://www.epa.gov/region07/water/apprtmdl.htm#Missouri.

This water quality limited segment of West Fork Niangua River in Webster County, Missouri, is included on the EPA-approved 2008 Missouri 303(d) List. This TMDL is being established by EPA to meet the requirements of the 2001 Consent Decree, *American Canoe Association, et al. v. EPA,* No. 98-1195-CV-W in consolidation with No. 98-4282-CV-W, February 27, 2001. EPA is developing this TMDL in cooperation with the state of Missouri and EPA is establishing this TMDL at this time to meet the *American Canoe Association, et al.* consent decree milestones. Missouri may submit and EPA may approve a revised or modified TMDL for this water at any time.

Before finalizing EPA established TMDLs, the public is notified that a comment period is open on the EPA Region 7 website for at least 30 days. EPA's public notices to comment on draft TMDLs are also distributed via mail and electronic mail to major stakeholders in the watershed and other potentially impacted parties. After the comment period closes, EPA reviews all comments, edits the TMDL as is appropriate, writes a Summary of Response to Comments and establishes the TMDL. For Missouri TMDLs, groups receiving the public notice announcement include a distribution list provided by MDNR, the Missouri Clean Water Commission, the Missouri Water Quality Coordinating Committee, stream team volunteers, state legislators, County Commissioners, the County Soil and Water Conservation District and potentially impacted cities, towns and facilities. EPA followed this public notice process for this TMDL. Links to active public notices for draft TMDLs, final (approved and established) TMDLs and Summary of Response to Comments are posted on the EPA website: http://www.epa.gov/region07/water/tmdl.htm.

14 ADMINISTRATIVE RECORD AND SUPPORTING DOCUMENTS

An administrative record on the West Fork Niangua River TMDL has been assembled and is being kept on file with EPA.

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Appendix A

West Fork Niangua River Water Quality Data

Org	Site	Site Name	Year	Mo.	Day	Time	Flow (cfs)	DO (mg/L)	pH	TKN (mg/L)	NH3N (mg/L)	NO3N (mg/L	TN (mg/L)	BOD (mg/L)	CBOD (mg/L)
MDNR	1175/6.7	W. Fk. Niangua R. 0.1 mi.ab. Marshfield WWTP	1985	9	17			4			0.2	1.55		0.99	
MDNR	1175/5.6	W. Fk. Niangua R. 1.0 mi.bl. Marshfield WWTP	1985	9	17			7			3.02	3.45		6	
MDNR	1175/4.6	W. Fk. Niangua R. 2 mi.bl. Marshfield WWTP	1985	9	17			10			0.06	1.47		0.99	
MDNR	1175/6.7	W. Fk. Niangua R. 0.1 mi.ab. Marshfield WWTP	1988	4	21		0.5	10	7.2		0.02499	0.54			0.999
MDNR	1175/5.6	W. Fk. Niangua R. 1.0 mi.bl. Marshfield WWTP	1988	4	21		1.3	14.4	7.6		0.02499	6.1			0.999
MDNR	1175/4.6	W. Fk. Niangua R. 2 mi.bl. Marshfield WWTP	1988	4	21		1.6	14.1	7.8		0.02499	2.3			1.99
MDNR	1175/6.7	W. Fk. Niangua R. 0.1 mi.ab. Marshfield WWTP	1988	6	22	1215	0								
MDNR	1175/5.6	W. Fk. Niangua R. 1.0 mi.bl. Marshfield WWTP	1988	6	22	1200	0	6.8	7.6		0.09	1.4			1.99
MDNR	1175/4.6	W. Fk. Niangua R. 2 mi.bl. Marshfield WWTP	1988	6	22	1145	0.4	7.9	8		0.06	0.57			1.99
MDNR	1175/3.3	W. Fk. Niangua R. 3.3 mi.bl. Marshfield WWTP	1988	6	22	1125	0.7	10.2	8		0.02499	0.3			1.99
MDNR	1175/5.6	W. Fk. Niangua R. 1.0 mi.bl. Marshfield WWTP	1988	6	23	1240		11.2							
MDNR	1175/5.6	W. Fk. Niangua R. 1.0 mi.bl. Marshfield WWTP	1988	6	23	630	0.1	3.5	8.3		0.02499	0.28			0.999
MDNR	1175/4.6	W. Fk. Niangua R. 2 mi.bl. Marshfield WWTP	1988	6	23	1300		8.6	8.1		0.15	1.3			1.99
MDNR	1175/4.6	W. Fk. Niangua R. 2 mi.bl. Marshfield WWTP	1988	6	23	615	0.4	4							
MDNR	1175/3.3	W. Fk. Niangua R. 3.3 mi.bl. Marshfield WWTP	1988	6	23	1315		10.6	8.6		0.08	0.28			1.99
MDNR	1175/3.3	W. Fk. Niangua R. 3.3 mi.bl. Marshfield WWTP	1988	6	23	600		4.2							
MDNR	1175/5.6	W. Fk. Niangua R. 1.0 mi.bl. Marshfield WWTP	1988	6	24	550		3.8							
MDNR	1175/4.6	W. Fk. Niangua R. 2 mi.bl. Marshfield WWTP	1988	6	24	610		3.4							
MDNR	1175/3.3	W. Fk. Niangua R. 3.3 mi.bl. Marshfield WWTP	1988	6	24	625		4.2							
MDNR	1175/5.6	W. Fk. Niangua R. 1.0 mi.bl. Marshfield WWTP	1988	8	31	1300	0.05	14.6	8.1		0.02499	5.7			1.99

Org	Site	Site Name	Year	Mo.	Day	Time	Flow (cfs)	DO (mg/L)	pH	TKN (mg/L)	NH3N (mg/L)	NO3N (mg/L	TN (mg/L)	BOD (mg/L)	CBOD (mg/L)
MDNR	1175/4.6	W. Fk. Niangua R. 2 mi.bl. Marshfield WWTP	1988	8	31	1325	0.4	8.5	8.2		0.02499	4.7			1.99
MDNR	1175/3.3	W. Fk. Niangua R. 3.3 mi.bl. Marshfield WWTP	1988	8	31	1340	0.6	10.2	8.5		0.02499	2.3			1.99
MDNR	1175/6.0	W. Fk. Niangua R. 0.6 mi.bl. Marshfield WWTP	1993	7	23	640		4.2	7.7						
MDNR	1175/4.6	W. Fk. Niangua R. 2 mi.bl. Marshfield WWTP	1993	7	23	652		6	7.8						
MDNR	1175/6.0	W. Fk. Niangua R. 0.6 mi.bl. Marshfield WWTP	1998	7	22	1240		9.3	8.1						
MDNR	1175/4.6	W. Fk. Niangua R. 2 mi.bl. Marshfield WWTP	1998	7	22	1300		10.7	8.3						
MDNR	1175/5.6	W. Fk. Niangua R. 1.0 mi.bl. Marshfield WWTP	2000	7	12	545	0	3.2	7.8	1	0.02499	3.09	4.09		0.999
MDNR	1175/5.6	W. Fk. Niangua R. 1.0 mi.bl. Marshfield WWTP	2000	7	12	1130	0.4	7.5	7.9		0.05	2.53			0.999
MDNR	1175/4.6	W. Fk. Niangua R. 2 mi.bl. Marshfield WWTP	2000	7	12	1145	0.75	9.4	8.1	0.499	0.02499	1.76	2.26		0.999
MDNR	1175/4.6	W. Fk. Niangua R. 2 mi.bl. Marshfield WWTP	2000	7	12	600	0.75	4.6	7.7	1	0.05	1.93	2.93		0.999

Notes: Blank cells indicate that data was not collected for that parameter.
Ammonia samples below detection limit entered as 0.02499
BOD samples below detection limit entered as 0.99
CBOD samples below detection limit entered as 0.999 and 1.99
TKN samples below detection limit entered as 0.499

Acronyms and abbreviations:

Org =	Organization	MDNR =	Missouri Department of Natural Resources
Mo.=	Month	cfs =	cubic feet per second
mg/L =	milligrams per liter	DO =	dissolved oxygen
TKN =	total kjeldahl nitrogen	NH3N =	ammonia nitrogen
NO3N =	nitrate nitrogen	TN =	total nitrogen
BOD =	biochemical oxygen demand	CBOD =	carbonaceous biochemical oxygen demand
mi. =		WWTP =	wastewater treatment plant
bl. =	below	W.Fk. Niangua R. =	West Fork Niangua River

miles

Appendix B

West Fork Niangua River QUAL2K Modeling

B.1 OVERVIEW OF QUAL2K

The QUAL2K water quality model was selected for the development of the West Fork Niangua River DO TMDL. QUAL2K is supported by the EPA and has been used extensively for TMDL development and point source permitting issues across the country, especially for issues related to DO concentrations. The QUAL2K model is suitable for simulating hydraulics and water quality conditions of small rivers and creeks. It is a one-dimensional uniform flow model with the assumption of a completely mixed system for each computational cell. QUAL2K assumes that the major pollutant transport mechanisms, advection and dispersion, are significant only along the longitudinal direction of flow. The model allows for multiple waste discharges, water withdrawals, nonpoint source loading, tributary flows and incremental inflows and outflows. The processes employed in QUAL2K can address nutrient cycles, algal growth, particulate settling, SOD and DO dynamics.

B.2 QUAL2K MODEL SETUP

This section describes the process that was used to setup the QUAL2K models for the West Fork Niangua River watershed.

B.2.1 Stream Segmentation

Figure B-1 and Figure B-2 provide a visual description of the West Fork Niangua River QUAL2K model structure; including locations of monitoring stations, point sources, nonpoint sources and boundaries. The impaired water body segment is divided into 7 reaches; the lengths of each reach are provided in Table B-1. Reach lengths are based on the location of water quality monitoring stations, stream hydrology, NPDES discharges and point/nonpoint sources. Reaches are further segmented into elements as identified in Table B-1. An element length between approximately 0.05-0.17 kilometers was used for all reaches.

The locations of the outfalls from city of Marshfield WWTP were denoted by two different sources. First, a general location was given by stream mile and text description with MDNR water quality monitoring locations. Second, individual locations of the three outfalls of the facility were provided with NPDES permitting information. Because the water quality monitoring locations provide only a general reference to the facility itself and not the individual outfalls, of which outfall #2 is of greatest concern due to its daily discharge, the decision was made to reference the city of Marshfield WWTP discharge to the location of the NPDES identified outfall #2 (stream location 10.77 km or 6.7 mi).

As shown in Figure B-2, the West Fork Niangua River includes nine minor unnamed tributaries and the Greer Creek tributary. Each minor tributary was represented in the model as a unique point source (Figure B-1). Average daily flow for each simulated day and tributary was estimated using a drainage area ratio approach. Using measured flow at the two mainstem monitoring locations less the flow due to major point sources (Stations 1 and 2), a watershed average flow/mi^2 was calculated for each of the nine minor tributaries. Measured flow within Greer Creek for each simulated day was used for this major tributary.

There are a number of permitted outfalls within the West Fork Niangua River watershed; however, due to their small flows not all of the discharges are included in the QUAL2K model (Table B-2). The city of Marshfield WWTP, the only major discharger in the watershed, is represented as a point source in Reach 2.

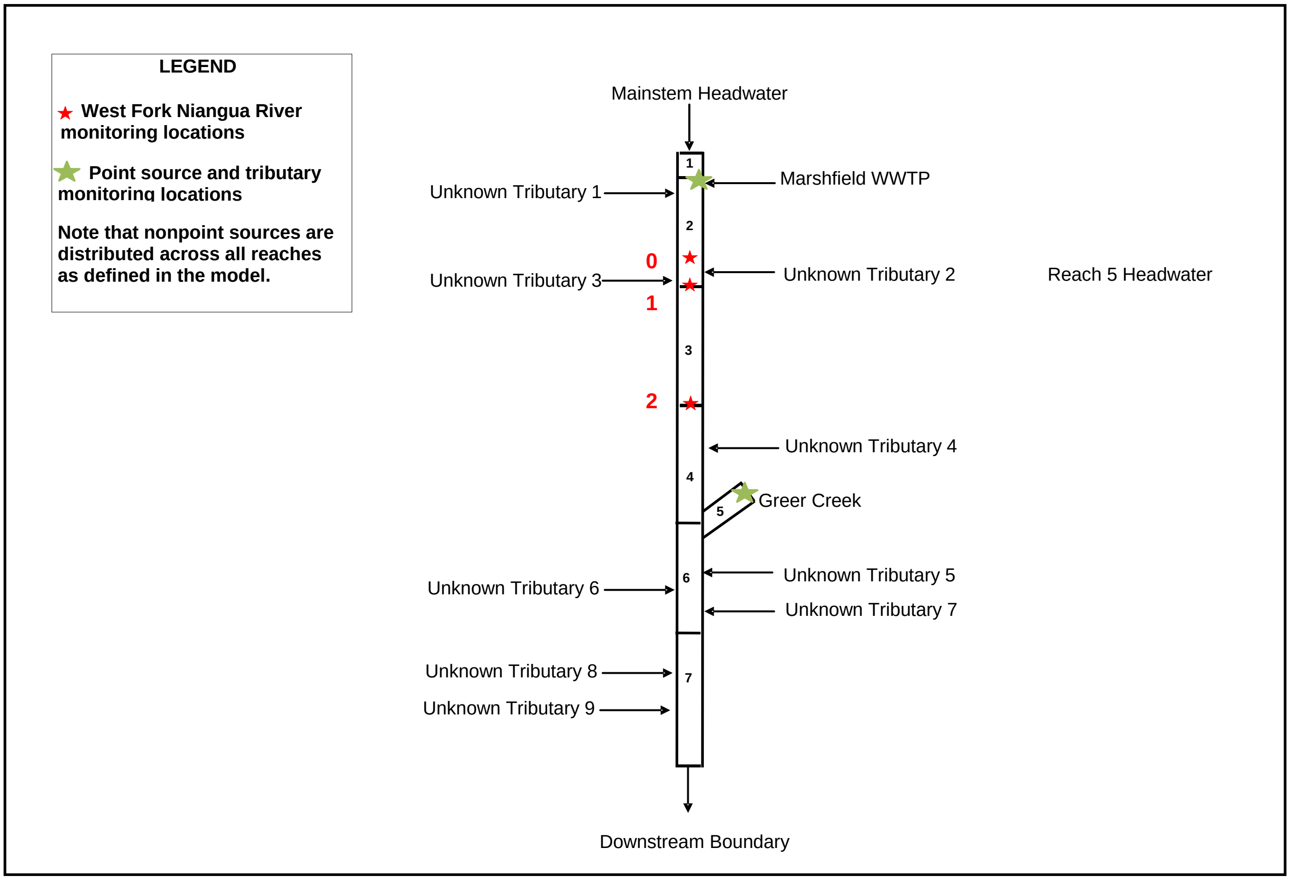


Figure. B-1. Diagram of West Fork Niangua River QUAL2K Stream Model

Table B-1. Number of Reaches and Elements Associated with Each Reach in West Fork Niangua River

Reach Number	Reach Length (kilometers)	Number of Elements	Element Length (kilometers)
1	0.26	5	0.05
2	1.77	12	0.15
3	1.61	11	0.15
4	1.69	10	0.17
5	0.32	4	0.08

Reach Number	Reach Length (kilometers)	Number of Elements	Element Length (kilometers)
6	2.37	20	0.12
7	3.34	20	0.17

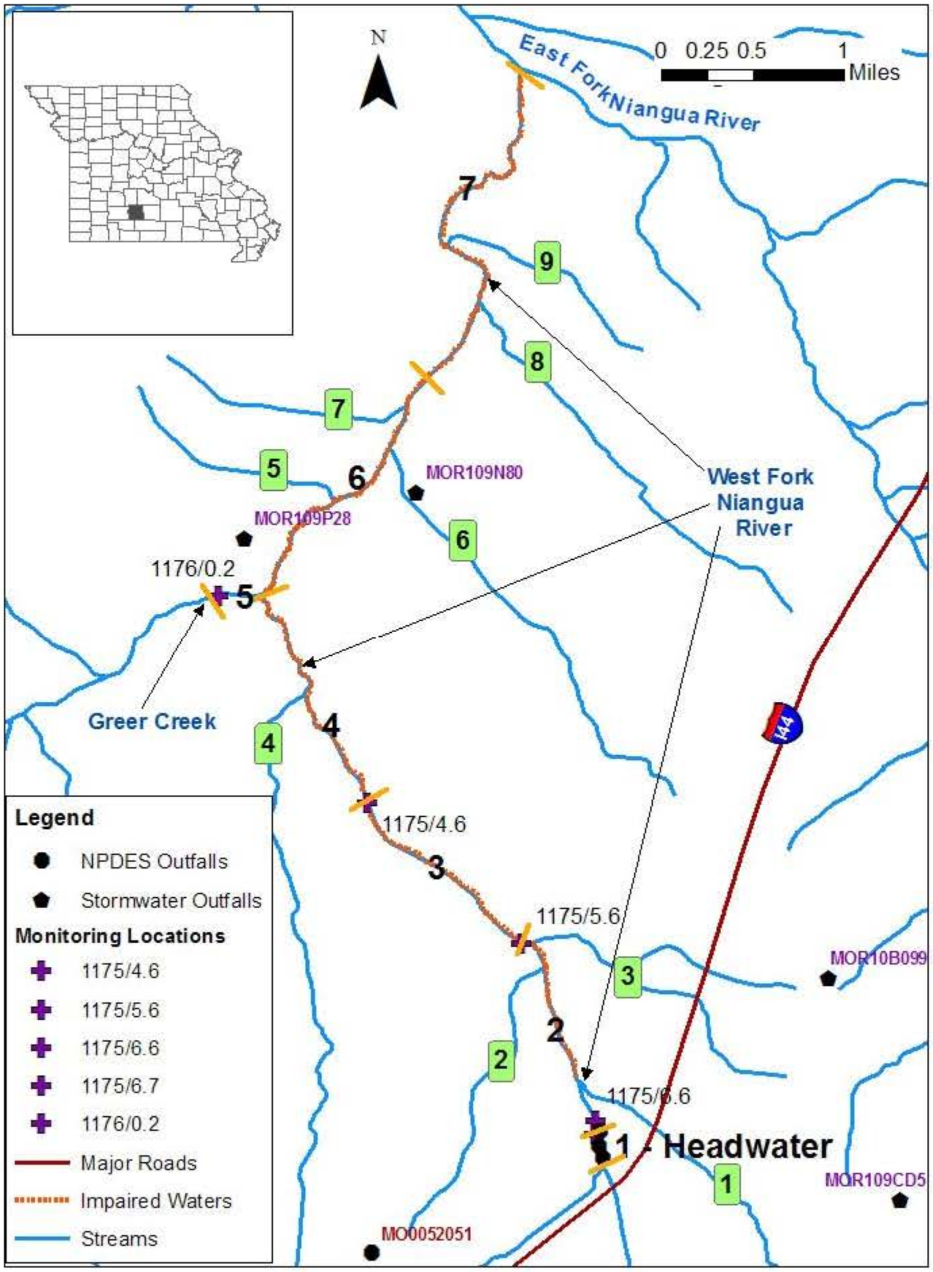


Figure B-2. Reaches in West Fork Niangua River QUAL2K Model. Green-backed numbers indicate minor tributaries. Reach numbers are shown between orange hashes.

Table B-2. Permitted Point Source Discharges within the West Fork Niangua River Watershed

ID	Name	Type	Design Flow (MGD)	Actual Flow (MGD)	Issue/Expire Date	Modeled As
MO0040843	Marshfield WWTP (Outfall #2)	Municipal	1.5	0.7	20010921/ 20060920	Point source input to Reach 2
MO0052051	Gaslight Village MHP WWTP	Non-Municipal	0.005	0.0	20060126/ 20110125	Given zero actual flow and minor design flow this point source is not modeled (Trib #4)
MO0109746	Fountain Plaza MHP WWTP	Non-Municipal	0.007	0.0	20070226/ 20120225	Given zero actual flow and minor design flow this point source is not modeled (Trib #4)
MOG822170	Hoerman Meat Company	Non-Municipal	0.0	0.0	20080205/ 20110608	Given zero actual flow and minor design flow this point source is not modeled (Greer Creek)
MOR109N80	Niangua Ranch Subdivision	Storm water			20070426/ 20120307	Not modeled
MOR109P28	Niangua Ranch Subdivision	Storm water			20070426/ 20120307	Not modeled
MOR10B099	Grayhawk Estates	Storm water			20070913/ 20120207	Not modeled
MOR203310	Avatar Components Corporation	Storm water			20040513/ 20090304	Not modeled

B.2.2 Geometry, Elevation and Weather Data

QUAL2K allows the user to calculate the flow balance using one of three approaches: weirs, rating curves and Manning equations. While streamflow measurements are reported with many of the water quality measurements available for the West Fork Niangua River, only one study was conducted where measurements of stream velocity, width and depth were made. This study was conducted by MEC Water Resources to establish a wasteload allocation for the city of Marshfield WWTP and as such characterizes the stream channel from the WWTP outfall to 4000 feet downstream. A single rating curve for the stream channel was developed using Equations 2 and 3.

$$U = aQ^b$$ **Equation 2**

Where,
U = Velocity (m/s)
a = Empirical Coefficient
Q = Flow (m^3/s)
b = Empirical Coefficient

$$H = \alpha Q^\beta$$ **Equation 3**

Where,
H = Depth (m)
α = Empirical Coefficient
Q = Flow (m^3/s)
β = Empirical Coefficient

a, *b*, α and β are empirical coefficients that are determined from velocity-discharge and stage-discharge rating curves. Within Q2K the values of velocity and depth are used to estimate reach average cross-sectional area and width by:

$$A_c = \frac{Q}{U}$$

Where,
A_c = average cross-sectional area (m^2)
Q = flow (m^3/s)
U = velocity (m/s)

$$B = \frac{A_c}{H}$$

Where,
B = width (m)
A_c = average cross-sectional area (m^2)
H = depth (m)
The surface area and volume of the element can then be computed as:

$$A_s = B\Delta x$$

Where,

A_s = surface area (m^2)
B = width (m)
Δx = length of element
$V = BH\Delta x$

Where,

V = volume (m^3)
B = width (m)
H = depth (m)
Δx = length of element

The rating curve produced during the MEC Water Resources study has been converted to metric units for model input (Table B-3). The raw data from this study were not available for plotting.

Table B-3. Rating Curve QUAL2K Model Inputs

Stream	Velocity (m/s)		Depth (m)	
	Coefficient	Exponent	Coefficient	Exponent
West Fork Niangua River	0.2156	0.400	0.6826	0.450
Greer Creek	Assumed to follow same curves as West Fork Niangua River in the absence of any monitored hydraulic data			

Hourly weather data for air temperature, dew point temperature and wind speed were retrieved from the National Weather Service Climatic Data Center. Weather data from the Springfield, Missouri Weather Station (KSGF; 237976) were used because this was the closest station with the appropriate data. Table B-4 displays the hourly weather data used for July 12, 2000 calibration period, and the daily data available for the October 19, 2004 validation period.

Table B-4. Hourly Weather Data for July 12, 2000 and Daily Weather Data for October 19, 2004 from the Springfield, Missouri, Weather Station (KSGF; 237976)

Date/Time	Air temperature C	Dew point temperature C	Wind speed (meters/second)	Cloud cover
July 12, 2000				
12:00 AM	31.1	25.6	1.34	0
12:54 AM	30.0	25.0	2.24	0
01:54 AM	28.9	24.4	0	0
02:54 AM	28.3	24.4	0	0
03:54 AM	27.2	24.4	2.24	30
04:54 AM	27.2	24.4	2.24	100
05:54 AM	27.2	23.9	3.58	75
06:54 AM	25.6	22.8	2.68	100
07:54 AM	23.9	22.2	6.26	100
08:54 AM	21.1	20.0	9.83	100
09:54 AM	21.7	20.6	11.18	100
10:54 AM	21.1	20.6	5.36	100
11:54 AM	21.1	20.0	3.13	75
12:54 PM	20.6	20.0	3.58	100
13:54 PM	21.1	21.1	4.02	100
14:54 PM	22.8	21.7	3.58	0
15:54 PM	25.6	22.2	2.68	0
16:54 PM	27.8	22.8	2.68	0
17:54 PM	27.8	22.2	2.68	0
18:54 PM	28.3	23.3	2.68	0
19:54 PM	30.0	22.8	3.58	0
20:54 PM	30.6	23.3	2.68	0
21:54 PM	30.6	23.9	3.13	30
22:54 PM	31.1	24.4	3.58	0
23:54 PM	30.0	23.9	2.24	0
October 19, 2004				
12:07 AM	13.0	12.0	3.62	100
12:52 AM	13.3	13.3	4.11	100
1:52 AM	12.8	12.8	3.62	100
2:52 AM	12.8	12.8	3.62	100

Date/Time	Air temperature C	Dew point temperature C	Wind speed (meters/second)	Cloud cover
3:52 AM	13.3	12.2	2.59	100
4:52 AM	12.8	12.2	3.62	100
5:52 AM	12.8	12.2	2.59	100
6:52 AM	12.8	11.7	0.00	100
7:52 AM	12.8	12.2	2.06	100
8:52 AM	12.8	12.2	0.00	100
9:52 AM	12.8	12.2	2.06	100
10:52 AM	13.3	12.2	2.59	100
11:52 AM	13.9	12.2	3.62	100
12:52 PM	13.9	12.8	3.62	100
1:52 PM	14.4	12.8	4.11	100
2:52 PM	15.0	12.8	3.08	100
3:52 PM	15.0	12.2	4.11	100
4:52 PM	15.0	12.2	3.62	100
5:52 PM	15.0	12.2	4.65	100
6:52 PM	14.4	12.2	5.14	100
7:52 PM	14.4	12.2	4.11	100
8:52 PM	13.9	11.7	4.11	100
9:52 PM	13.9	11.7	3.62	100
10:52 PM	13.3	11.1	4.65	100
11:52 PM	12.8	11.1	5.14	100

B.2.3 Boundary Conditions

Monitoring upstream of the city of Marshfield WWTP has only been completed on a few number of occasions in the past. Given the sparse data that is available upstream of the outfall from the 1980s it appears that during summer months the West Fork Niangua River stream channel is likely dry upstream of the outfall. Therefore, the discharge from the WWTP constitutes the headwaters of the impaired segments of the stream for the summer months. Monitoring data (without flow) is available for the October 19, 2004, sampling date indicating that during the cooler months natural flow does exist in the stream channel. The summer condition of no natural flow upstream of the WWTP outfall constitutes the most conservative case.

For the July 12, 2000 model, no monitoring data upstream of the WWTP outfall is available. Flow is expected to be minimal and is assumed to be 0.1 cfs (0.0028 m^3/s). In the absence of other data, the headwater boundary conditions were set according to regional and Missouri criteria data, downstream monitoring conditions and best professional judgments.

Headwater flow and water quality concentrations are reported in Table B-5. Hourly estimates for temperature and DO were calculated using a polynomial regression on daily measurements. Separate regressions were developed for DO and temperature on each day by utilizing estimated AM and PM temperatures for each day at monitoring location 1. Given the use of the 7Q10 flow for Class "P" streams (0.1 cfs or 0.0028 cubic meters per second [m3/s]) and the short reach length before the introduction of the much larger, controlling WWTP discharge the upstream estimated water quality conditions are expected to play a small role in the stream conditions compared to the discharge.

For the October 19, 2004 model, water quality and stream channel information collected at the most upstream monitoring location were used to specify headwater boundary conditions for most parameters. The following constituents and parameters were based directly on data collected at the most upstream monitoring location 1: flow, CBOD, organic nitrogen, ammonium-nitrogen, organic phosphorus, inorganic phosphorus, pH, rating curve velocity, depth coefficient and exponent inputs. Hourly estimates for temperature, solids and DO were calculated using a polynomial regression on daily measurements. Separate regressions were developed for DO, temperature and suspended solids by utilizing AM and PM samples for each day at monitoring location 1. Headwater inputs are provided in Table B-5.

In order to estimate inflows for each of the nine minor tributaries, the area of each monitoring location was divided by its respective area and all flow/area ratios were averaged to calculate a flow/area ratio for the entire watershed. The drainage area of each tributary was then multiplied by the West Fork Niangua River flow/area ratio to estimate a flow (cfs) for each tributary. Prior to calculating the flow/area ratio for each sample location, the flow contributed by the city of Marshfield WWTP was subtracted from the monitored flow, as it should have no impact on tributaries draining into the river. Water quality concentrations for the tributaries were estimated using water quality conditions at sample location #1 (upstream of the city of Marshfield WWTP) during the October 19, 2004, sampling event. These concentrations were adjusted during calibration as needed.

Table B-5. West Fork Niangua River QUAL2K headwater model input values for July 12, 2000 and October 19, 2004

Constituent	QUAL2K Headwater Model Inputs	
	July 12, 2000	October 19, 2004
Flow (cubic meters per second [cms])	0.001	0.0059
Temperature (degree C)[1]	24[2]	12.4 – 16.1
DO (mg/L)[1]	6.0[2]	7.7 – 8.7
CBOD Ultimate (milligrams of oxygen per liter [mg O_2/L])	1.0[2]	<2 (1.0)
Organic Nitrogen (micrograms of nitrogen per liter [µg N/L])	10[3]	200
NH4-Nitrogen (µg N/L)	40[3]	ND (0)
NO3-Nitrogen (µg N/L)	240[3]	500

Constituent	QUAL2K Headwater Model Inputs	
	July 12, 2000	October 19, 2004
Organic Phosphorus (micrograms of phosphorus per liter [µg P/L])	3.3[3]	15
Inorganic Phosphorus (µg P/L)	3.3[3]	15
Alkalinity (milligrams calcium carbonate per liter [mg $CaCO_3$/L])	150[4]	150[4]
pH	7.8[2]	8.2
Conductivity (micro Siemens [µmhos])	430[4]	593
TSS (mg/L)	15[4]	5 – 24

[1] Values for temperature and DO vary hourly

[2] Estimated value based on downstream monitoring on the same date. Measured data were below detection limit of 2.0 mg/L. Half of the detection limit was used for modeling purposes.

[3] Calculated based on reference conditions for Level III Ecoregion 39

[4] Best professional judgment in the absence of monitoring data or reference criterion

B.2.4 Point Sources

Point source inputs for the QUAL2K model were obtained from discharge monitoring reports and the water quality database provided by MDNR (summarized in Table B-6). Only one point source was simulated in the model explicitly; the city of Marshfield WWTP which discharges at kilometer 10.6. Two other minor WWTP were simulated as additions to minor Tributary #4 (already simulated as a point source) at their design flows. A third point source, which is located on Greer Creek, was considered but not simulated in the model because no design nor actual flow for this point source could be obtained

Water quality parameters for the city of Marshfield WWTP available from monthly and daily monitoring of the facility are reported in Table B-6. These values are used within the model. Because only maximum allowable limits are reported for BOD for the remaining two point sources, the nutrient and BOD concentrations in Minor Tributary #4 were simulated at levels slightly above the other tributaries.

Table B-6. Point Source Data Summary

Facility Name & NPDES	Date	Discharge Point (km)[1]	Flow (cms)	BOD5 (mg/L)	NH_3 (µg/L)	Organic N[3] (µg/L)	Nitrate+ Nitrite N (µg/L)	Organic P (µg/L)	Inorganic P (µg/L)	DO (mg/L)
city of Marshfield WWTP[2]	7/12/2000	10.6	0.0198	< 2.0	3,060	194	7,300	2,000	800	6.5
	10/19/2004	10.6	0.0255	1.5	130	300	18,000	1,300	1,300	8.02
Gaslight Village MHP WWTP	Estimated (Permit limits)	Unknown Tributary #4	0.00023	1.0 (65)	NS	NS	NS	NS	NS	NS
Fountain Plaza MHP WWTP	Estimated (Permit limits)	Unknown Tributary #4	0.00032	1.0 (65)	NS	NS	NS	NS	NS	NS
Hoerman Meat Company	Estimated (Permit limits)	Greer Creek	NA[4]	1.0 (45)	NS	NS	NS	NS	NS	NS
Niangua Ranch Subdivision	Storm water Permitted Flow Only – No limits specified									
Niangua Ranch Subdivision	Storm water Permitted Flow Only – No limits specified									
Grayhawk Estates	Storm water Permitted Flow Only – No limits specified									
Avatar Components Corporation	Storm water Permitted Flow Only – No limits specified									

[1] Discharge location is based on the distance to the confluence with the East Fork of Niangua River; The city of Marshfield WWTP discharges directly into the West Fork Niangua River, all others discharge to tributaries of the river.

[2] Flow, pH, temperature and DO values reported on daily monitoring reports for October 19 were used as model inputs. Inputs for BOD and ammonia (NH^3) on October 19 were based on values reported on October 20 (BOD) and October 18 (NH^3). Organic nitrogen, nitrate+nitrite N, organic phosphorus and inorganic phosphorus model inputs were not reported by the city of Marshfield WWTP daily monitoring reports. These model inputs were selected based on instream measurements at the monitoring location 2 on October 19. Values for nutrients were adjusted during calibration. For the July 12 date, estimates were based on instream sampling at the outfall; for the October 19 date, estimates were based on effluent concentrations. Values for nutrients were again adjusted during calibration.

[3] Organic N is set equal to TKN minus NH_3 (July 12, 2000) or Total Nitrogen minus the sum of NO_3+NO_2 and NH_3 (October 19, 2004).

NA = Parameter not available; NS = Parameter was not included in the model for this point source.

[4] Given that no flow was reported for this point source, it was not explicitly modeled as a point source on Greer Creek.

B.2.5 Critical Conditions

Dissolved oxygen levels that threaten the integrity of aquatic communities generally occur during low flow periods, so these periods are considered the critical condition. For Class P streams, mixing zones are applicable to all pollutants (with the exception of bacteria) that have specific criteria. Mixing zones are typically based on the 7Q10 low flow of the receiving water body to account for critical low-flow conditions. Missouri uses 1/4 of the 7Q10 for the mixing zone flow. The rationale for limiting the size of mixing zones is three-fold. First, the assumption of rapid and complete mixing is not a conservative assumption. Meaning, many times effluent plumes exist and cause areas of chronically toxic conditions that can extend laterally and longitudinally downstream. Second, state rule requires that a zone of passage be provided so that aquatic organisms may pass by facility outfalls without becoming adversely affected. Third, for antidegradation purposes, the entire assimilative capacity of the water body cannot be allocated to a single discharger.

In the case of West Fork Niangua River, a mixing zone of one-quarter (1/4) of the stream width, cross-sectional area or volume of flow and a length of 1/4 mile is required. For modeling purposes, this means 1/4 of the 7Q10 flow should be the volume of flow available to the facility for mixing and this is the critical flow condition for 1/4 mile downstream of the WWTP discharge. At the default 7Q10 for Class P streams of 0.1 cfs, a mixing zone of 0.025 cfs is the appropriate headwater flow for West Fork Niangua River upstream of the facility. For DO targeting purposes, the 5.0 mg/L minimum DO criteria must be met at 1/4 mile below the facility outfall. The applicable mixing zone regulation can be found at 10 CSR 20-7.031(4)(A)4.B.(II) (CSR, 2008). At distances greater than 1/4 mile downstream the critical condition is the 7Q10 flow.

The modeling conducted for West Fork Niangua River included both the 7Q10 and mixing zone flow of 1/4 of the 7Q10. Since the mixing zone DO requirement is applicable 1/4 mile downstream of the discharge and the 7Q10 DO requirements are applicable the entire length of the segment, both conditions must be evaluated. The modeling results indicated that the critical DO condition occurred downstream of the mixing zone; thus the 7Q10 flows were used to develop TMDL loads.

Table B-7 presents minimum DO measurements collected on July 12, 2000 and October 19, 2004. Of these measurements, DO was found to be lowest during the July morning sampling events. Based on this result, critical conditions are represented in this TMDL through low flow conditions (7Q10 flow) using the July 12, 2000 model.

Table B-7. Minimum DO (mg/L) measurement at each sampling location

Sampling Location	Stream distance (km)	7/12/2000	10/19/2004
0[1]	9.46	NA	8.3
1	9.01	3.2	6.5
2	7.40	4.6	7.4

[1]Sampling location available only for October 19, 2004

B.3 MODEL CALIBRATION

This section of the appendix describes the process that was used to calibrate the QUAL2K model for the West Fork Niangua River watershed and presents the calibration results.

B.3.1 Flow and Water Depth Simulations

The model was calibrated for flow, stream velocities and depths for the data collected on October 19, 2004, with additional consideration given to calibration to estimated flows on July 12, 2000. QUAL2K provides the user with the option to simulate the following flows: boundary headwater flows, point source flows and nonpoint source diffuse flow. In the West Fork Niangua River models, nonpoint sources are grouped with tributary flows that are included in the model as point sources.

Portions of West Fork Niangua River have been identified as a losing stream through monitoring data, even though the current Missouri GIS layer on gaining and losing streams within the state does not reflect this finding. Measured flows between approximately 1.1 km (0.72 mile) downstream of the city of Marshfield WWTP outfall and the upstream end of Reach 3, suggest the presence of water losses that were not otherwise estimated based on watershed area and tributaries for both the July 12, 2000 and October 19, 2004, sampling dates, as well as previous monitoring dates (June 22 and August 31, 1988). Additionally, monitoring at the downstream end of Reach 3 indicates that the stream regains a large portion of the flow. To simulate this phenomenon, a diffuse abstraction was input into the model for the losing portion of the stream, and a diffuse source was used to represent the gaining portion of the stream (Table B-8). The flows attributed to the individual diffuse abstraction and source were adjusted to monitored flows during calibration. An additional gaining section of stream was identified by the monitoring data for the October 19, 2004, sampling date between the city of Marshfield WWTP outfall and the upstream end of the identified losing section of the stream. Given the time of year differences and the larger flows measured and estimated in the stream, an occurrence of groundwater recharge in additional stream segments compared to the summertime is not an unexpected phenomenon. For this monitoring date, an additional diffuse source was added to the model for that section of river and calibrated to monitored flow data.

Table B-8. Diffuse Sources and Abstractions in the Model for Gaining and Losing Stream Segments

Type	Date	Start Point (km)	End Point (km)[1]	Flow (cms)	Nitrate+ Nitrite N (µg/L)	Organic P (µg/L)	Inorganic P (µg/L)	DO (mg/L)
Gaining Segment 1	7/12/2000	10.62	9.46	NA	NA	NA	NA	NA
	10/19/2004			0.012	NS	NS	NS	6.5
Losing Segment	7/12/2000	9.50	9.01	0.018	NS	NS	NS	6.5
	10/19/2004			0.037	NS	NS	NS	6.5
Gaining Segment 2	7/12/2000	8.10	7.40	0.018	3,500	NS	NS	6.5
	10/19/2004			0.0270	6,000	500	500	6.5

Stream velocity, depth and discharge are all critical to the water quality simulation because they influence reaeration, DO, biogeochemical reactions and deposition rates, growth of algal species and the influence of SOD in the stream. Calibration results for flow, depth and velocity are provided for July 12, 2000 and October 19, 2004, in Figure B-3. A summary of all calibration statistics is provided in Table B-9.

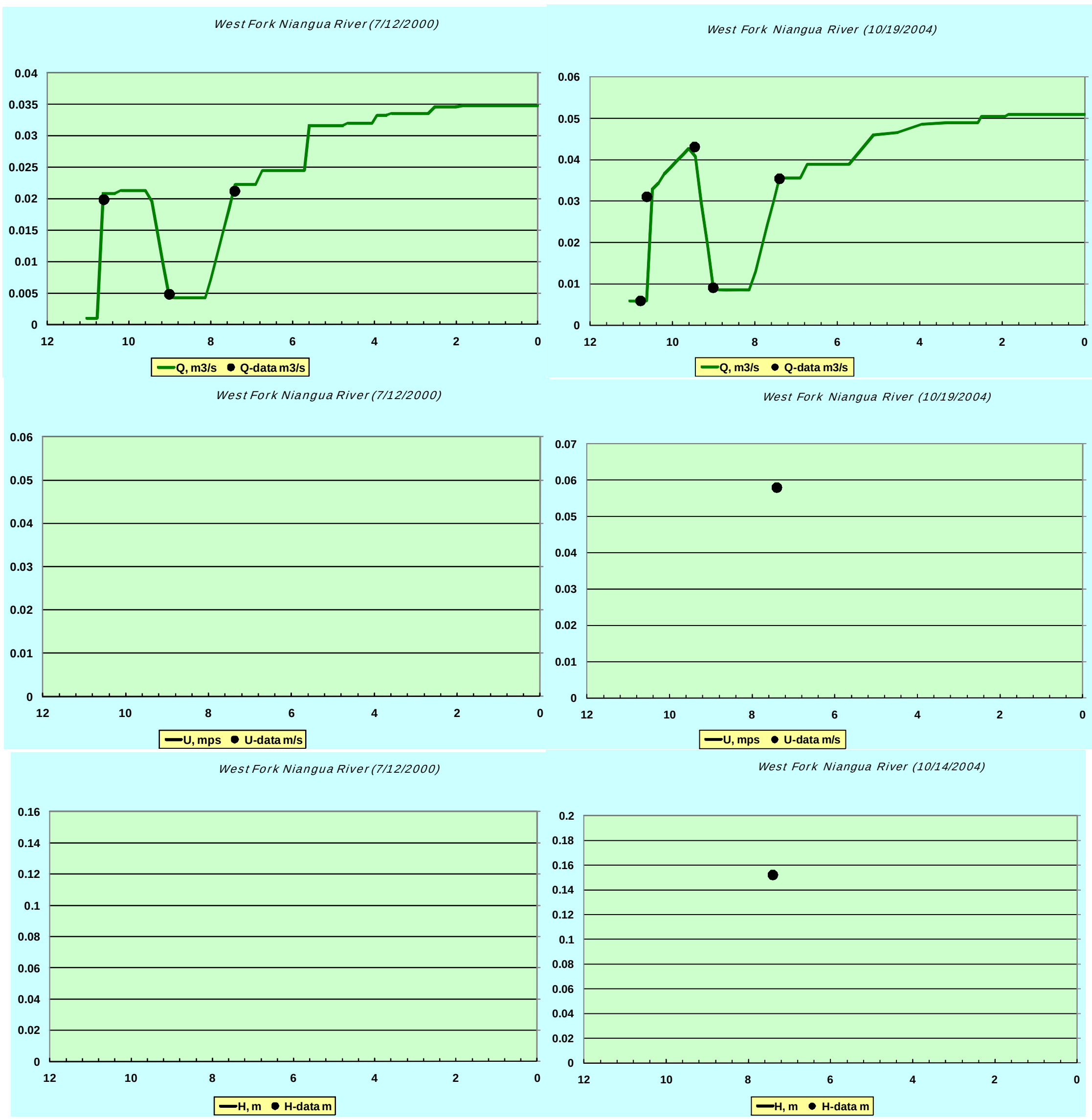


Figure B-3. Comparisons of observed and simulated flow (Q), velocity (U) and depth (H) in West Fork Niangua River

B.3.2 Water Quality Calibration

Calibration consists of the process of adjusting model parameters and the initial estimates of boundary conditions to provide a suitable representation of observed conditions. Calibration is necessary because of the semiempirical nature of water quality models. Although these models are formulated from mass balance principles, most of the kinetic descriptions in the models are empirically derived. These empirical derivations contain a number of coefficients that are usually determined by calibration to data collected in the water body. In addition, there is uncertainty associated with the specification of boundary conditions, point source loads and tributary loads. The boundary conditions and tributary loads might need to be adjusted within the uncertainty bounds of available data to achieve model calibration. Water quality calibration for the West Fork Niangua River QUAL2K model relied on comparison of model predictions to observations at two stations (July 12, 2000), and three stations (October 19, 2004) on the mainstem of the system.

Water quality models are often evaluated through visual comparisons, in which the simulated results are plotted against the observed data for the same location and time and are visually evaluated to determine if the model is able to mimic the trend and overall magnitude of the observed conditions. If the model predictions follow the general trend and reproduce the overall magnitude of the observed data, the model is said to represent the dynamics of the system well. The merit of this method is that it is straightforward, taking full advantage of the strength of human intelligence in pattern identification. This method works particularly well when data are limited in quantity and contain significant uncertainty. The limitation of this method is that it relies on the subjective judgment of modelers and lacks quantitative measures to differentiate among sets of calibration result. Because of this, both a visual comparison and quantitative measures were used during the West Fork Niangua River calibration.

Biochemical oxygen demand (BOD) is an important calibration parameter because of its influence on DO concentrations. BOD typically consists of two parts: CBOD and NBOD. CBOD is the result of the breakdown of organic carbon molecules such as cellulose and sugars into carbon dioxide and water. NBOD is the result of ammonia oxidation, which is a conversion of ammonia to nitrate in the environment. The consumption of nitrogen usually occurs slower than that of CBOD. CBOD is the oxygen consumed by heterotrophic microbes that utilize the organic matter of the waste in their metabolism. Nitrifying bacteria grow slower than the heterotrophic bacteria, which is one of the reasons why NBOD occurs slower.

The parameter “fast reacting CBOD” was used to simulate CBOD in the models. Instream measurements of CBOD were assumed to be CBOD5 measurements. WWTP monitoring was reported as BOD5 and assumed to represent CBOD5. CBOD5 measurements were adjusted through Equation 4:

$$\mathrm{CBODU} = \frac{\mathrm{CBOD5}}{1 - e^{-k_1 5}}$$ **Equation 4**

where CBODU = the ultimate dissolved carbonaceous BOD [mgO_2/L], CBOD5 = the 5-day dissolved carbonaceous BOD [mgO_2/L] and k_1 = the CBOD decomposition rate in the bottle [/d] assumed to 0.1/day for this analysis. Estimated measures of CBODU were entered as “fast reacting CBOD” in the QUAL2K model.

The first order kinetic reaction rates for biogeochemical reactions are influenced from the various flow and chemical conditions in streams. Kinetic rates are a function of different physical and chemical mechanisms such as mixing and turbulence, the particulate and dissolved chemical components ratio, physical settling, biochemical decompositions and sorption by biological slimes on river bottom. In all West Fork Niangua River models, first order reaction rates were selected for the final calibration because they were found to produce the best match to the observed data.

Sediment oxygen demand (SOD) by benthic sediments and organisms can be a large fraction of oxygen consumption in the stream. Benthic sediments can be composed of inorganic minerals and organic material such as leaf litter, particulate and dissolved BOD, detritus from phytoplankton/periphyton and macrophytes. Reduced inorganic and organic materials can exert SOD by diffused oxygen into sediments or oxygen consumption in water column after the inorganic and organic materials are suspended from the sediments. In addition to physical and chemical characteristics of sediments, the impact that SOD has on water column DO can be affected by water depth, stream velocity and water temperature.

Sediment oxygen demand is primarily a function of oxidation of dissolved ammonium, methane and decomposition of organic matter by bacteria. Additionally, dissolved hydrogen sulfide and reduced iron and manganese could consume DO once they diffuse into the aerobic sediment layers. The amount of organic matter can be related to SOD consumption.

Organic matter can be described by Redfield ratio, $C_{106}H_{263}O_{110}N_{16}P$. As this ratio suggests, the bacterial conversion (decomposition) of the organic matter can generate the rapidly reactive dissolved N and C species. These species eventually exert SOD from both in sediments and at the interface between water column and sediments. SOD can be measured using the respiration chamber but the method can have high uncertainty and the data was not collected for West Fork Niangua River. SOD values were estimated in combination with other reactions kinetics. Prescribed SOD rates for each reach within the model were adjusted during calibration. The prescribed SOD rates for the West Fork Niangua River were required to be slightly higher than typically expected in order to calibrate the model to the observed data while keeping growth, respiration and light rates within reasonable values.

For the West Fork Niangua River, benthic algae were simulated in addition to prescribing SOD conditions for each reach. Given that phytoplankton is assumed to be less prevalent in shallow, low-flow streams, model runs attempting to simulate phytoplankton in addition to benthic algae were completed. These model runs confirmed that phytoplankton concentrations are not influential on stream dynamics and could be eliminated from the calibration and allocation runs in favor of prescribed SOD and benthic algae simulation. Therefore, the phytoplankton growth rate is set to 0.

The “USGS (pool-riffle)”method was selected to simulate oxygen reaeration. Equations 5 and 6 present formulas for calculating reaeration using the USGS (pool-riffle) method (Chapra, 2008).

Low flow, Q < 0.556 cms (< 19.64 cfs):

$$k_{ah}(20) = 517(US)^{0.524}Q^{-0.242}$$ **Equation 5**

High flow, Q > 0.556 cms (> 19.64 cfs):

$$k_{ah}(20) = 596(US)^{0.528} Q^{-0.136}$$ **Equation 6**

The final rates used for the West Fork Niangua River calibration are presented in Table B-9. Figures B-4 through B-11 present the results of the model calibration, including: temperature, DO, CBOD, TKN, ammonium, nitrate, TN and TP. A visual inspection of the plots indicates that the model predictions follow the general trend and reproduce the overall magnitude of the observed data well.

The quantitative calibration metrics that were used to assess the calibration include the evaluation of average error, residual error, root mean squared error (RMSE), relative error and percent bias. Table B-10 reports the statistical measure and equation for each quantitative calibration metrics used to evaluate the calibration. Table B-11 presents statistical results for calibration model runs for flow, DO, nitrate, TKN and TP.

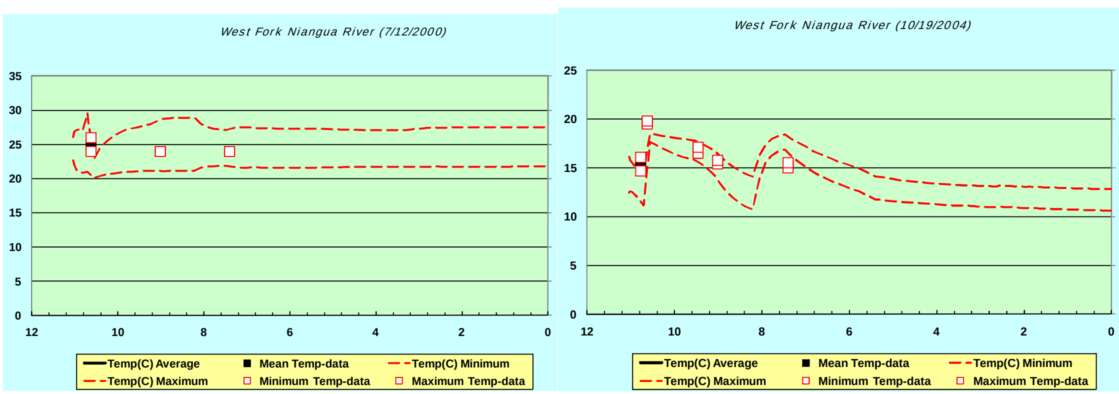


Figure B-4. Temperature calibration in West Fork Niangua River

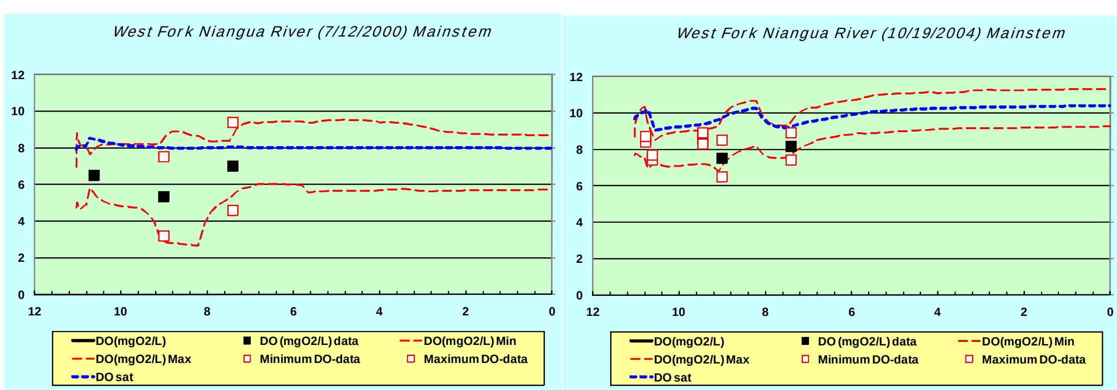


Figure B-5. DO calibration in West Fork Niangua River

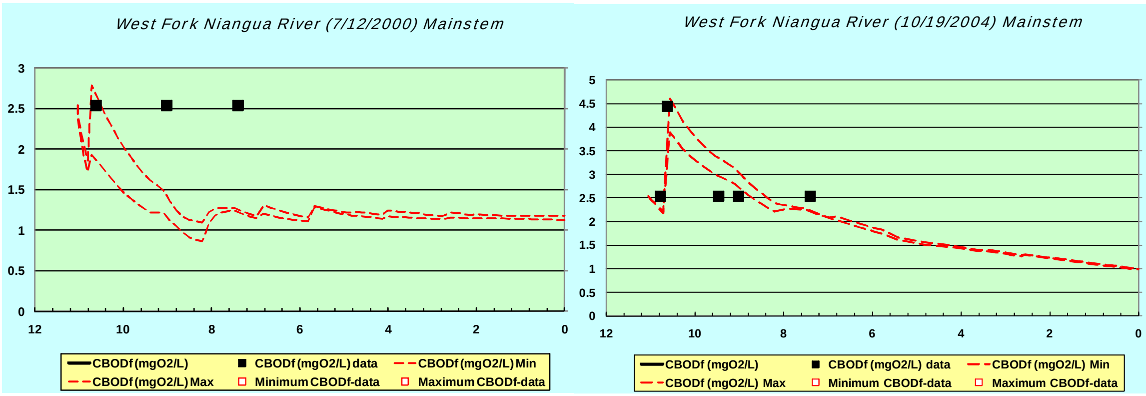


Figure B-6. CBOD calibration in West Fork Niangua River (Half the detection limit, as reported by MDNR, of converted CBOD measurements equals approximately 2.5 mg O_2/L)

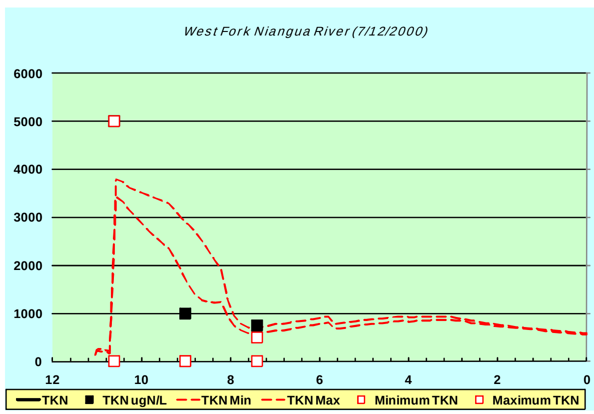


Figure B-7. TKN calibration in West Fork Niangua River (July 12, 2000 only)

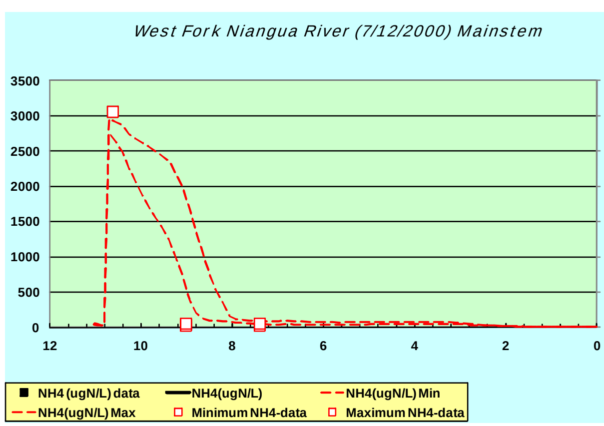


Figure B-8. Ammonia/ammonium calibration in West Fork Niangua River (July 12, 2000 only; Detection limit of instream measurements approximately 25 ug N/L)

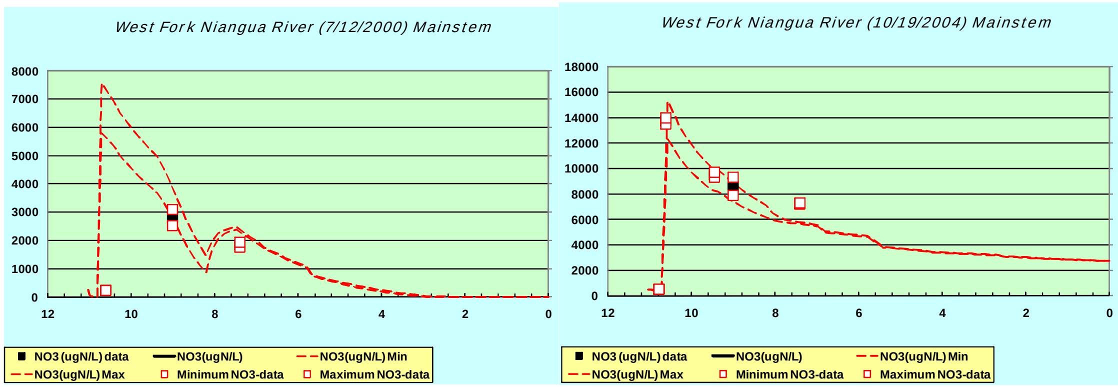


Figure B-9. Nitrate calibration in West Fork Niangua River

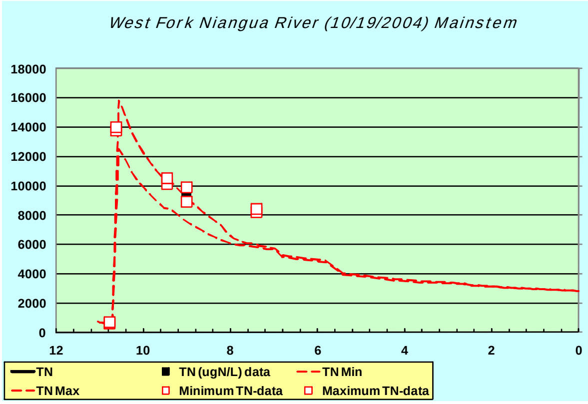


Figure B-10. Total nitrogen calibration in West Fork Niangua River (October 19, 2004 only)

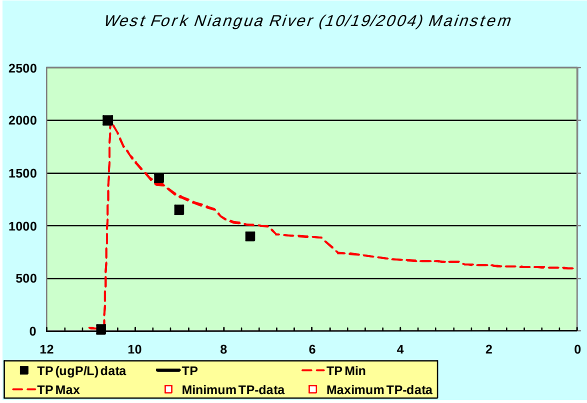


Figure B-11. Total phosphorus calibration in West Fork Niangua River (October 19, 2004 only)

Table B-9. Rates used for the West Fork Niangua River QUAL2K calibration

Parameter	***Value***	***Units***	***Symbol***
Stoichiometry:			
Carbon	40	gC	gC
Nitrogen	7.2	gN	gN
Phosphorus	1	gP	gP
Dry weight	100	gD	gD
Chlorophyll	1	gA	gA
Inorganic suspended solids:			
Settling velocity	1.304	m/d	v_i
Oxygen:			
Reaeration model	USGS(pool-riffle)		
User reaeration coefficient α	0		α
User reaeration coefficient β	0		β
User reaeration coefficient γ	0		γ
Temp correction	1.024		θ_a
Reaeration wind effect	Banks-Herrera		
O2 for carbon oxidation	2.69	gO_2/gC	r_{oc}
O2 for NH4 nitrification	4.57	gO_2/gN	r_{on}
Oxygen inhib model CBOD oxidation	Exponential		
Oxygen inhib parameter CBOD oxidation	0.60	L/mgO2	K_{socf}
Oxygen inhib model nitrification	Exponential		
Oxygen inhib parameter nitrification	0.60	L/mgO2	K_{sona}
Oxygen enhance model denitrification	Exponential		
Oxygen enhance parameter denitrification	0.60	L/mgO2	K_{sodn}
Oxygen inhib model phyto resp	Exponential		
Oxygen inhib parameter phyto resp	0.60	L/mgO2	K_{sop}
Oxygen enhance model bot alg resp	Exponential		
Oxygen enhance parameter bot alg resp	0.60	L/mgO2	K_{sob}
Slow CBOD:			
Hydrolysis rate	0.6	/d	k_{hc}
Temp correction	1.047		θ_{hc}
Oxidation rate	0	/d	k_{dcs}
Temp correction	1.047		θ_{dcs}
Fast CBOD:			
Oxidation rate	0.9	/d	k_{dc}
Temp correction	1.047		θ_{dc}
Organic N:			
Hydrolysis	0.1	/d	k_{hn}
Temp correction	1.07		θ_{hn}
Settling velocity	0.2	m/d	v_{on}
Ammonium:			
Nitrification	0.1	/d	k_{na}
Temp correction	1.07		θ_{na}
Nitrate:			

Parameter	***Value***	***Units***	***Symbol***
Denitrification	0.1	/d	k_{dn}
Temp correction	1.07		θ_{dn}
Sed denitrification transfer coeff	0.1	m/d	v_{di}
Temp correction	1.07		θ_{di}
Organic P:			
Hydrolysis	0.1	/d	k_{hp}
Temp correction	1.07		θ_{hp}
Settling velocity	0.1	m/d	v_{op}
Inorganic P:			
Settling velocity	0	m/d	v_{ip}
Inorganic P sorption coefficient	0.073	L/mgD	K_{dpi}
Sed P oxygen attenuation half sat constant	1.831	mgO_2/L	k_{spi}
Phytoplankton:			
Max Growth rate	0	/d	k_{gp}
Temp correction	1.07		θ_{gp}
Respiration rate	0.05	/d	k_{rp}
Temp correction	1.07		θ_{rp}
Excretion rate	0.04	/d	k_{ep}
Temp correction	1.07		θ_{dp}
Death rate	0.01	/d	k_{dp}
Temp correction	1.047		θ_{dp}
External Nitrogen half sat constant	100	ugN/L	k_{sPp}
External Phosphorus half sat constant	40	ugP/L	k_{sNp}
Inorganic carbon half sat constant	1.30E-05	moles/L	k_{sCp}
Light model	Half saturation		
Light constant	15	langleys/d	K_{Lp}
Ammonia preference	25	ugN/L	k_{hnxp}
Subsistence quota for nitrogen	0.72	mgN/mgA	q_{0Np}
Subsistence quota for phosphorus	0.1	mgP/mgA	q_{0Pp}
Maximum uptake rate for nitrogen	72	mgN/mgA/d	ρ_{mNp}
Maximum uptake rate for phosphorus	5	mgP/mgA/d	ρ_{mPp}
Internal nitrogen half sat constant	0.9	mgN/mgA	K_{qNp}
Internal phosphorus half sat constant	0.13	mgP/mgA	K_{qPp}
Settling velocity	0	m/d	v_a
Bottom Algae:			
Growth model	Zero-order		
Max Growth rate	100	$mgA/m^2/d$ or /d	C_{gb}
Temp correction	1.07		θ_{gb}
First-order model carrying capacity	1000	mgA/m^2	$a_{b,max}$
Respiration rate	0.08	/d	k_{rb}
Temp correction	1.07		θ_{rb}
Excretion rate	0.09	/d	k_{eb}
Temp correction	1.07		θ_{db}
Death rate	0.05	/d	k_{db}

Parameter	Value	Units	Symbol
Temp correction	1.07		θ_{db}
External nitrogen half sat constant	100	ugN/L	k_{sPb}
External phosphorus half sat constant	40	ugP/L	k_{sNb}
Inorganic carbon half sat constant	1.30E-05	moles/L	k_{sCb}
Light model	Steele		
Light constant	140	langleys/d	K_{Lb}
Ammonia preference	25	ugN/L	k_{hnxb}
Subsistence quota for nitrogen	0.72	mgN/mgA	q_{0N}
Subsistence quota for phosphorus	0.1	mgP/mgA	q_{0P}
Maximum uptake rate for nitrogen	72	mgN/mgA/d	ρ_{mN}
Maximum uptake rate for phosphorus	5	mgP/mgA/d	ρ_{mP}
Internal nitrogen half sat constant	0.9	mgN/mgA	K_{qN}
Internal phosphorus half sat constant	0.13	mgP/mgA	K_{qP}
Detritus (POM):			
Dissolution rate	0.2	/d	k_{dt}
Temp correction	1.07		θ_{dt}
Fraction of dissolution to fast CBOD	1.00		F_f
Settling velocity	0.1	m/d	v_{dt}
Pathogens:			
Decay rate	0.8	/d	k_{dx}
Temp correction	1.07		k_{dx}
Settling velocity	1	m/d	θ_{dx}
Light efficiency factor	1.00		v_x
pH:			
Partial pressure of carbon dioxide	347	Ppm	p_{CO2}

B.4 MODEL VALIDATION

Typically, the performance of a calibrated model is evaluated through "validation." Model validation is defined as "subsequent testing of a pre-calibrated model to additional field data, usually under different external conditions, to further examine the model's ability to predict future conditions" (EPA, 1997). Its purpose is to ensure that the calibrated model properly assesses all the variables and conditions that can affect model results and demonstrate the ability to predict field observations for periods separate from the calibration effort (Donigian, 2003).

Validation of the West Fork Niangua River model could not be conducted due to a lack of monitoring data, including flow estimates for the impaired portion of the river. Two calibration dates, one during summer and one during the fall, provided some measure of validation of hydrology and kinetics.

B.5 MODEL GOODNESS OF FIT DISCUSSION

The calibration periods were assessed visually and statistically. The figures presented above demonstrate that the model follows the same patterns and trends, and the measured data and the statistics quantify the differences between the simulated and measured data. The statistics used to evaluate the model are listed in Table B-10, and the statistical comparison between the model results and observed data are included in Table B-11.

The statistics demonstrate that the model results in prediction similar to those measured in the field. Specifically, the following statistics demonstrate a good model fit:

- The RMSE for average DO is less than 0.5 mg/L and near 1 mg/L for minimum DO.
- Coefficient of determination (r^2) is high for flow and DO and relatively high for nitrate. Given the lack of sampling data for comparison the degree of correlation between the simulated model results and observed water quality data is acceptable for this TMDL development.
- The percent Bias is generally close to 0 for parameters of importance. For DO it is less than 1%.
- The bias for minimum DO is slightly positive for the combination of the two calibration periods.

The model calibration and validation runs use the same kinetic parameters to achieve a good comparison with measured data. This is supported with a visual and statistical comparison. Based on this comparison the QUAL2K model for West Fork Niangua River is suitable for assessing DO problems and for TMDL development.

Table B-10. Quantitative calibration metrics

Calibration Metric	Equation
Root Mean Squared Error (RMSE)	$\sqrt{\frac{\sum(\mathrm{Pr}edicted - Observed)^2}{n-1}}$
Coefficient of determination	$1 - \frac{\sum(Squared\ Errors)}{\sum(Total\ Sum\ of\ Squares)}$
Percent Bias (pBias)	$\frac{\sum(\mathrm{Pr}edicted - Observed)}{\sum Observed} * 100$
Average Error	$\sum_{i=1}^{n} \frac{\lvert Simulated\ Value - Observed\ Value \rvert}{n_{obs}}$
Residual Error	$\sum_{i=1}^{n} \frac{(Simulated\ Value - Observed\ Value)}{n_{obs}}$
Relative Error	$\frac{\sum \lvert Simulated\ Value - Observed\ Value \rvert}{\sum Observed} * 100$

Table B-11. Summary statistics for calibration runs

Statistic	Model Period	Flow	DO	Min DO	NO_3
Root Mean Squared Error (RMSE)	Calibration	0.004	0.37	0.81	2,986
Coefficient of determination	Calibration	0.91	0.89	0.82	0.74
Percent Bias (pBias)	Calibration	6.0	0.38	4.04	-5.75
Average Error	Calibration	0.002	0.28	0.68	1870
Residual Error	Calibration	-0.001	-0.028	-0.26	426
Relative Error (%)	Calibration	8.59	3.83	10.42	25.23

Appendix C

Development of TSS Targets Using Reference LDCs

C.1 OVERVIEW

This procedure is used when a lotic system is placed on the 303(d) list for a pollutant and the designated use being addressed is aquatic life. In cases where pollutant data for the impaired stream is not available a reference approach is used. The target for pollutant loading is the 25th percentile calculated from all data available within the Ecological Drainage Unit (EDU) in which the water body is located. Additionally, it is also unlikely that a flow record for the impaired stream is available. If this is the case, a synthetic flow record is needed. A synthetic flow record is developed from an average of the log discharge per square mile of USGS gaged rivers whose drainage areas are entirely contained within the EDU. Selection of these gages is based on location, land use/soil/topography similarities to the West Fork Niangua River watershed and the availability of sufficient flow data. The synthetic record is used to develop a flow duration curve from which to build an LDC for the pollutant within the EDU.

The setting of pollutant target follows the reference method used in setting pollutant targets in lakes and reservoirs. In this methodology the average concentration of either the 75th percentile of reference lakes or the 25th percentile of all lakes in the region is targeted in the TMDL. In most cases, pollutant data for reference streams is not likely to be available. As an alternative, the pollutant target is set at the 25th percentile of the available data within the EDU.

C.2 METHODOLOGY

The first step in this procedure is to locate available pollutant data within the EDU of interest. These data along with the instantaneous flow measurement taken at the time of sample collection for the specific date are recorded to create the population from which to develop the load duration. Both the date and pollutant concentration are needed in order to match the measured data to the synthetic EDU flow record.

Secondly, collect average daily flow data for gages with a variety of drainage areas for a period of time to cover the pollutant record. From these flow records normalize the flow to a per square mile basis. Average the log transformations of the average daily discharge for each day in the period of record. For each gage record used to build this synthetic flow record calculate the Nash-Sutcliffe statistic to determine if the relationship is valid for each record. This relationship must be valid in order to use this methodology. This new synthetic record of flow per square mile is used to develop the load duration for the EDU. The flow record should be of sufficient length to be able to calculate percentiles of flow (typically 20 years or more).

Figure B-1 shows the application of the approach in the West Fork Niangua River EDU (Ozark/Osage EDU). Watershed-size normalized data for the individual gages in the EDU were calculated and compared to a pooled data set of all the gages (Figure C-1, Table C-1). Table C-1 demonstrates the pooled data set can confidently be used as a surrogate for the EDU analyses.

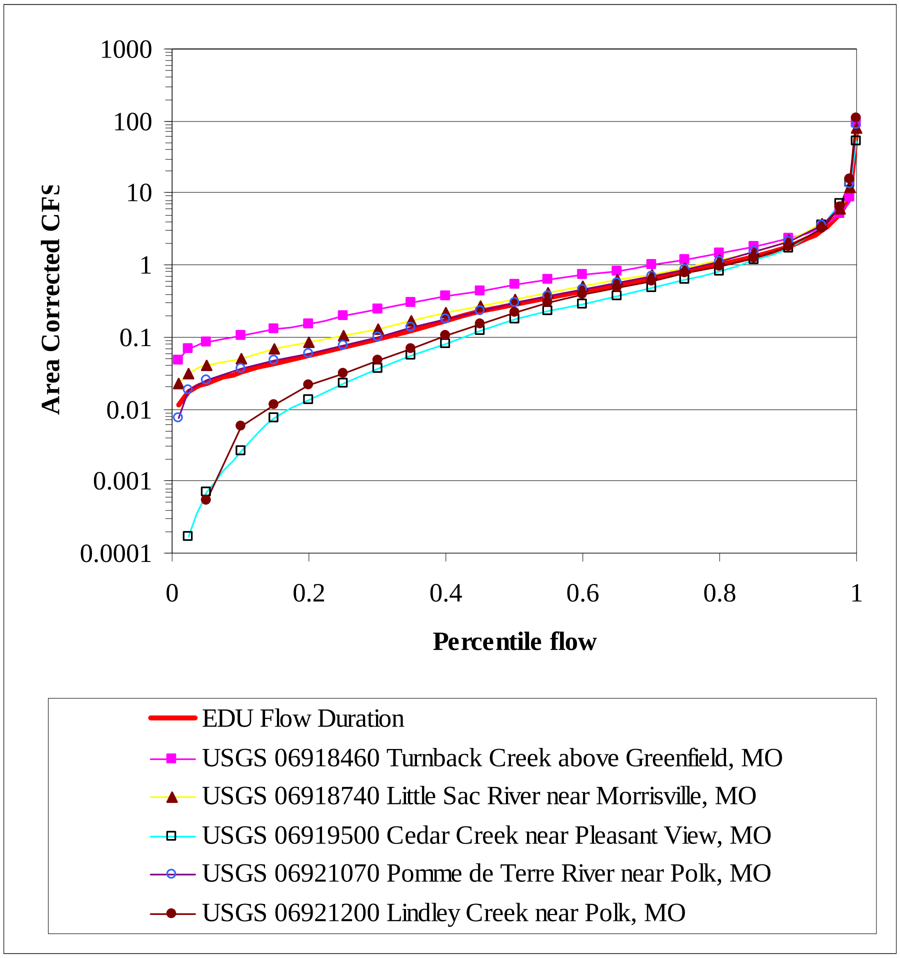


Figure C-1. Synthetic Flow Development in the Ozark/Osage EDU

Table C-1. Stream Flow Stations Used to Estimate Flows in West Fork Niangua River

River/Station Name	Data Source	Station Number	Drainage Area (mi^2)	Lognormal Nash-Sutcliffe
Turnback Creek above Greenfield, MO	USGS	06918460	252	97%
Little Sac River near Morrisville, MO	USGS	06918740	237	100%
Cedar Creek near Pleasant View, MO	USGS	06919500	420	76%
Pomme de Terre River near Polk, MO	USGS	06921070	276	98%
Lindley Creek near Polk, MO	USGS	06921200	112	92%

Note: No gages in the Niangua watershed had a sufficiently long record to be used to generate a synthetic flow record.

The next step is to calculate pollutant-discharge relationships for the EDU; these are log transformed data for the load (lbs/day) and the instantaneous flow (cfs). Figure C-2 shows the EDU relationship. Further statistical analyses on this relationship are included in Table C-2.

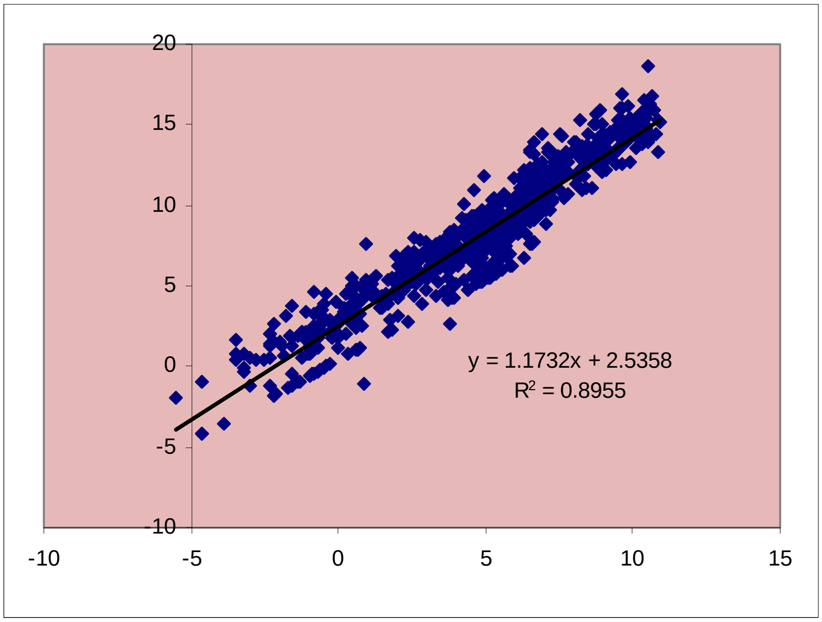


Figure C-2. Estimate of Power Function from Instantaneous Flow in the Ozark/Osage EDU

Table C-2. Ozark/Osage EDU Flow and Sediment Statistics

m	1.17321391	**b**	-4.475326095
Standard Error (m)	0.01363522	**Standard Error (b)**	0.076406671
r2	0.89549291	**Standard Error (y)**	1.277485554
F	7403.38182	**DF**	864
SSreg	12082.0921	**SSres**	1410.02151

A resulting pooled TMDL of all data in the watershed is shown in Figure C-3.

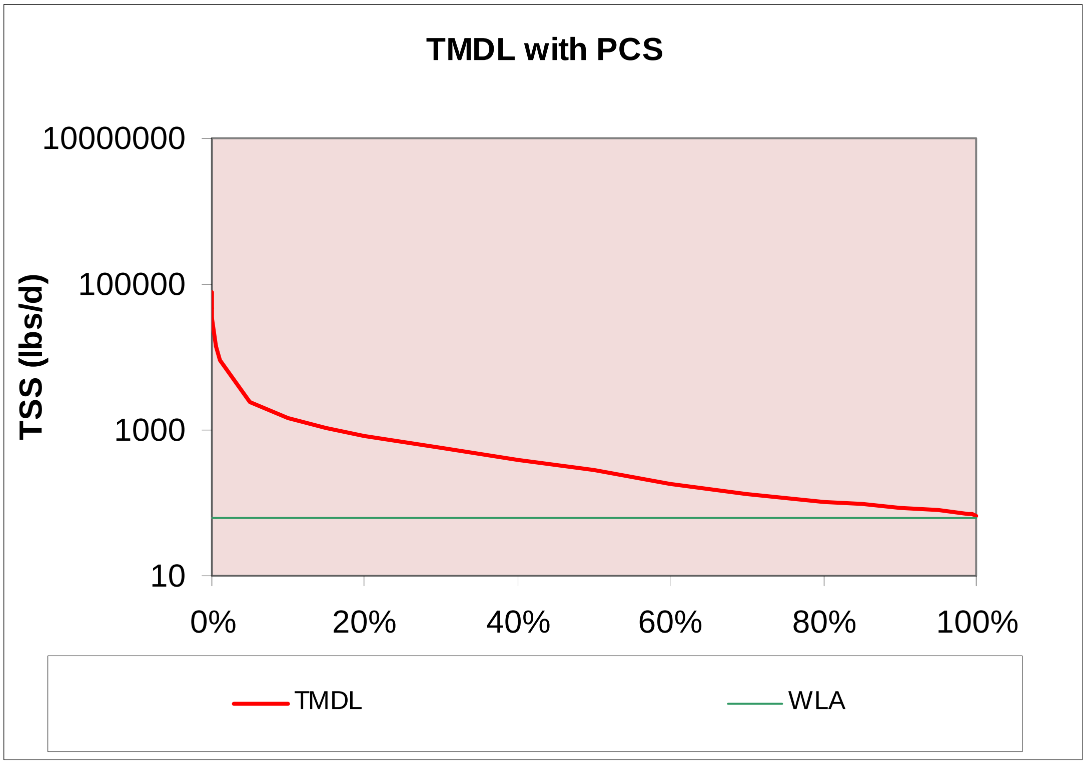


Figure C-3. TMDL LDC for TSS

To apply this process to a specific watershed would entail using the individual watershed data compared to the above TMDL curve that has been multiplied by the watershed area. Data from the impaired segment is then plotted as a load (lb/day) for the y-axis and as the percentile of flow for the EDU on the day the sample was taken for the x-axis.

For West Fork Niangua River the 25th percentile TSS concentration target is 5 mg/L. The TMDL, LA and WLA were calculated based on this concentration.

For more information contact:

U.S. Environmental Protection Agency, Region 7
Water, Wetlands and Pesticides Division
Total Maximum Daily Load Program
901 North 5th Street
Kansas City, Kansas 66101
Website: http://www.epa.gov/region07/water/tmdl.htm

Appendix D

Development of Nutrient Targets Using Ecoregion

Nutrient Criteria with LDCs

D.1 OVERVIEW

This procedure is used when a lotic system is placed on the 303(d) impaired water body list for nutrient pollutants and the designated use being addressed is aquatic life. In cases where an EPA-approved state numeric criterion for the impaired stream is not available, a reference approach is used. The target for pollutant loading is the EPA recommended ecoregion nutrient criterion for the specific ecoregion in which the water body is located (EPA, 2000). If a flow record for the impaired stream is not available, a synthetic flow record is needed. To develop a synthetic flow record, a user should calculate an average of the log discharge per square mile of USGS-gaged rivers whose drainage areas are contained within the Ecological Drainage Unit (EDU). Selection of these gages is based on location, land use/soil/topography similarities to the West Fork Niangua River watershed and the availability of sufficient flow data. From this synthetic record develop flow duration and build a LDC for the pollutant within the EDU.

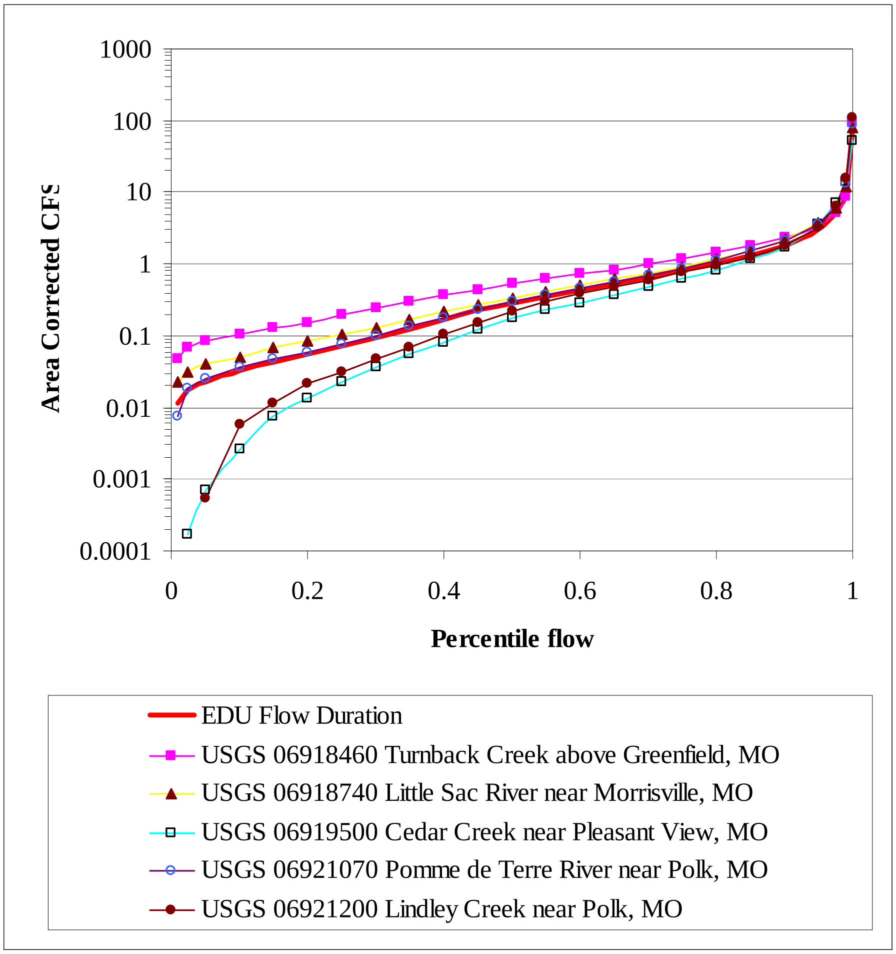
See EPA (2000) for more detailed information as to how recommended ecoregion nutrient criteria were developed. This appendix describes how the nutrient criteria (TN and TP) are expressed in this TMDL.

D.2 METHODOLOGY

The first step in this procedure is to gather available nutrient data within the ecoregion of interest. These data along with the instantaneous flow measurement taken at the time of sample collection for the specific date are required to develop the LDC. Both dates and nutrient concentrations are needed in order to match the measured data used with the synthetic EDU flow record.

Secondly, collect average daily flow data from gages with a variety of drainage areas for a period of time to cover the nutrient record. From these flow records normalize the flow to a per square mile basis. Average the log transformations of the average daily discharge for each day in the period of record. For each gage record used to build the synthetic flow record calculate the Nash-Sutcliffe value to determine if the relationship is valid for each record. This relationship must be valid in order to use this methodology. This new synthetic record of flow per square mile is then used to develop the LDC for the EDU. The flow record should be of sufficient length to be able to calculate percentiles of flow (typically 20 years or more).

The following example shows the application of the approach for the Ozark/Osage EDU. Watershed-size normalized data for the individual gages in the EDU were calculated and compared to a pooled data set of all the gages (Figure D-1, Table D-1). Table D-1 demonstrates the pooled data set can confidently be used as a surrogate for the EDU analyses.



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Turnback Creek above Greenfield, MO	USGS	06918460	252	97%
Little Sac River near Morrisville, MO	USGS	06918740	237	100%
Cedar Creek near Pleasant View, MO	USGS	06919500	420	76%
Pomme de Terre River near Polk, MO	USGS	06921070	276	98%
Lindley Creek near Polk, MO	USGS	06921200	112	92%

Note: No gages in the Niangua watershed had a sufficiently long record to be used to generate a synthetic flow record.

The next step was to collect previously measured water quality data from within the ecoregion. Measured TN concentrations are adjusted such that the median of the distribution is equal to the EPA recommended ecoregion TN criterion. This is accomplished by using a ratio of the EPA recommended ecoregion TN criterion to the median from the measured data. This results in the data retaining most of its natural variability yet having a median which meets the EPA recommended ecoregion TN criterion. Figure D-2 shows an example of this process where the solid line is the measured distribution of the natural log TN concentration with the natural log flow and the dashed line represents a data distribution (the adjusted data) which would comply with the EPA recommended ecoregion TN criterion.

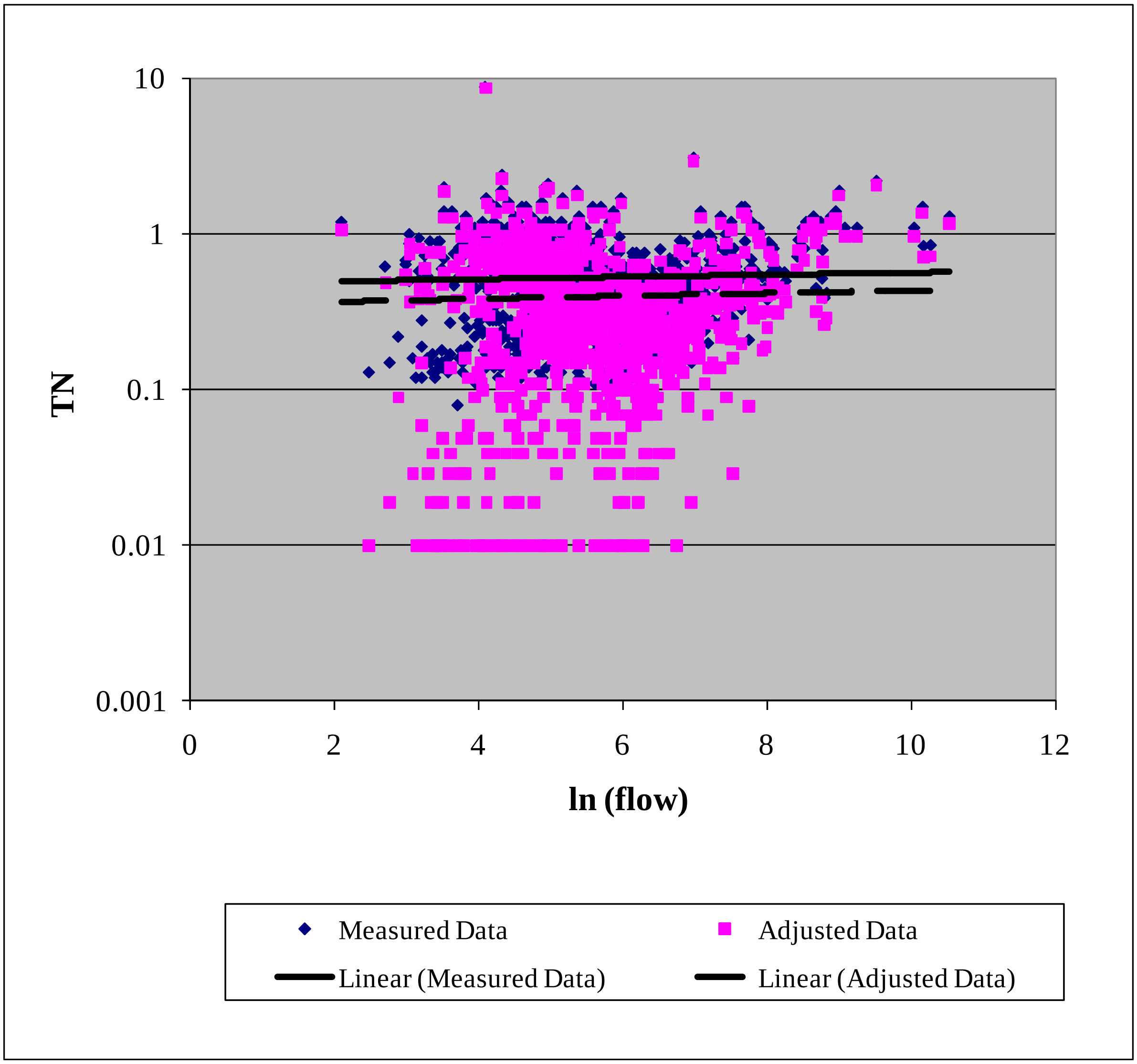

Figure D-2. Graphic Representation of Data Adjustment in Ozark/Osage EDU

The next step was to calculate the TN-discharge relationship for the ecoregion using the adjusted data; this is natural log transformed data for the load (pounds/day) and the instantaneous flow (cfs). Figure D-3 shows this relationship for this TMDL.

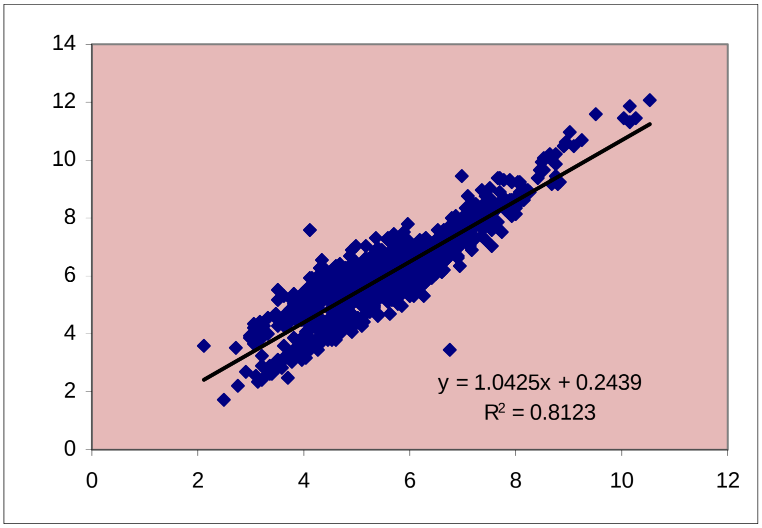

Figure D-3. Load / Flow Relationship Used to Set LDC TMDL

This relationship was used to develop a LDC for which the relationship between flow and nutrient distribution is taken into account. In this LDC the targeted concentration is allowed to change at different percentiles of flow exceedance. However, meeting the LDC will result in a water body in which the median concentration is equal to the EPA recommended ecoregion criterion.

To apply this process to a specific watershed entails using the individual watershed data compared to the TMDL curve that has been multiplied by the watershed area (mi^2). Data from the impaired segment is then plotted as a load (pounds/day) for the y-axis and as the percentile of flow for the EDU on the day the sample was taken for the x-axis. These data points do not have to be collected at the segment outlet. The spreadsheet applies an outlet flow (percentile exceedance) to the concentration based on the synthetic flow estimate for the specific date the sample was taken (Figure D-4).

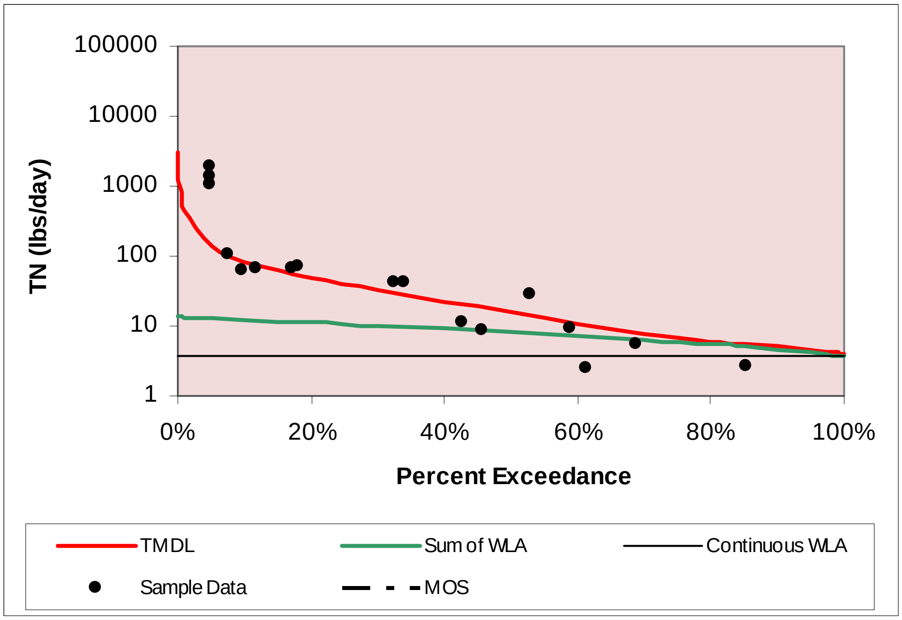

Figure D-4. Example of TMDL LDC Using This Method

The resulting LDC with plotted site specific measured data can now be used to target implementation by identifying flows in which TN concentrations are higher than would be expected in a stream meeting the EPA recommended ecoregion TN criterion.

For more information contact:

U.S. Environmental Protection Agency, Region 7
Water, Wetlands and Pesticides Division
Total Maximum Daily Load Program
901 North 5th Street
Kansas City, Kansas 66101
Website: http://www.epa.gov/region07/water/tmdl.htm

Appendix E

Stream Flow and Water Quality Stations Used to Develop TMDLs in the West Fork Niangua River Watershed

Table E-1. Stations Used to Develop Water Quality Data Targets in West Fork Niangua River

USGS Station	Station Name
6930800	Gasconade River above Jerome, MO
7010500	Maramec Spring near St. James, MO
7014000	Huzzah Creek near Steelville, MO
7014200	Courtois Creek at Berryman, MO
7014500	Meramec River near Sullivan, MO
7061600	Black River below Annapolis, MO
7064400	Montauk Springs at Montauk, MO
7064440	Current River at Montauk State Park, MO
7064530	Welch Spring near Akers, MO
7064555	Pulltite Spring near Round Spring, MO
7065000	Round Spring at Round Spring, MO
7065500	Alley Spring at Alley, MO
7066000	Jacks Fork at Eminence, MO
7066110	Jacks Fork above Two River, MO
7066510	Current River above Powder Mill, MO
7066550	Blue Spring near Eminence, MO
370857091265901	Jacks Fork River above Alley Spring, MO
370901091262001	Alley Spring Below Alley, MO
370905091204001	Jacks Fork Above 2nd Unnamed Hollow below Eminence, MO
371014091201301	Jacks Fork above Lick Log Hollow below Eminence, MO
371026091183301	Jacks Fork above Powell Springs above Two Rivers, MO
371054091173501	Jacks Fork below 3rd Hollow above Two Rivers, MO

Table E-2. Water Quality Data Used in TMDL Development

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
370901091262001	5/10/1999	0.8	208
370901091262001	6/22/1999	0.85	136
370901091262001	11/8/1999	0.71	89
370901091262001	2/29/2000	0.83	173
370901091262001	6/6/2000	0.64	75
370901091262001	6/28/2000	0.62	99
370901091262001	8/22/2000	0.62	73
370901091262001	2/22/2001	0.85	208
370901091262001	3/21/2001	0.95	123
370901091262001	5/25/2001	0.65	75
370901091262001	5/27/2001	0.65	80
370901091262001	8/9/2001	0.6	69
370901091262001	10/11/2001	0.98	66
370901091262001	4/2/2002	0.76	200
370901091262001	4/30/2002	0.59	250
370901091262001	5/29/2002	0.7	293
370901091262001	6/28/2002	0.77	145
370901091262001	6/29/2002	0.79	142
370901091262001	10/8/2002	1.1	89
370901091262001	10/9/2002	0.74	89
370901091262001	6/2/2003	0.71	113
370901091262001	6/9/2003	0.81	117
370901091262001	9/23/2003	0.71	87
370901091262001	7/13/2004	0.31	108
370901091262001	9/21/2004	0.72	88
6930800	2/1/1999	0.89	3060
6930800	3/16/1999	0.92	4780
6930800	4/12/1999	0.45	2900
6930800	5/26/1999	0.35	1700
6930800	6/24/1999	0.42	921
6930800	7/12/1999	0.44	826
6930800	8/12/1999	0.32	642
6930800	9/2/1999	0.27	482
6930800	10/5/1999	0.47	492
6930800	11/16/1999	0.25	516
6930800	12/8/1999	0.36	879
6930800	1/13/2000	0.6	722
6930800	2/9/2000	0.31	560
6930800	3/13/2000	0.49	1010
6930800	4/4/2000	0.32	935
6930800	5/16/2000	0.3	504
6930800	6/13/2000	0.44	481
6930800	7/5/2000	0.48	493
6930800	8/1/2000	0.36	541
6930800	9/5/2000	0.23	350
6930800	10/24/2000	0.2	463

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
370901091262001	5/10/1999	0.026	208
370901091262001	6/22/1999	0.008	136
370901091262001	8/10/1999	0.015	128
370901091262001	11/8/1999	0.01	89
370901091262001	12/14/1999	0.009	94
370901091262001	1/18/2000	0.009	85
370901091262001	2/29/2000	0.011	173
370901091262001	4/4/2000	0.006	87
370901091262001	5/10/2000	0.006	77
370901091262001	5/23/2000	0.009	80
370901091262001	5/25/2000	0.01	85
370901091262001	6/6/2000	0.011	75
370901091262001	6/28/2000	0.008	99
370901091262001	7/10/2000	0.009	82
370901091262001	7/28/2000	0.009	76
370901091262001	8/11/2000	0.009	73
370901091262001	8/22/2000	0.007	73
370901091262001	9/20/2000	0.012	74
370901091262001	10/4/2000	0.009	66
370901091262001	11/9/2000	0.009	79
370901091262001	12/20/2000	0.009	73
370901091262001	1/24/2001	0.01	79
370901091262001	2/22/2001	0.012	208
370901091262001	3/21/2001	0.011	123
370901091262001	4/25/2001	0.011	88
370901091262001	5/25/2001	0.009	75
370901091262001	5/26/2001	0.008	80
370901091262001	5/26/2001	0.01	80
370901091262001	5/27/2001	0.01	80
370901091262001	5/27/2001	0.01	80
370901091262001	6/7/2001	0.01	74
370901091262001	8/1/2001	0.009	64
370901091262001	8/8/2001	0.008	69
370901091262001	8/8/2001	0.009	69
370901091262001	8/9/2001	0.006	69
370901091262001	8/9/2001	0.01	69
370901091262001	9/18/2001	0.009	68
370901091262001	10/2/2001	0.009	66
370901091262001	10/10/2001	0.008	66
370901091262001	10/10/2001	0.009	66
370901091262001	10/11/2001	0.009	66
370901091262001	10/11/2001	0.01	66
370901091262001	11/20/2001	0.002	62
370901091262001	4/2/2002	0.015	200
370901091262001	4/30/2002	0.013	250
370901091262001	5/29/2002	0.021	293

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
6930800	11/21/2000	0.1	535
6930800	12/6/2000	0.24	523
6930800	1/9/2001	0.35	475
6930800	2/15/2001	1.3	1570
6930800	3/28/2001	0.91	894
6930800	4/9/2001	0.62	1400
6930800	5/3/2001	0.32	681
6930800	6/13/2001	0.43	1150
6930800	7/18/2001	0.36	547
6930800	8/14/2001	0.32	429
6930800	9/6/2001	0.25	381
6930800	10/22/2001	0.21	504
6930800	11/19/2001	0.19	469
6930800	12/4/2001	0.71	1820
6930800	1/28/2002	0.8	1630
6930800	2/13/2002	1.5	2100
6930800	3/26/2002	1.1	8780
6930800	4/9/2002	0.54	2100
6930800	5/20/2002	0.84	26100
6930800	6/11/2002	0.37	1670
6930800	7/16/2002	0.27	729
6930800	8/12/2002	0.29	547
6930800	9/3/2002	0.26	598
6930800	10/1/2002	0.12	498
6930800	11/13/2002	0.17	547
6930800	12/5/2002	0.16	547
6930800	1/15/2003	0.88	952
6930800	2/4/2003	0.53	631
6930800	3/5/2003	1.1	2660
6930800	4/8/2003	0.44	2720
6930800	5/8/2003	1.1	4900
6930800	6/9/2003	0.42	952
6930800	7/28/2003	0.19	475
6930800	9/5/2003	1.2	5300
6930800	10/29/2003	0.17	665
6930800	11/21/2003	2.2	13600
6930800	12/22/2003	1.2	2410
6930800	1/20/2004	1.1	5910
6930800	2/4/2004	1	2730
6930800	3/10/2004	1.3	5690
6930800	4/20/2004	0.28	1410
6930800	5/19/2004	0.42	1680
6930800	6/14/2004	0.44	864
6930800	7/8/2004	0.3	787
6930800	9/21/2004	0.2	481
6930800	10/13/2004	0.36	467
6930800	11/18/2004	1.2	1820
6930800	12/10/2004	1.4	7740

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
370901091262001	6/4/2002	0.019	226
370901091262001	6/28/2002	0.012	145
370901091262001	6/29/2002	0.012	142
370901091262001	7/29/2002	0.013	118
370901091262001	8/6/2002	0.011	105
370901091262001	8/7/2002	0.012	105
370901091262001	10/8/2002	0.01	89
370901091262001	10/9/2002	0.01	89
370901091262001	6/2/2003	0.011	113
370901091262001	6/9/2003	0.007	117
370901091262001	6/28/2003	0.01	91
370901091262001	7/26/2003	0.009	86
370901091262001	8/6/2003	0.01	86
370901091262001	9/23/2003	0.011	87
370901091262001	10/8/2003	0.01	74
370901091262001	6/15/2004	0.012	127
370901091262001	6/26/2004	0.013	127
370901091262001	7/13/2004	0.009	108
370901091262001	8/11/2004	0.01	103
370901091262001	8/21/2004	0.009	108
370901091262001	9/21/2004	0.012	88
370901091262001	10/5/2004	0.01	85
370901091262001	6/14/2005	0.011	100
370901091262001	7/5/2005	0.01	94
370901091262001	8/9/2005	0.009	88
6930800	3/16/1999	0.03	4780
6930800	4/12/1999	0.03	2900
6930800	7/12/1999	0.04	826
6930800	10/5/1999	0.04	492
6930800	4/4/2000	0.03	935
6930800	6/13/2000	0.04	481
6930800	7/5/2000	0.04	493
6930800	8/1/2000	0.05	541
6930800	4/9/2001	0.03	1400
6930800	6/13/2001	0.03	1150
6930800	8/14/2001	0.03	429
6930800	12/4/2001	0.03	1820
6930800	3/26/2002	0.07	8780
6930800	5/20/2002	0.13	26100
6930800	3/5/2003	0.02	2660
6930800	5/8/2003	0.09	4900
6930800	6/9/2003	0.03	952
6930800	9/5/2003	0.11	5300
6930800	11/21/2003	0.3	13600
6930800	12/22/2003	0.03	2410
6930800	1/20/2004	0.07	5910
6930800	2/4/2004	0.02	2730
6930800	3/10/2004	0.05	5690

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
6930800	1/19/2005	1.2	5130
6930800	2/1/2005	1	1710
6930800	3/2/2005	0.49	1990
6930800	4/5/2005	0.27	1320
6930800	5/23/2005	0.31	763
6930800	6/9/2005	0.47	580
6930800	7/7/2005	0.28	484
6930800	8/1/2005	0.23	344
6930800	8/11/2005	0.27	343
6930800	9/1/2005	0.3	473
6930800	10/13/2005	0.17	554
6930800	11/22/2005	1	1340
6930800	12/20/2005	0.49	611
6930800	1/10/2006	0.28	117
6930800	2/6/2006	0.31	1180
6930800	3/22/2006	0.78	1660
6930800	4/25/2006	0.35	943
6930800	5/8/2006	1	5860
6930800	6/6/2006	0.31	871
6930800	7/5/2006	0.3	481
6930800	8/1/2006	0.27	463
6930800	9/7/2006	0.25	424
6930800	10/4/2006	0.23	404
6930800	11/2/2006	0.22	637
6930800	12/11/2006	1.5	2200
6930800	1/23/2007	1.3	7240
6930800	2/7/2007	1	1680
6930800	3/14/2007	0.4	1300
6930800	4/25/2007	0.45	3360
6930800	5/8/2007	0.32	2930
6930800	6/4/2007	0.5	1540
6930800	7/11/2007	0.63	1360
6930800	8/16/2007	0.22	487
6930800	9/10/2007	0.81	1890
6930800	10/17/2007	0.24	542
6930800	11/19/2007	0.17	557
6930800	12/4/2007	0.23	580
6930800	1/9/2008	1.9	8130
6930800	2/6/2008	1.3	7290
6930800	3/18/2008	1.5	25800
6930800	4/2/2008	1.1	22900
6930800	5/14/2008	0.52	6400
6930800	6/3/2008	0.42	2470
6930800	7/31/2008	0.44	1000
6930800	8/4/2008	0.36	1080
6930800	9/3/2008	0.37	874
6930800	10/16/2008	0.31	1160
6930800	11/4/2008	0.26	927

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
6930800	6/14/2004	0.02	864
6930800	7/8/2004	0.03	787
6930800	10/13/2004	0.04	467
6930800	11/18/2004	0.05	1820
6930800	12/10/2004	0.1	7740
6930800	1/19/2005	0.04	5130
6930800	2/1/2005	0.03	1710
6930800	6/9/2005	0.03	580
6930800	8/1/2005	0.02	344
6930800	8/11/2005	0.02	343
6930800	11/22/2005	0.06	1340
6930800	3/22/2006	0.03	1660
6930800	4/25/2006	0.03	943
6930800	5/8/2006	0.12	5860
6930800	6/6/2006	0.03	871
6930800	7/5/2006	0.02	481
6930800	8/1/2006	0.03	463
6930800	11/2/2006	0.02	637
6930800	12/11/2006	0.04	2200
6930800	1/23/2007	0.04	7240
6930800	3/14/2007	0.02	1300
6930800	4/25/2007	0.04	3360
6930800	5/8/2007	0.03	2930
6930800	6/4/2007	0.02	1540
6930800	7/11/2007	0.06	1360
6930800	9/10/2007	0.07	1890
6930800	12/4/2007	0.03	580
6930800	1/9/2008	0.31	8130
6930800	2/6/2008	0.11	7290
6930800	3/18/2008	0.21	25800
6930800	4/2/2008	0.13	22900
6930800	5/14/2008	0.03	6400
6930800	6/3/2008	0.03	2470
6930800	7/31/2008	0.03	1000
6930800	8/4/2008	0.02	1080
6930800	9/3/2008	0.02	874
6930800	1/26/2009	0.04	787
6930800	2/2/2009	0.02	825
6930800	4/6/2009	0.02	3230
6930800	5/18/2009	0.06	6440
6930800	7/6/2009	0.03	1150
6930800	9/2/2009	0.03	592
6930800	10/5/2009	0.03	856
6930800	11/2/2009	0.21	37400
371054091173501	3/2/2000	0.005	470
371054091173501	5/12/2000	0.004	146
371054091173501	5/25/2000	0.014	225
371054091173501	6/8/2000	0.005	177

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
6930800	12/1/2008	0.36	795
6930800	1/26/2009	0.66	787
6930800	2/2/2009	0.54	825
6930800	3/16/2009	0.27	1560
6930800	4/6/2009	0.55	3230
6930800	5/18/2009	0.79	6440
6930800	6/1/2009	0.21	2320
6930800	7/6/2009	0.46	1150
6930800	8/17/2009	0.38	625
6930800	9/2/2009	0.49	592
6930800	10/5/2009	0.46	856
6930800	11/2/2009	1.3	37400
371054091173501	11/10/1999	0.37	169
371054091173501	12/16/1999	0.47	276
371054091173501	3/2/2000	0.72	470
371054091173501	4/6/2000	0.45	241
371054091173501	5/12/2000	0.36	146
371054091173501	5/25/2000	0.58	225
371054091173501	6/8/2000	0.48	177
371054091173501	6/30/2000	0.3	250
371054091173501	7/12/2000	0.4	171
371054091173501	7/26/2000	0.31	165
371054091173501	8/9/2000	0.43	132
371054091173501	8/21/2000	0.35	128
371054091173501	12/12/2000	0.42	195
371054091173501	1/24/2001	0.41	186
371054091173501	2/21/2001	0.63	475
371054091173501	4/25/2001	0.34	235
371054091173501	5/26/2001	0.33	218
371054091173501	5/27/2001	0.31	193
371054091173501	5/27/2001	0.33	193
371054091173501	8/1/2001	0.33	150
371054091173501	8/8/2001	0.33	122
371054091173501	8/8/2001	0.35	122
371054091173501	8/9/2001	0.36	122
371054091173501	8/9/2001	0.37	122
371054091173501	9/19/2001	0.33	125
371054091173501	10/10/2001	0.3	129
371054091173501	10/10/2001	0.49	129
371054091173501	10/11/2001	0.33	129
371054091173501	4/3/2002	0.46	551
371054091173501	5/1/2002	0.31	728
371054091173501	5/30/2002	0.37	738
371054091173501	6/5/2002	0.39	548
371054091173501	6/28/2002	0.48	310
371054091173501	6/29/2002	0.45	298
371054091173501	8/7/2002	0.39	226
371054091173501	10/9/2002	0.38	167

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
371054091173501	6/30/2000	0.004	250
371054091173501	7/12/2000	0.008	171
371054091173501	7/26/2000	0.005	165
371054091173501	8/9/2000	0.014	132
371054091173501	9/19/2000	0.004	113
371054091173501	12/12/2000	0.003	195
371054091173501	1/24/2001	0.002	186
371054091173501	2/21/2001	0.003	475
371054091173501	4/25/2001	0.004	235
371054091173501	5/26/2001	0.009	218
371054091173501	5/27/2001	0.006	193
371054091173501	5/27/2001	0.006	193
371054091173501	8/1/2001	0.008	150
371054091173501	8/8/2001	0.005	122
371054091173501	8/8/2001	0.006	122
371054091173501	8/9/2001	0.007	122
371054091173501	8/9/2001	0.008	122
371054091173501	9/19/2001	0.006	125
371054091173501	10/3/2001	0.004	110
371054091173501	10/10/2001	0.004	129
371054091173501	10/10/2001	0.004	129
371054091173501	10/11/2001	0.004	129
371054091173501	10/11/2001	0.006	129
371054091173501	4/3/2002	0.005	551
371054091173501	5/1/2002	0.006	728
371054091173501	5/30/2002	0.008	738
371054091173501	6/5/2002	0.005	548
371054091173501	6/28/2002	0.007	310
371054091173501	6/29/2002	0.006	298
371054091173501	7/30/2002	0.006	268
371054091173501	8/6/2002	0.004	226
371054091173501	8/7/2002	0.006	226
371054091173501	10/8/2002	0.004	167
371054091173501	10/9/2002	0.005	167
371054091173501	6/4/2003	0.003	344
371054091173501	6/28/2003	0.006	209
371054091173501	7/26/2003	0.007	185
371054091173501	8/6/2003	0.009	229
371054091173501	9/23/2003	0.005	210
371054091173501	10/8/2003	0.006	158
371054091173501	6/15/2004	0.007	342
371054091173501	6/26/2004	0.005	266
371054091173501	7/13/2004	0.005	228
371054091173501	8/11/2004	0.008	181
371054091173501	8/21/2004	0.003	184
371054091173501	9/21/2004	0.005	150
371054091173501	10/5/2004	0.004	146
371054091173501	6/14/2005	0.007	186

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
371054091173501	6/4/2003	0.4	344
371054091173501	7/26/2003	0.3	185
371054091173501	8/6/2003	0.35	229
371054091173501	9/23/2003	0.37	210
371054091173501	10/8/2003	0.35	158
371054091173501	6/15/2004	0.42	342
371054091173501	6/26/2004	0.35	266
371054091173501	7/13/2004	0.36	228
371054091173501	8/11/2004	0.37	181
371054091173501	8/21/2004	0.38	184
371054091173501	6/14/2005	0.4	186
371054091173501	7/6/2005	0.38	120
371054091173501	8/10/2005	0.37	149
371014091201301	11/9/1999	0.39	151
371014091201301	12/15/1999	0.51	298
371014091201301	1/19/2000	0.77	173
371014091201301	3/1/2000	0.73	524
371014091201301	4/5/2000	0.46	234
371014091201301	5/11/2000	0.42	138
371014091201301	5/24/2000	0.4	133
371014091201301	5/25/2000	0.4	221
371014091201301	6/7/2000	0.52	168
371014091201301	6/29/2000	0.29	265
371014091201301	7/11/2000	0.4	144
371014091201301	7/27/2000	0.38	143
371014091201301	8/10/2000	0.41	127
371014091201301	8/22/2000	0.42	122
371014091201301	10/4/2000	0.37	111
371014091201301	11/8/2000	0.28	227
371014091201301	3/21/2001	0.64	272
371014091201301	4/24/2001	0.36	226
371014091201301	5/25/2001	0.32	220
371014091201301	5/26/2001	0.33	208
371014091201301	5/26/2001	0.35	208
371014091201301	5/27/2001	0.36	208
371014091201301	5/27/2001	0.38	208
371014091201301	6/7/2001	0.33	192
371014091201301	7/31/2001	0.35	140
371014091201301	8/8/2001	0.4	97
371014091201301	8/9/2001	0.4	97
371014091201301	8/9/2001	0.4	97
371014091201301	10/2/2001	0.33	106
371014091201301	10/10/2001	0.37	109
371014091201301	10/11/2001	0.39	116
371014091201301	10/11/2001	0.48	116
371014091201301	4/2/2002	0.43	590
371014091201301	4/30/2002	0.28	760
371014091201301	5/29/2002	0.39	657

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
371054091173501	7/6/2005	0.007	120
371054091173501	8/10/2005	0.007	149
371014091201301	11/9/1999	0.004	151
371014091201301	3/1/2000	0.006	524
371014091201301	5/11/2000	0.006	138
371014091201301	5/24/2000	0.005	133
371014091201301	5/25/2000	0.008	221
371014091201301	6/7/2000	0.01	168
371014091201301	6/29/2000	0.004	265
371014091201301	7/11/2000	0.008	144
371014091201301	7/27/2000	0.006	143
371014091201301	8/10/2000	0.013	127
371014091201301	8/22/2000	0.004	122
371014091201301	10/4/2000	0.005	111
371014091201301	11/8/2000	0.003	227
371014091201301	1/23/2001	0.003	204
371014091201301	3/21/2001	0.005	272
371014091201301	4/24/2001	0.005	226
371014091201301	5/25/2001	0.006	220
371014091201301	5/26/2001	0.006	208
371014091201301	5/26/2001	0.007	208
371014091201301	5/27/2001	0.005	208
371014091201301	5/27/2001	0.009	208
371014091201301	6/7/2001	0.014	192
371014091201301	7/31/2001	0.009	140
371014091201301	8/8/2001	0.012	97
371014091201301	8/9/2001	0.009	97
371014091201301	8/9/2001	0.013	97
371014091201301	9/18/2001	0.005	115
371014091201301	10/2/2001	0.004	106
371014091201301	10/10/2001	0.004	109
371014091201301	10/10/2001	0.009	109
371014091201301	10/11/2001	0.009	116
371014091201301	10/11/2001	0.015	116
371014091201301	11/21/2001	0.004	114
371014091201301	4/2/2002	0.005	590
371014091201301	4/30/2002	0.006	760
371014091201301	5/29/2002	0.007	657
371014091201301	6/4/2002	0.005	488
371014091201301	6/28/2002	0.008	309
371014091201301	6/29/2002	0.009	297
371014091201301	7/29/2002	0.007	266
371014091201301	8/6/2002	0.009	220
371014091201301	8/7/2002	0.007	216
371014091201301	10/8/2002	0.005	168
371014091201301	10/9/2002	0.007	171
371014091201301	6/3/2003	0.007	308
371014091201301	6/10/2003	0.022	296

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
371014091201301	6/4/2002	0.39	488
371014091201301	6/28/2002	0.5	309
371014091201301	6/29/2002	0.47	297
371014091201301	7/29/2002	0.41	266
371014091201301	8/6/2002	0.42	220
371014091201301	8/7/2002	0.39	216
371014091201301	10/8/2002	0.47	168
371014091201301	10/9/2002	0.48	171
371014091201301	6/3/2003	0.46	308
371014091201301	6/10/2003	0.52	296
371014091201301	6/28/2003	0.41	220
371014091201301	7/26/2003	0.36	170
371014091201301	8/6/2003	0.37	253
371014091201301	9/23/2003	0.4	208
371014091201301	10/8/2003	0.44	157
371014091201301	6/15/2004	0.45	355
371014091201301	6/26/2004	0.39	279
371014091201301	7/13/2004	0.39	223
371014091201301	8/21/2004	0.42	182
371014091201301	10/5/2004	0.4	151
371014091201301	6/15/2005	0.47	179
371014091201301	7/6/2005	0.44	164
371014091201301	8/10/2005	0.43	144
371026091183301	6/24/1999	0.49	267
371026091183301	8/12/1999	0.48	186
371026091183301	11/10/1999	0.39	164
371026091183301	12/15/1999	0.46	298
371026091183301	3/2/2000	0.76	489
371026091183301	4/5/2000	0.45	258
371026091183301	5/11/2000	0.38	144
371026091183301	5/24/2000	0.36	137
371026091183301	6/7/2000	0.45	191
371026091183301	6/29/2000	0.3	246
371026091183301	7/11/2000	0.34	155
371026091183301	7/27/2000	0.37	147
371026091183301	8/10/2000	0.34	133
371026091183301	8/22/2000	0.37	125
371026091183301	10/4/2000	0.33	114
371026091183301	12/20/2000	0.4	164
371026091183301	3/20/2001	0.64	302
371026091183301	4/24/2001	0.37	235
371026091183301	5/25/2001	0.38	235
371026091183301	5/26/2001	0.3	207
371026091183301	5/26/2001	0.33	207
371026091183301	5/27/2001	0.28	207
371026091183301	5/27/2001	0.32	207
371026091183301	6/7/2001	0.31	201
371026091183301	7/31/2001	0.36	147

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
371014091201301	6/28/2003	0.006	220
371014091201301	7/26/2003	0.009	170
371014091201301	8/6/2003	0.012	253
371014091201301	9/23/2003	0.005	208
371014091201301	10/8/2003	0.009	157
371014091201301	6/15/2004	0.008	355
371014091201301	6/26/2004	0.006	279
371014091201301	7/13/2004	0.009	223
371014091201301	8/11/2004	0.006	195
371014091201301	8/21/2004	0.003	182
371014091201301	9/21/2004	0.011	135
371014091201301	10/5/2004	0.004	151
371014091201301	6/15/2005	0.011	179
371014091201301	7/6/2005	0.008	164
371014091201301	8/10/2005	0.012	144
371026091183301	5/12/1999	0.004	582
371026091183301	8/12/1999	0.005	186
371026091183301	3/2/2000	0.005	489
371026091183301	5/24/2000	0.005	137
371026091183301	6/7/2000	0.008	191
371026091183301	6/29/2000	0.005	246
371026091183301	7/11/2000	0.007	155
371026091183301	7/27/2000	0.006	147
371026091183301	8/10/2000	0.006	133
371026091183301	9/20/2000	0.005	114
371026091183301	10/4/2000	0.004	114
371026091183301	12/20/2000	0.002	164
371026091183301	3/20/2001	0.006	302
371026091183301	4/24/2001	0.004	235
371026091183301	5/25/2001	0.008	235
371026091183301	5/26/2001	0.007	207
371026091183301	5/26/2001	0.007	207
371026091183301	5/27/2001	0.006	207
371026091183301	5/27/2001	0.006	207
371026091183301	6/7/2001	0.009	201
371026091183301	7/31/2001	0.01	147
371026091183301	8/8/2001	0.005	121
371026091183301	8/8/2001	0.008	121
371026091183301	8/9/2001	0.007	121
371026091183301	8/9/2001	0.01	121
371026091183301	9/18/2001	0.004	118
371026091183301	10/2/2001	0.004	108
371026091183301	10/10/2001	0.005	109
371026091183301	10/10/2001	0.005	109
371026091183301	10/11/2001	0.006	116
371026091183301	10/11/2001	0.006	116
371026091183301	11/21/2001	0.003	119
371026091183301	4/2/2002	0.007	590

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
371026091183301	8/8/2001	0.33	121
371026091183301	8/8/2001	0.43	121
371026091183301	8/9/2001	0.36	121
371026091183301	8/9/2001	0.38	121
371026091183301	9/18/2001	0.3	118
371026091183301	10/10/2001	0.3	109
371026091183301	10/11/2001	0.33	116
371026091183301	10/11/2001	0.34	116
371026091183301	6/28/2002	0.49	314
371026091183301	6/29/2002	0.45	312
371026091183301	7/29/2002	0.4	249
371026091183301	8/7/2002	0.4	216
371026091183301	10/8/2002	0.4	168
371026091183301	10/9/2002	0.55	171
371026091183301	6/3/2003	0.45	308
371026091183301	6/10/2003	0.43	296
371026091183301	6/28/2003	0.36	220
371026091183301	7/26/2003	0.34	170
371026091183301	8/6/2003	0.35	253
371026091183301	9/23/2003	0.35	208
371026091183301	10/8/2003	0.41	157
371026091183301	6/15/2004	0.43	355
371026091183301	6/26/2004	0.36	279
371026091183301	7/13/2004	0.41	223
371026091183301	8/11/2004	0.39	195
371026091183301	8/21/2004	0.4	182
371026091183301	9/21/2004	0.37	135
371026091183301	6/15/2005	0.42	179
371026091183301	7/6/2005	0.39	164
371026091183301	8/10/2005	0.4	144
370857091265901	5/10/1999	0.24	307
370857091265901	6/22/1999	0.22	82
370857091265901	8/10/1999	0.17	61
370857091265901	12/14/1999	0.37	233
370857091265901	2/29/2000	0.79	359
370857091265901	4/4/2000	0.3	117
370857091265901	5/10/2000	0.22	52
370857091265901	5/23/2000	0.16	42
370857091265901	5/25/2000	0.24	129
370857091265901	6/6/2000	0.22	73
370857091265901	6/28/2000	0.18	123
370857091265901	7/28/2000	0.15	44
370857091265901	8/11/2000	0.16	36
370857091265901	8/22/2000	0.18	33
370857091265901	9/20/2000	0.12	25
370857091265901	11/9/2000	0.18	121
370857091265901	2/22/2001	0.54	328
370857091265901	3/21/2001	0.34	127

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
371026091183301	4/30/2002	0.006	751
371026091183301	5/29/2002	0.008	657
371026091183301	6/4/2002	0.006	492
371026091183301	6/28/2002	0.005	314
371026091183301	6/29/2002	0.007	312
371026091183301	7/29/2002	0.007	249
371026091183301	8/6/2002	0.005	216
371026091183301	8/7/2002	0.005	216
371026091183301	10/8/2002	0.004	168
371026091183301	10/9/2002	0.006	171
371026091183301	6/3/2003	0.004	308
371026091183301	6/10/2003	0.003	296
371026091183301	6/28/2003	0.007	220
371026091183301	7/26/2003	0.008	170
371026091183301	8/6/2003	0.013	253
371026091183301	9/23/2003	0.004	208
371026091183301	10/8/2003	0.007	157
371026091183301	6/15/2004	0.008	355
371026091183301	6/26/2004	0.005	279
371026091183301	7/13/2004	0.008	223
371026091183301	8/11/2004	0.005	195
371026091183301	8/21/2004	0.005	182
371026091183301	9/21/2004	0.004	135
371026091183301	10/5/2004	0.004	151
371026091183301	6/15/2005	0.007	179
371026091183301	7/6/2005	0.007	164
371026091183301	8/10/2005	0.008	144
370905091204001	5/11/1999	0.006	616
370905091204001	6/23/1999	0.005	239
370905091204001	8/11/1999	0.008	190
370905091204001	3/1/2000	0.006	547
370905091204001	5/11/2000	0.005	142
370905091204001	5/24/2000	0.007	129
370905091204001	6/7/2000	0.007	177
370905091204001	7/11/2000	0.009	155
370905091204001	7/27/2000	0.007	144
370905091204001	8/10/2000	0.006	128
370905091204001	8/21/2000	0.007	124
370905091204001	10/2/2001	0.008	104
370905091204001	10/10/2001	0.007	109
370905091204001	10/10/2001	0.009	109
370905091204001	10/11/2001	0.01	116
370905091204001	10/11/2001	0.018	116
370905091204001	11/20/2001	0.002	112
370905091204001	4/2/2002	0.006	590
370905091204001	5/29/2002	0.008	657
370905091204001	6/4/2002	0.006	488
370905091204001	6/28/2002	0.008	309

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
370857091265901	4/25/2001	0.2	107
370857091265901	5/25/2001	0.17	102
370857091265901	5/26/2001	0.15	94
370857091265901	5/26/2001	0.17	94
370857091265901	5/27/2001	0.14	85
370857091265901	5/27/2001	0.15	85
370857091265901	6/7/2001	0.15	94
370857091265901	8/1/2001	0.16	45
370857091265901	8/8/2001	0.12	30
370857091265901	8/8/2001	0.18	33
370857091265901	8/9/2001	0.14	33
370857091265901	8/9/2001	0.15	33
370857091265901	9/18/2001	0.13	30
370857091265901	4/30/2002	0.15	382
370857091265901	5/29/2002	0.21	303
370857091265901	6/4/2002	0.23	201
370857091265901	6/28/2002	0.23	99
370857091265901	6/29/2002	0.22	90
370857091265901	10/8/2002	0.11	53
370857091265901	10/9/2002	0.26	54
370857091265901	6/2/2003	0.24	112
370857091265901	6/9/2003	0.2	101
370857091265901	8/6/2003	0.13	128
370857091265901	9/23/2003	0.21	94
370857091265901	10/8/2003	0.18	62
370857091265901	6/15/2004	0.26	162
370857091265901	6/26/2004	0.18	117
370857091265901	8/21/2004	0.16	64
370857091265901	6/14/2005	0.21	75
370857091265901	7/5/2005	0.18	59
370857091265901	8/9/2005	0.13	44
370905091204001	5/11/1999	0.34	616
370905091204001	6/23/1999	0.5	239
370905091204001	8/11/1999	0.52	190
370905091204001	11/9/1999	0.38	154
370905091204001	12/15/1999	0.56	299
370905091204001	1/19/2000	0.45	172
370905091204001	3/1/2000	0.76	547
370905091204001	4/5/2000	0.47	240
370905091204001	5/24/2000	0.41	129
370905091204001	6/7/2000	0.5	177
370905091204001	6/29/2000	0.36	244
370905091204001	7/27/2000	0.46	144
370905091204001	8/10/2000	0.31	128
370905091204001	8/21/2000	0.43	124
370905091204001	10/2/2001	0.41	104
370905091204001	10/10/2001	0.39	109
370905091204001	10/10/2001	0.4	109

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
370905091204001	6/29/2002	0.009	297
370905091204001	7/29/2002	0.008	266
370905091204001	8/6/2002	0.004	220
370905091204001	8/7/2002	0.007	216
370905091204001	10/8/2002	0.007	161
370905091204001	10/9/2002	0.009	164
370905091204001	6/3/2003	0.007	270
370905091204001	6/10/2003	0.014	263
370905091204001	6/28/2003	0.022	185
370905091204001	7/26/2003	0.009	169
370905091204001	8/6/2003	0.011	226
370905091204001	9/23/2003	0.006	201
370905091204001	10/8/2003	0.009	151
370905091204001	6/15/2004	0.007	368
370905091204001	6/26/2004	0.005	266
370905091204001	7/13/2004	0.008	216
370905091204001	8/11/2004	0.005	186
370905091204001	8/21/2004	0.005	174
370905091204001	9/21/2004	0.012	147
370905091204001	10/5/2004	0.006	135
370905091204001	6/14/2005	0.008	156
370905091204001	7/6/2005	0.005	164
370905091204001	4/30/2002	0.006	760
7066110	6/20/1973	0.03	478
7066110	8/1/1973	0.02	288
7066110	10/17/1973	0.04	439
7066110	1/18/1974	0.03	560
7066110	4/17/1974	0.03	680
7066110	7/10/1974	0.01	326
7066110	10/22/1974	0.02	233
7066110	1/21/1975	0.01	490
7066110	5/4/1977	0.01	242
7066110	5/16/1979	0.01	980
7066110	9/5/1979	0.01	293
7066110	5/6/1980	0.09	279
7066110	6/10/1981	0.01	395
7066110	9/22/1981	0.02	127
7066110	6/30/1982	0.04	464
7066110	5/25/1983	0.01	700
7066110	5/16/1984	0.01	775
7066110	5/7/1986	0.01	300
7066110	5/12/1987	0.01	220
7066110	5/18/1988	0.02	282
7066110	10/12/1988	0.01	172
7066110	10/24/1989	0.01	159
7066110	11/20/1990	0.03	126
7066110	10/23/1991	0.01	166
7066110	11/12/1992	0.13	2200

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
370905091204001	10/11/2001	0.37	116
370905091204001	4/2/2002	0.43	590
370905091204001	4/30/2002	0.34	760
370905091204001	5/29/2002	0.36	657
370905091204001	6/4/2002	0.42	488
370905091204001	6/28/2002	0.51	309
370905091204001	6/29/2002	0.46	297
370905091204001	7/29/2002	0.42	266
370905091204001	8/7/2002	0.42	216
370905091204001	10/8/2002	0.47	161
370905091204001	10/9/2002	0.48	164
370905091204001	6/3/2003	0.47	270
370905091204001	6/10/2003	0.5	263
370905091204001	6/28/2003	0.43	185
370905091204001	7/26/2003	0.36	169
370905091204001	8/6/2003	0.35	226
370905091204001	9/23/2003	0.47	201
370905091204001	10/8/2003	0.45	151
370905091204001	6/15/2004	0.47	368
370905091204001	6/26/2004	0.4	266
370905091204001	7/13/2004	0.42	216
370905091204001	8/11/2004	0.44	186
370905091204001	8/21/2004	0.46	174
370905091204001	9/21/2004	0.5	147
370905091204001	6/14/2005	0.45	156
370905091204001	7/6/2005	0.43	164
370905091204001	8/10/2005	0.46	138
7066110	6/20/1973	0.37	478
7066110	8/1/1973	0.45	288
7066110	10/17/1973	0.58	439
7066110	1/18/1974	0.39	560
7066110	4/17/1974	0.46	680
7066110	7/10/1974	0.46	326
7066110	10/22/1974	0.35	233
7066110	1/21/1975	0.48	490
7066110	4/15/1975	0.53	530
7066110	9/23/1976	0.3	132
7066110	5/4/1977	0.53	242
7066110	9/22/1977	0.69	210
7066110	5/11/1978	0.53	626
7066110	9/13/1978	0.56	140
7066110	5/16/1979	0.29	980
7066110	9/5/1979	0.34	293
7066110	5/6/1980	0.54	279
7066110	8/27/1980	0.73	121
7066110	6/10/1981	1.7	395
7066110	9/22/1981	0.6	127
7066110	6/30/1982	0.76	464

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7066110	12/8/1992	0.01	344
7066110	1/22/1993	0.02	1200
7066110	4/7/1993	0.05	1100
7066110	4/14/1993	0.02	702
7066110	6/3/1993	0.03	366
7066110	4/14/1994	0.04	4140
7066110	10/20/1994	0.06	251
7066110	5/22/1995	0.02	680
7066110	8/7/1995	0.12	262
7066110	10/11/1995	0.02	189
7066110	4/1/1996	0.03	1340
7066110	4/7/1997	0.03	3200
7066110	11/13/2000	0.17	215
7066110	5/13/2002	0.06	2400
7066110	2/14/2007	0.04	2400
7064555	4/3/1973	0.007	151
7064555	6/18/1973	0.04	164
7064555	7/30/1973	0.02	93
7064555	5/5/1977	0.02	55
7064555	5/11/1978	0.01	105
7064555	5/15/1979	0.01	110
7064555	9/5/1979	0.01	57
7064555	5/7/1980	0.02	61
7064555	8/26/1980	0.01	21
7064555	6/11/1981	0.02	98
7064555	9/21/1981	0.02	9.8
7064555	7/1/1982	0.05	119
7064555	5/26/1983	0.02	132
7064555	5/15/1984	0.01	141
7064555	5/6/1986	0.01	101
7064555	10/14/1986	0.01	70
7064555	5/11/1987	0.01	85
7064555	10/13/1987	0.01	23
7064555	5/17/1988	0.02	75
7064555	10/11/1988	0.01	32
7064555	10/23/1989	0.01	28
7064555	10/22/1991	0.02	34
7064555	4/13/1993	0.04	124
7064555	10/19/1993	0.03	112
7064555	10/10/1995	0.04	49
7064555	10/1/1996	0.18	126
7064530	4/2/1973	0.004	500
7064530	6/18/1973	0.02	232
7064530	7/30/1973	0.03	272
7064530	5/5/1977	0.03	130
7064530	5/12/1978	0.01	299
7064530	5/15/1979	0.01	387
7064530	9/4/1979	0.01	127

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7066110	5/25/1983	0.6	700
7066110	9/14/1983	0.6	180
7066110	5/16/1984	0.7	775
7066110	5/15/1985	0.6	1140
7066110	9/11/1985	0.6	329
7066110	10/15/1986	1.1	205
7066110	5/12/1987	0.8	220
7066110	10/14/1987	0.5	145
7066110	5/18/1988	0.6	282
7066110	10/12/1988	0.5	172
7066110	5/24/1989	0.9	1380
7066110	11/20/1990	0.6	126
7066110	11/12/1992	0.9	2200
7066110	1/22/1993	0.52	1200
7066110	7/9/1993	0.59	274
7066110	8/7/1995	0.58	262
7066110	4/1/1996	0.69	1340
7066110	11/6/1996	0.54	123
7066110	6/10/1997	0.49	410
7066110	1/26/1999	0.45	530
7066110	3/2/1999	0.52	390
7066110	4/5/1999	0.29	860
7066110	6/17/1999	0.51	220
7066110	8/18/1999	0.5	196
7066110	11/1/1999	0.41	179
7066110	3/20/2000	0.66	333
7066110	5/8/2000	0.43	180
7066110	7/17/2000	0.4	170
7066110	9/11/2000	0.35	145
7066110	11/13/2000	1.2	215
7066110	5/10/2001	0.39	225
7066110	7/17/2001	0.29	152
7066110	9/4/2001	0.31	110
7066110	1/22/2002	0.51	144
7066110	3/5/2002	0.4	504
7066110	5/13/2002	0.5	2400
7066110	7/15/2002	0.37	304
7066110	9/5/2002	0.48	288
7066110	3/11/2003	0.48	398
7066110	5/19/2003	0.37	1170
7066110	7/7/2003	0.41	271
7066110	9/5/2003	0.53	761
7066110	11/17/2003	0.33	340
7066110	1/22/2004	0.42	853
7066110	5/5/2004	0.44	1020
7066110	7/6/2004	0.35	404
7066110	9/7/2004	0.42	230
7066110	11/22/2004	0.54	425

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7064530	5/8/1980	0.03	158
7064530	8/26/1980	0.01	103
7064530	6/11/1981	0.19	144
7064530	9/21/1981	0.02	111
7064530	6/29/1982	0.05	337
7064530	5/24/1983	0.01	356
7064530	9/15/1983	0.01	90
7064530	5/15/1984	0.01	271
7064530	9/18/1984	0.01	172
7064530	9/10/1985	0.01	244
7064530	5/6/1986	0.01	209
7064530	10/14/1986	0.01	176
7064530	5/11/1987	0.01	173
7064530	10/13/1987	0.01	97
7064530	5/17/1988	0.02	240
7064530	10/11/1988	0.01	115
7064530	10/23/1989	0.01	101
7064530	11/19/1990	0.01	171
7064530	10/22/1991	0.01	117
7064530	10/19/1994	0.18	169
7064530	10/10/1995	0.02	138
7065500	9/23/1976	0.01	78
7065500	5/10/1978	0.01	189
7065500	9/5/1979	0.01	118
7065500	8/27/1980	0.01	73
7065500	9/22/1981	0.01	82
7065500	5/16/1984	0.01	297
7065500	5/7/1986	0.01	139
7065500	5/12/1987	0.01	115
7065500	10/25/1989	0.01	88
7065500	5/30/1991	0.01	163
7065500	10/16/1973	0.02	201
7065500	5/4/1977	0.02	148
7065500	5/16/1979	0.02	320
7065500	5/6/1980	0.02	138
7065500	6/10/1981	0.02	137
7065500	5/25/1983	0.02	197
7065500	5/18/1988	0.02	129
7065500	10/12/1988	0.02	96
7065500	10/22/1991	0.02	87
7065500	10/10/1995	0.02	103
7065500	10/8/2002	0.02	98
7065500	4/4/1973	0.021	309
7065500	6/19/1973	0.03	179
7065500	7/31/1973	0.03	141
7065500	7/10/1974	0.03	169
7065500	4/14/1993	0.03	204
7065500	6/30/1982	0.04	147

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7066110	1/25/2005	0.62	760
7066110	3/15/2005	0.45	428
7066110	5/19/2005	0.37	310
7066110	7/18/2005	0.38	210
7066110	9/1/2005	0.33	206
7066110	1/4/2006	0.5	165
7066110	3/1/2006	0.34	170
7066110	5/8/2006	0.29	1170
7066110	7/10/2006	0.39	166
7066110	11/15/2006	0.49	384
7066110	1/24/2007	0.29	984
7066110	2/14/2007	0.69	2400
7066110	4/3/2007	0.31	440
7066110	5/2/2007	0.34	530
7066110	6/11/2007	0.38	282
7066110	7/16/2007	0.44	206
7066110	9/4/2007	0.36	162
7066110	5/5/2008	0.35	650
7066110	7/7/2008	0.39	340
7066110	10/6/2008	0.4	230
7066110	1/12/2009	0.5	250
7066110	3/2/2009	0.49	322
7066110	5/28/2009	0.38	613
7066110	7/6/2009	0.48	310
7066110	9/9/2009	0.42	334
7066110	10/28/2009	0.51	1600
7064555	6/18/1973	0.76	164
7064555	7/30/1973	0.63	93
7064555	10/15/1973	0.68	114
7064555	9/24/1976	0.51	24
7064555	5/5/1977	0.67	55
7064555	9/22/1977	0.62	15
7064555	5/11/1978	0.69	105
7064555	9/14/1978	1	21
7064555	5/15/1979	0.48	110
7064555	9/5/1979	0.66	57
7064555	5/7/1980	0.9	61
7064555	8/26/1980	0.87	21
7064555	6/11/1981	1	98
7064555	7/1/1982	1	119
7064555	5/26/1983	0.8	132
7064555	9/15/1983	0.9	49
7064555	5/14/1985	0.8	153
7064555	9/10/1985	0.9	77
7064555	10/14/1986	1.1	70
7064555	5/11/1987	0.7	85
7064555	10/11/1988	0.9	32
7064555	10/23/1989	0.9	28

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7066550	6/21/1973	0.03	176
7066550	8/1/1973	0.02	155
7066550	10/17/1973	0.02	180
7066550	5/4/1977	0.01	154
7066550	5/16/1979	0.01	273
7066550	9/5/1979	0.01	103
7066550	5/6/1980	0.03	102
7066550	6/10/1981	0.01	114
7066550	6/30/1982	0.04	128
7066550	5/25/1983	0.02	237
7066550	5/16/1984	0.01	254
7066550	9/11/1985	0.01	121
7066550	5/12/1987	0.01	118
7066550	5/18/1988	0.02	118
7066550	10/12/1988	0.01	96
7066550	10/23/1991	0.01	108
7066550	10/20/1994	0.02	98
7066550	5/23/1995	0.03	242
7066550	10/2/1996	0.02	232
7066550	10/7/2002	0.02	96
7014000	11/23/1993	0.03	244
7014000	3/11/1994	0.02	266
7014000	3/11/1994	0.02	266
7014000	6/23/1994	0.02	175
7014000	8/29/1994	0.09	115
7014000	1/13/1995	0.03	352
7014000	3/20/1995	0.02	245
7014000	8/7/1995	0.02	127
7014000	4/9/1996	0.02	245
7014000	6/24/1996	0.02	310
7014000	3/10/1997	0.03	330
7014000	11/15/2000	0.078	105
7014000	5/9/2002	0.06	3050
7014500	1/19/1993	0.02	1450
7014500	4/8/1993	0.03	2090
7014500	5/19/1993	0.08	5020
7014500	6/1/1993	0.02	870
7014500	7/6/1993	0.05	833
7014500	8/12/1993	0.17	6830
7014500	9/30/1993	0.03	3210
7014500	10/6/1993	0.02	1640
7014500	11/3/1993	0.02	1070
7014500	12/2/1993	0.04	1840
7014500	2/14/1994	0.03	703
7014500	3/1/1994	0.04	1580
7014500	3/8/1994	0.02	1190
7014500	5/25/1994	0.02	1660
7014500	6/23/1994	0.02	966

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7064555	5/30/1991	0.63	115
7064555	5/2/2000	0.62	26
7064555	5/8/2001	0.58	24
7064555	5/30/2002	0.42	150
7064555	10/8/2002	0.6	33
7064555	5/6/2003	0.54	113
7064530	6/18/1973	0.81	232
7064530	7/30/1973	0.87	272
7064530	10/15/1973	0.91	284
7064530	9/24/1976	0.58	65
7064530	5/5/1977	0.86	130
7064530	9/23/1977	0.8	75
7064530	5/12/1978	1.5	299
7064530	9/14/1978	1.1	113
7064530	5/15/1979	0.96	387
7064530	9/4/1979	1.1	127
7064530	5/8/1980	0.82	158
7064530	8/26/1980	1	103
7064530	6/11/1981	2.1	144
7064530	9/21/1981	1.1	111
7064530	6/29/1982	1.2	337
7064530	5/24/1983	1.4	356
7064530	9/15/1983	1.1	90
7064530	5/15/1984	1.4	271
7064530	9/10/1985	0.9	244
7064530	10/14/1986	1.7	176
7064530	5/11/1987	1.2	173
7064530	10/13/1987	0.9	97
7064530	10/11/1988	1	115
7064530	5/30/1991	0.83	300
7064530	10/1/1996	1.1	241
7065500	6/19/1973	0.74	179
7065500	7/31/1973	0.74	141
7065500	10/16/1973	0.97	201
7065500	7/10/1974	0.7	169
7065500	9/23/1976	0.57	78
7065500	5/4/1977	0.96	148
7065500	9/21/1977	0.82	105
7065500	5/10/1978	1	189
7065500	9/13/1978	0.77	96
7065500	5/16/1979	0.62	320
7065500	9/5/1979	0.79	118
7065500	5/6/1980	0.86	138
7065500	8/27/1980	0.68	73
7065500	6/10/1981	2	137
7065500	9/22/1981	1	82
7065500	6/30/1982	1.2	147
7065500	5/25/1983	1.1	197

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7014500	8/31/1994	0.02	811
7014500	9/12/1994	0.02	669
7014500	3/22/1995	0.02	1270
7014500	5/9/1995	0.07	5890
7014500	6/12/1995	0.03	4620
7014500	7/18/1995	0.02	727
7014500	9/11/1995	0.02	405
7014500	10/3/1995	0.03	392
7014500	2/27/1996	0.02	500
7014500	7/24/1996	0.02	505
7014500	1/14/1997	0.02	670
7014500	2/5/1997	0.02	3450
7014500	3/13/1997	0.03	2230
7014500	4/7/1997	0.02	3800
7014500	1/19/1999	0.04	3180
7014500	2/9/1999	0.16	7760
7014500	4/26/1999	0.07	4540
7014500	5/20/1999	0.04	1260
7014500	8/10/1999	0.08	1380
7014500	10/6/1999	0.03	267
7014500	11/16/1999	0.04	302
7014500	6/13/2000	0.04	274
7014500	8/2/2000	0.03	242
7014500	11/7/2000	0.04	322
7014500	7/25/2001	0.03	226
7014500	3/28/2002	0.04	3000
7014500	5/23/2002	0.03	2800
7014500	8/12/2002	0.03	373
7014500	4/8/2003	0.02	1870
7014500	5/5/2003	0.06	2450
7014500	8/6/2003	0.03	373
7014500	12/17/2003	0.02	772
7014500	1/21/2004	0.02	1770
7014500	5/4/2004	0.05	3140
7014500	9/1/2004	0.03	642
7014500	11/3/2004	0.07	1570
7014500	12/14/2004	0.02	1180
7014500	5/17/2006	0.03	1710
7014500	4/2/2007	0.05	2660
7014500	7/10/2007	0.02	425
7014500	2/6/2008	0.02	1950
7014500	3/25/2008	0.04	3270
7014500	4/15/2008	0.04	3310
7014500	6/3/2008	0.02	903
7014500	7/22/2008	0.02	415
7014500	9/2/2008	0.03	440
7014500	4/20/2009	0.18	10400
7014500	10/29/2009	0.04	3870

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7065500	9/14/1983	1	93
7065500	5/16/1984	1	297
7065500	5/15/1985	0.8	213
7065500	9/11/1985	1.1	139
7065500	5/7/1986	0.9	139
7065500	10/15/1986	1.5	100
7065500	5/12/1987	1.1	115
7065500	10/12/1988	1.1	96
7065500	5/25/1989	0.8	202
7065500	5/29/2002	0.68	311
7065500	5/6/2003	0.7	175
7065500	5/18/2004	0.66	262
7065500	5/9/2006	0.62	350
7066550	6/21/1973	0.45	176
7066550	8/1/1973	0.68	155
7066550	10/17/1973	0.63	180
7066550	9/23/1976	0.37	91
7066550	5/4/1977	0.58	154
7066550	9/22/1977	0.54	104
7066550	5/11/1978	0.66	115
7066550	9/13/1978	1	93
7066550	5/16/1979	0.63	273
7066550	9/5/1979	0.9	103
7066550	5/6/1980	0.86	102
7066550	8/27/1980	0.78	92
7066550	6/10/1981	1.1	114
7066550	9/22/1981	1.1	116
7066550	6/30/1982	1.1	128
7066550	5/25/1983	1	237
7066550	9/14/1983	0.9	88
7066550	5/16/1984	0.9	254
7066550	9/11/1985	0.6	121
7066550	10/15/1986	1.2	119
7066550	5/12/1987	0.6	118
7066550	5/29/1991	1.9	214
7066550	5/7/2001	0.43	100
7066550	5/28/2002	0.65	239
7066550	5/9/2006	0.31	154
7014000	11/23/1993	0.48	244
7014000	8/7/1995	0.39	127
7014000	3/4/1999	0.36	200
7014000	4/8/1999	0.28	394
7014000	6/14/1999	0.36	153
7014000	8/19/1999	0.73	66
7014000	11/15/1999	0.25	56
7014000	1/11/2000	0.26	92
7014000	3/14/2000	0.26	100
7014000	5/17/2000	0.25	47

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7010500	11/17/1993	0.04	1100
7010500	1/20/1994	0.02	135
7010500	3/8/1994	0.03	255
7010500	6/23/1994	0.03	135
7010500	8/29/1994	0.02	80
7010500	11/3/1994	0.04	130
7010500	1/13/1995	0.02	285
7010500	3/22/1995	0.05	90
7010500	8/8/1995	0.02	140
7010500	3/5/1996	0.18	55
7010500	4/10/1996	0.04	163
7010500	6/25/1996	0.03	170
7010500	11/13/1996	0.02	207
7010500	3/10/1997	0.04	318
7010500	11/16/1999	0.05	92
7010500	3/14/2000	0.03	114
7010500	5/17/2000	0.04	95
7010500	9/14/2000	0.04	75
7010500	11/8/2000	0.05	115
7010500	5/14/2001	0.04	72
7010500	7/20/2001	0.04	63
7010500	11/2/2001	0.04	72
7010500	9/5/2002	0.03	103
7010500	11/13/2002	0.03	105
7010500	1/14/2003	0.03	92
7010500	3/4/2003	0.02	129
7010500	5/5/2003	0.04	215
7010500	7/30/2003	0.03	129
7010500	11/10/2003	0.03	141
7010500	1/6/2004	0.03	287
7010500	3/15/2004	0.04	208
7010500	5/5/2004	0.03	190
7010500	7/27/2004	0.03	205
7010500	9/2/2004	0.02	197
7066000	5/11/1999	0.068	627
7066000	8/11/1999	0.004	194
7066000	11/8/1999	0.006	154
7066000	3/1/2000	0.004	542
7066000	5/24/2000	0.005	130
7066000	5/25/2000	0.01	235
7066000	7/11/2000	0.004	160
7066000	7/27/2000	0.004	143
7066000	8/10/2000	0.005	129
7066000	12/20/2000	0.002	160
7066000	2/21/2001	0.005	410
7066000	3/21/2001	0.004	242
7066000	4/24/2001	0.004	218
7066000	5/25/2001	0.006	215

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7014000	7/6/2000	0.24	76
7014000	9/7/2000	0.17	29
7014000	11/15/2000	0.76	105
7014000	3/22/2001	0.64	110
7014000	5/10/2001	0.36	66
7014000	7/11/2001	0.27	37
7014000	11/1/2001	0.11	57
7014000	1/23/2002	0.35	70
7014000	3/28/2002	0.37	469
7014000	5/9/2002	0.55	3050
7014000	9/3/2002	0.3	77
7014000	11/12/2002	0.19	84
7014000	1/13/2003	0.47	127
7014000	3/3/2003	0.34	255
7014000	5/6/2003	0.28	478
7014000	7/29/2003	0.31	69
7014000	9/11/2003	0.28	56
7014000	1/8/2004	0.38	88
7014000	3/17/2004	0.43	63
7014000	5/5/2004	0.31	438
7014000	7/27/2004	0.28	64
7014000	9/2/2004	0.28	163
7014000	11/9/2004	0.28	101
7014000	3/1/2005	0.28	175
7014000	5/18/2005	0.22	135
7014000	7/6/2005	0.23	58
7014000	9/7/2005	0.28	67
7014000	11/22/2005	0.38	139
7014000	1/10/2006	0.28	86
7014000	3/21/2006	0.43	408
7014000	5/9/2006	0.24	238
7014000	11/8/2006	0.24	163
7014000	2/14/2007	0.46	659
7014000	4/2/2007	0.28	579
7014000	5/22/2007	0.24	114
7014000	6/5/2007	0.26	86
7014000	7/13/2007	0.24	57
7014000	3/24/2008	0.54	629
7014000	5/19/2008	0.18	394
7014000	7/21/2008	0.28	70
7014000	9/2/2008	0.28	81
7014000	10/27/2008	0.14	141
7014000	5/26/2009	0.15	494
7014000	7/21/2009	0.24	221
7014000	10/27/2009	0.46	255
7014500	1/19/1993	0.82	1450
7014500	5/19/1993	0.81	5020
7014500	7/6/1993	0.67	833

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7066000	5/26/2001	0.003	202
7066000	5/26/2001	0.006	202
7066000	5/27/2001	0.003	190
7066000	5/27/2001	0.003	186
7066000	6/6/2001	0.007	211
7066000	7/31/2001	0.005	136
7066000	8/8/2001	0.004	112
7066000	8/8/2001	0.005	112
7066000	8/9/2001	0.005	116
7066000	8/9/2001	0.008	116
7066000	9/18/2001	0.003	112
7066000	10/2/2001	0.003	104
7066000	10/10/2001	0.002	109
7066000	10/10/2001	0.007	109
7066000	10/11/2001	0.003	116
7066000	10/11/2001	0.004	116
7066000	11/20/2001	0.002	112
7066000	4/2/2002	0.005	590
7066000	4/30/2002	0.006	760
7066000	5/29/2002	0.009	657
7066000	6/4/2002	0.005	488
7066000	6/28/2002	0.006	309
7066000	6/29/2002	0.01	297
7066000	7/29/2002	0.006	266
7066000	8/6/2002	0.004	220
7066000	8/7/2002	0.004	216
7066000	10/8/2002	0.005	161
7066000	10/9/2002	0.004	164
7066000	6/3/2003	0.003	270
7066000	6/9/2003	0.019	263
7066000	6/28/2003	0.004	185
7066000	7/26/2003	0.005	169
7066000	8/6/2003	0.005	226
7066000	9/23/2003	0.004	201
7066000	10/8/2003	0.004	151
7066000	6/15/2004	0.01	368
7066000	6/26/2004	0.005	266
7066000	7/13/2004	0.005	216
7066000	8/11/2004	0.002	186
7066000	8/21/2004	0.003	174
7066000	9/21/2004	0.005	147
7066000	10/5/2004	0.004	125
7066000	6/14/2005	0.005	150
7066000	7/5/2005	0.005	127
7066000	8/9/2005	0.005	142
7065000	4/3/1973	0.013	158
7065000	6/19/1973	0.04	60
7065000	7/31/1973	0.02	48

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7014500	11/3/1993	0.35	1070
7014500	3/1/1994	0.64	1580
7014500	3/21/1994	0.34	854
7014500	8/31/1994	0.68	811
7014500	9/12/1994	0.41	669
7014500	10/12/1994	0.41	480
7014500	4/24/1995	0.44	3490
7014500	5/9/1995	0.45	5890
7014500	6/12/1995	0.92	4620
7014500	7/5/1995	0.42	1260
7014500	7/18/1995	0.48	727
7014500	9/11/1995	0.4	405
7014500	10/3/1995	0.3	392
7014500	1/9/1996	0.56	500
7014500	1/22/1996	0.7	1440
7014500	4/16/1996	0.48	1470
7014500	5/22/1996	0.46	1450
7014500	7/24/1996	0.51	505
7014500	10/7/1996	0.6	592
7014500	12/5/1996	0.56	2460
7014500	2/5/1997	0.59	3450
7014500	4/7/1997	0.57	3800
7014500	6/17/1997	0.54	2220
7014500	7/9/1997	0.27	812
7014500	1/19/1999	0.85	3180
7014500	2/9/1999	1.3	7760
7014500	3/24/1999	0.37	1800
7014500	4/26/1999	0.72	4540
7014500	5/20/1999	0.24	1260
7014500	6/29/1999	0.42	1170
7014500	7/21/1999	0.24	381
7014500	8/10/1999	0.95	1380
7014500	9/9/1999	0.28	272
7014500	10/6/1999	1.5	267
7014500	11/16/1999	0.16	302
7014500	12/8/1999	0.25	494
7014500	1/11/2000	0.16	517
7014500	2/8/2000	0.22	338
7014500	3/15/2000	0.22	662
7014500	4/4/2000	0.2	576
7014500	6/13/2000	0.59	274
7014500	7/5/2000	0.27	288
7014500	1/24/2001	0.16	333
7014500	2/15/2001	0.6	895
7014500	3/27/2001	0.35	489
7014500	4/18/2001	0.4	1000
7014500	5/14/2001	0.23	324
7014500	6/13/2001	0.21	523

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7065000	10/16/1973	0.02	71
7065000	5/5/1977	0.04	28
7065000	5/16/1979	0.01	118
7065000	9/5/1979	0.01	40
7065000	5/7/1980	0.03	31
7065000	6/9/1981	0.03	34
7065000	9/23/1981	0.01	20
7065000	7/1/1982	0.06	38
7065000	5/24/1983	0.02	100
7065000	5/17/1984	0.01	52
7065000	5/6/1986	0.01	58
7065000	10/14/1986	0.02	34
7065000	5/11/1987	0.01	52
7065000	5/17/1988	0.02	38
7065000	10/11/1988	0.01	21
7065000	10/22/1991	0.01	25
7065000	4/14/1993	0.04	214
7065000	10/21/1993	0.1	47
7065000	5/23/1995	0.02	82
7065000	10/1/1996	0.08	65
7064440	4/2/1973	0.013	253
7064440	6/18/1973	0.04	139
7064440	7/30/1973	0.04	107
7064440	10/15/1973	0.01	152
7064440	1/18/1974	0.04	160
7064440	4/17/1974	0.04	204
7064440	7/9/1974	0.03	146
7064440	10/21/1974	0.13	109
7064440	1/22/1975	0.04	153
7064440	4/15/1975	0.01	165
7064440	9/24/1976	0.03	64
7064440	5/6/1977	0.07	74
7064440	9/23/1977	0.03	45
7064440	5/12/1978	0.02	155
7064440	9/14/1978	0.02	58
7064440	5/15/1979	0.01	181
7064440	9/4/1979	0.04	90
7064440	5/8/1980	0.03	76
7064440	8/26/1980	0.03	62
7064440	6/9/1981	0.09	75
7064440	9/21/1981	0.03	52
7064440	6/29/1982	0.06	114
7064440	5/24/1983	0.01	172
7064440	9/13/1983	0.01	90
7064440	5/15/1984	0.02	181
7064440	9/18/1984	0.01	100
7064440	5/14/1985	0.01	196
7064440	9/10/1985	0.02	125

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7014500	7/25/2001	0.28	226
7014500	8/14/2001	0.23	355
7014500	9/6/2001	0.19	175
7014500	12/5/2001	0.34	673
7014500	1/23/2002	0.3	312
7014500	2/12/2002	0.66	821
7014500	3/28/2002	0.53	3000
7014500	4/10/2002	0.29	1860
7014500	5/23/2002	0.53	2800
7014500	6/20/2002	0.26	729
7014500	7/30/2002	0.24	419
7014500	8/12/2002	0.39	373
7014500	9/3/2002	0.3	411
7014500	11/14/2002	0.15	411
7014500	12/2/2002	0.11	351
7014500	1/14/2003	0.32	580
7014500	2/4/2003	0.29	388
7014500	3/4/2003	0.4	1050
7014500	4/8/2003	0.39	1870
7014500	5/5/2003	0.6	2450
7014500	6/9/2003	0.28	621
7014500	7/30/2003	0.29	351
7014500	8/6/2003	0.28	373
7014500	9/4/2003	0.46	626
7014500	10/20/2003	0.14	396
7014500	12/17/2003	0.41	772
7014500	1/21/2004	0.48	1770
7014500	2/9/2004	0.3	766
7014500	3/2/2004	0.23	506
7014500	4/20/2004	0.28	637
7014500	5/4/2004	0.54	3140
7014500	6/1/2004	0.24	784
7014500	7/19/2004	0.26	358
7014500	9/1/2004	0.53	642
7014500	10/14/2004	0.27	367
7014500	11/3/2004	0.67	1570
7014500	12/14/2004	0.47	1180
7014500	1/3/2005	0.31	465
7014500	2/2/2005	0.6	877
7014500	3/10/2005	0.24	754
7014500	4/5/2005	0.17	760
7014500	5/4/2005	0.15	1050
7014500	6/8/2005	0.37	386
7014500	7/25/2005	0.2	353
7014500	8/17/2005	0.39	896
7014500	9/1/2005	0.22	283
7014500	10/12/2005	0.17	381
7014500	11/9/2005	0.21	581

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7064440	5/6/1986	0.02	130
7064440	10/14/1986	0.02	113
7064440	5/11/1987	0.02	114
7064440	10/13/1987	0.03	77
7064440	5/17/1988	0.02	116
7064440	10/11/1988	0.03	82
7064440	5/23/1989	0.02	221
7064440	10/23/1989	0.02	76
7064440	11/19/1990	0.01	90
7064440	5/30/1991	0.01	167
7064440	10/22/1991	0.03	81
7064440	4/14/1992	0.01	122
7064440	9/30/1992	0.03	100
7064440	4/29/1993	0.02	173
7064440	10/21/1993	0.02	122
7064440	10/19/1994	0.02	91
7064440	5/22/1995	0.03	164
7064440	10/10/1995	0.07	98
7064440	5/8/2001	0.03	53
7064440	10/3/2001	0.03	48
7064440	10/9/2002	0.02	71
7064440	10/7/2004	0.03	51
7064440	5/8/2006	0.02	120
7066510	6/20/1973	0.03	1560
7066510	8/1/1973	0.02	1240
7066510	1/18/1974	0.03	1820
7066510	4/17/1974	0.03	2420
7066510	7/10/1974	0.02	1260
7066510	10/22/1974	0.02	850
7066510	1/21/1975	0.01	1870
7066510	5/4/1977	0.01	928
7066510	9/22/1977	0.01	738
7066510	5/16/1979	0.01	3000
7066510	9/5/1979	0.01	894
7066510	5/6/1980	0.01	798
7066510	6/10/1981	0.01	1190
7066510	9/22/1981	0.01	462
7066510	6/30/1982	0.04	1150
7066510	5/25/1983	0.02	2240
7066510	9/14/1983	0.04	680
7066510	5/12/1987	0.01	985
7066510	5/18/1988	0.02	932
7066510	10/12/1988	0.01	639
7066510	10/23/1991	0.01	659
7066510	4/13/1993	0.03	3500
7066510	5/23/1995	0.05	2400
7066510	10/7/2002	0.02	1000
7061600	1/13/2009	0.02	136

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7014500	12/5/2005	0.33	760
7014500	1/9/2006	0.23	425
7014500	2/7/2006	0.16	620
7014500	3/6/2006	0.2	415
7014500	4/12/2006	0.17	742
7014500	5/17/2006	0.49	1710
7014500	6/14/2006	0.29	420
7014500	7/20/2006	0.22	214
7014500	9/5/2006	0.19	206
7014500	10/11/2006	0.12	222
7014500	11/7/2006	0.14	401
7014500	12/4/2006	0.7	1910
7014500	1/8/2007	0.33	522
7014500	2/15/2007	0.59	1690
7014500	3/13/2007	0.22	642
7014500	4/2/2007	0.55	2660
7014500	5/21/2007	0.2	648
7014500	6/5/2007	0.53	565
7014500	7/10/2007	0.25	425
7014500	8/13/2007	0.33	214
7014500	9/5/2007	0.13	218
7014500	10/23/2007	0.2	278
7014500	11/5/2007	0.11	274
7014500	1/24/2008	0.57	396
7014500	2/6/2008	0.62	1950
7014500	3/25/2008	0.81	3270
7014500	4/15/2008	0.58	3310
7014500	5/21/2008	0.22	1710
7014500	6/3/2008	0.28	903
7014500	7/22/2008	0.36	415
7014500	8/5/2008	0.2	425
7014500	9/2/2008	0.33	440
7014500	10/28/2008	0.13	430
7014500	11/13/2008	0.2	559
7014500	12/8/2008	0.31	363
7014500	1/20/2009	0.37	363
7014500	2/3/2009	0.19	460
7014500	3/23/2009	0.16	548
7014500	4/20/2009	1.1	10400
7014500	6/1/2009	0.35	1580
7014500	7/21/2009	0.24	815
7014500	8/24/2009	0.28	614
7014500	9/2/2009	0.22	543
7014500	10/29/2009	0.5	3870
7010500	11/17/1993	0.78	1100
7010500	8/8/1995	0.93	140
7010500	11/13/1996	0.88	207
7010500	6/19/1997	0.76	384

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7061600	8/10/1995	0.01	248
7061600	9/8/2009	0.02	280
7061600	2/15/1994	0.01	360
7061600	2/12/2007	0.03	370
7061600	3/22/1995	0.02	416
7061600	7/11/1995	0.02	565
7061600	5/7/2008	0.03	735
7061600	1/29/2006	0.04	1140
7061600	5/21/2003	0.02	1320
7061600	11/18/2003	0.17	6280
7061600	5/14/2002	0.06	6630
7061600	5/11/2006	0.07	6830
7061600	4/12/1994	0.17	28800
7064400	9/24/1976	0.01	51
7064400	5/6/1977	0.03	60
7064400	5/12/1978	0.01	112
7064400	5/15/1979	0.01	140
7064400	9/4/1979	0.02	70
7064400	8/26/1980	0.01	43
7064400	6/9/1981	0.02	64
7064400	9/21/1981	0.01	46
7064400	6/29/1982	0.07	106
7064400	5/24/1983	0.01	132
7064400	9/13/1983	0.05	70
7064400	5/15/1984	0.01	123
7064400	9/18/1984	0.01	77
7064400	5/14/1985	0.05	151
7064400	9/10/1985	0.02	95
7064400	5/6/1986	0.01	102
7064400	10/14/1986	0.02	83
7064400	5/11/1987	0.01	8.2
7064400	10/13/1987	0.02	61
7064400	5/17/1988	0.02	93
7064400	10/11/1988	0.02	68
7064400	10/23/1989	0.02	62
7064400	5/30/1991	0.01	132
7064400	10/22/1991	0.02	69
7064400	4/29/1993	0.02	92
7064400	10/21/1993	0.02	70
7064400	10/19/1994	0.04	78
7064400	10/10/1995	0.03	81
7014200	11/23/1993	0.04	240
7014200	8/7/1995	0.02	45
7014200	4/9/1996	0.02	140
7014200	6/24/1996	0.02	47
7014200	3/10/1997	0.03	240
7014200	8/19/1999	0.03	68
7014200	11/15/2000	0.09	39

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7010500	11/16/1999	0.87	92
7010500	1/12/2000	0.88	102
7010500	5/17/2000	0.72	95
7010500	7/5/2000	0.64	79
7010500	9/14/2000	0.84	75
7010500	11/8/2000	0.77	115
7010500	1/9/2001	0.89	58
7010500	3/27/2001	1	104
7010500	5/14/2001	0.75	72
7010500	7/20/2001	0.76	63
7010500	9/6/2001	0.66	72
7010500	11/2/2001	0.75	72
7010500	1/28/2002	0.87	77
7010500	5/21/2002	0.6	411
7010500	7/29/2002	0.88	135
7010500	9/5/2002	0.91	103
7010500	11/13/2002	0.47	105
7010500	1/14/2003	0.89	92
7010500	5/5/2003	0.7	215
7010500	7/30/2003	0.92	129
7010500	9/4/2003	0.84	123
7010500	1/6/2004	0.78	287
7010500	3/15/2004	0.89	208
7010500	5/5/2004	0.63	190
7010500	9/2/2004	0.96	197
7066000	5/11/1999	0.37	627
7066000	6/23/1999	0.5	227
7066000	8/11/1999	0.59	194
7066000	11/8/1999	0.35	154
7066000	12/15/1999	0.45	305
7066000	3/1/2000	0.75	542
7066000	4/5/2000	0.46	241
7066000	5/25/2000	0.36	235
7066000	6/7/2000	0.41	172
7066000	6/29/2000	0.34	245
7066000	7/27/2000	0.4	143
7066000	8/10/2000	0.36	129
7066000	8/22/2000	0.41	127
7066000	9/19/2000	0.4	113
7066000	2/21/2001	0.63	410
7066000	3/21/2001	0.6	242
7066000	5/25/2001	0.33	215
7066000	5/26/2001	0.31	202
7066000	5/26/2001	0.34	202
7066000	5/27/2001	0.22	186
7066000	5/27/2001	0.33	190
7066000	6/6/2001	0.29	211
7066000	7/31/2001	0.34	136

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7014200	5/9/2002	0.07	3250
7014200	2/14/2007	0.04	264

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7066000	8/8/2001	0.32	112
7066000	8/8/2001	0.34	112
7066000	8/9/2001	0.34	116
7066000	8/9/2001	0.38	116
7066000	10/11/2001	0.35	116
7066000	10/11/2001	0.36	116
7066000	4/2/2002	0.44	590
7066000	4/30/2002	0.26	760
7066000	5/29/2002	0.37	657
7066000	6/28/2002	0.49	309
7066000	6/29/2002	0.31	297
7066000	8/7/2002	0.38	216
7066000	10/8/2002	0.44	161
7066000	6/3/2003	0.46	270
7066000	6/9/2003	0.46	263
7066000	6/28/2003	0.4	185
7066000	7/26/2003	0.35	169
7066000	8/6/2003	0.32	226
7066000	9/23/2003	0.37	201
7066000	10/8/2003	0.39	151
7066000	6/15/2004	0.46	368
7066000	6/26/2004	0.42	266
7066000	8/21/2004	0.44	174
7066000	9/21/2004	0.45	147
7066000	7/5/2005	0.39	127
7066000	8/9/2005	0.46	142
7065000	6/19/1973	0.47	60
7065000	7/31/1973	0.53	48
7065000	10/16/1973	0.5	71
7065000	9/22/1976	0.28	25
7065000	5/5/1977	0.51	28
7065000	9/22/1977	0.94	24
7065000	5/11/1978	0.47	39
7065000	9/13/1978	0.73	26
7065000	5/16/1979	0.5	118
7065000	9/5/1979	0.51	40
7065000	5/7/1980	0.89	31
7065000	8/26/1980	0.64	20
7065000	6/9/1981	2	34
7065000	9/23/1981	0.68	20
7065000	7/1/1982	1.4	38
7065000	5/24/1983	0.8	100
7065000	9/13/1983	0.7	34
7065000	5/17/1984	0.7	52
7065000	5/16/1985	0.5	97
7065000	9/11/1985	0.7	43
7065000	5/6/1986	0.5	58
7065000	10/14/1986	1.4	34

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7065000	5/11/1987	0.9	52
7065000	10/11/1988	0.5	21
7065000	5/23/1989	0.8	179
7065000	5/8/2001	0.54	27
7065000	5/29/2002	0.5	153
7065000	5/5/2003	0.45	53
7065000	5/18/2004	0.5	88
7065000	5/10/2006	0.42	250
7064440	6/18/1973	1.2	139
7064440	7/30/1973	0.97	107
7064440	10/15/1973	0.93	152
7064440	1/18/1974	0.66	160
7064440	4/17/1974	0.79	204
7064440	7/9/1974	0.86	146
7064440	10/21/1974	0.84	109
7064440	1/22/1975	0.82	153
7064440	4/15/1975	0.84	165
7064440	9/24/1976	0.9	64
7064440	5/6/1977	1.1	74
7064440	9/23/1977	0.91	45
7064440	5/12/1978	0.9	155
7064440	9/14/1978	1.2	58
7064440	5/15/1979	0.55	181
7064440	9/4/1979	0.89	90
7064440	5/8/1980	2.4	76
7064440	8/26/1980	1	62
7064440	6/9/1981	1.9	75
7064440	9/21/1981	1.1	52
7064440	6/29/1982	1.1	114
7064440	5/24/1983	1	172
7064440	9/13/1983	1.3	90
7064440	5/15/1984	1	181
7064440	5/14/1985	0.9	196
7064440	5/6/1986	1	130
7064440	10/14/1986	1.3	113
7064440	5/11/1987	1.3	114
7064440	10/11/1988	1.1	82
7064440	5/23/1989	1.3	221
7064440	4/29/1993	0.86	173
7064440	5/29/1996	0.79	182
7064440	10/6/1999	0.96	96
7064440	5/3/2000	0.87	72
7064440	5/8/2001	0.79	53
7064440	10/3/2001	0.58	48
7064440	5/30/2002	0.56	189
7064440	10/9/2002	0.85	71
7064440	5/7/2003	0.64	151
7064440	10/7/2003	0.79	57

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7064440	5/17/2004	0.62	186
7064440	10/7/2004	0.82	51
7064440	5/25/2005	0.83	80
7064440	5/8/2006	0.59	120
7066510	6/20/1973	0.38	1560
7066510	8/1/1973	0.5	1240
7066510	10/17/1973	0.52	1480
7066510	1/18/1974	0.34	1820
7066510	4/17/1974	0.49	2420
7066510	7/10/1974	0.46	1260
7066510	10/22/1974	0.01	850
7066510	1/21/1975	0.16	1870
7066510	4/15/1975	0.58	1880
7066510	9/23/1976	0.25	533
7066510	5/4/1977	0.36	928
7066510	9/22/1977	0.49	738
7066510	5/11/1978	0.51	2050
7066510	9/13/1978	0.58	532
7066510	5/16/1979	0.38	3000
7066510	9/5/1979	0.42	894
7066510	5/6/1980	0.48	798
7066510	8/27/1980	0.35	441
7066510	6/10/1981	1.4	1190
7066510	9/22/1981	0.59	462
7066510	6/30/1982	0.97	1150
7066510	5/25/1983	1.4	2240
7066510	9/14/1983	0.8	680
7066510	5/16/1984	0.6	2350
7066510	5/15/1985	0.6	2480
7066510	9/11/1985	0.7	1080
7066510	5/7/1986	0.5	1290
7066510	10/15/1986	3.1	1080
7066510	5/12/1987	0.7	985
7066510	5/29/1991	0.66	1750
7066510	5/1/2000	0.32	600
7066510	5/7/2001	0.38	720
7066510	10/7/2002	0.37	1000
7066510	5/5/2003	0.43	2500
7066510	10/6/2003	0.32	552
7066510	5/17/2004	0.33	2100
7066510	5/24/2005	0.31	713
7066510	5/8/2006	0.31	2800
7061600	4/12/1994	0.85	28800
7061600	11/2/1999	0.13	172
7061600	1/10/2000	0.39	316
7061600	7/24/2000	0.21	121
7061600	9/14/2000	0.12	99
7061600	1/16/2001	0.21	599

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7061600	3/12/2001	0.58	271
7061600	5/8/2001	0.38	164
7061600	7/16/2001	0.18	95
7061600	9/4/2001	0.13	93
7061600	5/14/2002	0.39	6630
7061600	9/5/2002	0.12	163
7061600	3/10/2003	0.29	329
7061600	5/21/2003	0.2	1320
7061600	7/7/2003	0.19	203
7061600	9/2/2003	0.26	468
7061600	11/18/2003	1.2	6280
7061600	5/5/2004	0.22	1000
7061600	11/23/2004	0.27	374
7061600	1/25/2005	0.34	444
7061600	3/15/2005	0.19	136
7061600	5/16/2005	0.13	322
7061600	9/6/2005	0.12	133
7061600	11/2/2005	0.21	501
7061600	1/4/2006	0.38	203
7061600	1/29/2006	0.34	1140
7061600	2/2/2006	0.24	802
7061600	2/13/2006	0.25	305
7061600	3/7/2006	0.24	225
7061600	4/18/2006	0.17	268
7061600	5/11/2006	0.42	6830
7061600	6/20/2006	0.17	191
7061600	7/12/2006	0.18	204
7061600	8/3/2006	0.17	134
7061600	10/23/2006	0.25	287
7061600	11/13/2006	0.34	348
7061600	12/19/2006	0.38	422
7061600	1/4/2007	0.23	614
7061600	3/29/2007	0.29	866
7061600	4/3/2007	0.21	990
7061600	9/10/2007	0.5	1020
7061600	5/7/2008	0.17	735
7061600	10/7/2008	0.14	110
7061600	3/3/2009	0.28	430
7061600	5/26/2009	0.15	497
7061600	7/6/2009	0.18	312
7061600	9/8/2009	0.18	280
7061600	10/27/2009	0.39	936
7064400	7/9/1974	1	101
7064400	9/23/1975	0.82	42
7064400	9/24/1976	0.84	51
7064400	5/6/1977	1	60
7064400	9/23/1977	0.82	42
7064400	5/12/1978	0.89	112

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7064400	9/14/1978	1	51
7064400	5/15/1979	0.67	140
7064400	9/4/1979	1	70
7064400	5/8/1980	8.8	60
7064400	8/26/1980	1.1	43
7064400	6/9/1981	1.6	64
7064400	9/21/1981	1.3	46
7064400	6/29/1982	1.5	106
7064400	5/24/1983	1.6	132
7064400	9/13/1983	1.5	70
7064400	5/15/1984	1.2	123
7064400	5/14/1985	0.9	151
7064400	9/10/1985	1.2	95
7064400	10/14/1986	1.6	83
7064400	5/11/1987	1.2	8.2
7064400	10/13/1987	1.7	61
7064400	10/11/1988	1.2	68
7064400	10/6/1999	1.1	75
7064400	5/3/2000	0.89	61
7064400	5/30/2002	0.5	155
7064400	5/7/2003	0.63	111
7064400	5/17/2004	0.62	113
7064400	5/8/2006	0.59	90
7014200	8/7/1995	0.29	45
7014200	6/24/1996	0.52	47
7014200	6/19/1997	0.29	313
7014200	3/4/1999	0.24	88
7014200	4/8/1999	0.21	359
7014200	6/14/1999	0.19	90
7014200	8/19/1999	0.31	68
7014200	3/14/2000	0.14	68
7014200	5/17/2000	0.16	27
7014200	7/6/2000	0.19	25
7014200	9/7/2000	0.13	12
7014200	11/15/2000	0.75	39
7014200	3/22/2001	0.32	60
7014200	5/10/2001	0.16	43
7014200	7/11/2001	0.22	18
7014200	11/1/2001	0.13	29
7014200	1/23/2002	0.19	47
7014200	3/28/2002	0.17	328
7014200	5/9/2002	0.62	3250
7014200	7/30/2002	0.15	31
7014200	9/3/2002	0.14	32
7014200	11/12/2002	0.14	57
7014200	1/13/2003	0.27	97
7014200	3/3/2003	0.17	150
7014200	5/6/2003	0.16	441

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7014200	9/11/2003	0.14	61
7014200	1/8/2004	0.21	210
7014200	3/17/2004	0.2	114
7014200	5/5/2004	0.16	289
7014200	7/27/2004	0.17	37
7014200	9/2/2004	0.18	46
7014200	11/9/2004	0.17	68
7014200	1/4/2005	0.15	61
7014200	3/1/2005	0.15	117
7014200	7/6/2005	0.16	22
7014200	9/7/2005	0.15	16
7014200	11/22/2005	0.24	82
7014200	3/21/2006	0.29	311
7014200	5/9/2006	0.16	162
7014200	11/8/2006	0.14	75
7014200	2/14/2007	0.34	264
7014200	4/2/2007	0.15	414
7014200	5/22/2007	0.12	72
7014200	6/5/2007	0.18	43
7014200	7/10/2007	0.15	28
7014200	3/24/2008	0.32	355
7014200	7/21/2008	0.17	80
7014200	10/27/2008	0.08	41
7014200	5/26/2009	0.28	73
7014200	7/21/2009	0.12	23
7014200	9/1/2009	0.13	36
7014200	10/27/2009	0.31	228

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	L. Sac R. @Walnut Grove	10/2/1984	4	14
USGS	L. Sac R. @Walnut Grove	11/5/1984	3	136
USGS	L. Sac R. @Walnut Grove	12/4/1984	14	80
USGS	L. Sac R. @Walnut Grove	1/10/1985	4	160
USGS	L. Sac R. @Walnut Grove	2/19/1985	8	135
USGS	L. Sac R. @Walnut Grove	3/18/1985	8	225
USGS	L. Sac R. @Walnut Grove	4/15/1985	20	220
USGS	L. Sac R. @Walnut Grove	5/21/1985	14	84
USGS	L. Sac R. @Walnut Grove	6/11/1985	113	660
USGS	L. Sac R. @Walnut Grove	8/5/1985	12	50
USGS	L. Sac R. @Walnut Grove	9/9/1985	1	35
USGS	L. Sac R. @Walnut Grove	10/8/1985	14	120
USGS	L. Sac R. @Walnut Grove	11/12/1985	2	40
USGS	L. Sac R. @Walnut Grove	12/6/1985	1	320
USGS	L. Sac R. @Walnut Grove	1/7/1986	1	120
USGS	L. Sac R. @Walnut Grove	2/10/1986	2	100
USGS	L. Sac R. @Walnut Grove	10/3/1988	6	33
USGS	L. Sac R. @Walnut Grove	11/1/1988	7	32
USGS	L. Sac R. @Walnut Grove	12/6/1988	6	114
USGS	L. Sac R. @Walnut Grove	1/3/1989	10	275
USGS	L. Sac R. @Walnut Grove	2/7/1989	3	88
USGS	L. Sac R. @Walnut Grove	3/9/1989	4	195
USGS	L. Sac R. @Walnut Grove	4/3/1989	7	290
USGS	L. Sac R. @Walnut Grove	5/9/1989	1	72
USGS	L. Sac R. @Walnut Grove	6/6/1989	13	88
USGS	L. Sac R. @Walnut Grove	7/17/1989	0.499	42
USGS	L. Sac R. @Walnut Grove	8/3/1989	15	88
USGS	L. Sac R. @Walnut Grove	9/5/1989	10	48
USGS	L. Sac R. @Walnut Grove	10/10/1989	0.499	50
USGS	L. Sac R. @Walnut Grove	11/6/1989	0.499	48
USGS	L. Sac R. @Walnut Grove	12/4/1989	3	48
USGS	L. Sac R. @Walnut Grove	1/8/1990	13	42
USGS	L. Sac R. @Walnut Grove	2/6/1990	11	100
USGS	L. Sac R. @Walnut Grove	3/5/1990	194	98
USGS	L. Sac R. @Walnut Grove	4/4/1990	0.499	166
USGS	L. Sac R. @Walnut Grove	5/10/1990	16	190
USGS	L. Sac R. @Walnut Grove	6/4/1990	6	195
USGS	L. Sac R. @Walnut Grove	1/26/1994	14	74
USGS	L. Sac R. @Walnut Grove	6/28/1994	8	22
USGS	L. Sac R. @Walnut Grove	1/10/1995	6	21
USGS	L. Sac R. @Walnut Grove	6/29/1995	14	120
USGS	L. Sac R. @Walnut Grove	1/16/1996	7	28
USGS	L. Sac R. @Walnut Grove	6/18/1996	37	76
COEKC	Sac R. nr. Dadeville	4/14/1993	25	370
COEKC	Sac R. nr. Dadeville	3/16/1994	14	440

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
COEKC	Sac R. nr. Dadeville	4/13/1994	127	3020
COEKC	Sac R. nr. Dadeville	5/10/1994	36	1200
COEKC	Sac R. nr. Dadeville	6/16/1994	33	185
COEKC	Sac R. nr. Dadeville	7/12/1994	16	70
COEKC	Sac R. nr. Dadeville	8/16/1994	18	39
COEKC	Sac R. nr. Dadeville	9/7/1994	25	130
COEKC	Sac R. nr. Dadeville	10/11/1994	11	174
COEKC	Sac R. nr. Dadeville	11/21/1994	47	1120
USGS	L. Sac R. @Walnut Grove	11/3/1999	0.499	6.2
USGS	L. Sac R. @Walnut Grove	1/11/2000	2	20
USGS	L. Sac R. @Walnut Grove	5/24/2000	33	13
USGS	L. Sac R. @Walnut Grove	7/26/2000	4.99	106
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 11)	1/30/2001	6	0.9
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 13)	1/30/2001	2	1.3
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 14)	1/30/2001	6	5
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 15)	1/30/2001	4	8.4
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 16)	1/30/2001	8	1.2
Murphy	Trib to Cynthia Cr. US of Murphy OOP (Site 26)	1/30/2001	6	0.1
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 11)	2/19/2001	8	0.3
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 13)	2/19/2001	2	0.05
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 16)	2/19/2001	2	0.3
Murphy	Trib to Cynthia Cr. US of Murphy OOP (Site 26)	2/19/2001	4	0.5
Murphy	Trib to Cynthia Cr. US of Murphy OOP (Site 27)	2/19/2001	1	0.1
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 11)	3/24/2001	8	0.4
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 15)	3/24/2001	20	0.9
Murphy	Trib to Cynthia Cr. US of Murphy OOP (Site 26)	3/24/2001	25	0.1
Murphy	Wilkey Cr. @ Murphy OOP (Site 17)	1/30/2001	76	13.3
Murphy	Trib to Cynthia Cr. @ Murphy OOP (Site 20)	1/30/2001	260	2.5
Murphy	Cynthia Cr. DS of Murphy OOP (Site 23)	1/30/2001	4	15.3
Murphy	Wilkey Cr. @ Murphy OOP (Site 17)	2/19/2001	8	9.6
Murphy	Trib to Cynthia Cr. @ Murphy OOP (Site 20)	2/19/2001	4	0.8
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 22)	2/19/2001	6	4.4
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 32)	2/19/2001	4	0.4
Murphy	Wilkey Cr. @ Murphy OOP (Site 17)	3/24/2001	28	2.6
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 22)	3/24/2001	28	1.8
Murphy	Cynthia Cr. DS of Murphy OOP (Site 23)	3/24/2001	10	1.2
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 32)	3/24/2001	1	0.2
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 14)	4/16/2001	4	0.46
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 15)	4/16/2001	3	0.95
Murphy	Trib to Cynthia Cr. US of Murphy OOP (Site 26)	4/16/2001	6	0.04
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 11)	5/22/2001	8	0.04
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 13)	5/22/2001	42	0.11
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 14)	5/22/2001	14	0.11
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 15)	5/22/2001	0.499	0.43
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 16)	5/22/2001	6.45	0.08
Murphy	Trib to Cynthia Cr. US of Murphy OOP (Site 26)	5/22/2001	25.6	0.03
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 11)	6/5/2001	0.499	0.11

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 13)	6/5/2001	0.499	0.27
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 14)	6/5/2001	0.499	0.12
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 15)	6/5/2001	0.499	0.37
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 16)	6/5/2001	0.499	0.37
Murphy	Trib to Cynthia Cr. US of Murphy OOP (Site 26)	6/5/2001	0.499	0.02
Murphy	Trib to Cynthia Cr. US of Murphy OOP (Site 27)	6/5/2001	0.499	0.42
Murphy	Wilkey Cr. @ Murphy OOP (Site 17)	4/16/2001	7	3.88
Murphy	Trib to Cynthia Cr. @ Murphy OOP (Site 20)	4/16/2001	12	0.19
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 22)	4/16/2001	23	1.32
Murphy	Cynthia Cr. DS of Murphy OOP (Site 23)	4/16/2001	23	2.74
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 32)	4/16/2001	5	0.88
Murphy	Wilkey Cr. @ Murphy OOP (Site 17)	5/22/2001	12	3.23
Murphy	Trib to Cynthia Cr. @ Murphy OOP (Site 20)	5/22/2001	16	0.03
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 22)	5/22/2001	19	0.56
Murphy	Cynthia Cr. DS of Murphy OOP (Site 23)	5/22/2001	22	1.45
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 32)	5/22/2001	10	0.2
Murphy	Wilkey Cr. @ Murphy OOP (Site 17)	6/5/2001	0.499	2.1
Murphy	Trib to Cynthia Cr. @ Murphy OOP (Site 20)	6/5/2001	58	0.03
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 22)	6/5/2001	0.499	0.76
Murphy	Cynthia Cr. DS of Murphy OOP (Site 23)	6/5/2001	0.0499	2.32
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 32)	6/5/2001	0.499	0.6
Murphy	Trib to Cynthia Cr. US of Murphy OOP (Site 26)	11/6/2001	13	0.01
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 11)	12/17/2001	0.499	0.01
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 14)	12/17/2001	0.499	0.11
Murphy	Trib to Cynthia Cr. US of Murphy OOP (Site 26)	12/17/2001	0.499	0.01
Murphy	Trib. to McCarty Cr. DS of Murphy OOP (Site 28)	11/6/2001	18	0.04
Murphy	Trib. to McCarty Cr. DS of Murphy OOP (Site 28)	12/17/2001	9	0.58
USGS	Sac R. nr. Dadeville	5/24/1994	96	1510
USGS	Sac R. nr. Dadeville	9/20/1994	34	44
USGS	Sac R. nr. Dadeville	5/23/1995	107	380
USGS	Brush Creek ab Green Spring	9/21/1994	3	0.39
USGS	Brush Creek ab Green Spring	5/23/1995	21	62
USGS	Brush Creek ab Green Spring	5/25/1994	15	13
USGS	L. Sac R. @Walnut Grove	11/29/2000	4.99	9.2
USGS	L. Sac R. @Walnut Grove	1/17/2001	4.99	38
USGS	L. Sac R. @Walnut Grove	5/23/2001	23	29
USGS	Sac R. nr. Dadeville	10/14/1986	5	353
USGS	Sac R. nr. Dadeville	11/5/1986	0.499	207
USGS	Sac R. nr. Dadeville	12/2/1986	6	148
USGS	Sac R. nr. Dadeville	1/5/1987	1	114
USGS	Sac R. nr. Dadeville	2/2/1987	5	253
USGS	Sac R. nr. Dadeville	3/2/1987	24	1010
USGS	Sac R. nr. Dadeville	4/7/1987	6	277
USGS	Sac R. nr. Dadeville	5/19/1987	28	103
USGS	Sac R. nr. Dadeville	6/9/1987	32	51
Murphy	Trib. to McCarty Cr. DS of Murphy OOP (Site 28)	2/20/2003	24	2.6
Murphy	Trib. to McCarty Cr. DS of Murphy OOP (Site 28)	3/25/2003	13	0.56

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
Murphy	Wilkey Cr. @ Murphy OOP (Site 17)	2/20/2003	12	2.8
Murphy	Wilkey Cr. @ Murphy OOP (Site 17)	3/25/2003	4	1.8
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 15)	2/20/2003	10	1.6
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 15)	3/25/2003	1.99	2.2
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 16)	3/25/2003	4	2.1
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 14)	3/25/2003	1.99	0.4
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 13)	3/25/2003	7	1.7
Murphy	Trib to Cynthia Cr. @ Murphy OOP (Site 20)	3/25/2003	8	0.15
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 22)	2/20/2003	1.99	0.35
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 22)	3/25/2003	1.99	0.36
Murphy	Cynthia Cr. DS of Murphy OOP (Site 23)	3/25/2003	5	0.53
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 32)	3/25/2003	1.99	0.38
Murphy	Trib to Cynthia Cr. US of Murphy OOP (Site 26)	3/25/2003	8	0.06
MDNR	Stockton Br. 0.1 mi ab. WWTP	6/24/2003	9	0.25
MDNR	Stockton WWTP effluent	6/24/2003	70	0.2
MDNR	Stockton Br. 40 yds. bl. WWTP	6/24/2003	19	0.45
MDNR	Stockton Br. 1.7 mi bl. WWTP	6/24/2003	30	0.33
USGS	L. Sac R. @Walnut Grove	10/4/2001	4.99	8.1
USGS	L. Sac R. @Walnut Grove	11/26/2001	20	22
USGS	L. Sac R. @Walnut Grove	12/10/2001	4.99	18
USGS	L. Sac R. @Walnut Grove	1/8/2002	4.99	36
USGS	L. Sac R. @Walnut Grove	2/12/2002	4.99	78
USGS	L. Sac R. @Walnut Grove	3/13/2002	4.99	78
USGS	L. Sac R. @Walnut Grove	4/15/2002	16	111
USGS	L. Sac R. @Walnut Grove	5/20/2002	18	526
USGS	L. Sac R. @Walnut Grove	6/19/2002	4.9	51
USGS	L. Sac R. @Walnut Grove	7/22/2002	18	24
USGS	L. Sac R. @Walnut Grove	8/27/2002	4.99	26
USGS	L. Sac R. @Walnut Grove	9/11/2002	10	8
USGS	Sac R. nr. Dadeville	10/8/1985	15	30
USGS	Sac R. nr. Dadeville	11/12/1985	1	54
USGS	Sac R. nr. Dadeville	12/6/1985	1	679
USGS	Sac R. nr. Dadeville	1/7/1986	2	230
USGS	Sac R. nr. Dadeville	2/10/1986	1	202
USGS	Sac R. nr. Dadeville	3/20/1986	4	234
USGS	Sac R. nr. Dadeville	4/8/1986	480	749
USGS	Sac R. nr. Dadeville	5/13/1986	40	97
USGS	Sac R. nr. Dadeville	6/3/1986	106	72
USGS	Sac R. nr. Dadeville	7/9/1986	20	32
USGS	Sac R. nr. Dadeville	8/4/1986	24	32
USGS	Sac R. nr. Dadeville	9/16/1986	57	16
USGS	Sac R. nr. Dadeville	10/2/1984	5	22
USGS	Sac R. nr. Dadeville	11/5/1984	11	400
USGS	Sac R. nr. Dadeville	12/4/1984	8	258
USGS	Sac R. nr. Dadeville	1/10/1985	7	566
USGS	Sac R. nr. Dadeville	2/19/1985	15	386
USGS	Sac R. nr. Dadeville	3/18/1985	16	361

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	Sac R. nr. Dadeville	4/15/1985	18	560
USGS	Sac R. nr. Dadeville	5/21/1985	24	171
USGS	Sac R. nr. Dadeville	6/11/1985	74	533
USGS	Sac R. nr. Dadeville	7/10/1985	24	69
USGS	Sac R. nr. Dadeville	8/5/1985	11	37
USGS	Sac R. nr. Dadeville	9/9/1985	10	60
USGS	Sac R. nr. Dadeville	11/10/1983	16	265
USGS	Sac R. nr. Dadeville	12/6/1983	5	389
USGS	Sac R. nr. Dadeville	1/3/1984	0.499	131
USGS	Sac R. nr. Dadeville	2/6/1984	0.99	101
USGS	Sac R. nr. Dadeville	3/5/1984	120	1560
USGS	Sac R. nr. Dadeville	4/2/1984	42	674
USGS	Sac R. nr. Dadeville	5/8/1984	19	752
USGS	Sac R. nr. Dadeville	6/5/1984	33	84
USGS	Sac R. nr. Dadeville	7/10/1984	0.99	136
USGS	Sac R. nr. Dadeville	8/6/1984	12	29
USGS	Sac R. nr. Dadeville	9/11/1984	12	29
USGS	L. Sac R. @Walnut Grove	10/18/1983	22	40
USGS	L. Sac R. @Walnut Grove	11/10/1983	1	50
USGS	L. Sac R. @Walnut Grove	12/6/1983	2	194
USGS	L. Sac R. @Walnut Grove	1/3/1984	5	40
USGS	L. Sac R. @Walnut Grove	2/6/1984	0.99	40
USGS	L. Sac R. @Walnut Grove	3/5/1984	45	895
USGS	L. Sac R. @Walnut Grove	4/2/1984	17	250
USGS	L. Sac R. @Walnut Grove	5/8/1984	5	100
USGS	L. Sac R. @Walnut Grove	6/5/1984	21	28
USGS	L. Sac R. @Walnut Grove	7/10/1984	23	40
USGS	L. Sac R. @Walnut Grove	8/6/1984	12	30
USGS	L. Sac R. @Walnut Grove	9/11/1984	14	30
USGS	L. Sac R. @Walnut Grove	10/15/2002	4.99	8.4
USGS	L. Sac R. @Walnut Grove	11/4/2002	4.99	15
USGS	L. Sac R. @Walnut Grove	12/9/2002	4.99	10
USGS	L. Sac R. @Walnut Grove	1/22/2003	4.99	47
USGS	L. Sac R. @Walnut Grove	2/11/2003	4.99	6.2
USGS	L. Sac R. @Walnut Grove	3/18/2003	4.99	56
USGS	L. Sac R. @Walnut Grove	4/15/2003	10	26
USGS	L. Sac R. @Walnut Grove	5/14/2003	30	128
USGS	L. Sac R. @Walnut Grove	6/17/2003	10	196
USGS	L. Sac R. @Walnut Grove	7/8/2003	23	20
USGS	L. Sac R. @Walnut Grove	8/21/2003	13	8.3
USGS	L. Sac R. @Walnut Grove	9/8/2003	4.99	19
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 14)	4/28/2003	6	0.98
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 15)	4/28/2003	0.499	1.88
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 16)	4/28/2003	22	0.53
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 13)	5/29/2003	12	0.1
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 14)	5/29/2003	11	0.05
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 15)	5/29/2003	0.499	1.89

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 16)	5/29/2003	0.499	0.51
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 13)	6/19/2003	24	0.1
Murphy	Trib to Wilkey Cr. US of Murphy OOP (Site 15)	6/19/2003	7	1.2
Murphy	Wilkey Cr. @ Murphy OOP (Site 17)	4/28/2003	5	1
Murphy	Trib to Cynthia Cr. @ Murphy OOP (Site 20)	4/28/2003	4	0.16
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 22)	4/28/2003	0.499	0.25
Murphy	Cynthia Cr. DS of Murphy OOP (Site 23)	4/28/2003	4	1.5
Murphy	Trib. to McCarty Cr. DS of Murphy OOP (Site 28)	4/28/2003	10	0.29
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 32)	4/28/2003	11	0.14
Murphy	Wilkey Cr. @ Murphy OOP (Site 17)	5/29/2003	0.499	0.67
Murphy	Trib to Cynthia Cr. @ Murphy OOP (Site 20)	5/22/2003	8	0.29
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 22)	5/22/2003	7	0.34
Murphy	Cynthia Cr. DS of Murphy OOP (Site 23)	5/22/2003	0.499	1.4
Murphy	Trib. to McCarty Cr. DS of Murphy OOP (Site 28)	5/22/2003	14	0.1
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 32)	5/22/2003	5	0.34
Murphy	Wilkey Cr. @ Murphy OOP (Site 17)	6/19/2003	9	0.33
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 22)	6/19/2003	48	1.6
Murphy	Cynthia Cr. DS of Murphy OOP (Site 23)	6/19/2003	81	0.43
Murphy	Trib to Cynthia Cr. DS of Murphy OOP (Site 32)	6/19/2003	47	0.17
USGS	L. Sac R. @Walnut Grove	10/15/2003	4.99	9.1
USGS	L. Sac R. @Walnut Grove	11/5/2003	4.99	21
USGS	L. Sac R. @Walnut Grove	12/9/2003	4.99	21
USGS	L. Sac R. @Walnut Grove	1/20/2004	4.99	203
USGS	L. Sac R. @Walnut Grove	2/9/2004	4.99	73
USGS	L. Sac R. @Walnut Grove	3/11/2004	10	194
USGS	L. Sac R. @Walnut Grove	4/19/2004	17	37
USGS	L. Sac R. @Walnut Grove	5/12/2004	18	71
USGS	L. Sac R. @Walnut Grove	6/7/2004	16	22
USGS	L. Sac R. @Walnut Grove	7/19/2004	15	9.1
USGS	L. Sac R. @Walnut Grove	8/24/2004	14	9.4
USGS	L. Sac R. @Walnut Grove	9/13/2004	10	7.8
MDNR	Brush Cr. 6.2 mi.bl. Humansville WWTP	7/6/2005	8	3.14
MDNR	Brush Cr. 2.9 mi.bl. Humansville WWTP	7/6/2005	10	1.76
MDNR	Brush Cr. 1.8 mi.bl. Humansville WWTP	7/6/2005	9	2.19
MDNR	Brush Cr. 0.2 mi.bl. Humansville WWTP	7/6/2005	7	1.59
MDNR	Brush Cr. 0.3 mi.ab. Humansville WWTP	7/6/2005	2.499	0.82
MDNR	Panther Cr. @Hwy 13	7/5/2005	12	0.56
MDNR	Sadler Br. At Hwy N	7/5/2005	5	0.44
MDNR	Brush Cr. 1.8 mi.bl. Humansville WWTP	7/19/2005	6	0.96
MDNR	Brush Cr. 2.9 mi.bl. Humansville WWTP	7/19/2005	5	0.57
MDNR	Brush Cr. 6.2 mi.bl. Humansville WWTP	7/19/2005	8	0.75
MDNR	Panther Cr. @Hwy 13	7/19/2005	12	0.004
MDNR	Brush Cr. 0.3 mi.ab. Humansville WWTP	7/19/2005	9	0.44
MDNR	Sadler Br. At Hwy N	7/19/2005	10	0.3
MDNR	Brush Cr. 0.2 mi.bl. Humansville WWTP	7/19/2005	8	0.56
USGS	L. Sac R. @Walnut Grove	10/25/2004	4.99	12
USGS	L. Sac R. @Walnut Grove	11/16/2004	4.99	81

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	L. Sac R. @Walnut Grove	12/14/2004	4.99	130
USGS	L. Sac R. @Walnut Grove	1/20/2005	4.99	233
USGS	L. Sac R. @Walnut Grove	2/8/2005	4.99	42
USGS	L. Sac R. @Walnut Grove	3/29/2005	4.99	80
USGS	L. Sac R. @Walnut Grove	4/11/2005	10	186
USGS	L. Sac R. @Walnut Grove	5/24/2005	45	7.3
USGS	L. Sac R. @Walnut Grove	6/14/2005	23	14
USGS	L. Sac R. @Walnut Grove	7/27/2005	21	52
USGS	L. Sac R. @Walnut Grove	8/9/2005	12	8.8
USGS	L. Sac R. @Walnut Grove	9/19/2005	18	19
USGS	L. Sac R. @Walnut Grove	10/24/2005	4.99	6.1
USGS	L. Sac R. @Walnut Grove	11/29/2005	4.99	14
USGS	L. Sac R. @Walnut Grove	12/12/2005	4.99	13
USGS	L. Sac R. @Walnut Grove	1/17/2006	15	16
USGS	L. Sac R. @Walnut Grove	2/14/2006	4.99	8.9
USGS	L. Sac R. @Walnut Grove	3/20/2006	4.99	5.6
USGS	L. Sac R. @Walnut Grove	4/18/2006	4.99	10
USGS	L. Sac R. @Walnut Grove	5/23/2006	29	74
USGS	L. Sac R. @Walnut Grove	6/19/2006	4.99	7
USGS	L. Sac R. @Walnut Grove	7/27/2006	11	10
USGS	L. Sac R. @Walnut Grove	8/29/2006	20	21
USGS	L. Sac R. @Walnut Grove	9/18/2006	50	65
USGS	L. Sac R. @Walnut Grove	10/24/2006	4.99	6.7
USGS	L. Sac R. @Walnut Grove	11/15/2006	4.99	14
USGS	L. Sac R. @Walnut Grove	12/11/2006	4.99	5.6
USGS	L. Sac R. @Walnut Grove	1/22/2007	10	317
USGS	L. Sac R. @Walnut Grove	2/26/2007	4.99	30
USGS	L. Sac R. @Walnut Grove	3/5/2007	4.99	17
USGS	L. Sac R. @Walnut Grove	4/17/2007	4.99	254
USGS	L. Sac R. @Walnut Grove	5/8/2007	4.99	88
USGS	L. Sac R. @Walnut Grove	6/25/2007	4.99	28
USGS	L. Sac R. @Walnut Grove	7/23/2007	12	6.1
USGS	L. Sac R. @Walnut Grove	8/7/2007	4.99	18
USGS	L. Sac R. @Walnut Grove	9/17/2007	4.99	54
USGS	L. Sac R. @Walnut Grove	10/16/2007	4.99	16
USGS	L. Sac R. @Walnut Grove	11/6/2007	4.99	10
USGS	L. Sac R. @Walnut Grove	12/17/2007	4.99	9
USGS	L. Sac R. @Walnut Grove	1/22/2008	4.99	14
USGS	L. Sac R. @Walnut Grove	2/13/2008	4.99	218
USGS	L. Sac R. @Walnut Grove	3/17/2008	4.99	59
USGS	L. Sac R. @Walnut Grove	4/22/2008	4.99	80
USGS	L. Sac R. @Walnut Grove	5/27/2008	4.99	41
USGS	L. Sac R. @Walnut Grove	6/3/2008	15	31
USGS	L. Sac R. @Walnut Grove	7/22/2008	4.99	5.6
USGS	L. Sac R. @Walnut Grove	8/4/2008	4.99	12
USGS	L. Sac R. @Walnut Grove	9/16/2008	4.99	255
USGS	Pomme de Terre R. nr. Polk	11/3/1999	7	9.7

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	Pomme de Terre R. nr. Polk	5/22/2000	4.99	16
USGS	Pomme de Terre R. nr. Polk	1/11/1999	0.499	170
USGS	Pomme de Terre R. nr. Polk	7/12/1999	6	58
USGS	Pomme de Terre R. nr. Polk	11/4/1997	5	19
USGS	Pomme de Terre R. nr. Polk	1/8/1998	12	546
USGS	Pomme de Terre R. nr. Polk	7/13/1998	23	105
USGS	Pomme de Terre R. nr. Polk	11/4/1996	2	222
USGS	Pomme de Terre R. nr. Polk	1/22/1997	8	416
USGS	Pomme de Terre R. nr. Polk	6/24/1997	19	27
USGS	Pomme de Terre R. nr. Polk	8/12/1997	28	43
USGS	Pomme de Terre R. nr. Polk	11/7/1995	9	8.3
USGS	Pomme de Terre R. nr. Polk	1/16/1996	0.499	40
USGS	Pomme de Terre R. nr. Polk	6/19/1996	9	35
USGS	Pomme de Terre R. nr. Polk	8/5/1996	0.499	11
USGS	Pomme de Terre R. nr. Polk	11/23/1994	44	475
USGS	Pomme de Terre R. nr. Polk	1/11/1995	4	66
USGS	Pomme de Terre R. nr. Polk	6/29/1995	56	1660
USGS	Pomme de Terre R. nr. Polk	8/24/1995	26	10
USGS	Pomme de Terre R. nr. Polk	5/25/1994	45	129
USGS	Pomme de Terre R. nr. Polk	9/21/1994	11	9.1
USGS	Pomme de Terre R. nr. Polk	11/24/1993	4	257
USGS	Pomme de Terre R. nr. Polk	1/27/1994	28	461
USGS	Pomme de Terre R. nr. Polk	5/28/1994	20	27
USGS	Pomme de Terre R. nr. Polk	11/17/1992	0.499	183
USGS	Pomme de Terre R. nr. Polk	1/12/1993	20	536
USGS	Pomme de Terre R. nr. Polk	3/10/1993	8	331
USGS	Pomme de Terre R. nr. Polk	5/5/1993	25	337
USGS	Pomme de Terre R. nr. Polk	7/27/1993	19	56
USGS	Pomme de Terre R. nr. Polk	9/28/1993	18	1040
USGS	Pomme de Terre R. nr. Polk	11/27/2000	4.99	20
USGS	Pomme de Terre R. nr. Polk	5/23/2001	16	100
USGS	Pomme de Terre R. nr. Polk	11/26/2001	4.99	38
USGS	Pomme de Terre R. nr. Polk	1/9/2002	4.99	78
USGS	Pomme de Terre R. nr. Polk	3/13/2002	4.99	212
USGS	Pomme de Terre R. nr. Polk	5/20/2002	17	630
USGS	Pomme de Terre R. nr. Polk	7/22/2002	12	12
USGS	Pomme de Terre R. nr. Polk	9/9/2002	4.99	9.7
USGS	Pomme de Terre R. nr. Polk	10/8/1985	7	7.9
USGS	Pomme de Terre R. nr. Polk	11/12/1985	1	28
USGS	Pomme de Terre R. nr. Polk	12/3/1985	1	761
USGS	Pomme de Terre R. nr. Polk	1/7/1986	1	95
USGS	Pomme de Terre R. nr. Polk	2/10/1986	4	348
USGS	Pomme de Terre R. nr. Polk	11/5/1984	4	307
USGS	Pomme de Terre R. nr. Polk	12/4/1984	9	150
USGS	Pomme de Terre R. nr. Polk	1/11/1985	4	268
USGS	Pomme de Terre R. nr. Polk	2/19/1985	34	959
USGS	Pomme de Terre R. nr. Polk	3/18/1985	11	420

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	Pomme de Terre R. nr. Polk	4/15/1985	8	451
USGS	Pomme de Terre R. nr. Polk	5/21/1985	13	80
USGS	Pomme de Terre R. nr. Polk	6/11/1985	43	974
USGS	Pomme de Terre R. nr. Polk	7/9/1985	3	58
USGS	Pomme de Terre R. nr. Polk	8/5/1985	9	15
USGS	Pomme de Terre R. nr. Polk	9/9/1985	20	16
USGS	Pomme de Terre R. nr. Polk	11/10/1983	13	275
USGS	Pomme de Terre R. nr. Polk	12/6/1983	6	536
USGS	Pomme de Terre R. nr. Polk	1/3/1984	2	114
USGS	Pomme de Terre R. nr. Polk	2/6/1984	0.99	104
USGS	Pomme de Terre R. nr. Polk	3/5/1984	72	1540
USGS	Pomme de Terre R. nr. Polk	4/2/1984	11	481
USGS	Pomme de Terre R. nr. Polk	5/8/1984	6	238
USGS	Pomme de Terre R. nr. Polk	6/5/1984	16	47
USGS	Pomme de Terre R. nr. Polk	7/10/1984	24	74
USGS	Pomme de Terre R. nr. Polk	8/6/1984	8	7.5
USGS	Pomme de Terre R. nr. Polk	9/11/1984	21	31
USGS	Pomme de Terre R. nr. Polk	11/4/2002	4.99	11
USGS	Pomme de Terre R. nr. Polk	1/23/2003	4.99	17
USGS	Pomme de Terre R. nr. Polk	3/18/2003	4.99	76
USGS	Pomme de Terre R. nr. Polk	5/14/2003	18	125
USGS	Pomme de Terre R. nr. Polk	7/9/2003	19	11
USGS	Pomme de Terre R. nr. Polk	9/8/2003	4.99	13
USGS	Pomme de Terre R. nr. Polk	11/5/2003	10	27
USGS	Pomme de Terre R. nr. Polk	1/20/2004	10	641
USGS	Pomme de Terre R. nr. Polk	3/8/2004	11	674
USGS	Pomme de Terre R. nr. Polk	5/12/2004	12	135
USGS	Pomme de Terre R. nr. Polk	7/19/2004	4.99	29
USGS	Pomme de Terre R. nr. Polk	9/13/2004	4.99	5.2
USGS	Pomme de Terre R. nr. Polk	11/16/2004	4.99	221
USGS	Pomme de Terre R. nr. Polk	1/20/2005	4.99	377
USGS	Pomme de Terre R. nr. Polk	3/28/2005	4.99	256
USGS	Pomme de Terre R. nr. Polk	5/23/2005	11	44
USGS	Pomme de Terre R. nr. Polk	7/27/2005	15	11
USGS	Pomme de Terre R. nr. Polk	9/19/2005	22	62
USGS	Pomme de Terre R. nr. Polk	11/29/2005	4.99	19
USGS	Pomme de Terre R. nr. Polk	1/17/2006	4.99	31
USGS	Pomme de Terre R. nr. Polk	3/20/2006	4.99	38
USGS	Pomme de Terre R. nr. Polk	5/22/2006	56	270
USGS	Pomme de Terre R. nr. Polk	7/12/2006	13	21
USGS	Pomme de Terre R. nr. Polk	9/18/2006	19	1.6
USGS	Pomme de Terre R. nr. Polk	11/15/2006	4.99	21
USGS	Pomme de Terre R. nr. Polk	1/22/2007	28	1250
USGS	Pomme de Terre R. nr. Polk	2/27/2007	4.99	227
USGS	Pomme de Terre R. nr. Polk	3/5/2007	4.99	141
USGS	Pomme de Terre R. nr. Polk	4/17/2007	23	510
USGS	Pomme de Terre R. nr. Polk	5/8/2007	4.99	204

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	Pomme de Terre R. nr. Polk	6/25/2007	10	143
USGS	Pomme de Terre R. nr. Polk	7/23/2007	4.99	43
USGS	Pomme de Terre R. nr. Polk	9/17/2007	4.99	59
USGS	Pomme de Terre R. nr. Polk	11/5/2007	4.99	15
USGS	Pomme de Terre R. nr. Polk	1/22/2008	4.99	100
USGS	Pomme de Terre R. nr. Polk	3/17/2008	4.99	236
USGS	Pomme de Terre R. nr. Polk	5/27/2008	4.99	404
USGS	Pomme de Terre R. nr. Polk	7/21/2008	4.99	85
USGS	Pomme de Terre R. nr. Polk	9/15/2008	69	988
USGS	Big Buffalo Cr. 2 mi. SW of Boylers Mill	1/21/1997	0.499	5.5
USGS	Big Buffalo Cr. 2 mi. SW of Boylers Mill	6/13/1997	11	124
USGS	Big Buffalo Cr. 2 mi. SW of Boylers Mill	1/30/1996	3	7.8
USGS	Big Buffalo Cr. 2 mi. SW of Boylers Mill	6/14/1996	1	5.9
USGS	Coakley Hollow	4/24/1996	1	1
USGS	Coakley Hollow	6/12/1996	2	0.5
USGS	Coakley Hollow	8/21/1996	0.499	0.18
USGS	Big Buffalo Cr. 2 mi. SW of Boylers Mill	1/25/1995	2	13
USGS	Big Buffalo Cr. 2 mi. SW of Boylers Mill	6/23/1995	4	20
USGS	Coakley Hollow	11/15/1994	8	2
USGS	Coakley Hollow	4/24/1995	6	11
USGS	Coakley Hollow	6/26/1995	2	1
USGS	Coakley Hollow	8/30/1995	6	0.2
USGS	Big Buffalo Cr. 2 mi. SW of Boylers Mill	1/14/1994	4	9.3
USGS	Big Buffalo Cr. 2 mi. SW of Boylers Mill	6/9/1994	8	14
USGS	Coakley Hollow	11/9/1993	0.499	0.55
USGS	Coakley Hollow	6/3/1994	6	0.32
USGS	Coakley Hollow	8/25/1994	0.499	0.2
USGS	Niangua R.@Hwy 64	11/15/1999	1	148
USGS	Niangua R.@Hwy 64	5/16/2000	4.99	150
USGS	Niangua R.@Hwy 64	1/19/1999	5	860
USGS	Niangua R.@Hwy 64	6/9/1999	1	307
USGS	Niangua R.@Hwy 64	1/20/1998	10	390
USGS	Niangua R.@Hwy 64	6/8/1998	4	250
USGS	Dousinbury Cr. @Hwy JJ	11/15/1996	0.1	45
USGS	Dousinbury Cr. @Hwy JJ	2/27/1997	0.5	110
USGS	Niangua R.@Hwy 64	1/22/1997	6	660
USGS	Niangua R.@Hwy 64	6/26/1997	8	270
USGS	Dousinbury Cr. @Hwy JJ	11/21/1995	31	1.6
USGS	Dousinbury Cr. @Hwy JJ	1/19/1996	20	51
USGS	Dousinbury Cr. @Hwy JJ	4/3/1996	20	21
USGS	Dousinbury Cr. @Hwy JJ	5/15/1996	10	88
USGS	Dousinbury Cr. @Hwy JJ	6/27/1996	13	5.3
USGS	Dousinbury Cr. @Hwy JJ	7/24/1996	19	2.2
USGS	Dousinbury Cr. @Hwy JJ	8/19/1996	44	0.67
USGS	Niangua R.@Hwy 64	1/31/1996	0.499	170
USGS	Hahatonka Spring	12/5/1995	0.499	79
USGS	Hahatonka Spring	4/25/1996	9	250

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	Hahatonka Spring	6/12/1996	2	124
USGS	Hahatonka Spring	8/21/1996	0.499	124
USGS	Dousinbury Cr. @Hwy JJ	10/4/1994	10	2.3
USGS	Dousinbury Cr. @Hwy JJ	10/31/1994	3	4.3
USGS	Dousinbury Cr. @Hwy JJ	12/6/1994	10	13
USGS	Dousinbury Cr. @Hwy JJ	1/9/1995	3	4
USGS	Dousinbury Cr. @Hwy JJ	2/6/1995	2	30
USGS	Dousinbury Cr. @Hwy JJ	3/8/1995	6	48
USGS	Dousinbury Cr. @Hwy JJ	4/3/1995	23	7.8
USGS	Dousinbury Cr. @Hwy JJ	5/17/1995	336	137
USGS	Dousinbury Cr. @Hwy JJ	6/20/1995	20	17
USGS	Dousinbury Cr. @Hwy JJ	7/12/1995	35	9.3
USGS	Dousinbury Cr. @Hwy JJ	8/16/1995	24	3.7
USGS	Niangua R. nr. Windyville	10/4/1994	25	38
USGS	Niangua R. nr. Windyville	11/1/1994	8	88
USGS	Niangua R. nr. Windyville	12/6/1994	55	186
USGS	Niangua R. nr. Windyville	1/10/1995	10	101
USGS	Niangua R. nr. Windyville	2/6/1995	5	425
USGS	Niangua R. nr. Windyville	3/9/1995	18	569
USGS	Niangua R. nr. Windyville	4/3/1995	27	123
USGS	Niangua R. nr. Windyville	5/17/1995	33	438
USGS	Niangua R. nr. Windyville	6/20/1995	31	319
USGS	Niangua R. nr. Windyville	7/12/1995	32	164
USGS	Niangua R. nr. Windyville	8/16/1995	42	94
USGS	Niangua R.@Hwy 64	1/26/1995	4	747
USGS	Niangua R.@Hwy 64	6/30/1995	22	840
USGS	Hahatonka Spring	11/15/1994	32	177
USGS	Hahatonka Spring	4/24/1995	8	170
USGS	Hahatonka Spring	6/26/1995	6	250
USGS	Hahatonka Spring	8/29/1995	2	104
USGS	Dousinbury Cr. @Hwy JJ	10/5/1993	17	22
USGS	Dousinbury Cr. @Hwy JJ	11/15/1993	28	372
USGS	Dousinbury Cr. @Hwy JJ	12/6/1993	12	216
USGS	Dousinbury Cr. @Hwy JJ	2/7/1994	1	7.6
USGS	Dousinbury Cr. @Hwy JJ	2/22/1994	655	983
USGS	Dousinbury Cr. @Hwy JJ	3/7/1994	16	25
USGS	Dousinbury Cr. @Hwy JJ	3/22/1994	14	6
USGS	Dousinbury Cr. @Hwy JJ	4/5/1994	2	20
USGS	Dousinbury Cr. @Hwy JJ	4/14/1994	6	120
USGS	Dousinbury Cr. @Hwy JJ	4/18/1994	5	48
USGS	Dousinbury Cr. @Hwy JJ	4/28/1994	279	2020
USGS	Dousinbury Cr. @Hwy JJ	5/11/1994	4	48
USGS	Dousinbury Cr. @Hwy JJ	5/16/1994	4	73
USGS	Dousinbury Cr. @Hwy JJ	5/26/1994	1	17
USGS	Dousinbury Cr. @Hwy JJ	6/2/1994	16	12
USGS	Dousinbury Cr. @Hwy JJ	6/9/1994	5	25
USGS	Dousinbury Cr. @Hwy JJ	6/14/1994	11	10

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	Dousinbury Cr. @Hwy JJ	6/22/1994	3	5.3
USGS	Dousinbury Cr. @Hwy JJ	6/29/1994	18	3.2
USGS	Dousinbury Cr. @Hwy JJ	7/12/1994	3	1.6
USGS	Dousinbury Cr. @Hwy JJ	7/25/1994	3	7.7
USGS	Dousinbury Cr. @Hwy JJ	8/16/1994	2	1.8
USGS	Dousinbury Cr. @Hwy JJ	9/1/1994	4	21
USGS	Niangua R. nr. Windyville	10/5/1993	10	332
USGS	Niangua R. nr. Windyville	11/15/1993	58	1720
USGS	Niangua R. nr. Windyville	12/6/1993	13	627
USGS	Niangua R. nr. Windyville	1/4/1994	7	158
USGS	Niangua R. nr. Windyville	2/10/1994	4	160
USGS	Niangua R. nr. Windyville	3/7/1994	21	609
USGS	Niangua R. nr. Windyville	4/5/1994	6	393
USGS	Niangua R. nr. Windyville	5/17/1994	26	840
USGS	Niangua R. nr. Windyville	6/2/1994	13	225
USGS	Niangua R. nr. Windyville	6/14/1994	32	239
USGS	Niangua R. nr. Windyville	7/12/1994	19	44
USGS	Niangua R. nr. Windyville	8/11/1994	11	33
USGS	Niangua R. nr. Windyville	9/7/1994	31	133
USGS	Hahatonka Spring	11/5/1993	4	150
USGS	Hahatonka Spring	4/6/1994	6	162
USGS	Hahatonka Spring	6/7/1994	10	300
USGS	Hahatonka Spring	8/25/1994	30	97
USGS	Dousinbury Cr. @Hwy JJ	4/21/1993	24	28
USGS	Dousinbury Cr. @Hwy JJ	5/20/1993	9	44
USGS	Dousinbury Cr. @Hwy JJ	6/14/1993	17	38
USGS	Dousinbury Cr. @Hwy JJ	7/7/1993	37	11
USGS	Dousinbury Cr. @Hwy JJ	8/25/1993	26	0.62
USGS	Dousinbury Cr. @Hwy JJ	9/14/1993	90	720
USGS	Niangua R. nr. Windyville	4/21/1993	20	441
USGS	Niangua R. nr. Windyville	5/20/1993	45	638
USGS	Niangua R. nr. Windyville	6/14/1993	86	565
USGS	Niangua R. nr. Windyville	7/8/1993	60	201
USGS	Niangua R. nr. Windyville	8/25/1993	39	20
USGS	Niangua R. nr. Windyville	9/14/1993	343	6480
USGS	Niangua R.@Hwy 64	11/17/1992	0.499	364
USGS	Niangua R.@Hwy 64	3/11/1993	18	560
USGS	Niangua R.@Hwy 64	5/5/1993	27	1000
USGS	Niangua R.@Hwy 64	9/14/1993	396	7000
USGS	Niangua R.@Hwy 64	11/20/2000	4.99	119
USGS	Niangua R.@Hwy 64	5/24/2001	8	497
USGS	Niangua R.@Hwy 64	10/5/1987	3	100
USGS	Niangua R.@Hwy 64	11/3/1987	0.499	145
USGS	Niangua R.@Hwy 64	12/8/1987	9	1020
USGS	Niangua R.@Hwy 64	2/2/1988	4	1360
USGS	Niangua R.@Hwy 64	3/1/1988	14	600
USGS	Niangua R.@Hwy 64	4/5/1988	30	1650

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	Niangua R.@Hwy 64	5/10/1988	0.499	260
USGS	Niangua R.@Hwy 64	6/10/1988	1	340
USGS	Niangua R.@Hwy 64	7/12/1988	9	180
USGS	Niangua R.@Hwy 64	8/2/1988	4	160
USGS	Niangua R.@Hwy 64	9/6/1988	32	135
USGS	Niangua R.@Hwy 64	10/14/1986	10	840
USGS	Niangua R.@Hwy 64	11/5/1986	3	490
USGS	Niangua R.@Hwy 64	12/2/1986	0.499	80
USGS	Niangua R.@Hwy 64	1/5/1987	1	250
USGS	Niangua R.@Hwy 64	2/2/1987	4	460
USGS	Niangua R.@Hwy 64	3/2/1987	31	1460
USGS	Niangua R.@Hwy 64	4/7/1987	3	432
USGS	Niangua R.@Hwy 64	5/19/1987	1	190
USGS	Niangua R.@Hwy 64	6/9/1987	4	150
USGS	Niangua R.@Hwy 64	7/7/1987	0.499	80
USGS	Niangua R.@Hwy 64	8/4/1987	3	147
USGS	Niangua R.@Hwy 64	9/1/1987	1	125
USGS	Niangua R.@Hwy 64	11/1/2001	4.99	147
USGS	Niangua R.@Hwy 64	1/22/2002	4.99	171
USGS	Niangua R.@Hwy 64	3/18/2002	4.99	376
USGS	Niangua R.@Hwy 64	5/21/2002	18	1160
USGS	Niangua R.@Hwy 64	7/29/2002	4.99	165
USGS	Niangua R.@Hwy 64	9/9/2002	4.99	140
USGS	Niangua R.@Hwy 64	10/8/1985	6	270
USGS	Niangua R.@Hwy 64	11/12/1985	1	145
USGS	Niangua R.@Hwy 64	12/3/1985	10	1900
USGS	Niangua R.@Hwy 64	1/7/1986	1	265
USGS	Niangua R.@Hwy 64	2/10/1986	6	680
USGS	Niangua R.@Hwy 64	3/18/1986	4	260
USGS	Niangua R.@Hwy 64	4/8/1986	14	6300
USGS	Niangua R.@Hwy 64	5/13/1986	29	310
USGS	Niangua R.@Hwy 64	6/5/1986	153	1250
USGS	Niangua R.@Hwy 64	7/7/1986	6	225
USGS	Niangua R.@Hwy 64	8/4/1986	3	135
USGS	Niangua R.@Hwy 64	9/16/1986	3	150
USGS	Niangua R.@Hwy 64	10/2/1984	1	125
USGS	Niangua R.@Hwy 64	11/5/1984	5	753
USGS	Niangua R.@Hwy 64	12/4/1984	6	360
USGS	Niangua R.@Hwy 64	1/11/1985	2	605
USGS	Niangua R.@Hwy 64	2/19/1985	14	1050
USGS	Niangua R.@Hwy 64	3/18/1985	13	1050
USGS	Niangua R.@Hwy 64	4/15/1985	7	1130
USGS	Niangua R.@Hwy 64	5/21/1985	3	340
USGS	Niangua R.@Hwy 64	6/11/1985	107	3280
USGS	Niangua R.@Hwy 64	7/9/1985	2	300
USGS	Niangua R.@Hwy 64	8/5/1985	0.499	175
USGS	Niangua R.@Hwy 64	9/9/1985	1	174

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	Niangua R.@Hwy 64	10/18/1983	0.499	125
USGS	Niangua R.@Hwy 64	11/10/1983	5	540
USGS	Niangua R.@Hwy 64	12/6/1983	7	1100
USGS	Niangua R.@Hwy 64	1/3/1984	1	185
USGS	Niangua R.@Hwy 64	2/6/1984	1	200
USGS	Niangua R.@Hwy 64	3/5/1984	184	6290
USGS	Niangua R.@Hwy 64	4/2/1984	6	860
USGS	Niangua R.@Hwy 64	5/8/1984	1	700
USGS	Niangua R.@Hwy 64	6/5/1984	6	95
USGS	Niangua R.@Hwy 64	7/10/1984	3	271
USGS	Niangua R.@Hwy 64	8/6/1984	2	135
USGS	Niangua R.@Hwy 64	9/11/1984	7	200
USGS	Niangua R.@Hwy 64	10/6/1982	2	122
USGS	Niangua R.@Hwy 64	12/16/1982	0.499	550
USGS	Niangua R.@Hwy 64	2/8/1983	0.499	345
USGS	Niangua R.@Hwy 64	3/15/1983	1	320
USGS	Niangua R.@Hwy 64	4/5/1983	38	1840
USGS	Niangua R.@Hwy 64	5/3/1983	24	2200
USGS	Niangua R.@Hwy 64	6/6/1983	12	590
USGS	Niangua R.@Hwy 64	7/5/1983	5	40
USGS	Niangua R.@Hwy 64	8/9/1983	14	174
USGS	Niangua R.@Hwy 64	9/22/1983	5	112
USGS	Niangua R.@Hwy 64	11/13/2002	4.99	151
USGS	Niangua R.@Hwy 64	1/14/2003	4.99	160
USGS	Niangua R.@Hwy 64	3/11/2003	4.99	256
USGS	Niangua R.@Hwy 64	5/28/2003	4.99	160
USGS	Niangua R.@Hwy 64	7/17/2003	12	153
USGS	Niangua R.@Hwy 64	9/8/2003	4.99	110
USGS	Niangua R.@Hwy 64	11/25/2003	4.99	280
USGS	Niangua R.@Hwy 64	1/22/2004	4.99	510
USGS	Niangua R.@Hwy 64	3/11/2004	56	534
USGS	Niangua R.@Hwy 64	5/24/2004	4.99	627
USGS	Niangua R.@Hwy 64	7/7/2004	4.99	179
USGS	Niangua R.@Hwy 64	9/21/2004	4.99	113
USGS	Niangua R.@Hwy 64	11/17/2004	4.99	283
USGS	Niangua R.@Hwy 64	1/18/2005	4.99	760
USGS	Niangua R.@Hwy 64	3/21/2005	4.99	325
USGS	Niangua R.@Hwy 64	5/23/2005	4.99	153
USGS	Niangua R.@Hwy 64	7/25/2005	4.99	137
USGS	Niangua R.@Hwy 64	9/19/2005	12	261
USGS	Niangua R.@Hwy 64	11/29/2005	4.99	146
USGS	Niangua R.@Hwy 64	1/17/2006	4.99	146
USGS	Niangua R.@Hwy 64	3/20/2006	4.99	160
USGS	Niangua R.@Hwy 64	5/22/2006	4.99	184
USGS	Niangua R.@Hwy 64	7/24/2006	4.99	139
USGS	Niangua R.@Hwy 64	9/18/2006	4.99	113
USGS	Niangua R.@Hwy 64	11/2/2006	4.99	150

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	Niangua R.@Hwy 64	1/24/2007	4.99	1000
USGS	Niangua R.@Hwy 64	2/27/2007	4.99	300
USGS	Niangua R.@Hwy 64	3/5/2007	4.99	261
USGS	Niangua R.@Hwy 64	4/17/2007	15	1140
USGS	Niangua R.@Hwy 64	5/9/2007	4.99	283
USGS	Niangua R.@Hwy 64	6/25/2007	4.99	267
USGS	Niangua R.@Hwy 64	7/23/2007	4.99	130
USGS	Niangua R.@Hwy 64	9/17/2007	4.99	160
USGS	Niangua R.@Hwy 64	11/5/2007	4.99	39
USGS	Niangua R.@Hwy 64	1/22/2008	4.99	165
USGS	Niangua R.@Hwy 64	3/17/2008	12	372
USGS	Niangua R.@Hwy 64	5/27/2008	4.99	433
USGS	Niangua R.@Hwy 64	7/21/2008	4.99	296
USGS	Niangua R.@Hwy 64	9/15/2008	112	12900
USGS	Osage R. bl. St. Thomas	11/8/1999	10	564
USGS	Osage R. bl. St. Thomas	5/3/2000	6	1430
USGS	Osage R. bl. St. Thomas	1/6/1999	10	7130
USGS	Osage R. bl. St. Thomas	5/27/1999	23	54900
USGS	Osage R. bl. St. Thomas	11/7/1997	6	1090
USGS	Osage R. bl. St. Thomas	5/19/1998	14	11000
UE	Osage R. bl. St. Thomas	7/17/2001	16.9	13100
UE	Osage R. bl. St. Thomas	8/14/2001	8.8	708
UE	Osage R. bl. St. Thomas	8/30/2001	19.8	13200
UE	Osage R. bl. St. Thomas	6/22/2001	10.4	24200
UE	Osage R. bl. St. Thomas	7/31/2001	22	15900
UE	Osage R. bl. St. Thomas	9/13/2001	8	1420
USGS	L. Tavern Cr. nr mouth	5/19/1994	4	38
USGS	L. Tavern Cr. nr mouth	8/31/1994	5	14
USGS	L. Tavern Cr. nr mouth	5/30/1995	18	82
USGS	Osage R. bl. St. Thomas	11/10/1993	14	32400
USGS	Osage R. bl. St. Thomas	3/15/1994	20	13200
USGS	Osage R. bl. St. Thomas	3/24/1993	63	4600
USGS	Osage R. bl. St. Thomas	5/18/1993	36	31200
USGS	Osage R. bl. St. Thomas	7/21/1993	11	30400
USGS	Osage R. bl. St. Thomas	9/30/1993	64	44800
USGS	Osage R. bl. St. Thomas	11/14/1990	4	663
USGS	Osage R. bl. St. Thomas	1/9/1991	5	4000
USGS	Osage R. bl. St. Thomas	3/7/1991	7	1450
USGS	Osage R. bl. St. Thomas	5/6/1991	48	4500
USGS	Osage R. bl. St. Thomas	7/15/1991	7	625
USGS	Osage R. bl. St. Thomas	9/6/1991	11	960
USGS	Osage R. bl. St. Thomas	1/19/1990	4	800
USGS	Osage R. bl. St. Thomas	3/20/1990	29	34700
USGS	Osage R. bl. St. Thomas	5/7/1990	27	34800
USGS	Osage R. bl. St. Thomas	7/9/1990	71	31600
USGS	Osage R. bl. St. Thomas	11/1/1988	11	666
USGS	Osage R. bl. St. Thomas	1/10/1989	20	8550

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	Osage R. bl. St. Thomas	5/17/1989	7	804
USGS	Osage R. bl. St. Thomas	7/18/1989	221	788
USGS	Osage R. bl. St. Thomas	9/15/1989	35	14400
USGS	Osage R. bl. St. Thomas	11/21/2000	4.99	556
USGS	Osage R. bl. St. Thomas	5/2/2001	13	676
USGS	Osage R. bl. St. Thomas	10/18/1974	62	7740
USGS	Osage R. bl. St. Thomas	11/21/1974	44	17800
USGS	Osage R. bl. St. Thomas	12/19/1974	110	14500
USGS	Osage R. bl. St. Thomas	1/20/1975	30	8780
USGS	Osage R. bl. St. Thomas	2/13/1975	38	31000
USGS	Osage R. bl. St. Thomas	3/13/1975	62	35000
USGS	Osage R. bl. St. Thomas	4/17/1975	40	9080
USGS	Osage R. bl. St. Thomas	5/13/1975	54	6610
USGS	Osage R. bl. St. Thomas	6/4/1975	69	10100
USGS	Osage R. bl. St. Thomas	7/23/1975	20	4080
USGS	Osage R. bl. St. Thomas	8/29/1975	63	24700
USGS	Osage R. bl. St. Thomas	9/24/1975	46	5020
USGS	Osage R. bl. St. Thomas	11/6/1987	60	771
USGS	Osage R. bl. St. Thomas	1/14/1988	23	16800
USGS	Osage R. bl. St. Thomas	3/3/1988	35	17900
USGS	Osage R. bl. St. Thomas	5/9/1988	24	9250
USGS	Osage R. bl. St. Thomas	7/15/1988	24	2390
USGS	Osage R. bl. St. Thomas	9/7/1988	7	890
USGS	Osage R. bl. St. Thomas	11/19/1986	4	51400
USGS	Osage R. bl. St. Thomas	1/15/1987	15	6360
USGS	Osage R. bl. St. Thomas	3/12/1987	15	32700
USGS	Osage R. bl. St. Thomas	5/15/1987	7	7950
USGS	Osage R. bl. St. Thomas	7/9/1987	14	8080
USGS	Osage R. bl. St. Thomas	9/10/1987	6	2490
USGS	Osage R. bl. St. Thomas	11/7/2001	18	6190
USGS	Osage R. bl. St. Thomas	1/9/2002	10	7280
USGS	Osage R. bl. St. Thomas	3/7/2002	4.99	4420
USGS	Osage R. bl. St. Thomas	5/8/2002	152	43700
USGS	Osage R. bl. St. Thomas	7/15/2002	105	992
USGS	Osage R. bl. St. Thomas	9/3/2002	11	740
USGS	Osage R. bl. St. Thomas	11/15/1985	64	34200
USGS	Osage R. bl. St. Thomas	1/16/1986	29	4890
USGS	Osage R. bl. St. Thomas	3/4/1986	7	9150
USGS	Osage R. bl. St. Thomas	5/8/1986	20	6200
USGS	Osage R. bl. St. Thomas	7/18/1986	25	21800
USGS	Osage R. bl. St. Thomas	9/2/1986	2	1170
UE	Osage R. bl. St. Thomas	5/31/2001	18.6	3700
UE	Osage R. bl. St. Thomas	5/31/2001	18.6	3700
USGS	Osage R. bl. St. Thomas	11/16/1984	26	5800
USGS	Osage R. bl. St. Thomas	1/18/1985	16	31700
USGS	Osage R. bl. St. Thomas	3/15/1985	29	53000
USGS	Osage R. bl. St. Thomas	5/10/1985	6	15500

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	Osage R. bl. St. Thomas	7/19/1985	29	1980
USGS	Osage R. bl. St. Thomas	9/19/1985	68	2790
USGS	Osage R. bl. St. Thomas	10/28/1975	28	1110
USGS	Osage R. bl. St. Thomas	11/13/1975	122	554
USGS	Osage R. bl. St. Thomas	12/18/1975	208	14900
USGS	Osage R. bl. St. Thomas	1/14/1976	35	1970
USGS	Osage R. bl. St. Thomas	2/4/1976	19	5750
USGS	Osage R. bl. St. Thomas	3/19/1976	9	3200
USGS	Osage R. bl. St. Thomas	4/8/1976	11	3490
USGS	Osage R. bl. St. Thomas	5/17/1976	374	3680
USGS	Osage R. bl. St. Thomas	6/17/1976	8	1380
USGS	Osage R. bl. St. Thomas	7/19/1976	16	875
USGS	Osage R. bl. St. Thomas	8/19/1976	47	552
USGS	Osage R. bl. St. Thomas	9/28/1976	54	1470
USGS	Osage R. bl. St. Thomas	11/18/1976	21	1670
USGS	Osage R. bl. St. Thomas	12/13/1976	61	803
USGS	Osage R. bl. St. Thomas	1/12/1977	25	5810
USGS	Osage R. bl. St. Thomas	2/4/1977	65	521
USGS	Osage R. bl. St. Thomas	3/4/1977	1	742
USGS	Osage R. bl. St. Thomas	4/15/1977	64	957
USGS	Osage R. bl. St. Thomas	5/13/1977	25	706
USGS	Osage R. bl. St. Thomas	6/16/1977	55	1180
USGS	Osage R. bl. St. Thomas	7/7/1977	107	39100
USGS	Osage R. bl. St. Thomas	8/11/1977	192	6060
USGS	Osage R. bl. St. Thomas	9/15/1977	128	4660
USGS	Osage R. bl. St. Thomas	10/6/1977	93	2290
USGS	Osage R. bl. St. Thomas	11/4/1977	61	12300
USGS	Osage R. bl. St. Thomas	12/15/1977	64	4050
USGS	Osage R. bl. St. Thomas	1/23/1978	91	550
USGS	Osage R. bl. St. Thomas	2/23/1978	60	4910
USGS	Osage R. bl. St. Thomas	3/16/1978	58	20300
USGS	Osage R. bl. St. Thomas	4/12/1978	160	31800
USGS	Osage R. bl. St. Thomas	5/25/1978	92	34100
USGS	Osage R. bl. St. Thomas	6/22/1978	133	1310
USGS	Osage R. bl. St. Thomas	7/13/1978	96	1730
USGS	Osage R. bl. St. Thomas	8/10/1978	36	1380
USGS	Osage R. bl. St. Thomas	10/19/1978	209	1200
USGS	Osage R. bl. St. Thomas	12/14/1978	76	8400
USGS	Osage R. bl. St. Thomas	2/7/1979	52	11000
USGS	Osage R. bl. St. Thomas	3/22/1979	151	7530
USGS	Osage R. bl. St. Thomas	6/14/1979	189	18100
USGS	Osage R. bl. St. Thomas	7/12/1979	206	14200
USGS	Osage R. bl. St. Thomas	10/12/1979	8	560
USGS	Osage R. bl. St. Thomas	11/8/1979	357	1800
USGS	Osage R. bl. St. Thomas	12/12/1979	358	660
USGS	Osage R. bl. St. Thomas	2/22/1980	77	7300
USGS	Osage R. bl. St. Thomas	3/27/1980	67	6800

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	Osage R. bl. St. Thomas	4/29/1980	77	920
USGS	Osage R. bl. St. Thomas	6/12/1980	71	3900
USGS	Osage R. bl. St. Thomas	9/10/1980	68	2200
USGS	Osage R. bl. St. Thomas	10/23/1980	58	780
USGS	Osage R. bl. St. Thomas	11/25/1980	2	590
USGS	Osage R. bl. St. Thomas	12/16/1980	24	2300
USGS	Osage R. bl. St. Thomas	1/20/1981	22	570
USGS	Osage R. bl. St. Thomas	2/24/1981	44	2400
USGS	Osage R. bl. St. Thomas	3/26/1981	114	866
USGS	Osage R. bl. St. Thomas	4/22/1981	50	1770
USGS	Osage R. bl. St. Thomas	5/28/1981	495	15400
USGS	Osage R. bl. St. Thomas	6/24/1981	1070	37500
USGS	Osage R. bl. St. Thomas	7/28/1981	18	13500
USGS	Osage R. bl. St. Thomas	8/18/1981	11	4340
USGS	Osage R. bl. St. Thomas	11/12/1981	4	5600
USGS	Osage R. bl. St. Thomas	1/12/1982	28	15000
USGS	Osage R. bl. St. Thomas	3/25/1982	46	25500
USGS	Osage R. bl. St. Thomas	5/18/1982	71	13400
USGS	Osage R. bl. St. Thomas	9/15/1982	45	3700
USGS	Osage R. bl. St. Thomas	11/29/1983	39	20400
USGS	Osage R. bl. St. Thomas	1/12/1984	41	6730
USGS	Osage R. bl. St. Thomas	3/16/1984	42	22900
USGS	Osage R. bl. St. Thomas	5/18/1984	48	35100
USGS	Osage R. bl. St. Thomas	7/27/1984	28	2020
USGS	Osage R. bl. St. Thomas	11/16/1982	19	4000
USGS	Osage R. bl. St. Thomas	1/24/1983	16	800
USGS	Osage R. bl. St. Thomas	3/31/1983	63	16000
USGS	Osage R. bl. St. Thomas	7/25/1983	25	4750
USGS	Osage R. bl. St. Thomas	9/7/1983	313	660
USGS	Osage R. bl. St. Thomas	11/12/2002	19	562
USGS	Osage R. bl. St. Thomas	1/13/2003	4.99	568
USGS	Osage R. bl. St. Thomas	3/10/2003	4.99	676
USGS	Osage R. bl. St. Thomas	5/27/2003	4.99	820
USGS	Osage R. bl. St. Thomas	7/14/2003	14	3450
USGS	Osage R. bl. St. Thomas	9/3/2003	25	6110
USGS	Osage R. bl. St. Thomas	11/24/2003	15	955
USGS	Osage R. bl. St. Thomas	1/13/2004	8	12400
USGS	Osage R. bl. St. Thomas	3/8/2004	38	29000
USGS	Osage R. bl. St. Thomas	5/25/2004	47	21900
USGS	Osage R. bl. St. Thomas	7/6/2004	4.99	2200
USGS	Osage R. bl. St. Thomas	9/20/2004	17	992
USGS	Osage R. bl. St. Thomas	11/29/2004	10	37200
USGS	Osage R. bl. St. Thomas	1/26/2005	11	36800
USGS	Osage R. bl. St. Thomas	3/9/2005	4.99	20500
USGS	Osage R. bl. St. Thomas	5/2/2005	4.99	1160
USGS	Osage R. bl. St. Thomas	7/13/2005	14	8470
USGS	Osage R. bl. St. Thomas	9/1/2005	24	20300

Org	Site Name	Date	TSS (mg/L)	Instaneous Flow(cfs)
USGS	Osage R. bl. St. Thomas	11/3/2005	4.99	1070
USGS	Osage R. bl. St. Thomas	1/3/2006	4.99	648
USGS	Osage R. bl. St. Thomas	3/6/2006	4.99	956
USGS	Osage R. bl. St. Thomas	5/4/2006	81	27300
USGS	Osage R. bl. St. Thomas	7/6/2006	11	529
USGS	Osage R. bl. St. Thomas	9/5/2006	30	769
USGS	Maries R. 3 mi. W of Freeburg	8/10/2006	4	0.5
USGS	Osage R. bl. St. Thomas	11/2/2006	4.99	449
USGS	Osage R. bl. St. Thomas	1/23/2007	20	4660
USGS	Osage R. bl. St. Thomas	2/6/2007	21	6030
USGS	Osage R. bl. St. Thomas	3/13/2007	26	1200
USGS	Osage R. bl. St. Thomas	4/24/2007	16	34500
USGS	Osage R. bl. St. Thomas	5/8/2007	15	36600
USGS	Osage R. bl. St. Thomas	6/5/2007	23	31000
USGS	Osage R. bl. St. Thomas	7/11/2007	12	49900
USGS	Osage R. bl. St. Thomas	9/10/2007	15	6980
USGS	Osage R. bl. St. Thomas	11/20/2007	14	1440
USGS	Osage R. bl. St. Thomas	1/10/2008	38	3740
USGS	Osage R. bl. St. Thomas	3/27/2008	15	29100
USGS	Osage R. bl. St. Thomas	5/12/2008	14	41000
USGS	Osage R. bl. St. Thomas	7/30/2008	20	32900
USGS	Osage R. bl. St. Thomas	9/3/2008	81	20700

Appendix F

Supplemental Implementation Plan

States are not required under Section 303(d) of the Clean Water Act to develop TMDL implementation plans and EPA does not approve or disapprove them. However, the Missouri Department of Natural Resources (MDNR) included an implementation plan in this TMDL to provide information regarding how point and nonpoint sources can or should be controlled to ensure implementation efforts achieve the loading reductions identified in this TMDL. EPA recognizes that technical guidance and support are critical to determining the feasibility of and achieving the goals outlined in this TMDL. Therefore, this informational plan is included to be used by local professionals, watershed managers and citizens for decision-making support and planning purposes. It should not be considered to be a part of the established West Fork Niangua River TMDL.

Point Sources

This portion of the TMDL will be implemented through permit action. During implementation of this TMDL, an analysis of facility compliance history, sampling results, permit effluent limitations and monitoring requirements will be conducted during reissuance of site specific wastewater permits. If MDNR determines a permitted wastewater facility may be causing or contributing to the impairment of the West Fork Niangua River, then additional monitoring requirements (e.g., effluent or instream) will be included in the reissued permit. Should MDNR determine more protective effluent limitations or permit conditions are necessary, these requirements will be included in the facility permit upon renewal. It is also possible for the permit to be reopened between renewal periods and adjustments made.

Nonpoint Sources

To further reduce the loading and the effect of nutrients and TSS on dissolved oxygen levels in West Fork Niangua River, efforts should be made to encourage agricultural producers to adopt best management practices (BMPs). BMPs are recommended methods, structures and practices designed to prevent or reduce water pollution. The concept of BMPs is one of a voluntary and site specific approach to water quality problems. In the West Fork Niangua River watershed, agricultural BMPs should focus on irrigation and water management, fertilizer and manure management, riparian buffers and erosion control.

In an effort to most effectively implement these BMPs, MDNR may work with the Natural Resources Conservation Service (NRCS) and the local Soil and Water Conservation District (SWCD) to encourage area growers and livestock producers to implement these practices on their land. An additional approach may also be to work with the NRCS and SWCD to form a watershed group comprised of local stakeholders with a common interest in protecting water quality in West Fork Niangua River.