United States Environmental Protection Agency
Region 7
Total Maximum Daily Load
For Low Dissolved Oxygen, Ammonia and Organic Sediment

Big Bottom Creek (MO_1746)
Ste. Genevieve County, Missouri

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10/26/10
Date

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Total Maximum Daily Loads (TMDL)
For Big Bottom Creek
Pollutant: Low Dissolved Oxygen, Ammonia and Organic Sediment

Name: Big Bottom Creek

Location: Near Rocky Ridge in Ste. Genevieve County, Missouri

State map showing location of watershed

Hydrologic Unit Code (HUC): 07140101-0907

Water Body Identification (WBID): 1746

Missouri Stream Class: Class C[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 Classified Segment: 1.9 miles

Location of Classified Segment: Mouth to Lake Anne. Wholly contained in Land Grant 02046[2].

Location of Impaired Segment: Mouth to Lake Anne. Wholly contained in Land Grant 02046.

Impaired Use: Protection of Warm Water Aquatic Life

Size of Impaired Segment: 1.9 miles[3]

Length of Impairments within Segment: 0.5 miles for ammonia; 1.7 miles for low DO; 0.5 mile for organic sediment

Pollutants: Low Dissolved Oxygen (DO), Ammonia and Organic Sediment

Identified Source on 303(d) list: Lake Forest Estates Wastewater Treatment Plant (WWTP)

TMDL Priority Ranking: High

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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). The WQS can be found at the following uniform resource locator (URL): http://www.dnr.mo.gov/wpscd/wpcp/wqstandards/wq_standard_hm.htm

[2] Missouri's Public Land Survey System rectangular grid is interrupted by historic land grants that predated the surveying conducted for the Land Ordinance of 1785.

[3] The stream length listed corresponds to the EPA approved 2008 Missouri 303(d) List segment length. Due to the increased accuracy of Geographical Information System (GIS) data layers for analysis over previous methods of stream length measurements, the stream length used in the TMDL analysis may not correspond exactly to the 303(d) list. The descriptive start and end point of each segment remains the same and this TMDL addresses the impaired segment in its entirety.

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List of Acronyms

Σ	Sum
μg	Micrograms
μgN/L	Micrograms of Nitrogen per Liter
AFO	Animal Feeding Operation
BOD	Biochemical Oxygen Demand
CAFO	Concentrated Animal Feeding Operation
CBOD and $CBOD_5$	Carbonaceous Biochemical Oxygen Demand and 5-day CBOD
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
cms	Cubic Meters per Second
CSR	Code of State Regulation
CWA	Clean Water Act
Deg C	Temperature in Degrees Celsius
DMRs	Daily Monitoring Reports
DO	Dissolved Oxygen
EDU	Ecological Drainage Unit
e.g.	For Example
EPA	Environmental Protection Agency
GIS	Geographic Information System
HUC	Hydrologic Unit Code
km	Kilometer
LA	Load Allocation
Lbs/day	Pounds per day
LC	Loading Capacity
LDC	Load Duration Curve
m	Meters
m/s	Meters per Second
MDNR	Missouri Department of Natural Resources
mg	Milligrams
mg/L	Milligrams per Liter
MGD	Million Gallons per Day
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	Nitrogenous Biochemical Oxygen Demand
NESC	National Environmental Service Center
NH_3	Ammonia Nitrogen
NO_2	Nitrite Nitrogen
NO_3	Nitrate Nitrogen

List of Acronyms (continued)

NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
ºC	Temperature in Degrees Celsius
ºF	Temperature in Degrees Fahrenheit
PBIAS	Percent Bias Statistic
PCS	Permit Compliance System
R^2	Coefficient of Determination
QAPP	Quality Assurance Project Plan
RAM	Resource Assessment and Monitoring Program
RMSE	Root Mean Square Error Statistic
RTI	RTI International Corporation
SOD	Sediment Oxygen Demand
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
URS	URS Group Inc.
U.S.	United States
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VSS	Volatile Suspended Solids
WBID	Water Body Identification
WLA	Wasteload Allocation
WQS	Water Quality Standards
WWTP	Wastewater Treatment Plant

1 INTRODUCTION

The Big Bottom Creek 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 United States (U.S.) Environmental Protection Agency (EPA) approved 2008 Missouri 303(d) List. 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 under technology-based controls for pollutants of concern. The TMDL process quantitatively assesses the 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 exceeding the water quality standards (WQS) for that pollutant. WQS are benchmarks used to assess the quality of streams, rivers and lakes. The TMDL also establishes the pollutant loading capacity (LC) 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. The MOS accounts for the uncertainty associated with linking pollutant loads to water quality conditions. This is sometimes related to the model assumption and data limitations.

The goal of the TMDL program is to restore impaired designated beneficial uses to water bodies. Thus, reduction strategies for point and nonpoint sources and implementation of source controls throughout the watershed will be necessary to restore the protection of warm water aquatic life use in Big Bottom Creek. In addition to establishing a TMDL for Big Bottom Creek, 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.

Section 2 of this report provides background information on the Big Bottom Creek watershed and Section 3 describes potential sources of concern. Section 4 presents the applicable WQS, Section 5 describes the water quality problems and Section 6 describes the modeling that was done to support the TMDL. Sections 7 to 11 present the required TMDL elements (LC, WLA, LA, MOS, seasonal variation) and Sections 12 to 14 summarize the follow-up monitoring plan, reasonable assurances and public participation. A summary of the administrative record is presented in Section 15; Appendix A summarizes the available water quality data. Appendix B presents QUAL2K modeling conducted to support this TMDL. Methods and data used in the load duration curve (LDC) modeling are presented in Appendix C – Appendix E.

2 BACKGROUND

This section of the report provides information on Big Bottom Creek and its watershed.

2.1 The Setting

Big Bottom Creek is located in the Ozark/ Apple/ Joachim Ecological Drainage Unit (EDU). Big Bottom Creek flows north to Indian Creek which then flows into Establishment Creek. Establishment Creek flows north and eventually drains to the Mississippi River. The Big Bottom Creek watershed covers an area of approximately 4.86 square miles with a combined stream mileage distance of approximately 3.7 miles (Figure 1). Big Bottom Creek is impounded approximately 2 miles upstream with its confluence with Establishment Creek and forms Lake Anne (previously called Lake Forest), a 90 acre reservoir with 4.3 square mile drainage area. Lake Anne effectively splits the watershed into two distinct parts. The upper watershed drains to Lake Anne while the lower portion receives discharge from Lake Anne and runoff from the drainage area below Lake Anne (approximately 0.6 square miles).

The EPA-approved 2008 Missouri 303(d) List of impaired waters identifies the impaired segments of Big Bottom Creek at a length of 1.9 miles. Due to the increased accuracy of Geographic Information System (GIS) data layers for analysis over previous methods of stream length measurements, the stream length used in the TMDL analysis does not correspond exactly to the length shown in the 2008 Missouri 303(d) List. The descriptive start and end point of each segment remains the same. This TMDL addresses the impaired segment in its entirety and based on such improved estimates using GIS, the impaired segment is approximately 1.5 miles in length.

Big Bottom Creek, near Rocky Ridge in Ste. Genevieve County, Missouri, was on the Missouri 2002 303(d) List for Biochemical Oxygen Demand (BOD) and Volatile Suspended Solids (VSS). In 2004-2006 these listings were changed to low dissolved oxygen (DO) and organic sediment. In 2008 the listings were changed to DO, ammonia and organic sediment. The sole source of these impairments is the Lake Forest Estates Subdivision Wastewater Treatment Plant (WWTP), Missouri State Operating Permit (MSOP) number MO0035742. The Lake Forest Estates WWTP serves an established subdivision around Lake Anne with a population equivalent of 1,040 persons. A revised National Pollutant Discharge Elimination System (NPDES) permit was issued to the WWTP in order to correct the water quality exceedances of DO and scarcity of aquatic life observed downstream of the facility. In 2004, upgrades were made to the WWTP and monitoring was conducted in 2005, 2006 and 2009 to determine if plant upgrades had resolved the water quality issues. Big Bottom Creek remains on the 303(d) List due to DO criteria exceedances and reduced abundance and diversity of aquatic life.

The dam for Lake Anne, a classified lake (called Forest Lake in the current standards, WBID: 7267) is less than 0.2 mile upstream of the WWTP outfall. When Big Bottom Creek was assessed for the 1998 Missouri 303(d) List, there was no upstream flow and the poor condition of the creek was believed to be caused by the WWTP alone. In April 2005, all inspections found that water from the lake was not contributing to the impairment. Water only runs over the lake spillway during high flow periods. Otherwise there is no flow in Big Bottom Creek below the dam upstream of the WWTP. However, Lake Anne may contribute organic material to Big Bottom Creek during high flow periods which settle and affects DO via sediment oxygen demand (SOD).

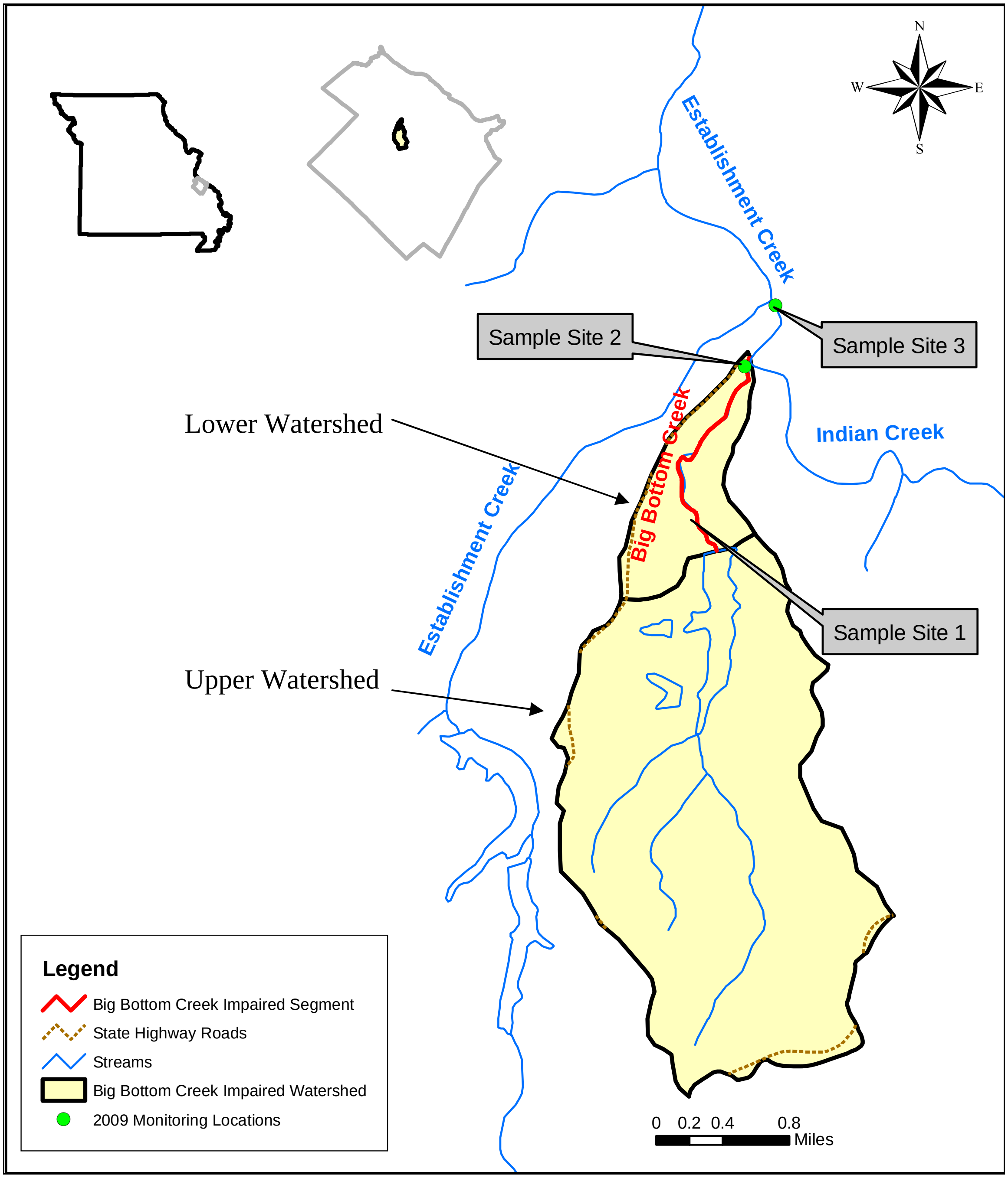

Figure 1. **Big Bottom Creek Location Map**

The current 303(d) listing for the impaired reach was based on visual inspections of Big Bottom Creek below the Lake Forest Estates WWTP during summer low flow conditions in 1995 and 2001. These inspections reported sludge deposits, green water, thick growths of prostrate algae, some filamentous algae and a scarcity of aquatic life. In addition, almost all of the life forms that were present during these surveys were known to have a high tolerance for pollution. These conditions are characteristic of streams suffering from impacts by wastewater treatment facilities. Big Bottom Creek was reassessed during the 2009 TMDL study (EPA, 2009) to determine whether conditions have changed since the WWTP upgrade and whether additional pollutant reductions are necessary.

2.2 Physiographic Location, Geology and Soils

Big Bottom Creek is located within the Interior Highlands; a division of the Springfield-Salem Plateau. The Springfield-Salem Plateau is a physiographic section of the Ozark Plateaus Province. Geologically, the Big Bottom Creek watershed is located in the Early Ordovician Ibexian Series. Predominant rock types include sandstone and dolostone (dolomite).

The soils hydrologic group relates to the rate at which surface water enters the soil profile, which in turn affects the amount of water that enters the stream as direct runoff. Table 1 and Figure 2 provide a summary of soil types in the impaired Big Bottom Creek watershed. The dominant soil type, C, covers approximately 86.2 percent of the watershed and 49.5 percent of the impaired watershed. Group C includes sandy clay 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. Soil type B covers approximately 5.8 percent of the Big Bottom Creek watershed and 20.6 percent of the impaired watershed. Group B includes silt loam and loam which have moderate infiltration rates. These soils consist of well drained soils with moderately fine to moderately coarse textures. Group D soil covers 4.7 percent of soils in the watershed and 28.8 percent of the impaired watershed. Group D soils include clay loam, silty clay loam, sandy clay, silty clay or clay. This soil group has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material (Purdue Research Foundation, 2009).

Table 1. Types and hydrologic group for soils in Big Bottom Creek.

		Lower Watershed (Impaired Reach)		**Upper Watershed**	
Soil Type	**Hydrologic Soil Group**	**Area Acres**	**Percent**	**Area Acres**	**Percent**
Bloomsdale silt loam	B	78.73	20.6	78.73	2.5
Midco gravelly silt loam	B	0.0	0	100.21	3.2
Subtotal	**B**	**78.73**	**20.6**	**178.95**	**5.8**
Caneyville silt loam	C	0.0	0.0	13.50	0.4
Goss very cobbly silt loam	C	110.31	28.9	1,223.88	39.3
Hildebrecht silt loam	C	0.0	0.0	28.12	0.9
Wrengart silt loam	C	78.52	20.6	1,418.83	45.6
Subtotal	**C**	**188.83**	**49.5**	**2,684.33**	**86.2**
Gasconade-Rock outcrop complex	D	109.96	28.8	145.75	4.7
Water	N/A	4.17	1.1	104.00	3.3

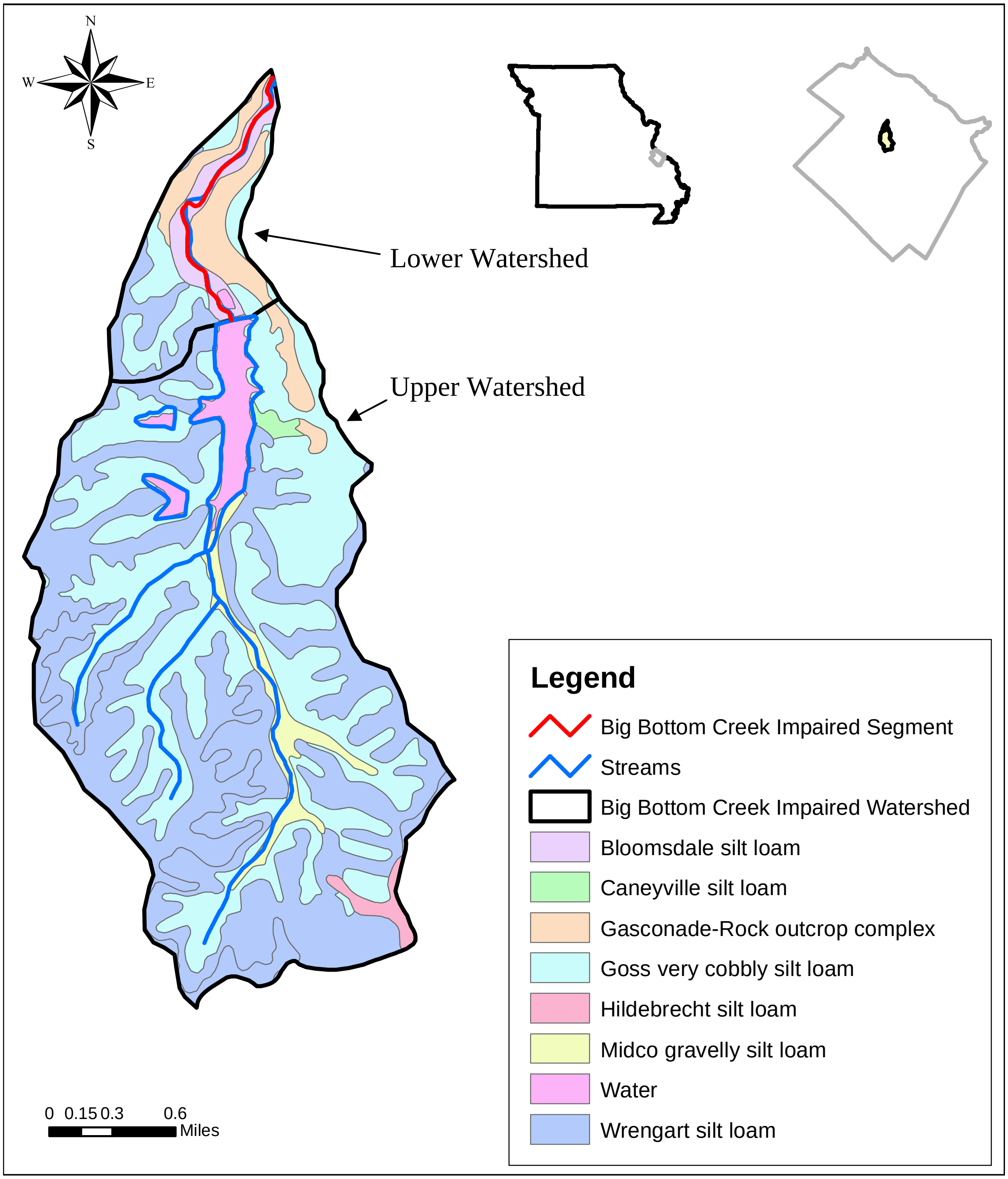

Figure 2. Big Bottom Creek Soils Map

2.3 Rainfall and Climate

Three weather stations are near the Big Bottom Creek watershed (Figure 3). These three stations record daily precipitation, maximum and minimum temperatures, snowfall, and snow depth. Figure 4 provides a summary of rainfall and climate data for Station 232850 (Festus, MO) based on 30 year totals (1971 – 2000) (NOAA, 2009). The annual average precipitation and temperature over the 30 year period is 39.91 inches and 53.7 degrees Fahrenheit, respectively. These nearby weather stations will provide useful information for simulating stream temperature which impacts the growth of algae, decay of Carbonaceous Biochemical Oxygen Demand (CBOD), transformations of nutrients and solubility of DO.

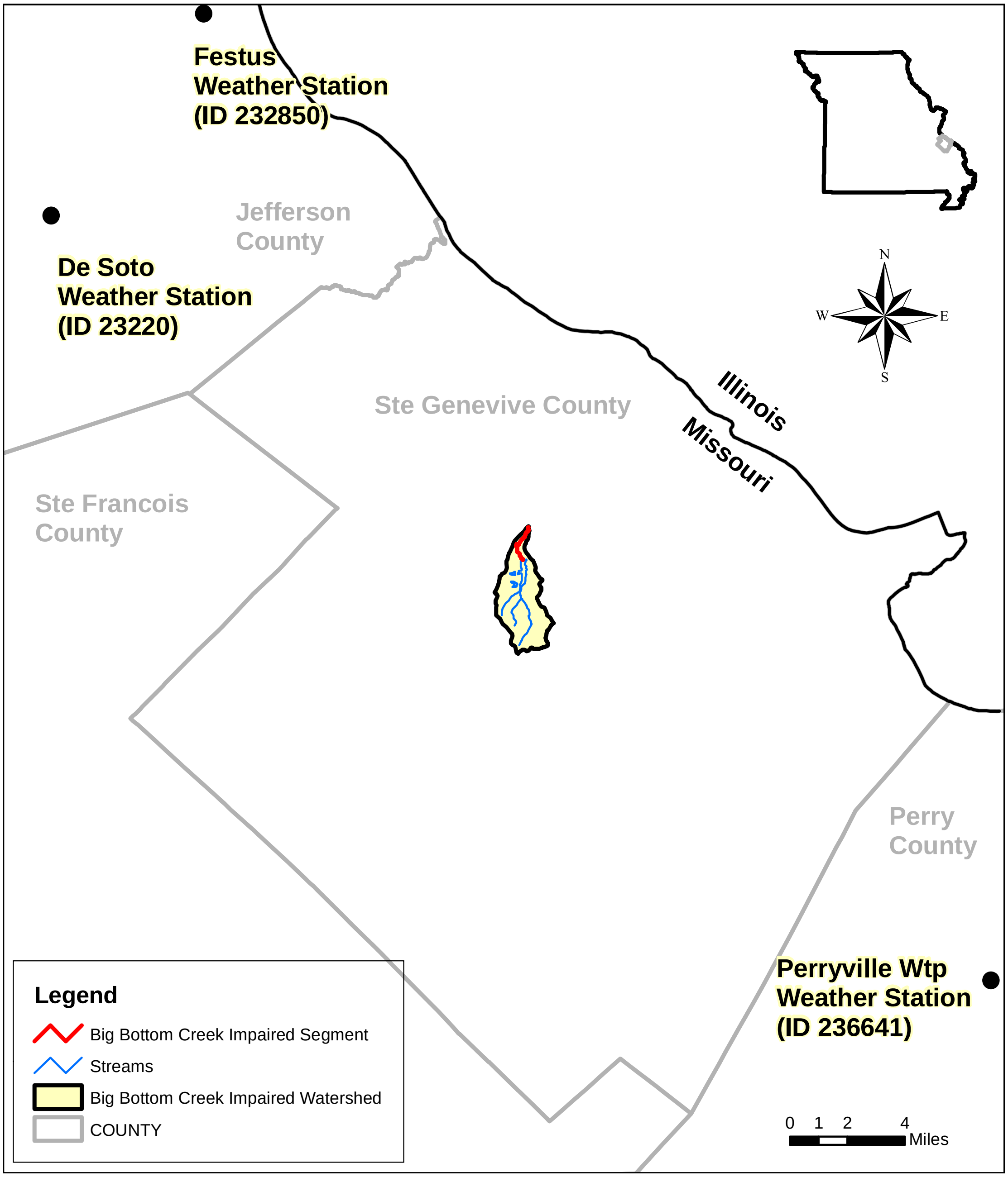

Figure 3. Location of Big Bottom Creek Watershed with weather stations

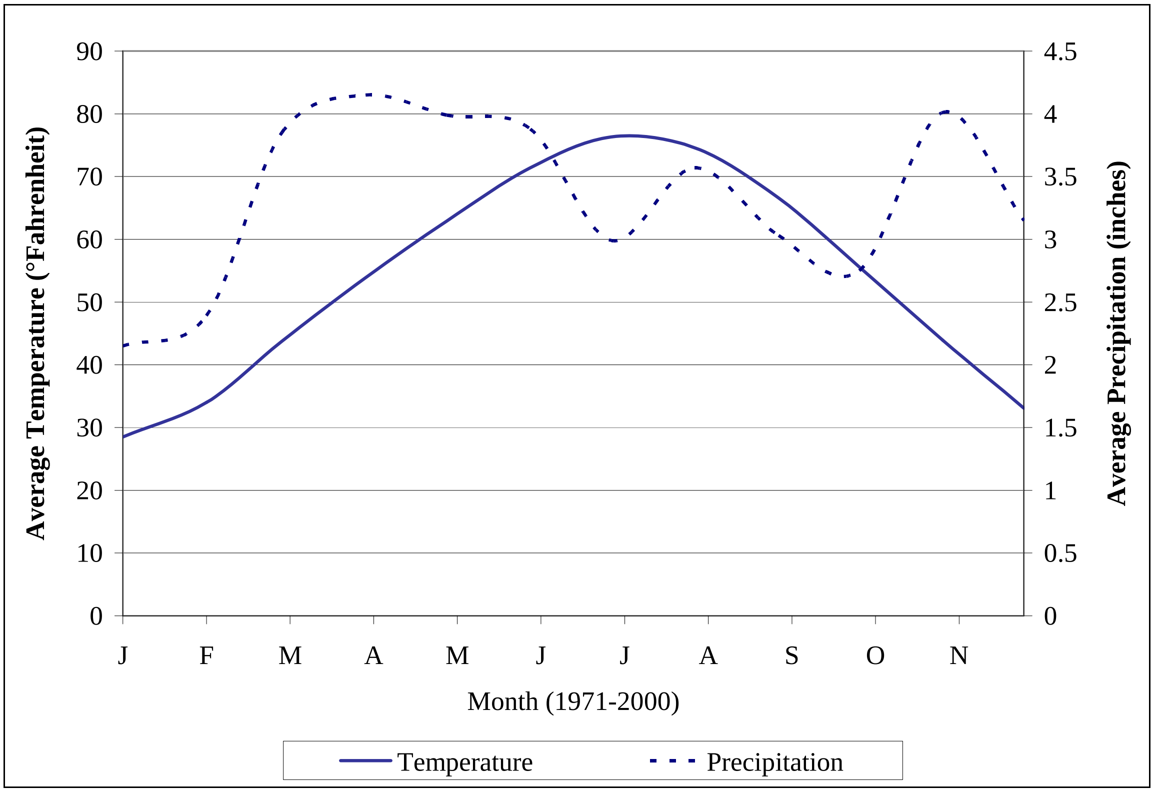

Figure 4. Thirty-year monthly temperature and precipitation averages for Station 232850 (Festus, MO) (NOAA, 2009)

2.4 Population

Population data for the Big Bottom Creek watershed is not directly available. However, the United States Census Bureau reports that the 2000 population for the cities of St. Mary’s, Bloomsdale and Ste. Genevieve were 377, 419 and 4,476 persons, respectively (U. S. Census Bureau, 2000). The urban population of the Big Bottom Creek watershed is zero, as there are no urban areas within the watershed. Lake Forest Estates is a planned community surrounding Lake Anne. The community includes year-around homes, seasonal homes and vacation rentals.

The rural population of the watershed can be estimated based on the proportion of the watershed compared to Ste. Genevieve County. Ste. Genevieve County covers an area of 509.67 square miles and has a population of 17,842 persons. The rural population in Ste. Genevieve County is approximately 12,570 people (total county population minus St. Mary’s, Bloomsdale and Ste. Genevieve population) and the rural county area is 503.29 square miles (total county area minus county urban area). The Big Bottom Creek watershed rural population was estimated to be 121 persons. This was calculated by dividing the rural watershed area (4.86 square miles) by the Ste. Genevieve County rural area (503.29 square miles) and multiplying the product by the Ste. Genevieve County rural population (12,750). The total estimated population of the Big Bottom Creek watershed is approximately 121 persons. An overall population density for the Big Bottom Creek watershed was calculated to be (121 persons divided by 4.86 square miles)

25 persons per square mile. Therefore, the impaired portion of the watershed has approximately 15 persons (25 persons per square mile multiplied by 0.6 square miles).

2.5 Land Use and Land Cover

The land use and land cover of the Big Bottom Creek watershed is summarized in Table 2 and is shown in Figure 5 (MoRAP, 2005). The primary land uses/land covers are forest (45.0 percent), grassland (28.6 percent) and herbaceous (14.6 percent) with impervious cover, low intensity urban areas, cropland and open water occupying the remaining area of the watershed.

Much of the Big Bottom Creek watershed is upstream of Lake Anne and the impaired segment. Since this watershed area drains to Lake Anne and influences conditions upstream of the impaired reach, it has been included in the land use assessment. Water from Lake Anne will have an effect on DO levels in the impaired segment because accumulated organics in the watershed are transported downstream and deposited in the impaired segment as runoff events occur. The deposited organics are the primary source of sediment oxygen demand (SOD) that can influence DO levels in the segment during critical (or low flow) periods. For completeness, land use for the total watershed area and the impaired lower watershed area has also been included in (Table 2).

Table 2. Land Use/Land Cover in the Big Bottom Creek Impaired Watershed (MoRAP, 2005)

Land Use/Land Cover	**Lower (Impaired Reach) Watershed**		**Upper Watershed**		**Total Watershed Area**	
	Square Miles	**Percent**	**Square Miles**	**Percent**	**Square Miles**	**Percent**
Impervious[4]	0.008	1.5	0.06	1.4	0.07	1.4
Low Intensity Urban[5]	0.003	0.5	0.15	3.5	0.15	3.1
Barren or Sparsely Vegetated	0.002	0.4	0.02	0.60	0.03	0.58
Cropland	0.046	8.0	0.05	1.1	0.09	1.9
Grassland	0.153	26.6	1.23	28.9	1.39	28.6
Forest	0.210	36.4	1.97	46.3	2.19	45.0
Herbaceous[6]	0.137	23.8	0.57	13.4	0.71	14.6
Wetland	0.001	0.24	0.0	0.0	0.00	0.04
Open Water	0.015	2.7	0.21	5.0	0.23	4.7
Total	0.57	100	4.3	100	4.9	100

Note: MoRAP = Missouri Resource Assessment Partnership

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[4] Impervious land use includes non-vegetated, impervious surfaces including areas dominated by streets, parking lots and buildings (MoRAP, 2005).

[5] Low Intensity Urban land use includes vegetated urban environments with a low density of buildings (MoRAP, 2005).

[6] Herbaceous land use includes shrublands, young woodlots and open woodlands

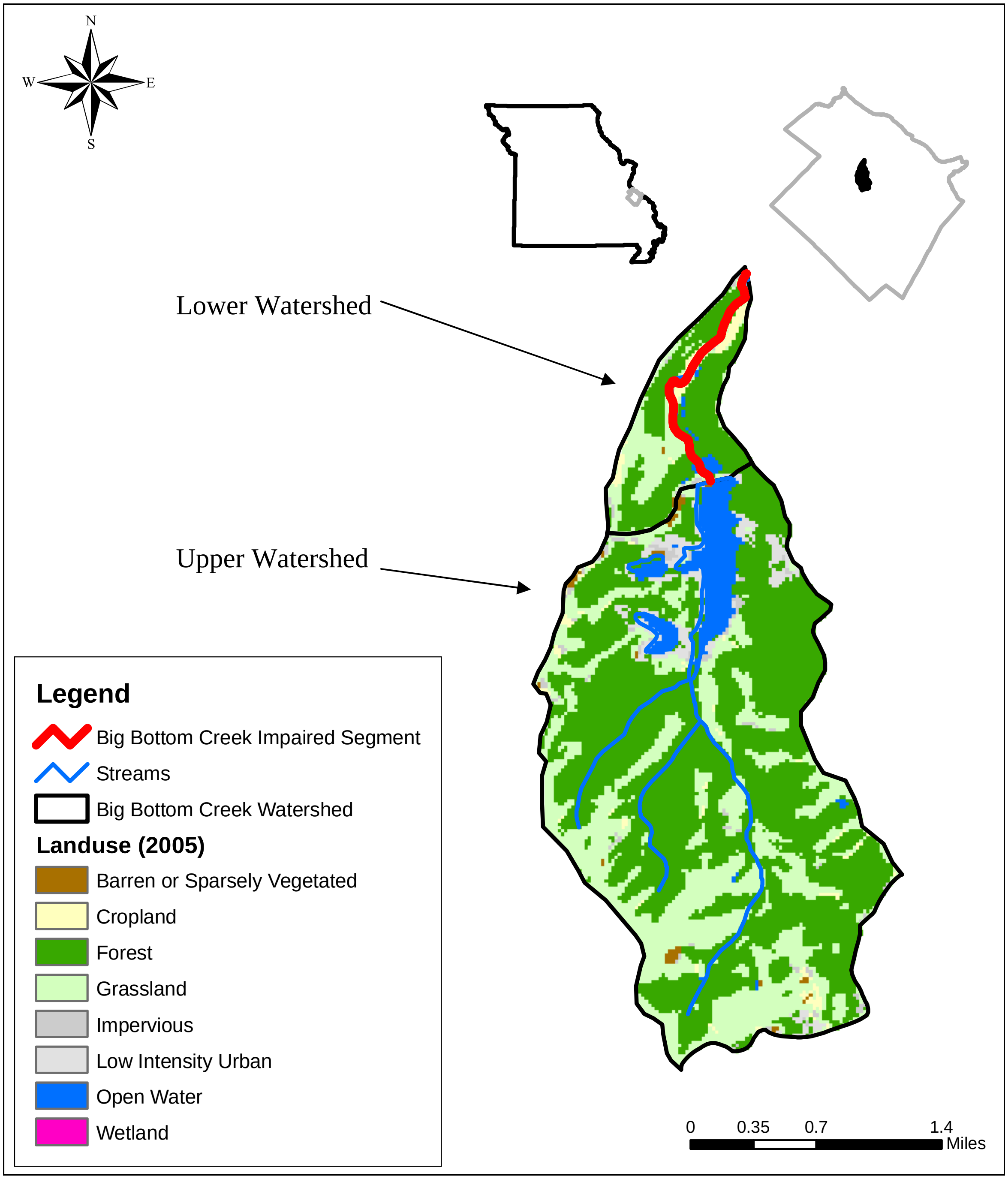

Figure 5. Land Use/Land Cover in the Big Bottom Creek Impaired Watershed (MoRAP, 2005)

3 DEFINING THE PROBLEM

Big Bottom Creek is impaired due to exceedances of Missouri's general water quality criteria for the protection of aquatic life and biological aquatic communities (10 CSR 20-7.031(3)). Historical water quality data collected from June 2004 to August 2007 show DO concentrations below 5 milligrams per liter (mg/L) in 17 of 34 samples collected at various locations in Big Bottom Creek (Table 3 and Appendix A). These data indicate Big Bottom Creek is not in compliance with the Missouri protection of aquatic life DO minimum water quality criterion of 5 mg/L for general warm water fisheries. Therefore, Big Bottom Creek is not in compliance with Missouri WQSs. Ammonia, CBOD and organic sediment from the Lake Forest Estates WWTP are the listed source of the impairment.

Table 3. Summary of Historical DO data for Big Bottom Creek.

Survey	Number of DO Samples	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Percentage of Samples < 5 mg/L
June 2004	3	4.8	5.6	6.4	33
July 2004	8	1.1	4.7	7.4	62.5
April 2005	8	1.1	7.6	13	25
June 2005	8	0.8	4.6	12	75
August 2006	6	2.0	4.9	7.2	50
August 2007	1	6.2	6.2	6.2	0

Source: The Missouri Department of Natural Resources

DO 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. Excessive nitrogen and phosphorus loading to water bodies can also contribute to DO problems because they can accelerate algal growth.

Algal growth in streams is most frequently assessed based on the amount of Chlorophyll-a in the water or attached to the stream bed. Algal growth is affected by numerous biotic and abiotic factors including light availability, flow and water velocity, nutrients (particularly phosphorus in freshwater systems), grazing and other influences. In the presence of light, respiration and photosynthesis can occur simultaneously in algae. However, the respiration rate is low compared with the photosynthesis rate, resulting in a net production of oxygen. In the absence of light, algal respiration continues while photosynthesis stops, resulting in a net consumption of oxygen. The breakdown of dead, decaying algae also removes oxygen from water. The most common approach to reducing excessive algal growth involves controls on activities that contribute nutrients to the water body.

Organic sediments can 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 BOD. Decaying matter can also accumulate on the bottom of a stream and cause

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 settle out of the water column and can smother aquatic invertebrates and fish eggs and cause offensive odors and unsightliness.

This TMDL study will characterize pollutant sources contributing to low DO through modeling temperature, nutrient dynamics, algal production and DO during critical, low-flow periods. Missouri's DO criterion for general warm water fisheries (5 mg/L) will be used as the TMDL target.

The DO impairment of Big Bottom Creek could be due to one or more of the following:

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

To better determine the cause of the low DO impairment, additional data from Big Bottom Creek were collected and analyzed in 2009 by URS Corporation under contract with EPA. These data are of sufficient quality to evaluate compliance with WQSs and to support TMDL development because they were collected in accordance with required quality assurance procedures and the Missouri Department of Natural Resources'(MDNR's) sampling protocols (MDNR, 2005).

The location of the stream survey sampling sites in July and August 2009 are provided in Figure 6 and the data are summarized in Table 4, Table 5, Table 6 and Table 7. Monitoring was conducted on July 7 - 8, and August 12 – 13, 2009. For each daily sampling period, flow and water quality data were collected during a morning and afternoon period at seven monitoring locations.

There are several issues worth noting from a review of the data collected from Big Bottom Creek in July and August of 2009 (Sampling locations in Figure 6):

- Sample Location #2 had no flow during the August 12 - 13 sampling events. The stream was dry upstream for at least 100 meters but was flowing further upstream at Sample Location #1. The stream was dry downstream from Sample Location #2 to the confluence with Indian Creek. Indian Creek was flowing and flow was observed further downstream at Sample Location #3.
- Sample Location #1 had observed DO concentration below the 5 mg/L minimum criterion during all four sampling periods and Sample Location #3 had observed DO concentrations below the 5 mg/L minimum criterion during the August 13 sampling period.

- Headwater flow from the spillway at Lake Anne is intermittent. During dry periods, the only flow contributing to the impaired segment of Big Bottom Creek is the discharge from the Lake Forest Estates Subdivision WWTP.

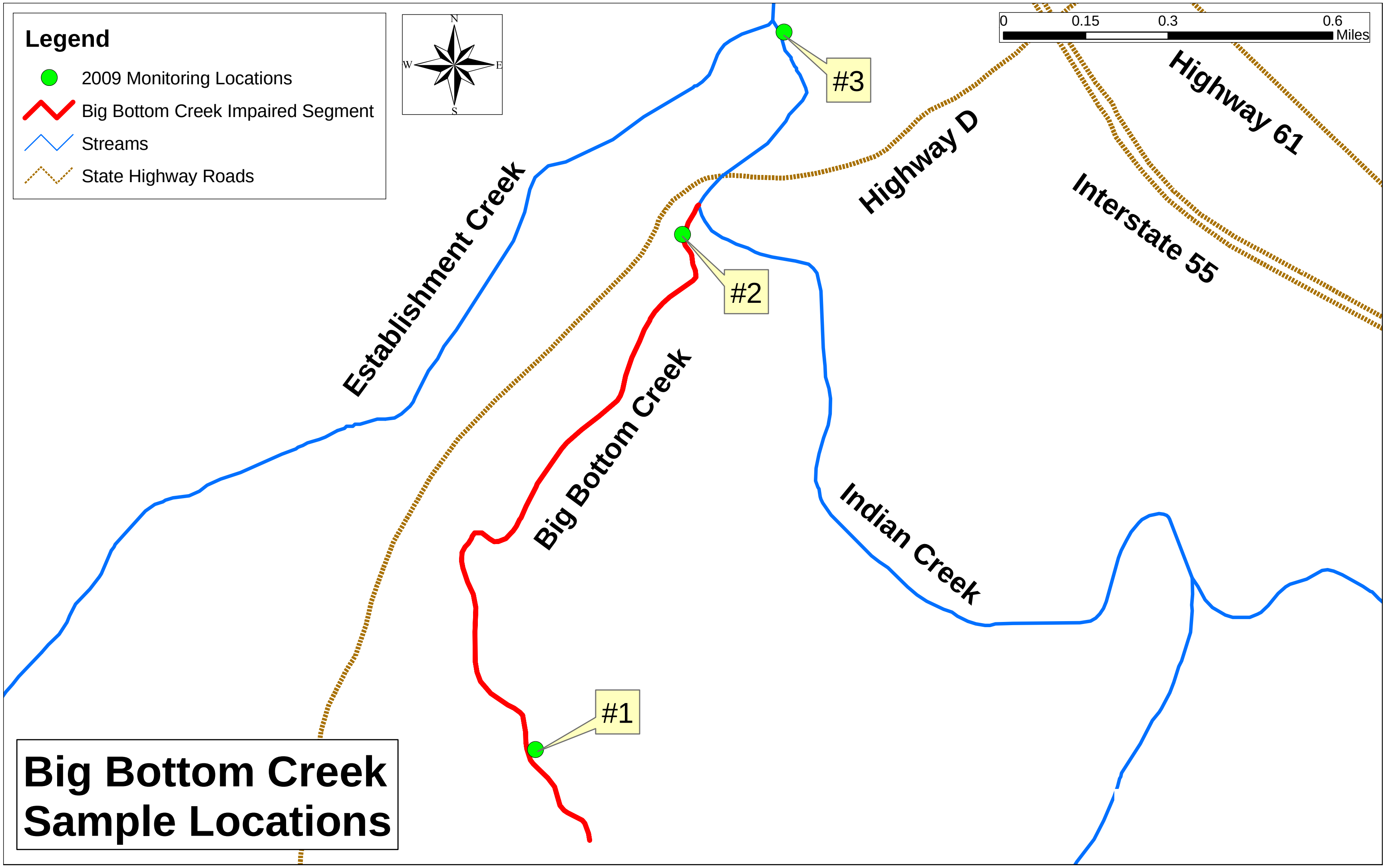

Figure 6. Location of July and August Sampling Sites

For these reasons, the Lake Forest Estates WWTP is listed as the main contributor to BOD and nutrient loads to Big Bottom Creek. Historical data (Appendix A) indicates DO concentrations greater than 5 mg/L upstream of the WWTP discharge (MDNR data: July 9, 2004 and August 7, 2007). The concentration of BOD in the WWTP effluent was below permit limits during both the July and August sampling events, with the exception of an August 9 sample result that reportedly had a CBOD of 174 mg/L (Allen Grass, Lake Forest Estates Manager, personal communication October 12, 2009).

Table 4. Summary of Big Bottom Creek water quality data collected on July 7, 2009

Sampling Station	Time	Flow (cms)	Velocity (m/sec)	$CBOD_5$ (mg/L)	Nitrogen, Ammonia (mg/L)	Nitrogen, TKN (mg/L)	Nitrogen, NO_2+NO_3 (mg/L)	DO (mg/L)	pH	Temp. (°C)	TP (mg/L)
1	7:20 AM	0.052	0.076	3.1	<0.5	1.301	0.615	4.97	6.14	22.55	0.157
1	1:15 PM	0.028	0.036	3.8	<0.5	0.978	0.144	7.25	8.20	26.30	0.0569
2	6:25 AM	0.054	0.061	2.6	<0.5	0.560	0.462	7.48	6.35	19.29	0.0735
2	12:35 PM	0.031	0.031	1.5	<0.5	0.446	0.319	10.06	8.48	22.84	0.0786
3	5:40 AM	0.337	0.077	1.7	<0.5	0.521	0.410	9.32	4.07	19.45	0.0599
3	12:02 PM	0.136	0.029	1.8	<0.5	0.547	0.385	8.44	7.92	21.03	0.0585

(See notes for Tables 4 – 7 after Table 7)

Table 5. Summary of Big Bottom Creek water quality data collected on July 8, 2009

Sampling Station	Time	Flow (cms)	Velocity (m/sec)	$CBOD_5$ (mg/L)	Nitrogen, Ammonia (mg/L)	Nitrogen, TKN (mg/L)	Nitrogen, NO_2+NO_3	DO (mg/L)	pH	Temp. (°C)	TP (mg/L)
1	6:45 AM	0.011	0.017	3.1	<0.5	1.630	0.930	3.68	7.21	23.27	0.330
1	1:30 PM	0.030	0.037	5.2	<0.5	0.897	0.397	4.64	7.21	26.08	0.0832
2	6:00 AM	0.010	0.012	1.3	<0.5	0.455	0.353	5.83	7.62	20.15	0.0667
2	12:50 PM	0.060	0.077	2.7	<0.5	0.264	0.297	8.08	7.40	23.92	0.0628
3	5:30 AM	0.109	0.024	1.15	<0.5	0.546	0.336	5.05	7.23	20.73	0.0591
3	12:10 PM	0.084	0.019	1.8	<0.5	0.295	0.339	6.66	7.01	21.97	0.0456

(See notes for Tables 4 – 7 after Table 7)

Table 6. Summary of Big Bottom Creek water quality data collected on August 12, 2009

Sampling Station	Time	Flow (cms)	Velocity (m/sec)	$CBOD_5$ (mg/L)	Nitrogen, Ammonia (mg/L)	Nitrogen, TKN (mg/L)	Nitrogen, NO_2+NO_3	DO (mg/L)	pH	Temp. (°C)	TP (mg/L)
1	6:55 AM	0.008	0.012	2.1	1.70	3.636	0.774	1.75	7.20	24.10	0.496
1	1:00 PM	0.008	0.012	1.2	1.05	1.307	0.546	3.68	7.34	25.30	0.272
3	5:20 AM	0.031	0.009	0.5	<0.50	0.445	0.117	4.72	7.20	21.80	0.046
3	12:05 PM	0.061	0.015	0.5	<0.50	0.441	0.099	6.51	7.46	23.50	0.044

(See notes for Tables 4 – 7 after Table 7)

Table 7. Summary of Big Bottom Creek water quality data collected on August 13, 2009

Sampling Station	Time	Flow (cms)	Velocity (m/sec)	$CBOD_5$ (mg/L)	Nitrogen, Ammonia (mg/L)	Nitrogen, TKN (mg/L)	Nitrogen, NO_2+NO_3	DO (mg/L)	pH	Temp. (°C)	TP (mg/L)
1	6:15 AM	0.010	0.015	5.5	2.05	3.462	0.598	1.84	7.07	23.30	0.548
1	1:15 PM	0.010	0.012	6.5	1.80	4.042	1.020	4.29	7.24	25.00	0.663
3	5:20 AM	0.041	0.009	0.7	<0.50	0.343	0.115	4.43	7.10	21.00	0.049
3	12:25 PM	0.045	0.012	0.6	<0.50	0.395	0.093	6.20	7.31	22.90	0.050

Notes for Tables 4 - 7:

cms = cubic meters per second
m/sec = meters per second
mg/L = milligrams per liter;
CBOD5 = Carbonaceous Biochemical Oxygen Demand (5 days)
TKN = Total Kjeldahl Nitrogen
NO2+NO3 = Nitrite + Nitrate
DO = Dissolved Oxygen
Temp. = Temperature in degrees Celsius
TP = Total Phosphorus

Method Detection Limits: $CBOD_5$ = 0.2 mg/L, NH_3 = 0.5 mg/L, TKN = 0.1 mg/L, NO_2 + NO_3 = 0.01 mg/L, TP = 0.003 mg/L.

4 SOURCE INVENTORY

A source assessment is used to identify and characterize the known and suspected pollutant sources contributing to the impairment in Big Bottom Creek. 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 Big Bottom Creek. It should be noted that the upper portion of the watershed drains into Lake Anne and does not have a direct impact on the water quality of the impaired segment; however, dams and impoundments are known to degrade water quality and aquatic life (FWS, 2009). The impacts of Lake Anne on the downstream aquatic life use of Big Bottom Creek include alteration of Big Bottom Creek hydrologic regime, increases to water temperature and greater nutrients loads during the summer months. Pollutant source information provided in this section encompasses the entire watershed (both upstream and downstream of Lake Anne). Historic water quality data used to identify and assess sources is presented in Appendix B of this document.

4.1 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). The NPDES and MSOP programs are the same and 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 (CAFOs),
- Storm water runoff from Municipal Separate Storm Sewer System (MS4) and
- General permitted facilities (including storm water runoff from construction and industrial sites).

General permits (as opposed to site specific or individual 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 Big Bottom Creek watershed were identified by consulting EPA's Permit Compliance System (PCS) website[7] and MDNR's GIS inventory[8] of NPDES permitted facilities covered under storm water or general permits. There are no permitted concentrated animal feeding operations in this watershed.

The single point source in Big Bottom Creek watershed is shown in Figure 7 and listed in Table 8. The Lake Forest Estates Subdivision WWTP is required to monitor and report effluent concentrations.

Lake Forest Estates upgraded their wastewater treatment facility in 2003. The community installed a new, three-cell, aerated lagoon adjacent to the existing lagoon site. The existing (old) three lagoons were converted to flow equalization basins to address infiltration and inflow to the subdivision collection system around the lake.

A draft operating permit with new effluent limits was public noticed October 28 through November 27, 2005. The draft included limits for BOD of 18 mg/L weekly average and 9 mg/L monthly average. The limits for total suspended solids (TSS) were 17 mg/L weekly average and 8 mg/L monthly average. These effluent limits were calculated from a WLA developed with a water quality model that used data collected in 2004 and 2005. The previous operating permit contained effluent limits of 60 mg /L weekly average and 30 mg/L monthly average for BOD, and 60 mg/L weekly average and 30 mg/L monthly average for TSS. The following ammonia limits were also included: a daily maximum of 3.4 mg/L and monthly average of 1.7 mg/L for summer (May through October), and daily maximum of 4.0 mg/L and monthly average of 2.0

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[7] www.epa.gov/enviro/html/pcs/index.html

[8] http://msdis.missouri.edu/datasearch/ThemeList.jsp; GIS layers updated May 2009 and June 2009

mg/L for winter (November through April). A compliance schedule was included in the permit stating (in part) that the facility was required to submit its engineering report for construction upgrades to MDNR by March 1, 2006. The permit also included instream monitoring requirements.

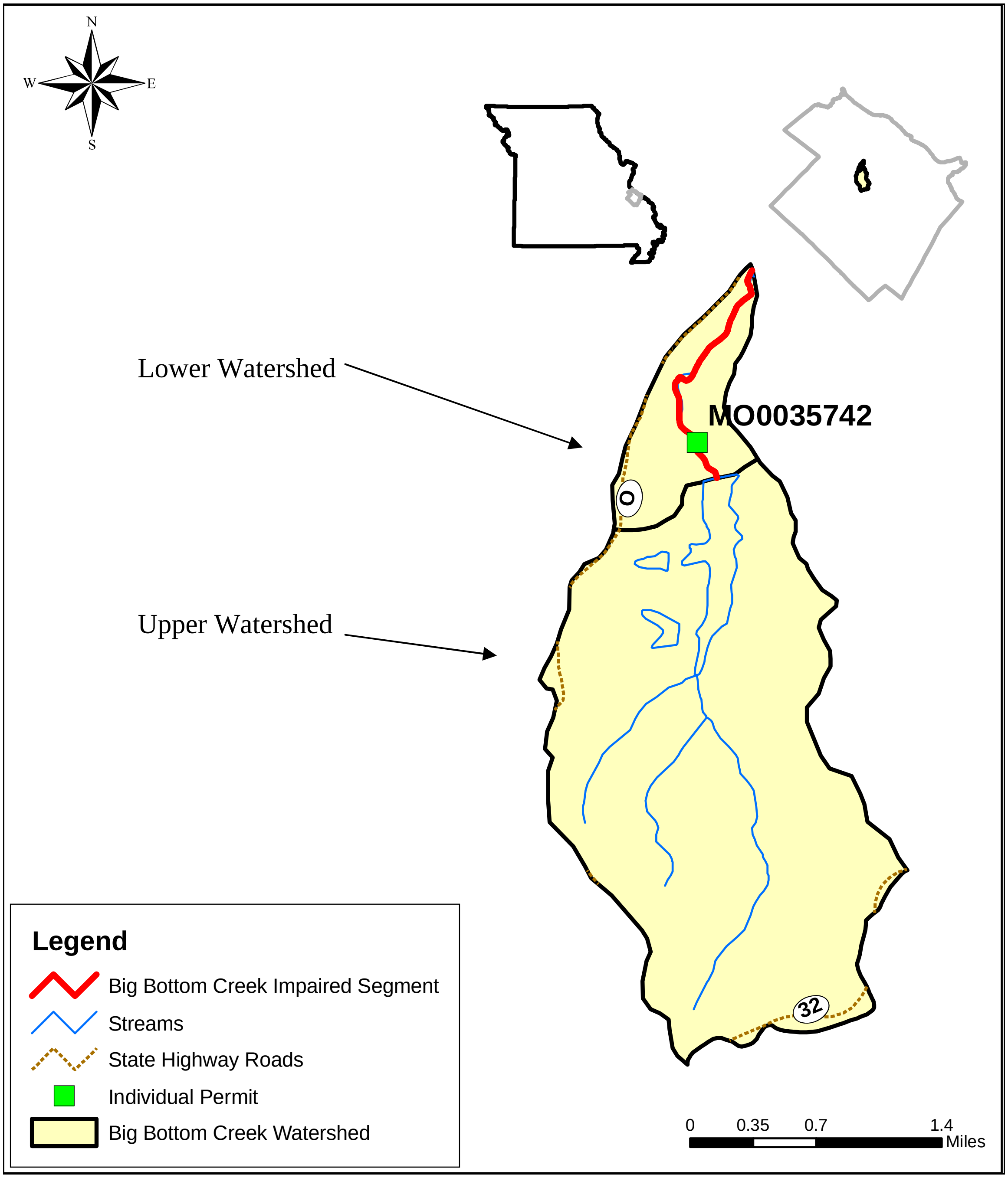

Figure 7. Location of permitted facilities in the Big Bottom Creek Watershed

Table 8. Permitted Facilities in the Big Bottom Creek Watershed

Facility ID	Facility Name	Receiving Stream	Classification/ Description	Reporting Requirements[1]	Design Flow (MGD)[2]	Permit Expiration Date
MO0035742	Lake Forest Estates Subdivision	Big Bottom Creek	Sewerage Systems	NH_3, Temperature, pH, DO, BOD, Flow, TSS	0.1183 (dry weather flow)	2011

[1] Where NH_3 = Ammonia, BOD = Biochemical Oxygen Demand, TSS = Total Suspended Solids, DO = Dissolved Oxygen

[2] MGD = Million Gallons per Day

The NPDES permit for the Lake Forest Estates WWTP was issued December 1, 2006 with existing effluent limitations for BOD, TSS and new seasonal effluent limits for ammonia. The reissued permit did not contain the proposed effluent limitations based upon the 2004-2005 water quality model. Subsequent to permit reissuance, MDNR inspected the stream and collected water quality data in 2007 and 2008 to evaluate water quality in Big Bottom Creek. These data were used to determine whether the operating permit effluent limits needed to be adjusted or if previous upgrades at the facility were sufficient to achieve water quality. In addition to water quality data collected by MDNR, twice per month permittee instream monitoring data for pH, ammonia as nitrogen, temperature and DO were also reviewed. The data indicates low DO persists below the 5 mg/L minimum criterion at critical flow conditions (Appendix A).

Illicit straight pipe discharges of household waste are also potential point sources in rural areas. These sources 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 Big Bottom Creek 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.

4.2 Nonpoint Sources

Nonpoint sources include all other categories of pollutant sources not classified as point sources. Potential nonpoint sources contributing to low DO problems in the Big Bottom Creek watershed include runoff from agricultural areas, runoff from urban areas, onsite wastewater treatment systems and various sources associated with riparian habitat conditions. Additional discussion on nonpoint sources is provided in the following sections.

Based on the information before us, the decision to apply discharges associated with unpermitted sources to the LA, as opposed to the WLA for purposes of this TMDL, is acceptable. 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 approving 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 pollutant 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 WLA in this TMDL. WLA in addition to that allocated here is not available.

4.2.1 Runoff from Agricultural Areas

Lands used for agricultural 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 indicates there are 0.09 square miles of cropland in the watershed, which comprises 2 percent of the entire watershed (Table 2). Cropland is concentrated in the lower watershed adjacent to the impaired reach (Figure 5) and comprises 8 percent of the lower watershed. An assessment of cropland in the riparian buffer of the impaired stream segment showed cropland to be approximately 24.3 percent (Table 9) of the entire watershed.

County wide data from the National Agricultural Statistics Service (NASS) (USDA, 2007) were combined with the land cover data for the Big Bottom Creek watershed to estimate approximately 364 cattle in the watershed[9]. The cattle are most likely located on the approximately 1.4 square miles acres of grassland/pastureland in the total watershed and the 0.153 square miles in the lower 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 Big Bottom Creek watershed (74 cattle per square mile or 364 cattle in the entire watershed) suggests they are not a potential source of pollutants. The NASS also reports there were 10,567 hogs and pigs, 933 horses and ponies, 150 sheep and lambs and 1,795 layers in Ste. Genevieve County in 2007 (USDA, 2007).

Permitted CAFOs identified in this TMDL are part of the assigned WLA. At this time, animal feeding operations (AFOs) and unpermitted CAFOs are considered under the LA because we do not currently have 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 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.

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[9] According to the NASS there are approximately 32,855 head of cattle in Ste. Genevieve County (USDA, 2007). There are 126 square miles of grasslands in Ste. Genevieve County (MoRAP, 2005). These two values result in a cattle density of approximately 261 cattle per square mile of grasslands. This density was multiplied by the number of grassland square miles in the Big Bottom Creek watershed to estimate the number of cattle in the watershed.

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, 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.

4.2.2 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 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 stream. Excessive discharge of suspended solids from urban areas can also lead to streambed siltation problems.

The areas within Big Bottom Creek watershed classified as urban land use are predominately composed of impervious surfaces (i.e., driveways, roads, rooftops, etc.). Since approximately 2.0 percent of the lower watershed and 4.5 percent of the total Big Bottom Creek watershed is classified as impervious and low intensity urban it is unlikely these areas are a major contributor of pollutants to the impaired reach.

4.2.3 Onsite Wastewater Treatment Systems

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

The exact number of onsite wastewater treatment systems in the Big Bottom Creek watershed is unknown. However, the National Environmental Service Center (NESC) reports that in 1998 there were 33,703 septic systems with an average population per septic system of 2.57 persons and a septic failure rate of 0.46 percent in the Cahokia-Joachim watershed (HUC 07140101). As discussed in Section 2.4, the estimated rural population of the lower Big Bottom Creek watershed, where the impaired reach is located, is approximately 15 persons. Based on this population and an average density of 2.57 persons per septic system, we can estimate that there are approximately six septic systems in the watershed. Based on a failure rate of 0.46 percent there is approximately one failing septic system within the Big Bottom Creek watershed (NESC 1998). EPA reports that the statewide failure rate of onsite wastewater systems in Missouri is 30 to 50 percent (EPA, 2002). If these higher numbers are more accurate there would be between 2 and 3 failing systems. Based on these estimates it is unlikely that failing onsite wastewater treatment systems are a contributor to water quality problems in Big Bottom Creek.

4.2.4 Riparian Habitat Conditions

Riparian[10] (streamside) habitat conditions can have a strong influence on in-stream DO. 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 wetlands are all natural sources of organic material that consume oxygen.

As indicated in Table 9, approximately 32 percent of the land in the lower Big Bottom Creek 30-meter riparian corridor is classified as forest (MoRAP, 2005). Grassland, including pasture areas, covers approximately 34 percent of the riparian corridor and cropland covers 24.3 percent. 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. Much of the riparian corridor is comprised of cropland and grassland. Since these land use types are associated with high nutrient loads their presence near Big Bottom Creek indicates that transport of pollutants from these areas is more likely to occur than similar land uses further from the creek.

Table 9. Percentage Land use / Land cover within 30-meter riparian buffer of lower Big Bottom Watershed (MoRAP, 2005)

Land Use/Land Cover	Percent Area
Barren or Sparsely Vegetated	0.4
Cropland	24.3
Deciduous Forest	32.4
Herbaceous	11.1
Grassland	23.5
Impervious	1.7
Low Intensity Urban	1.6
Open Water	2.1
Wetland	2.9
Total	100

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

5 APPLICABLE WQS 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 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 to restore and protect the quality of their water resources.

Under the CWA, every state must adopt WQS to protect, maintain and improve the quality of the nation's surface waters (US Code Title 33, Chapter 26, Subchapter III [US Code, 2009]). These standards represent a level of water quality that will support the CWA's goal of "fishable/swimmable" waters. Missouri's Surface WQS (10 Code of State Regulation [CSR, 2009] 20-7.031) consist of three components: designated uses, criteria (general and numeric) 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).

5.1 Designated Beneficial Uses

The designated beneficial uses of Big Bottom Creek (Water body ID [WBID]_1746) are:

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

The use that is impaired is Protection of Warm Water Aquatic Life. The designated beneficial uses and stream classifications for Missouri may be found in the WQS at 10 CSR 20-7.031(1)(C), (1)(F) and Table H available from the Missouri Secretary of State (CSR, 2009).

5.2 Criteria

Missouri's water quality criteria that relate to DO, ammonia and organic sediment are presented in the following sections. The sections also provide brief descriptions of why DO, organic sediment and ammonia are important to water quality, how they are measured and how they are related to other water quality parameters.

5.2.1 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) 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 Missouri streams except cold water fisheries require a daily minimum of 5 mg/L DO (10 CSR 20-7.031 Table A [CSR, 2009]).

DO 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. Excessive nitrogen and phosphorus loading to water bodies can also contribute to DO problems because they can accelerate algal growth.

Algal growth in streams is most frequently assessed based on the amount of chlorophyll-a in the water. Algal growth is affected by numerous biotic and abiotic factors including light availability, flow and water velocity, nutrients (particularly nitrogen and phosphorus), grazing and other influences. Algae contribute DO during photosynthesis and consume DO during respiration. This typically results in a net gain of DO during the day and net loss of DO during the night. The breakdown of dead, decaying algae also removes oxygen from water. The most common approach to reducing excessive algal growth involves controls on activities that contribute phosphorus to the water body.

5.2.2 Organic Sediment

As previously mentioned, organic sediments can contribute to fluctuating DO concentrations. Decaying matter can come from wastewater effluent, as well as agricultural and urban runoff and is typically measured in stream as BOD. Decaying matter can also accumulate on the bottom of a stream and cause 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 NH_3, 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).

High levels of organic sediment can contribute to sludge production along stream beds which smother aquatic invertebrates and fish eggs and cause offensive odors and unsightliness. Missouri’s WQS do not include specific numeric criteria for organic sediment, but given the natural effects of excessive organic sediment on aquatic life, Missouri’s narrative criteria are applicable [10 CSR 20-7.031(3)(A), (C), (D) and (G)] (CSR, 2009). Included in the narrative criteria are the following requirements:

- 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.

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. A detailed discussion of the method used to develop the TSS target is provided in Appendix D.

5.2.3 Ammonia

Ammonia is an important consideration in Big Bottom Creek because of its influence on DO concentrations and toxicity to aquatic life. Nitrogenous biochemical oxygen demand (NBOD) is the result of ammonia oxidation, which is a conversion of ammonia to nitrate in the aqueous environment. The consumption of nitrogen usually occurs more slowly than that of carbon. Nitrifying bacteria grow more slowly than the heterotrophic bacteria, which is one of the reasons why NBOD occurs at a slower rate than CBOD. The Missouri WQS contain acute and chronic numeric criteria for ammonia that are pH and temperature dependent. The numeric ammonia criteria are in 10 CSR 20-7 Table B1, B2 and B3 (CSR, 2009). These tables are also included in Appendix C.

5.2.4 Total Nitrogen and Total Phosphorus

An overabundance of nutrients, in particular nitrogen and phosphorus, is a serious threat to aquatic ecosystems. Excess nutrients support rapid algal growth, also referred to as algal blooms, which will cause significant changes to the water body. This phenomenon is called eutrophication. Eutrophication is the natural aging of lakes or streams caused by nutrient enrichment. Cultural eutrophication is the accelerated aging of the natural condition caused by human activities. Nutrient related water quality issues include the following:

- Proliferation of nuisance algae and the resulting unsightly and harmful bottom deposits;
- Turbidity due to suspended algae and the resulting green color;
- Organic enrichment when algal blooms die off, which perpetuates the cycle of excessive plant growth;
- Low DO caused by extreme swings in oxygen production by over abundant plant life and oxygen depletion resulting from decomposition of algae and other plants, which can have a negative impact on aquatic organisms.

Missouri does not have a numeric criterion for total nitrogen (TN) or total phosphorus (TP) in freshwater streams; therefore, targets and LCs are based on EPA-recommended Ecoregion 39 criteria and water quality observations at locations throughout the ecoregion (EPA, 2000). 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 ecoregion criteria are used directly in developing LCs for TN and TP. A detailed discussion of the method used to develop the TN and TP targets is provided in Appendix E of this report.

5.3 Antidegradation Policy

Missouri's WQS include EPA's "three-tiered" approach to antidegradation, which may be found at 10 CSR 20-7.031(2) (CSR, 2009).

> Tier 1 – Protects existing in-stream 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 in-stream 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 anti-degradation 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 or beneficial uses.
>
> Tier 3 – Protects the quality of outstanding national and state resource waters, such as waters of national and state parks, wildlife refuges and 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.

6 MODELING APPROACH

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 hydrological regime of historic alluvial streams was 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 LDC 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. The relationship between the source loadings of CBOD, nutrients (NH_3, TN and TP) and algal dynamics on DO is generated by the water quality model QUAL2K (Chapra et al., 2008) under steady 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 (U.S. Geological Survey [USGS], non-filterable residue) in the geographic region in which Big Bottom Creek is located. To address nutrient levels, the EPA nutrient ecoregion reference concentrations were used. For the ecoregion where Big Bottom Creek is located, the reference concentration for TN is 0.289 mg/L and the reference concentration for TP is 0.007 mg/L. This TMDL will not specifically target chlorophyll as a WLA, but will use a linkage between nutrient concentrations and chlorophyll response to achieve the ecoregion reference concentrations.

6.1 Load Duration Curves

The sediment target for this TMDL was derived using a reference approach. In this approach, the target for pollutant loading is the 25th percentile of the current EDU condition calculated from all TSS data available (USGS, non-filterable residue) within the EDU in which the water body is located (see Appendix C for a list of sites and data). Therefore, the 25th percentile (10mg/L) is targeted as the TMDL LDC (See Appendices D and F).

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 LDC. 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 curves in the LDCs flatten at low flow because at these lower flows the TMDL target is dominated by the point source flow.

6.2 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 NO_3+NO_2) and sediment demands of organic substances to instream oxygen levels.

Flow and water quality data collected on July 7 - 8, August 12 - 13 were used to calibrate and validate the QUAL2K model. Once the QUAL2K model was set up and calibrated for Big Bottom Creek, a series of scenarios were run to evaluate the pollutant load reductions needed to achieve the minimum DO criterion. These results are summarized in Section 7 and a detailed discussion of the QUAL2K model is included in Appendix B.

7 CALCULATION OF LOADING CAPACITY

LC is defined as the greatest amount of pollutant that a water body can assimilate without violating WQS. This load is then divided among the point source (WLA) and nonpoint source (LA) 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. If the MOS is implicit, no numeric allowance is necessary. Conceptually, this definition is represented by the equation:

$$LC = \sum WLA + \sum LA + MOS$$ **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 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 are considered when the LC is calculated. DO levels that threaten the integrity of aquatic communities generally occur during low flow periods, so these periods are considered the critical condition. Mixing zones and zones of initial dilution are not allowed in regulation for Class C streams [10 CSR 20-7.031(4)(A)4.B.(I)]. Therefore, in order to ensure attainment of applicable WQS, all water quality criteria must be met end of pipe for permitted facilities.

The QUAL2K model was set up and calibrated to the 2009 July and August sampling dates to further investigate the DO issues. The August 12, 2009, model was used to identify the LC since it represented a more critical condition (i.e., reduced DO and lower flows). 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 Lake Forest Estates 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 ammonia effluent limits for the Lake Forest Estates WWTP in Step 2 are not protective of the instream DO WQS, the QUAL2K model is iteratively run at reduced BOD and ammonia concentrations until compliance with the WQS is met. The difference between the baseline condition and BOD and ammonia WLA required to achieve the standard is the percent reduction needed at the facility.

The TMDL, summarized in Table 10, is based on 7Q10 flows[11] of 0.01 cfs (0.00028 cubic meters per second) and the environmental conditions (air temperature, dew point temperature and cloud cover) that were present on the August 12, 2009 model. For the purposes of QUAL2K modeling, MDNR assigns a 7Q10 flow of 0.01 cfs for Class C waters. The results of the modeling analysis indicate that the effluent needs to be aerated to above 8.0 mg/L DO in addition to the specified load reductions. Lower DO concentrations will require greater reductions in BOD, CBOD and/or ammonia. Based on the QUAL2K modeling the load reductions from baseline conditions required to meet 5 mg/L of DO are:

- 78 percent reduction in BOD,
- 72 percent reduction in SOD,
- 84 percent reduction in ammonia.

The SOD assumed for the impaired reach in the TMDL scenarios is a low value for enriched sediments and is a reasonable value downstream of a WWTP. The effluent characteristics of the Lake Forest Estates WWTP that results in a minimum DO of 5 mg/L are provided in Table 10. These values represent the daily load that will result in a DO of 5 mg/L during low flow critical conditions. During this period flow in the stream is almost entirely from the WWTP.

The treatment technology required to meet the BOD limits corresponding to the WLAs shown below should result in corresponding reductions of organic sediment that will eliminate the organic sediment impairment and reduce the SOD in Big Bottom Creek.

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 and 25th percentile EDU TSS concentrations and the sum of the design flows of permitted facilities in the watershed. The nonpoint sources or LA TMDL targets for TSS, TP and TN were calculated using nutrient ecoregion reference concentrations and 25th percentile EDU TSS concentrations and the sum of the headwater and tributary flows. For tributary loading (Indian Creek), the ecoregion target for nitrogen (289 micrograms nitrogen per liter [µgN/L]) was assigned as 289 µgN/L in the organic nitrogen fraction because there are no wastewater treatment facilities on the tributary and nitrogen from nonpoint sources is expected to be largely represented by the organic nitrogen fraction. For point source loading, the ecoregion target for nitrogen was assigned as 289 µgN/L ammonia, based on the assumption that ammonia is the primary parameter of concern, with respect to nitrogen, in treated WWTP effluent. For both point and nonpoint sources, the ecoregion criteria target for TP (7 ug/L) was split 80:20 between organic and inorganic phosphorus fractions, respectively, such that the organic phosphorus target was set equal to 5.6 micrograms per liter [µg/L] and the inorganic phosphorus target was set equal to 1.4 µg/L. TP and TN nonpoint source baseline flow conditions were obtained using existing loads sampled on August 12, 2009. The LDCs for the targeted pollutants are depicted in Figure 8, Figure 9 and Figure 10, where the TMDL line represents the total LC of all point and

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[11] For the purposes of QUAL2K modeling, MDNR assigns a 7Q10 flow of 0.01 cfs for Class C waters (personal communication with John Hoke, MDNR TMDL Unit Chief, October 15, 2009).

nonpoint sources of pollutants. The pollutant allocations under a range of flow conditions are presented in Table 11, Table 12 and Table 13.

Table 10. TMDL Summary for Big Bottom Creek at 7Q10 Low Flow Critical Conditions

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 (MGD)	0.118	0.001	0.119	0.118	0.001	0.119	0%	0%
BOD_5 (lbs/day)	29.6	0.23	29.9	6.4	0.26	6.7	78%	0%
$CBOD_{ult}$ (lbs/day)	No limit	0.12	Not applicable	10.9	0.34	11.2	Not applicable	0%
$NBOD_{ult}$ (lbs/day)	No limit	0.33	Not applicable	1.3	0.15	1.49	Not applicable	55%
NH_3 (lbs/day)	1.9	0.05	1.927	0.3	0.00	0.29	84%	100%
TSS (lbs/day)	29.6	1.3	30.9	9.9	1.1	11.0	67%	16%
TN (lbs/day)	No limit	0.57	Not applicable	0.285	0.031	0.317	Not applicable	94%
TP (lbs/day)	No limit	0.004	Not applicable	0.007	0.001	0.008	Not applicable	81%

Note: The WLA and LA specified in Table 10 results in a minimum DO of 5.0 mg/L when the effluent is aerated to at least 8.0 mg/L DO. Baseline conditions for point sources are based on permitted flow and concentration at the Lake Forest Estates Subdivision WWTP. Baseline conditions for nonpoint sources are based on inputs used in the August 12, 2009, QUAL2K model. Monthly average permit limits were used for baseline point source conditions. The Lake Forest Estates Subdivision WWTP has numeric limits for BOD_5, which are 60 mg/L weekly average and 30 mg/L monthly average and ammonia which are 3.7 mg/L daily maximum and 1.9 mg/L monthly average from May through October. Numeric limits for TSS are 60 mg/L weekly average and 30 mg/L monthly average. Point and nonpoint TMDL values for flow, BOD_5, $CBOD_{ult}$, $NBOD_{ult}$ and NH_3, are based on the August 12, 2009, QUAL2K TMDL model in which background and point source nutrient concentrations are set to ecoregion criteria (TN = 0.289 mg/L and TP = 0.007 mg/L), flows are adjusted to 7Q10 conditions and aeration (to 8.0 mg/L DO) is used at the Lake Forest Estates Subdivision WWTP. In developing the TMDL scenarios, the ecoregion target for nitrogen (289 µgN/L) was fully assigned to the organic nitrogen fraction for tributary loading because there are no wastewater treatment facilities on the tributary and nitrogen from nonpoint sources is expected to be largely represented by the organic nitrogen fraction. For point source loading, the ecoregion target for nitrogen was assigned as 289 µgN/L ammonia, based on the assumption that ammonia is the primary parameter of concern, with respect to nitrogen, in treated WWTP effluent.

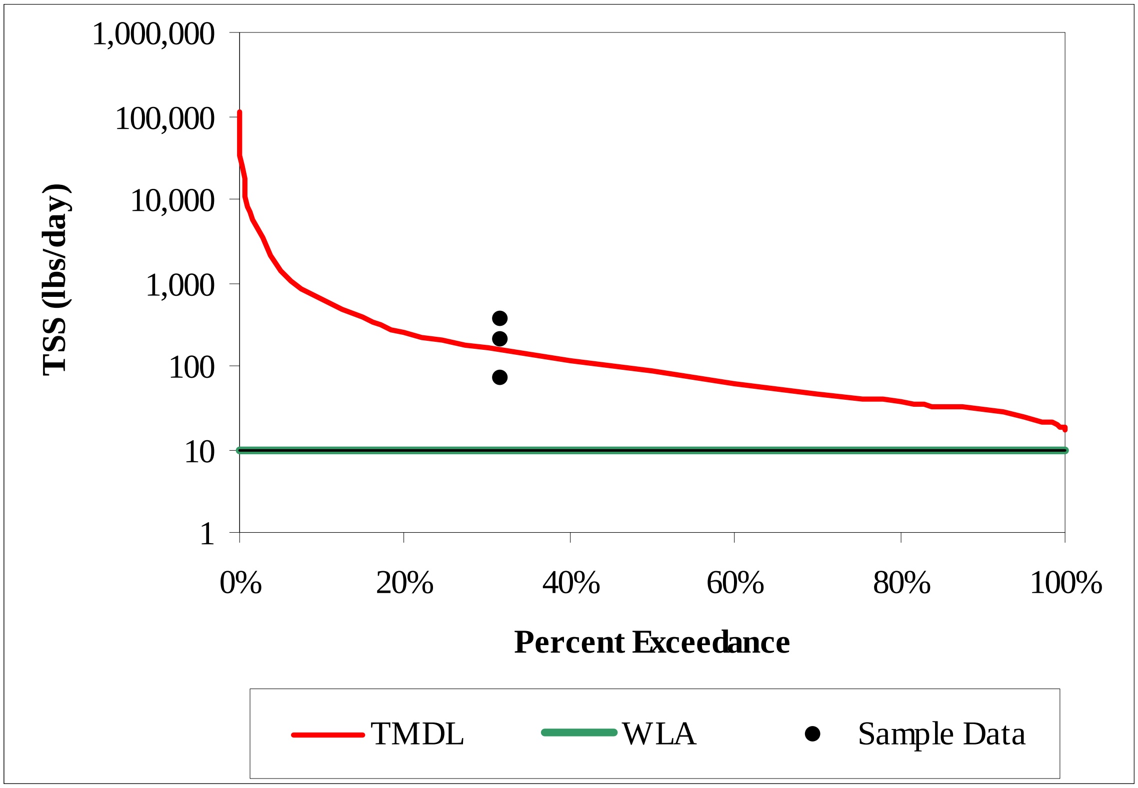

Figure 8. TSS LDC for Big Bottom Creek

Table 11. TSS TMDL under a range of flow conditions in Big Bottom Creek

Percent Flow Exceedance	Estimated Flow (cfs)	TMDL (lbs/day)	MOS[1] (lbs/day)	LA (lbs/day)	Lake Forest WWTP (lbs/day)
95%	0.46	25	--	15	10
90%	0.54	29	--	19	10
70%	0.86	47	--	37	10
50%	1.58	85	--	75	10
30%	3.05	164	--	154	10
10%	7.97	623	--	613	10
5%	12.98	1,370	--	1,360	10

[1] The TSS MOS is implicit.

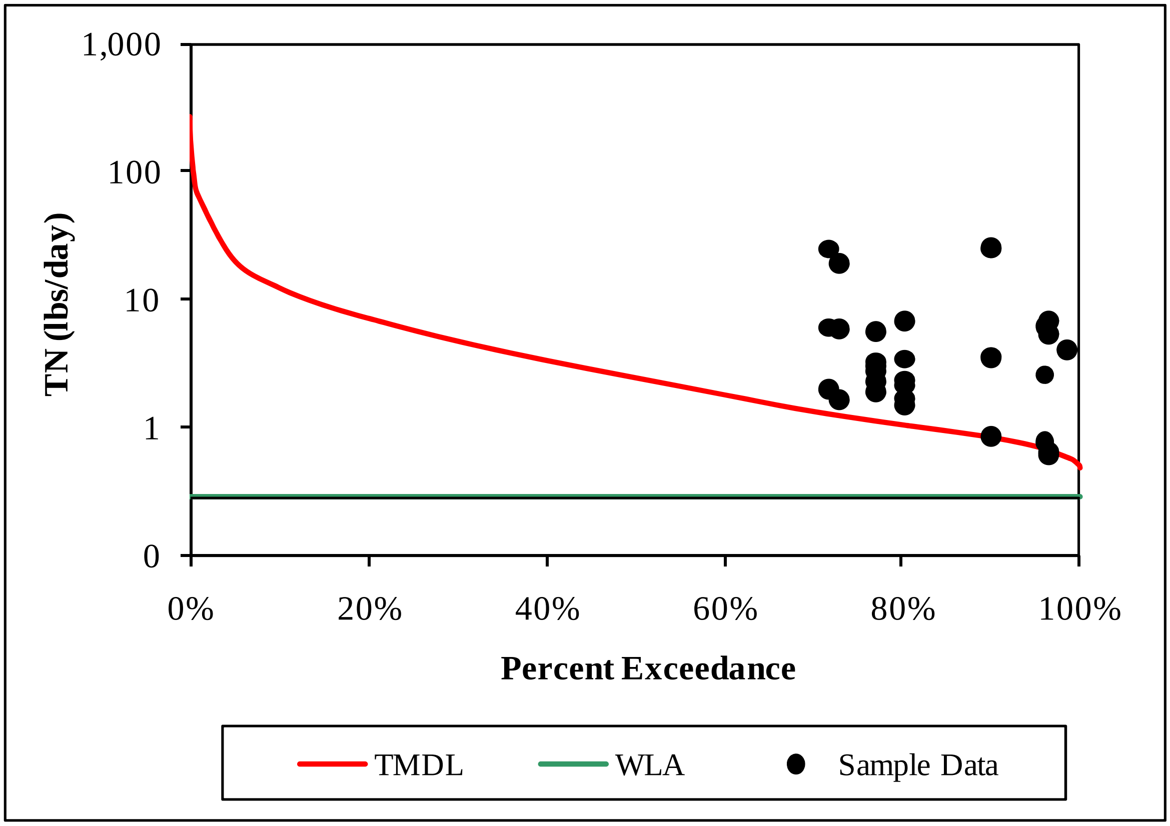

Figure 9. TN LDC for Big Bottom Creek

Table 12. TN TMDL under a range of flow conditions in Big Bottom Creek

Percent Flow Exceedance	Estimated Flow (cfs)	TMDL (lbs/day)	MOS[1] (lbs/day)	LA (lbs/day)	Lake Forest WWTP (lbs/day)
95%	0.46	0.72	--	0.43	0.29
90%	0.54	0.85	--	0.56	0.29
70%	0.86	1.35	--	1.06	0.29
50%	1.58	2.47	--	2.18	0.29
30%	3.05	4.75	--	4.46	0.29
10%	7.97	12.42	--	12.13	0.29
5%	12.98	20.24	--	19.95	0.29

[1] The TN MOS is implicit.

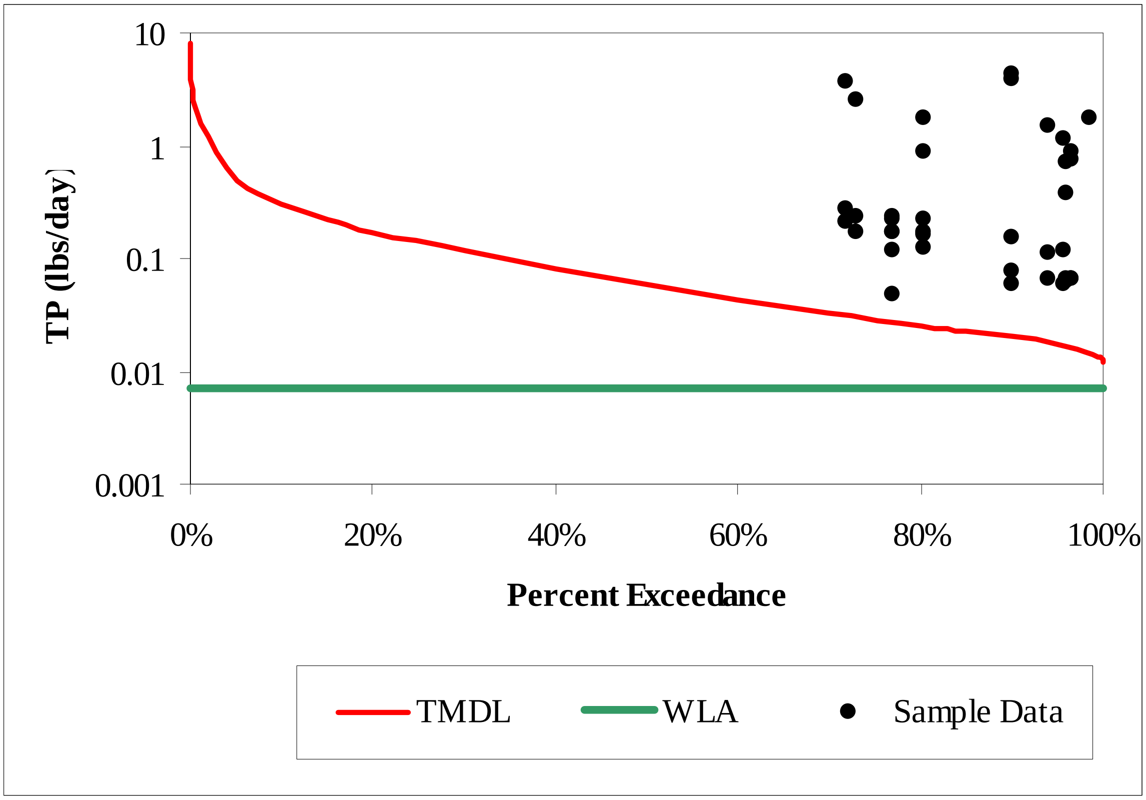

Figure 10. TP LDC for Big Bottom Creek

Table 13. TP TMDL under a range of flow conditions in Big Bottom Creek

Percent Flow Exceedance	Estimated Flow (cfs)	TMDL (lbs/day)	MOS[1] (lbs/day)	LA (lbs/day)	Lake Forest WWTP (lbs/day)
95%	0.46	0.02	--	0.01	0.01
90%	0.54	0.02	--	0.01	0.01
70%	0.86	0.03	--	0.02	0.01
50%	1.58	0.06	--	0.05	0.01
30%	3.05	0.12	--	0.11	0.01
10%	7.97	0.30	--	0.29	0.01
5%	12.98	0.49	--	0.48	0.01

[1] The TP MOS is implicit.

8 WASTELOAD ALLOCATION (POINT SOURCE LOADS)

The WLA is the portion of the LC that is allocated to existing or future point sources of pollutants. New WLAs for the Lake Forest Estates Subdivision WWTP were calculated through the modeling process and are shown in Table 14. The WLAs for CBOD and ammonia should ensure attainment of the DO water quality criterion in Big Bottom Creek if SOD is reduced by 72 percent and DO is increased to 8.0 mg/L. The treatment technology required to meet the CBOD limits corresponding to the WLAs should result in corresponding reductions of organic sediments that will reduce the SOD in Big Bottom Creek. To meet the WLAs, a reduction below existing permit limits is required. The existing and reduced permit limits are summarized in Table 14.

Table 14. WLAs for Lake Forest Estates Subdivision WWTP (MO0035742) in the Big Bottom Creek Watershed

Effluent Parameter	Design Flow (MGD)	Existing Permit Limit (mg/L)		WLA at Design Flow based on QUAL2K and LDC modeling (mg/L)		Percent Reduction
		Concentration (mg/L)	Load (lbs/day)	Concentration (mg/L)	Load (lbs/day)	
$CBOD_5$	0.1183	No limit	No limit	5.04	4.99	Not applicable
$NBOD_5$	0.1183	No limit	No limit	1.46	1.45	Not applicable
TN	0.1183	No limit	No limit	0.289	0.29	Not applicable
TP	0.1183	No limit	No limit	0.007	0.01	Not applicable
NH_3	0.1183	Daily Maximum = 3.7[12] - 7.5[13] Monthly Average = 1.9[14] - 3.7[15]	3.7 - 7.4 1.9 – 3.7	0.3	0.9	50
TSS	0.1183	Weekly Average = 60 Monthly Average = 30	= 59.2 = 29.6	10.0	9.9	67

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. Existing permit limit loads (lbs/day) are based on existing design flow and monthly average limits.

9 LOAD ALLOCATION (NONPOINT SOURCE LOADS)

The LA includes all existing and future nonpoint sources and natural background contributions (40 CFR § 130.2(g)). The LA for the Big Bottom Creek TMDL is for all nonpoint sources of CBOD, NBOD, TSS, TP and TN, which could include loads from agricultural lands, runoff from urban areas, livestock and failing onsite wastewater treatment systems. The LAs provided in Table 11, Table 12 and Table 13 are expected to be protective of water quality in Big Bottom Creek during critical low flow periods. During periods of higher flow, such as when Lake Anne overflows, low DO has not been identified as a water quality problem.

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[12] Represents limits from May 1 – October 31

[13] Represents limits from November 1 – April 30

[14] Represents limits from May 1 – October 31

[15] Represents limits from November 1 – April 30

10 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 BOD, CBOD and ammonia 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 included focusing calibration on the measured low DO concentrations, critical low flow conditions and DO concentrations under critical low flow conditions in deriving applicable CBOD, NBOD, NH3 and TSS targets.

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 Big Bottom Creek is located and to establish WLAs for the Lake Forest Estates 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 IX. 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).

11 SEASONAL VARIATION

A TMDL must consider seasonal variation in the derivation of the allocations. The pollutants that the TMDL addresses (DO, ammonia and organic sediment) are all affected by temperature and flow. 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 TMDL targets. Annual low-flow conditions in Missouri typically occur between July 1 and September 15. In this TMDL report, summer low flow is defined as a 7-day average flow of the 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.

DO 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).

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. The 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.

12 MONITORING PLAN FOR TMDLS DEVELOPED UNDER PHASED APPROACH

Post-TMDL monitoring will be scheduled by MDNR after new effluent limits in the Lake Forest Estates WWTP permit have gone into effect. In the interim, instream monitoring required by the facility operating permit for pH, temperature, ammonia, and DO upstream and downstream of the facility outfall will be reviewed by MDNR. MDNR will also routinely examine physical habitat, water quality, invertebrate and fish community data collected by the Missouri Department of Conservation under its Resource Assessment and Monitoring (RAM) Program. This program randomly samples streams across Missouri on a five to six year rotating schedule.

As with all of Missouri's TMDLs, if continuing monitoring reveals that water quality standards are not being met, the TMDL will be reopened and re-evaluated accordingly.

13 REASONABLE ASSURANCES

MDNR has the authority to issue and enforce Missouri State Operating Permits. Inclusion of effluent limits determined from WLAs established by TMDL modeling into a state permit and monitoring of the effluent and receiving stream reported to MDNR, should provide reasonable assurance that instream WQS will be met. In most cases, "Reasonable Assurance" in reference to TMDLs relates only to point sources. As a result, any assurances that nonpoint source contributors of oxygen consuming substances, ammonia and organic sediment will implement measures to reduce their contribution in the future will not be found in this section.

14 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 Big Bottom Creek 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 Big Bottom Creek in Ste. Genevieve 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* consent decree milestones. Missouri may submit and EPA may approve another TMDL for this water at a later time.

Before finalizing EPA established TMDLs (such as this TMDL), 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 or 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.

15 ADMINISTRATIVE RECORD AND SUPPORTING DOCUMENTATION

An administrative record on the Big Bottom Creek TMDL has been assembled and is being kept on file with EPA.

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APPENDIX A – BIG BOTTOM CREEK WATER QUALITY DATA

Table A-1. Historic Water Quality Data in Big Bottom Creek (See Sec 3, Tables 6 and 7 for 2009 data)

Org	Site	Site Name	Date	Temperature (ºC)	DO (mg/L)	pH	NH_3-N (mg/L)	CBOD (mg/L)
MDNR	1746/1.1	Big Bottom Cr. just ab. Lake Forest Lgn.	6/9/2004		5.7	7.8		
MDNR	1746/1.1	Lake Forest Lgn Effluent	6/9/2004		6.4	7.6		
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	6/9/2004		4.8	7.7		
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	7/1/2004	26	4.4	7.5	2.65	3.17
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	7/2/2004	23.5	1.1	7.5	5.58	2.91
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	4/19/2005	17	1.1			
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	4/19/2005	20	8.2			
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	6/9/2005	23.9	0.8	7.4	12.4	8
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	6/9/2005	24.9	1.9	7.5	12.5	6.5
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	8/18/2006	24.8	4.7			
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	8/18/2006	28.3	7.2			
MDNR	1746/1.1	Big Bottom Cr. just ab. Lake Forest Lgn.	8/2/2007	26	6.2	7.7	0.76	2.09
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	7/1/2004	18	4.7	7.5	0.01499	0.99
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	7/2/2004	17	4.2	7.5	0.01499	0.99
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	4/19/2005	13	4.2			
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	4/19/2005	17	9			
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	6/9/2005	14.1	2.4	7.3	0.01499	0.99
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	6/9/2005	14.2	2.6	7.4	0.01499	0.99
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	8/18/2006	20.7	5			
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	8/18/2006	26.8	6.9			
MDNR	1747/0.01	Indian Cr. nr. Mouth	7/1/2004	22	6.3	7.7	0.01499	0.99
MDNR	1747/0.01	Indian Cr. nr. Mouth	7/2/2004	19.5	5.5	7.5	0.01499	0.99
MDNR	1747/0.01	Indian Cr. nr. Mouth	4/19/2005	13	6.3			
MDNR	1747/0.01	Indian Cr. nr. Mouth	4/19/2005	21	13			
MDNR	1747/0.01	Indian Cr. nr. Mouth	6/9/2005	19.8	4.6	7.7	0.01499	0.99
MDNR	1747/0.01	Indian Cr. nr. Mouth	6/9/2005	25	12	8.4		

Org	**Site**	**Site Name**	**Date**	**Temperature (ºC)**	**DO (mg/L)**	**pH**	**NH_3-N (mg/L)**	**CBOD (mg/L)**
MDNR	1747/0.01	Indian Cr. nr. Mouth	8/18/2006					
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	7/1/2004	23	7.4	7.7	0.01499	0.99
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	7/2/2004	22	4.4	7.7	0.01499	0.99
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	4/19/2005	14	6			
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	4/19/2005	21	13			
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	6/9/2005	21.3	2.8	7.7	0.01499	0.99
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	6/9/2005	24	9.3	8		
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	8/18/2006	20.9	2			
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	8/18/2006	24.3	3.4			

Blank cells indicate that no sample was collected for that parameter and date.
Lgn = Lagoon; Cr = Creek; nr = near
C = temperature in degrees Celsius
DO = Dissolved Oxygen
NH_3N = Ammonia as Nitrogen
CBOD = Carbonaceous Biochemical Oxygen Demand (5 days)
MDNR = Missouri Department of Natural Resources

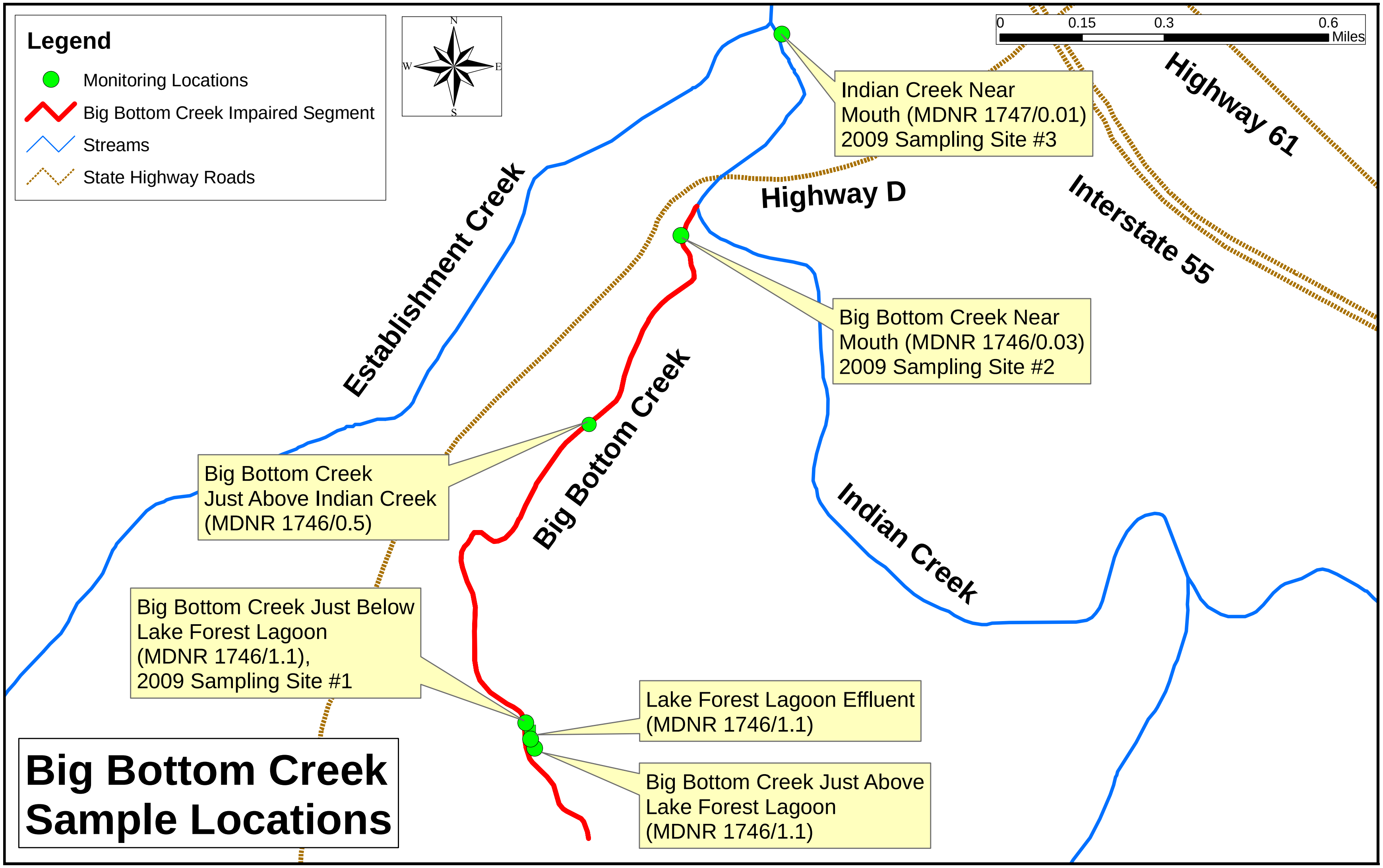

Figure A-1. Location of Big Bottom Creek 2009 Water Quality Monitoring Stations

APPENDIX B - BIG BOTTOM CREEK QUAL2K MODELING

B.1 Overview of QUAL2K

The QUAL2K water quality model, version 2.11b8, was selected for the development of the Big Bottom Creek Dissolved Oxygen (DO) Total Maximum Daily Load (TMDL). QUAL2K is supported by the U. S. Environmental Protection Agency (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, Sediment Oxygen Demand (SOD) and DO dynamics.

B.2 QUAL2K Model Setup

This section of the appendix describes the process that was used to setup the QUAL2K models for the Big Bottom Creek watershed.

B.2.1 Stream Segmentation

Figure B-1 and Figure B-2 provide a visual description of the Big Bottom Creek QUAL2K model structure; including locations of monitoring stations, point sources, nonpoint sources and boundaries. The impaired water body segment is divided into seven reaches; reach lengths are provided in Table B-1. The stream segment was divided into reaches based on the location of water quality monitoring stations, stream hydrology, National Pollutant Discharge Elimination System (NPDES) discharges, shading estimates and point/nonpoint sources. Reaches are further segmented into elements as identified in Table B-1. One wastewater treatment facility, the Lake Forest Estates Subdivision Wastewater Treatment Plant (WWTP), is represented as a point source in reach one and a tributary; Indian Creek is represented as a point source to reach seven.

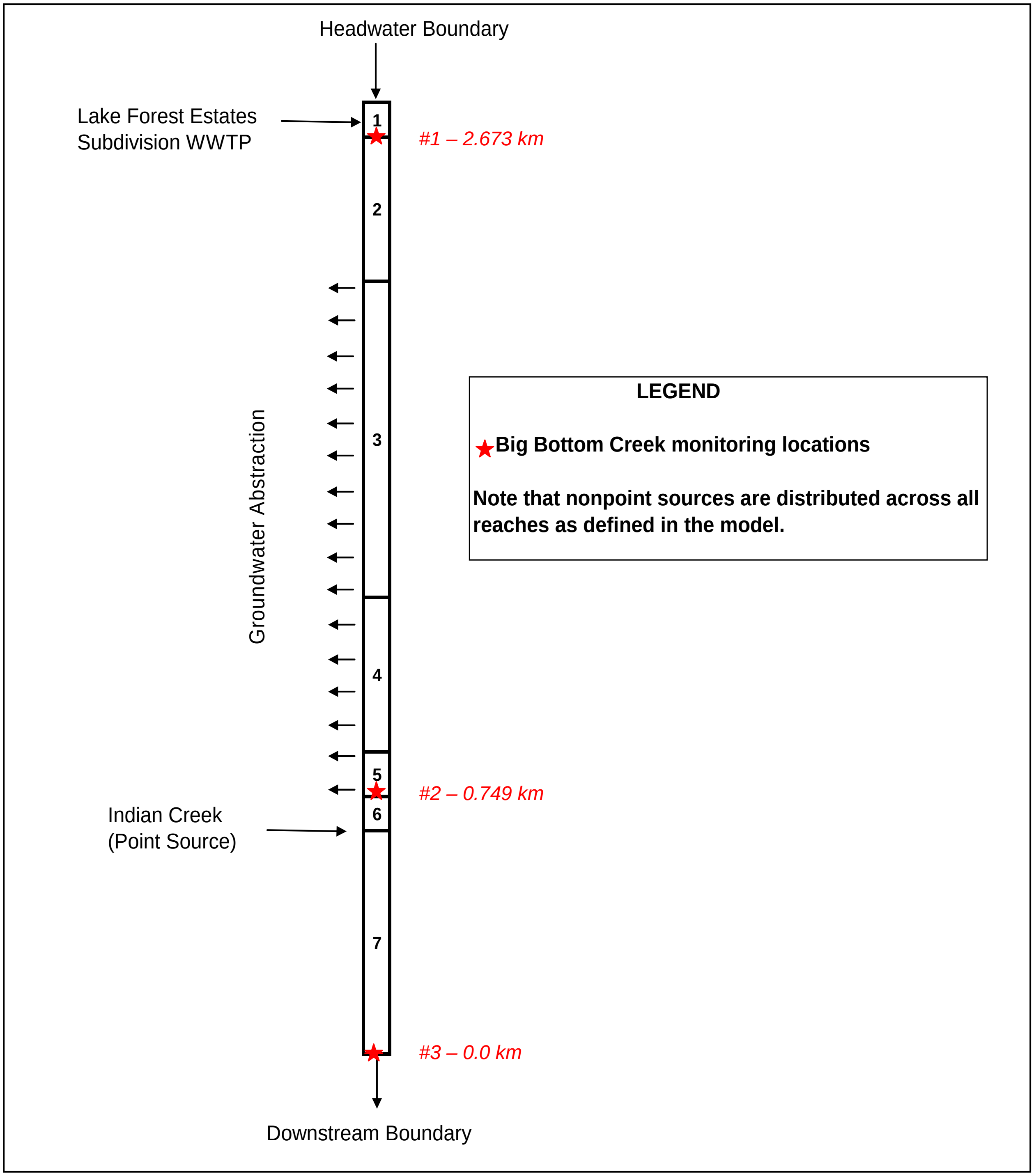

Figure B-1. Diagram of Big Bottom Creek QUAL2K Watershed Model

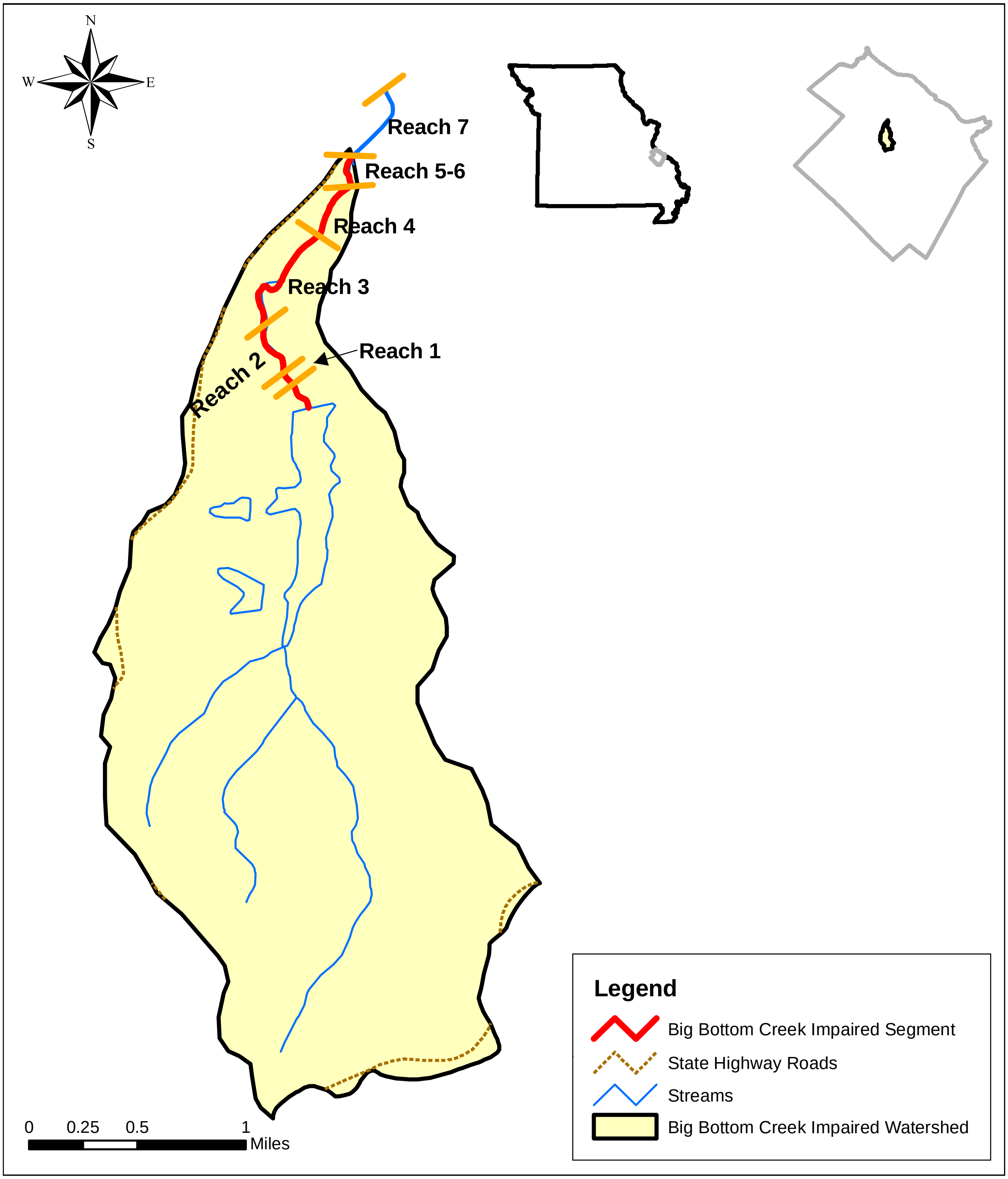

Figure B-2. Reaches in Big Bottom Creek QUAL2K Model

Table B-1. Number of Reaches and Elements Associated with Each Reach In Big Bottom Creek

Reach Number	Reach Length (kilometers)	Number of Elements	Element Length (meters)
1	0.10	1	100
2	0.42	6	70
3	0.92	8	115
4	0.45	5	90
5	0.13	2	65
6	0.10	1	100
7	0.65	7	93

B.2.2 Geometry, Elevation and Weather Data

Measurement of stream velocities, widths and depths collected at three locations in Big Bottom Creek were used to calculate flow rates at each location. QUAL2K allows the user to calculate the flow balance using one of three approaches: weirs, rating curves and Manning equations. The rating curve method was selected and applied to each QUAL2K simulation for Big Bottom Creek. Inputs for velocity and depth were developed from Equations 1 and 2, which are further described in the QUAL2K User's Manual (Chapra, 2008):

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

Where,

U = Velocity (m/s)
a = Empirical Coefficient
b = Empirical Coefficient
Q = Flow (m3/s)

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

Where,

H = Depth (m)
α = Empirical Coefficient
β = Empirical Coefficient

a, *b*, α and β are empirical coefficients that are determined from velocity-discharge and stage-discharge rating curves. Within QUAL2K the values of velocity and depth are used to estimate reach average cross-sectional area and width by:

$$A_c = \frac{Q}{U}$$ **Equation 4**

Where,

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

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

Equation 5

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:

$$A_s = B\Delta x$$

Equation 6

Where,

A_s = surface area (m^2)
B = width (m)
Δx = length of element

$$V = BH\Delta x$$

Equation 7

Where,

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

The measured hydraulic characteristics collected during the spring and summer of 2009 are included in Table B-2 and the rating curves calculated from this data are included in Table B-3.

Table B-2. Stream characteristics for Big Bottom Creek used to develop QUAL2K model hydraulic inputs

Time	Site	Date	Width (meters)	Average Depth (meters)	Area (square meters)	Velocity (m/s)	Flow (cms)	Event
AM	Big Bottom 1	07/07/09	3.659	0.185	0.68	0.07626	0.052	July WLA
PM	Big Bottom 1	07/07/09	3.659	0.208	0.76	0.03614	0.028	July WLA
AM	Big Bottom 1	07/08/09	3.659	0.165	0.6	0.01754	0.011	July WLA
PM	Big Bottom 1	07/08/09	3.659	0.216	0.79	0.03737	0.03	July WLA
AM	Big Bottom 1	08/12/09	3.582	0.174	0.63	0.0123	0.008	Aug WLA
PM	Big Bottom 1	08/12/09	3.659	0.175	0.64	0.01206	0.008	Aug WLA
AM	Big Bottom 1	08/13/09	3.659	0.165	0.6	0.01707	0.01	Aug WLA
PM	Big Bottom 1	08/13/09	3.811	0.175	0.67	0.01436	0.01	Aug WLA
AM	Big Bottom 2	07/07/09	3.659	0.241	0.88	0.06098	0.054	July WLA
PM	Big Bottom 2	07/07/09	3.354	0.294	0.99	0.03101	0.031	July WLA

Time	Site	Date	Width (meters)	Average Depth (meters)	Area (square meters)	Velocity (m/s)	Flow (cms)	Event
AM	Big Bottom 2	07/08/09	3.354	0.255	0.86	0.01223	0.01	July WLA
PM	Big Bottom 2	07/08/09	3.354	0.238	0.8	0.00773	0.006	July WLA
AM	Big Bottom 3	07/07/09	10.823	0.406	4.39	0.0768	0.337	July WLA
PM	Big Bottom 3	07/07/09	12.652	0.371	4.69	0.02894	0.136	July WLA
AM	Big Bottom 3	07/08/09	12.652	0.36	4.56	0.02397	0.109	July WLA
PM	Big Bottom 3	07/08/09	12.652	0.358	4.53	0.01862	0.084	July WLA
AM	Big Bottom 3	08/12/09	12.652	0.289	3.66	0.00857	0.031	Aug WLA
PM	Big Bottom 3	08/12/09	12.576	0.3	3.78	0.01617	0.061	Aug WLA
AM	Big Bottom 3	08/13/09	12.652	0.292	3.69	0.01115	0.041	Aug WLA
PM	Big Bottom 3	08/13/09	12.652	0.295	3.73	0.0121	0.045	Aug WLA

Table B-3. Rating Curve QUAL2K Model Inputs

	Velocity		Depth	
Reach	Coefficient	Exponent	Coefficient	Exponent
1	0.9979	0.9035	0.2746	0.0976
2	0.8867	0.9377	0.2877	0.0297
3	0.8867	0.9377	0.2877	0.0297
4	0.8867	0.9377	0.2877	0.0297
5	0.8867	0.9377	0.2877	0.0297
6	0.8867	0.9377	0.2877	0.0297
7	0.1837	0.8891	0.5036	0.1650

Hourly weather data for air temperature, dew point temperature and wind speed were retrieved from the National Climatic Data Center (NCDC). Weather data from the Farmington Regional Airport weather station (ID FAM) were used because this was the closest NCDC station with the appropriate data. Table B-4 displays the hourly weather data for July 7 - 8, and August 12 - 13, 2009, that was used during the calibration.

Table B-4. Hourly Weather Data for July 7 - 8, and August 12 - 13, 2009, from the Farmington Regional Airport weather station (ID FAM)

Date/Time	Air temperature C	Dew point temperature C	Wind speed (meters/second)	Cloud cover
July 7, 2009				
12:00 AM	18	17	0.0	0%
1:00 AM	16	14	0.0	0%
2:00 AM	16	14	0.0	0%
3:00 AM	15	14	0.0	0%
4:00 AM	14	13	0.0	0%
5:00 AM	14	13	0.0	0%
6:00 AM	14	13	0.0	0%
7:00 AM	14	14	0.0	0%
8:00 AM	18	16	0.0	0%
9:00 AM	23	17	2.0	0%
10:00 AM	25	15	2.0	0%

Date/Time	Air temperature C	Dew point temperature C	Wind speed (meters/second)	Cloud cover
11:00 AM	26	15	2.0	6%
12:00 PM	26	16	2.0	44%
1:00 PM	27	14	0.0	56%
2:00 PM	27	16	2.0	36%
3:00 PM	29	15	2.0	31%
4:00 PM	29	15	3.0	54%
5:00 PM	29	15	3.0	6%
6:00 PM	28	16	2.0	0%
7:00 PM	28	16	2.0	0%
8:00 PM	26	16	0.0	0%
9:00 PM	23	17	0.0	0%
10:00 PM	22	17	0.0	0%
11:00 PM	19	17	0.0	0%
July 8, 2009				
12:00 AM	18	17	0.0	0%
1:00 AM	17	16	0.0	0%
2:00 AM	17	16	0.0	0%
3:00 AM	17	16	0.0	0%
4:00 AM	16	16	0.0	0%
5:00 AM	16	15	0.0	72.9%
6:00 AM	16	15	0.0	64.6%
7:00 AM	16	16	0.0	20.9%
8:00 AM	19	17	0.0	0.0%
9:00 AM	23	18	0.0	0.0%
10:00 AM	26	16	2.2	0.0%
11:00 AM	28	16	3.1	0.0%
12:00 PM	28	15	2.7	0.0%
1:00 PM	29	14	0.0	14.6%
2:00 PM	29	15	3.1	6.3%
3:00 PM	30	15	1.3	6.3%
4:00 PM	30	14	0.0	64.6%
5:00 PM	30	14	2.2	12.5%
6:00 PM	29	14	2.7	14.6%
7:00 PM	29	15	1.3	6.3%
8:00 PM	27	17	2.7	0.0%
9:00 PM	24	18	2.2	0.0%
10:00 PM	21	18	0.0	0.0%
11:00 PM	20	18	0.0	0.0%
August 12, 2009				
12:00 AM	17	16	0.0	0.0%
1:00 AM	19	18	0.0	0.0%
2:00 AM	18	17	0.0	0.0%
3:00 AM	18	17	0.0	0.0%
4:00 AM	17	17	0.0	0.0%
5:00 AM	17	16	0.0	0.0%

Date/Time	Air temperature C	Dew point temperature C	Wind speed (meters/second)	Cloud cover
6:00 AM	18	16	0.0	0.0%
7:00 AM	17	16	0.0	0.0%
8:00 AM	20	18	0.0	0.0%
9:00 AM	23	19	2.0	0.0%
10:00 AM	24	19	0.0	0.0%
11:00 AM	26	18	2.0	14.6%
12:00 PM	27	17	3.0	75.0%
1:00 PM	28	16	4.0	56.3%
2:00 PM	28	16	2.0	64.6%
3:00 PM	28	16	3.0	35.5%
4:00 PM	29	16	4.0	20.9%
5:00 PM	28	17	5.0	18.8%
6:00 PM	28	16	4.0	12.5%
7:00 PM	26	17	3.0	0.0%
8:00 PM	23	17	3.0	0.0%
9:00 PM	21	17	3.0	0.0%
10:00 PM	19	16	0.0	0.0%
11:00 PM	18	16	0.0	0.0%
August 13, 2009				
12:00 AM	17	16	0.0	0.0%
1:00 AM	16	14	0.0	0.0%
2:00 AM	16	15	0.0	0.0%
3:00 AM	15	14	0.0	0.0%
4:00 AM	15	14	0.0	0.0%
5:00 AM	14	13	0.0	0.0%
6:00 AM	14	13	0.0	0.0%
7:00 AM	14	13	7.0	0.0%
8:00 AM	17	15	0.0	0.0%
9:00 AM	21	17	0.0	0.0%
10:00 AM	24	17	2.0	0.0%
11:00 AM	25	16	2.0	0.0%
12:00 PM	27	15	2.0	0.0%
1:00 PM	28	14	0.0	0.0%
2:00 PM	28	15	3.0	0.0%
3:00 PM	29	13	3.0	0.0%
4:00 PM	29	13	4.0	0.0%
5:00 PM	29	14	4.0	0.0%
6:00 PM	29	15	4.0	0.0%
7:00 PM	27	16	4.0	0.0%
8:00 PM	24	16	3.0	0.0%
9:00 PM	22	16	3.0	0.0%
10:00 PM	20	16	0.0	0.0%
11:00 PM	18	16	0.0	0.0%

B.2.3 Boundary Conditions

Headwater boundary conditions for the July QUAL2K model runs were estimated using data collected at site #3 and the point source loads were estimated by conducting a mass balance. Since there was flow above the WWTP during July and no data collected at this location water quality data from site #3 was used because it was far downstream and is relatively unimpacted by point sources. For the July events flows were known for the Lake Forest WWTP and site #1; therefore flows from the head waters were calculated using a flow balance approach. Water quality concentrations were known for sampling site #1 and estimated for the headwaters (from site #3 data); therefore the loads from the Lake Forest WWTP could be calculated using a simple mass balance approach.

Ammonia was assumed to be zero for the headwaters concentration because all measured concentrations were below the detection limit and total kjeldahl nitrogen (TKN) values were low at site #3. This assumption allowed the permitted ammonia limit to be used in the model for the July events.

Time-variable diel temperature and DO fluctuations were employed for headwater conditions. The diel output from initial model runs was used to calculate the magnitude and timing of headwater temperature and DO fluctuations. No headwater flow was observed during the August sampling events. Table B-5 summarizes each of the model headwater inputs.

Table B-5. Big Bottom Creek QUAL2K headwater model input values for July and August simulations

	QUAL2K Headwater Model Input values			
Constituent	**July 7, 2009**	**July 8, 2009**	**August 12, 2009**	**August 13, 2009**
Flow (cms)	0.0365	0.0156	No flow was present above the Lake Forest WWTP during the August sampling events. The Lake Forest WWTP discharge is the most upstream flow in the model.	
Temperature (Deg C)	22.87 – 26.22	24.80 – 27.80		
Dissolved Oxygen (mg/l)	4.00-7.25	2.50-3.30		
CBOD Ultimate (mg/L)	3.3	2.8		
Organic Nitrogen (µg/L)	284.0	490		
NH_4-Nitrogen (µg/L)	0.0	0.0		
NO_3-Nitrogen (µg/L)	398.0	340.0		
Organic Phosphorus (µg/L)	41.7	36.7		
Inorganic Phosphorus (µg/L)	17.9	15.71		
Total Alkalinity as $CaCO_3$ (mg/L)	50	25		
pH	7.9	7.00		

Notes: cms = cubic meters per second; temperature varies hourly; mg/L = milligrams per liter; µg/L = micrograms per liter; Deg C = degrees celsius

B.2.4 Point Sources

Two point sources are represented in the Big Bottom Creek QUAL2K models: 1) Lake Forest WWTP at 2.67 kilometers (km), and 2) Indian Creek tributary at 0.65 km. The Lake

Forest WWTP point source is the only known “end of pipe” discharge within the impaired reach and the only source identified on the CWA 303(d) list. Indian Creek tributary was modeled as a point source rather than a discrete stream segment, since little data is available on Indian Creek and the model only needs to account for its flow and estimated pollutant loads.

The Lake Forest WWTP point source boundary conditions were based upon a simple mass balance between assumed headwater concentrations and sampling site #1.and instream data collected at sample site #1 during the August event. During August there was no flow upstream of the Lake Forest WWTP; therefore, sampling Location #1, located approximately 15 meters downstream of the WWTP discharge, was used to represent WWTP discharge characteristics. Because there was no headwater flow during the August sample dates and the stream flow at this location was comprised entirely of the WWTP discharge. Point source input data used for the July and August modeling events are summarized in Table B-6.

Table B-6. Point Source Input Data Summary

Facility Name & NPDES	Date	Discharge Point (km)	Flow (cms)	$CBOD_u$ (mg/L)	NH_3 N (µg/L)	Organic N (µg/L)	Nitrate+Nitrite N (µg/L)	Organic P (µg/L)	Inorganic P (µg/L)	DO (mg/L)
Lake Forest Estates Subdivision WWTP	July 7, 2009	2.69	0.0044	33.5	1900	4400	871	394	169	2.20
Lake Forest Estates Subdivision WWTP	July 8, 2009	2.69	0.0044	33.5	1900	1885	871	394	169	2.20
Lake Forest Estates Subdivision WWTP	August 12, 2009	2.69	0.0033	5.2	1400	2500	700	450	182	2.72
Lake Forest Estates Subdivision WWTP	August 13, 2009	2.69	0.0033	6.05	1126	1827	809	424	182	3.07

Notes: Discharge location is based on the distance to the end of the stream; Inorganic P estimated to be 70 percent of TP and Organic P estimated to be 30 percent of TP based on EPA, 1997.

B.2.5 Critical Conditions

Critical conditions for developing the TMDL were selected based upon the available data. As shown in Table B-7, the August 12, 2009, sampling event included a DO measurement of 1.75 mg/L. This date was therefore adopted as the critical condition.

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

Sampling Location	Stream distance (km)	7/7/2009	7/8/2009	8/12/2009	8/13/2009
1	2.673	4.97	3.65	1.75	1.84
2	0.749	7.48	5.83	ND	ND
3	0.000	8.44	5.05	4.72	4.43

Notes: Stream distance is measured from the most downstream sampling station.
ND = No data was measured at this site

B.3 Model Calibration

This section of the appendix describes the process that was used to calibrate the QUAL2K model for the Big Bottom Creek watershed and presents the calibration results.

B.3.1 Flow and Water Depth Simulations

The QUAL2K model for Big Bottom Creek was calibrated for flow, stream velocities and depths for the data collected on July 7 - 8, and August 12 - 13, 2009. The power function included in the QUAL2K model was selected for the flow simulation method. The flow and its related parameters (velocity and depth) can be reasonably simulated using this method.

QUAL2K addresses boundary headwater flows and point source flows during calibration. Flow can also be "lost" from the model through the simulation of losing reaches or water withdrawals. Measured flow was not available for the upstream boundary headwater, so headwater flows were calibrated to flows measured at Sample Location #1 after allowing for the Lake Forest WWTP point source flow.

Point source flow data for the Lake Forest WWTP was obtained from daily monitoring reports (DMRs) that were provided by MDNR. The July and August daily flow data was obtained directly from the Lake Forest WWTP operator, since it had not yet been reported to MDNR when the models were constructed.

Field observations showed that portions of Big Bottom Creek ran dry during the August sampling events and flow decreased during the July sampling events. The streambed within the dry sections was largely composed of gravel. Since there was no headwater flow observed during this period, the only source of stream flow between Sample Location #1 and the dry stream bed was the Lake Forest WWTP. The reported WWTP flow data was used to estimate a groundwater withdrawal (abstraction) rate of 0.0033 cms between the 0.75 and 2.25 km segment of Big Bottom Creek during the August events. Because of the uncertainty associated with flow measurements this abstraction rate was used for all periods simulated.

Depths, widths and velocities for each reach were related to flow using the power equations. Stream velocity, depth, discharge and time of travel are all critical to the water quality simulation because they influence reaeration and DO, biogeochemical reactions and deposition rates, growth of algal species and the influence of SOD in the stream.

Figure B-3 shows the comparisons of flow, depth and velocity between the modeled results and the observed data for the July 7 - 8, 2009 simulations.

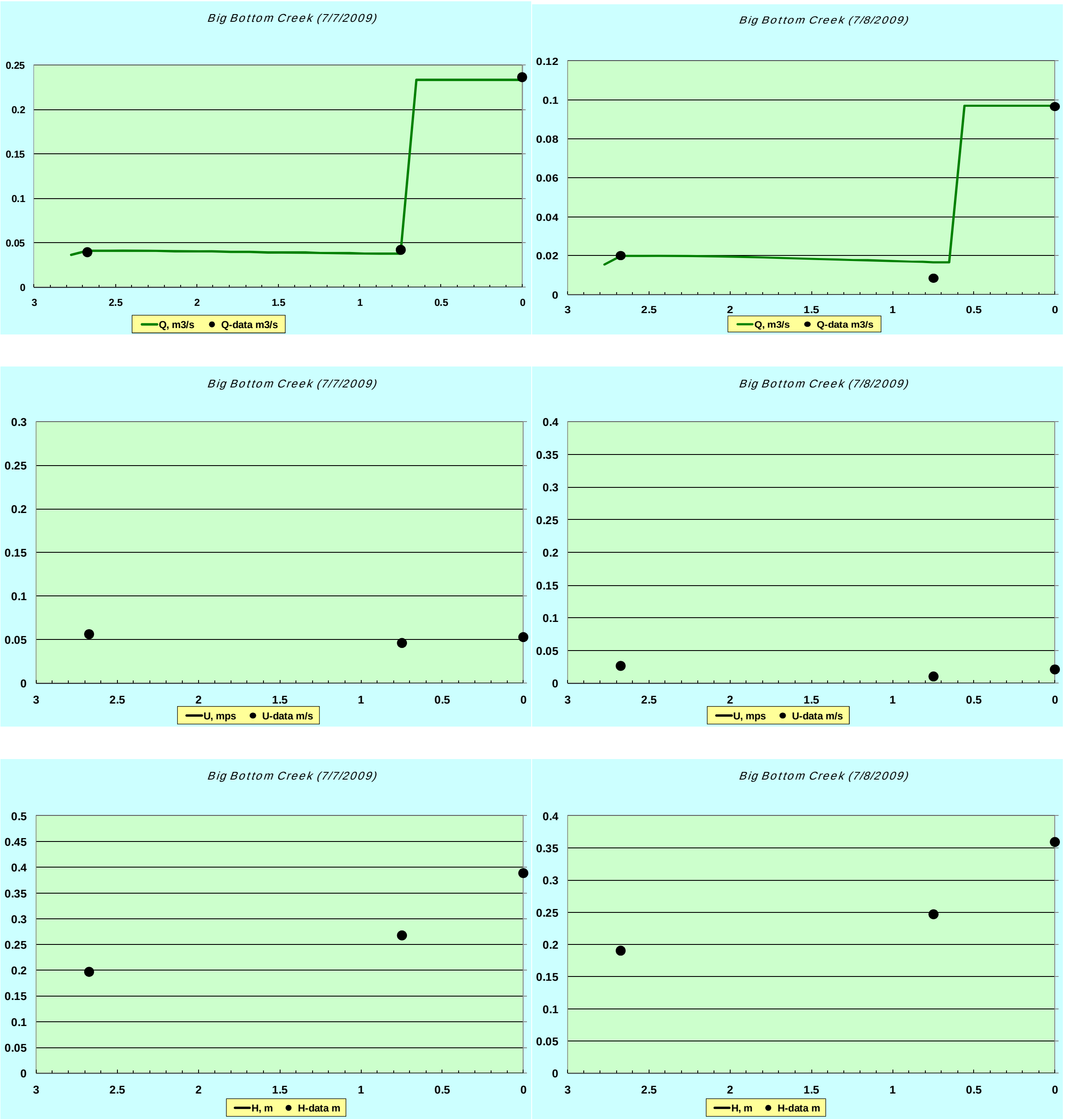

Figure B-3. Comparisons of observed and simulated flow (Q), velocity (U) and depth (H) in Big Bottom Creek

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 semi-empirical 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 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 results. Because of this, both a visual comparison and quantitative measures were used during the Big Bottom Creek calibration.

BOD is an important calibration parameter because of its influence on DO concentrations. BOD typically consists of two parts: CBOD and nitrogenous biological oxygen demand (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. $CBOD_5$ measurements were adjusted by multiplying each value by the average $CBOD_5$:CBOD-ultimate ratio observed at all stations on the July and August monitoring dates. The $CBOD_5$:CBOD-ultimate ratio was calculated to be 1.9. This approach to adjusting $CBOD_5$ model inputs was used for headwater, tributary and WWTP source loads. The first order kinetic reaction rates for biogeochemical reactions are influenced from the various flow and chemical conditions in streams. Kinetic rates may be estimated from the observed data, stream distance and velocity. However, the estimated rates based on the field data 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. The final selections were made as a result of sensitivity analyses to compare the model results to the observed value using the range from the literature values

(Brown and Barnwell, 1987; EPA, 1997; EPA, 1985). Reaction rates producing the best match to the observed data were selected for the final calibration.

Water quality calibration for the Big Bottom Creek QUAL2K model relied on comparison of model predictions to observations at three stations on the main stem of the system. The July 7 - 8, 2009, data sets were selected for model calibration. Model validation was subsequently performed with the August 12 - 13, 2009 data set. A single set of kinetic parameters was selected that resulted in the best fit for both the calibration and validation periods. This final calibration and validation parameter set was used in the TMDL model runs.

Lateral inflow concentrations representing the lone tributary were initially set equal to the observed headwater concentrations but were then adjusted to best match the observed data. The Indian Creek point source concentrations were initially estimated from the average Sampling Location #3 lab results for August, since there was no flow observed upstream at Sampling Location #2 and Indian Creek was the only source during the August sampling events. The BOD and nutrient concentrations were then calibrated to match the Sampling Location #3 observed data for each simulation. Temperature and DO inputs for Indian Creek were also calibrated to field observations at Sampling Location #3.

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 columns 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.

SOD 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 Big Bottom Creek. SOD values were estimated using the QUAL2K sediment diagenesis routines. Percent bottom SOD coverage was based on the percent fine material identified in the stream reach during the 2009 sampling events.

Benthic algae (periphyton) kinetics also has a marked effect on DO concentrations and diurnal swings (EPA, 1985). Periphyton dynamics were included in model calibration to account for the current observation and historical presence (e.g., Environmental Resources Coalition, 2005) of bottom algae and for the observed diurnal variation in DO. Algal growth, respiration, death and related nutrient kinetics were adjusted within typical ranges reported by the literature (EPA, 1985; Ambrose, 2006) to best match the observed DO variations and nutrient concentrations from the July sampling events.

The Tsivoglou-Neal reaeration model was selected for Big Bottom Creek because it is the most appropriate model to predict reaeration for flows less than 10 cfs (Tsivoglou and Neal, 1972; Thomann and Mueller, 1987). Under low flow (Q = 0.0283 to 0.4247 cms (1 to 15 cfs)), the reaeration model formula is as follows:

$$k_{ah}(20) = 31{,}183US \qquad \textbf{Equation 9}$$

Where,

k_{ah} = the reaeration rate at 20 ºC
U = velocity (m/s)
S = channel slope (m/m)

A sensitivity analysis showed that this method better accounted for the relatively shallow stream. Other methods tended to overestimate reaeration.

The final rates used for the Big Bottom Creek calibration are presented in Table B-8. Figures B-4 through B-10 show the results of the model calibrations, including temperature, DO, CBOD, TKN, NH_4-N, NO_3-N, TN, TP and bottom algae. A visual inspection of the plots indicates that the model predictions follow the general trend and reproduce the overall magnitude of the observed data reasonably well.

The quantitative calibration metrics that were used to assess the calibration include the evaluation of average error, residual error, root mean squared error (RSME), coefficient of determination (R^2), relative error and percent bias. Table B-9 reports the statistical measure and equation for each quantitative calibration metrics used to evaluate the calibration. Table B-10 presents statistical results for calibration and validation model runs for flow, DO, TN, NO_3, TKN and TP.

Table B-8. Rates used for the Big Bottom Creek QUAL2K calibration and validation

Parameter	*Value*	*Typical Range*	*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	0.5	0.2 – 30 (4)	m/d	v_i
Oxygen:				
Reaeration model	Tsivoglou-Neal			
User reaeration coefficient α	0			α
User reaeration coefficient β	0			β

Parameter	***Value***	***Typical Range***	***Units***	***Symbol***
Oxygen: (continued)				
User reaeration coefficient γ	0			γ
Temp correction	1.024			$_{a}$
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	0.25		/d	k_{hc}
Temp correction	1.047			$_{hc}$
Oxidation rate	0.6	0.02 – 3.4 (1)	/d	k_{dcs}
Temp correction	1.047	1.02 – 1.15 (3)		$_{dcs}$
Fast CBOD:				
Oxidation rate	0.8	0.02 – 3.4 (1)	/d	k_{dc}
Temp correction	1.047	1.02 – 1.15 (3)		$_{dc}$
Organic N:				
Hydrolysis	0.1	0.02 – 0.4 (1)	/d	k_{hn}
Temp correction	1.07	1.02 – 1.08 (2)		$_{hn}$
Settling velocity	0.5	0.2 – 30 (4)	m/d	v_{on}
Ammonium:				
Nitrification	0.1	0.1 – 1.0 (1)	/d	k_{na}
Temp correction	1.07			$\boldsymbol{\theta}_{na}$
Nitrate				
Denitrification	0.1	0.002 – 1.0 (2)	/d	k_{dn}
Temp correction	1.07	1.02 – 1.09 (2)		$_{dn}$
Sed denitrification transfer coeff	0		m/d	v_{di}
Temp correction	1.07			$_{di}$
Organic P:				
Hydrolysis	0.1	0.03 – 0.8 (2)	/d	k_{hp}
Temp correction	1.07	1.02 – 1.09 (2)		$_{hp}$
Settling velocity	0.25	0.2 – 30 (4)	m/d	v_{op}
Inorganic P:				
Settling velocity	0.25	0.2 – 30 (4)	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}

Parameter	***Value***	***Typical Range***	***Units***	***Symbol***
Bottom Algae:				
Growth model	First-order			
Max Growth rate	1.1	0.2 – 1.5 (2)	mgA/m^2/d or /d	C_{gb}
Temp correction	1.07	1.07 (3)		$_{gb}$
First-order model carrying capacity	1000	1500 (3)	mgA/m^2	$a_{b,max}$
Respiration rate	0.18	0.02 – 0.44 (2)	/d	k_{rb}
Temp correction	1.07	1.07 (3)		$_{rb}$
Excretion rate	0.09	0.09 (3)	/d	k_{eb}
Temp correction	1.07	1.07 (3)		$_{db}$
Death rate	0.05	0.05 (3)	/d	k_{db}
Temp correction	1.07	1.07 (3)		$_{db}$
External nitrogen half sat constant	100	100 (3)	µgN/L	k_{sPb}
External phosphorus half sat constant	40	40 (3)	µgP/L	k_{sNb}
Inorganic carbon half sat constant	1.30E-05	1.30E-05 (3)	moles/L	k_{sCb}
Light model	Steele			
Light constant	225	200 – 300 (2)	langleys/d	K_{Lb}
Ammonia preference	25	25 (3)	µgN/L	k_{hnxb}
Subsistence quota for nitrogen	0.72	0.72 (3)	mgN/mgA	q_{0N}
Subsistence quota for phosphorus	0.1	0.1 (3)	mgP/mgA	q_{0P}
Maximum uptake rate for nitrogen	72	72 (3)	mgN/mgA/d	$_{mN}$
Maximum uptake rate for phosphorus	5	5 (3)	mgP/mgA/d	$_{mP}$
Internal nitrogen half sat constant	0.9	0.9 (3)	mgN/mgA	K_{qN}
Internal phosphorus half sat constant	0.13	0.13 (3)	mgP/mgA	K_{qP}
Detritus (POM):				
Dissolution rate	0.2		/d	k_{dt}
Temp correction	1.07			$_{dt}$
Fraction of dissolution to fast CBOD	0.50			F_f
Settling velocity	0.25		m/d	v_{dt}
Pathogens:				
Decay rate	0.8		/d	k_{dx}
Temp correction	1.07			$_{dx}$
Settling velocity	1		m/d	v_x
Light efficiency factor	1.00			$_{path}$
pH:				
Partial pressure of carbon dioxide	347		ppm	p_{CO2}

(1) QUAL2E Manual
(2) Rates, Constants and Kinetic Formulations in Surface Water Quality (2nd Edition, June 1985)
(3) WASP 7 Benthic Algae – Model Theory and User Guide (EPA, 2006)
(4) Surface Water Quality Modeling (Chapra, 1997)

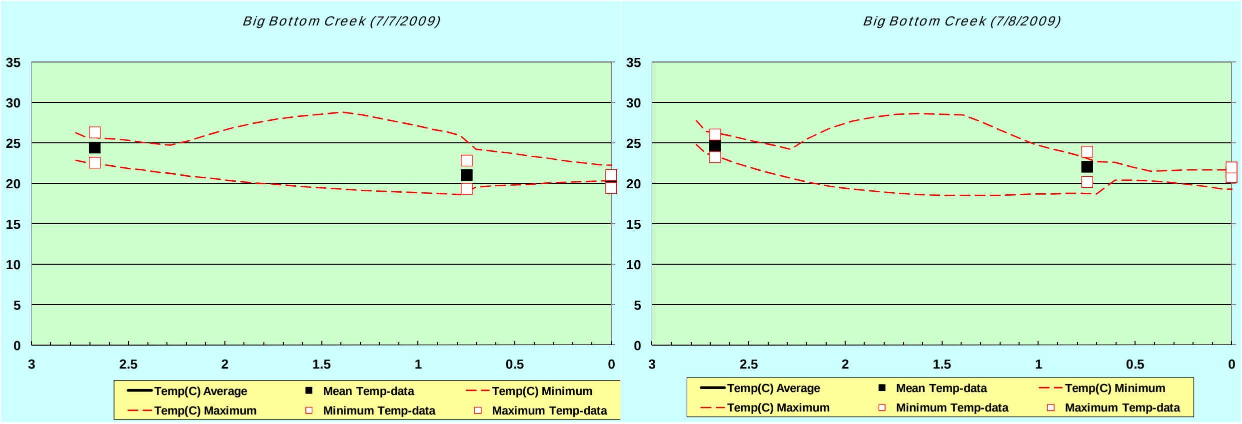

Figure B-4. Temperature calibration in Big Bottom Creek

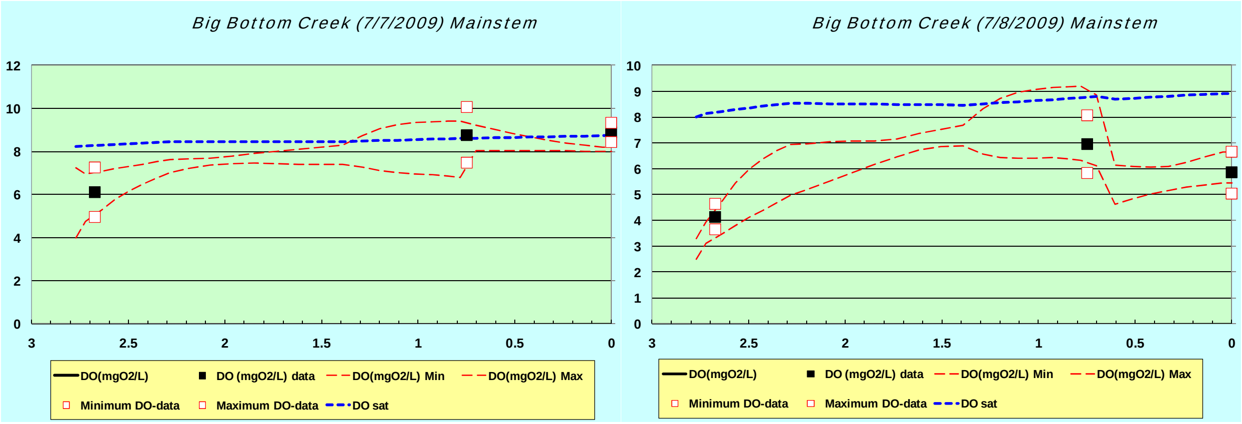

Figure B-5. DO calibration in Big Bottom Creek

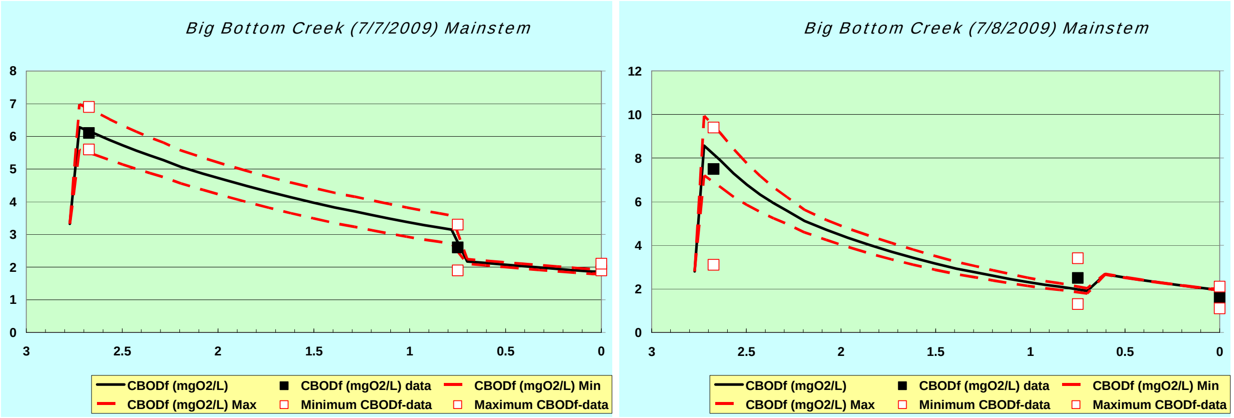

Figure B-6. CBOD calibration in Big Bottom Creek

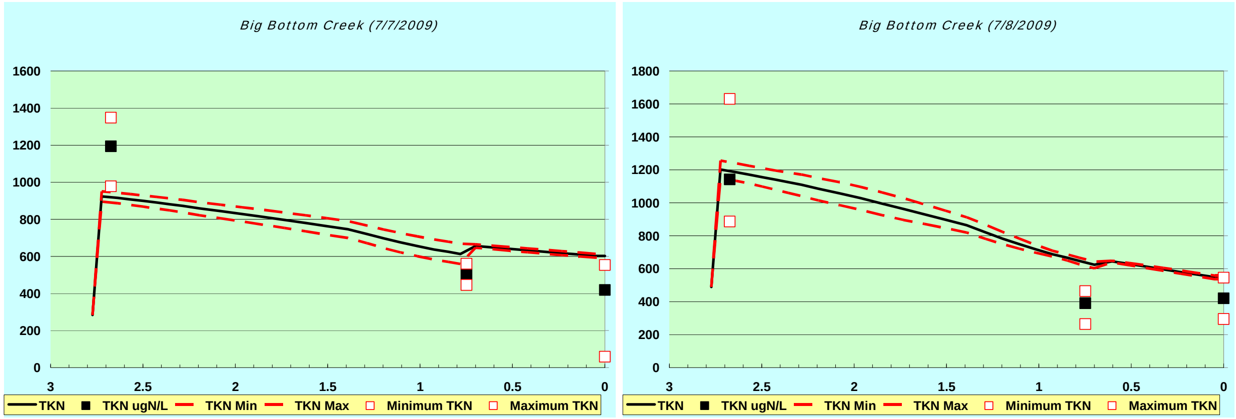

Figure B-7. TKN calibration in Big Bottom Creek

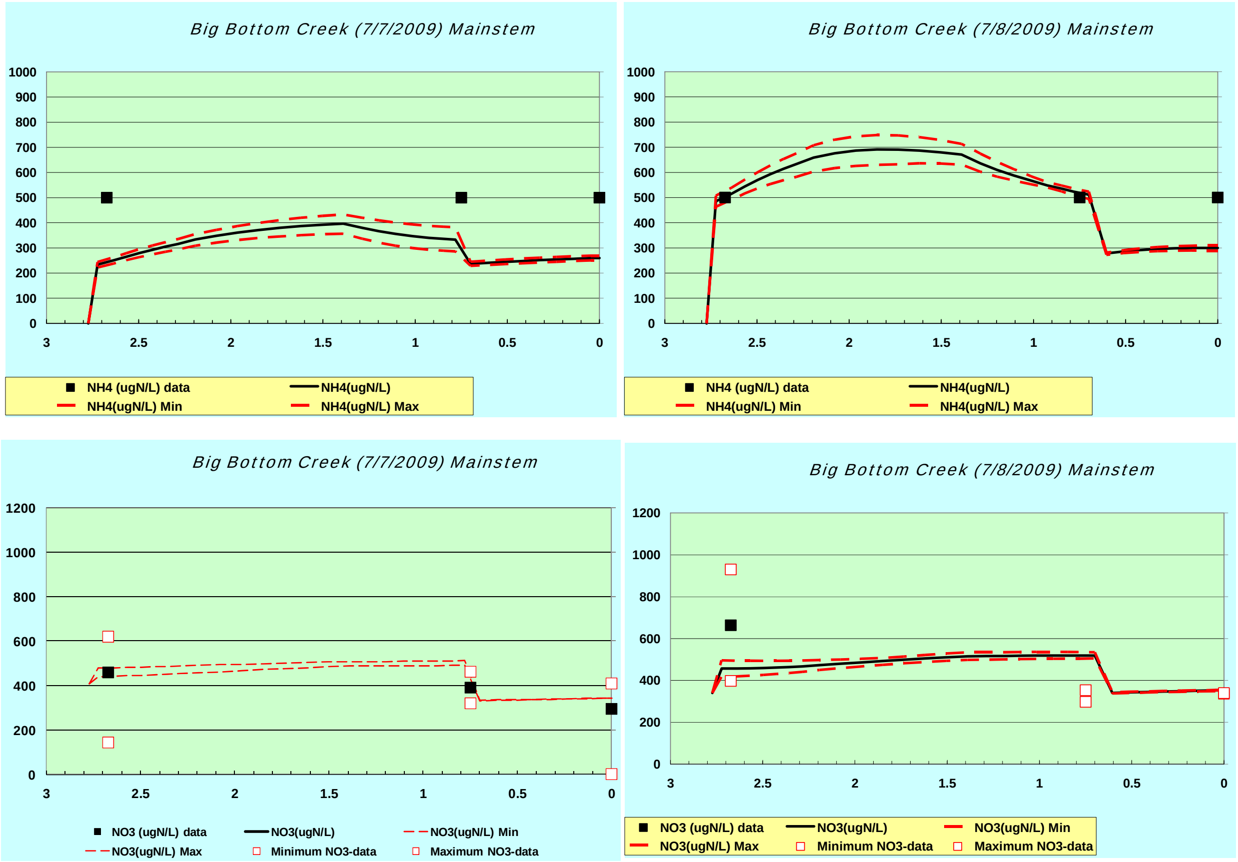

Figure B-8. Ammonium and nitrate calibration in Big Bottom Creek

Note: Ammonium was below laboratory detection limits of 0.5 mg/L in the majority of samples. Based on four samples that had both NH_4-N and TKN results, a NH_4-N:TKN ratio of 0.49 was calculated. Because TKN had a lower detection limit (0.3 mg/L), the NH_4-N:TKN ratio was used to estimate the remaining NH_4-N observed data.

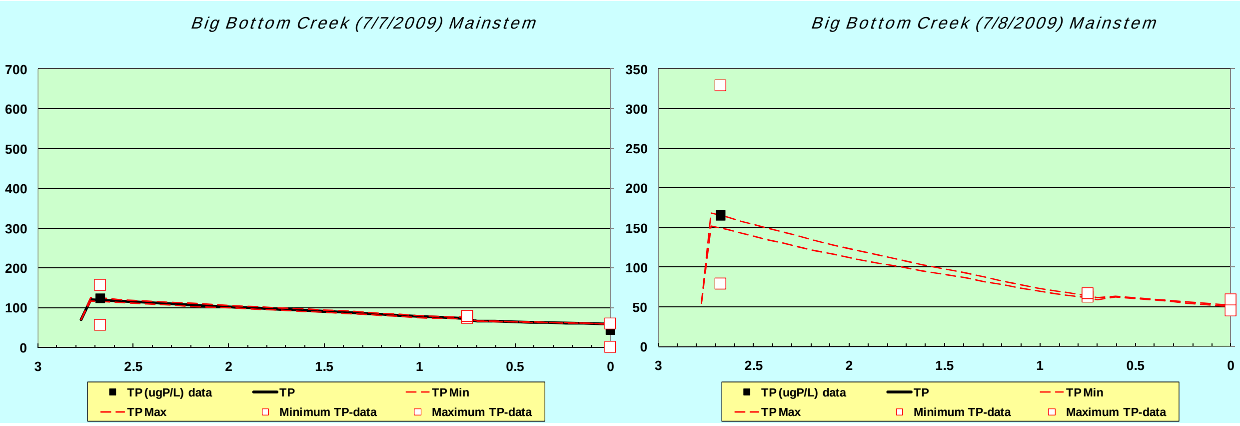

Figure B-9. Total Phosphorus calibration in Big Bottom Creek

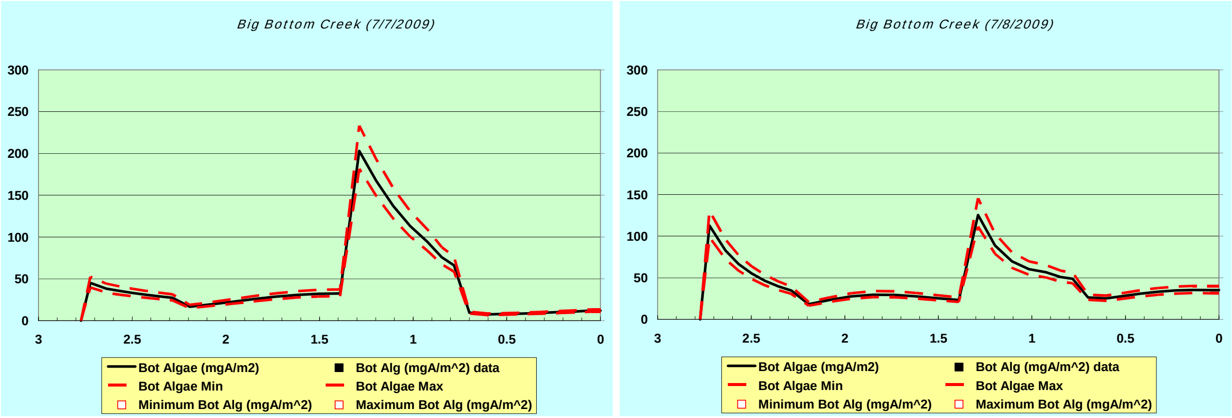

Figure B-10. Bottom algae from calibration runs in Big Bottom Creek

Note: Bottom algae were not sampled in 2009 but were calibrated to diurnal DO variations measured in stream.

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 Big Bottom Creek model was conducted using the data collected on August 12 - 13, 2009. System rates and coefficients were initially set equal to the values selected in the calibration runs. Minor adjustments were made to nutrient rates (oxidation, hydrolysis, sorption and settling rates) and bottom algae (growth and respiration rates). These adjustments were made using best professional judgment based on previous experience with similar modeling projects. All adjustments in validation runs were incorporated in the calibration model runs so that all four models contained the same system rates and coefficients.

Headwater and tributary flows were set equal to the average of morning and afternoon flow measurements on each respective day. Similarly, model inputs for headwater and tributary nutrients, DO, CBOD and pH were also based on average field measurements or calculated based on field measurements (in the case of organic nitrogen, organic phosphorus and inorganic phosphorus) on each respective day. Initial model inputs for air temperature, dew point temperature, wind speed, cloud cover and shade were based on weather station data (see Section 2.3 for discussion on station location. The station used for this analysis is approximately 22 miles from the Big Bottom Creek watershed).

The sediment digenesis routine was used to estimate SOD. Percent reach with SOD coverage was estimated from sediment characterization data collected during sampling. SOD coverage was set at the percent of creek bottom with sand, silt, or clay (Table B-9).

Table B-9. Rates used for the Percent Bottom SOD Coverage in Big Bottom Creek

	Reach Number						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Bottom Algae Coverage	0%	40%	40%	50%	50%	50%	50%
Bottom SOD Coverage	100%	100%	100%	100%	100%	100%	100%

The validation results are presented in Figures B-11 to B-15 and suggest that the model performs nearly as well as for the calibration for most parameters. The absence of observation points at Sampling Location #2 was due to the dry stream at this location. The model validation was complicated by the occurrence of a dry stream at Sampling Location #2 and for some distance upstream (at least 100 m) during the August 12 - 13 sampling period. In addition, there was no headwater flow during the August sampling events. The dry conditions, however, made it easier to assign flows and concentration to the two point sources, Lake Forest WWTP and Indian Creek.

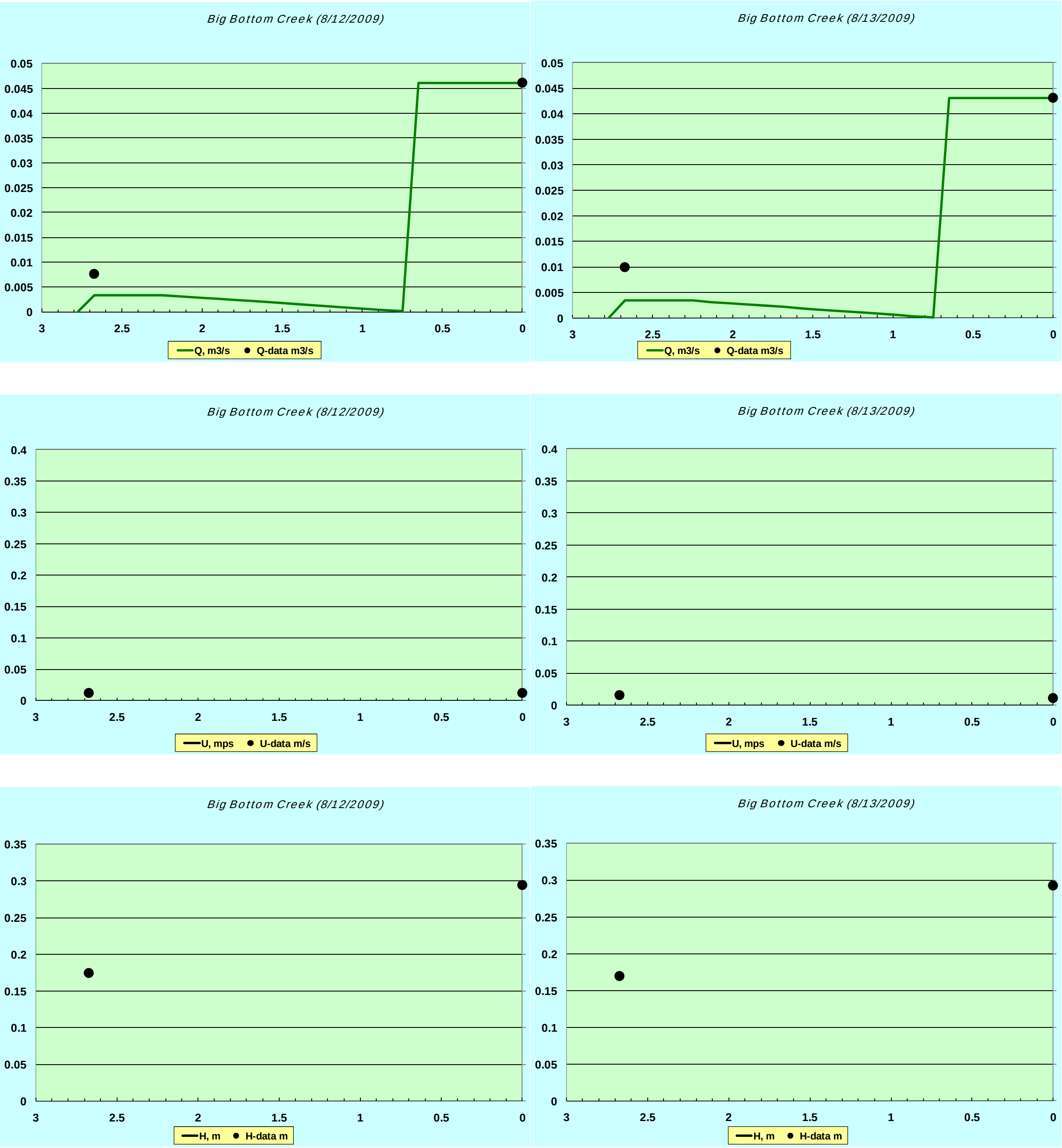

Figure B-11. Validations of observed and simulated flow (Q), velocity (U) and depth (H) in Big Bottom Creek

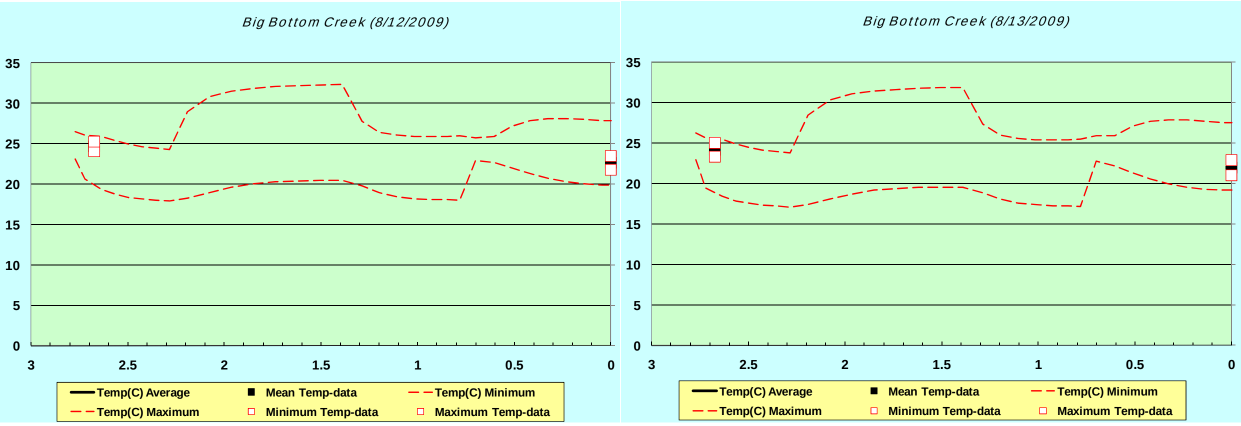

Figure B-12. Temperature validation in Big Bottom Creek

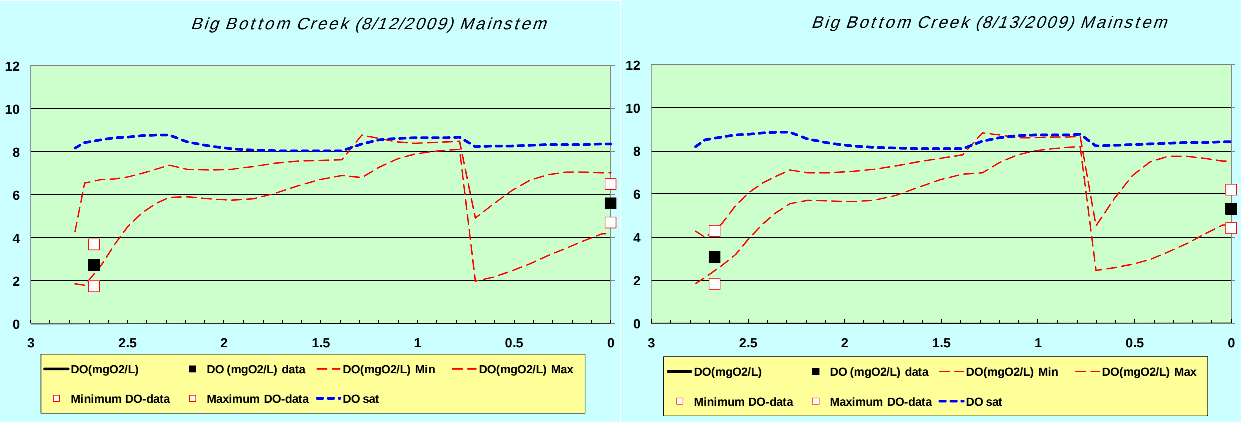

Figure B-13. DO validation in Big Bottom Creek

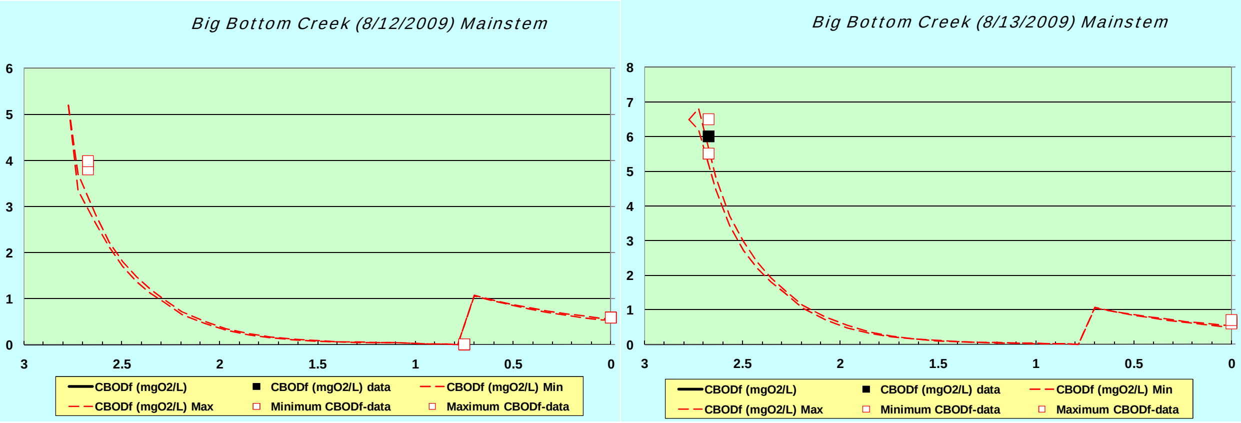

Figure B-14. CBOD validation in Big Bottom Creek

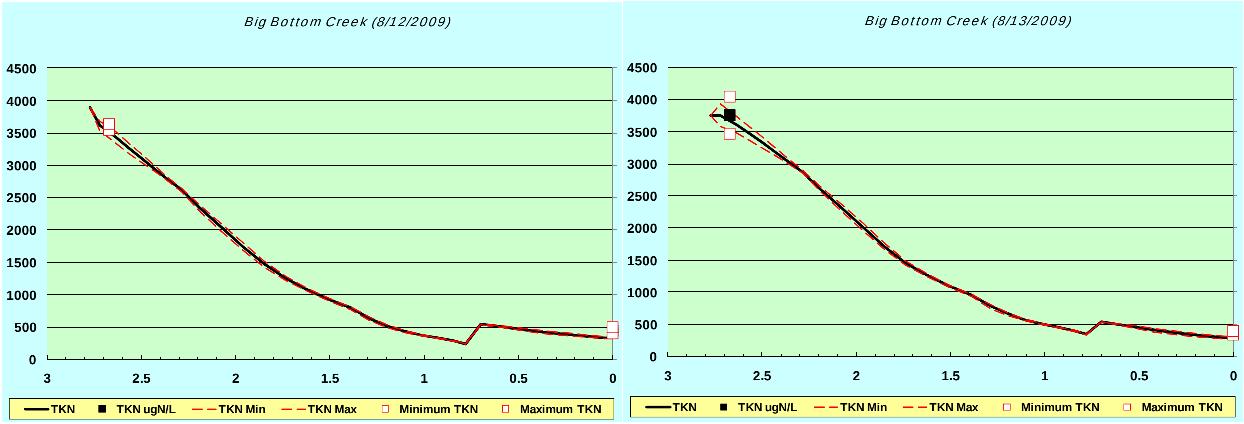

Figure B-15. TKN validation in Big Bottom Creek

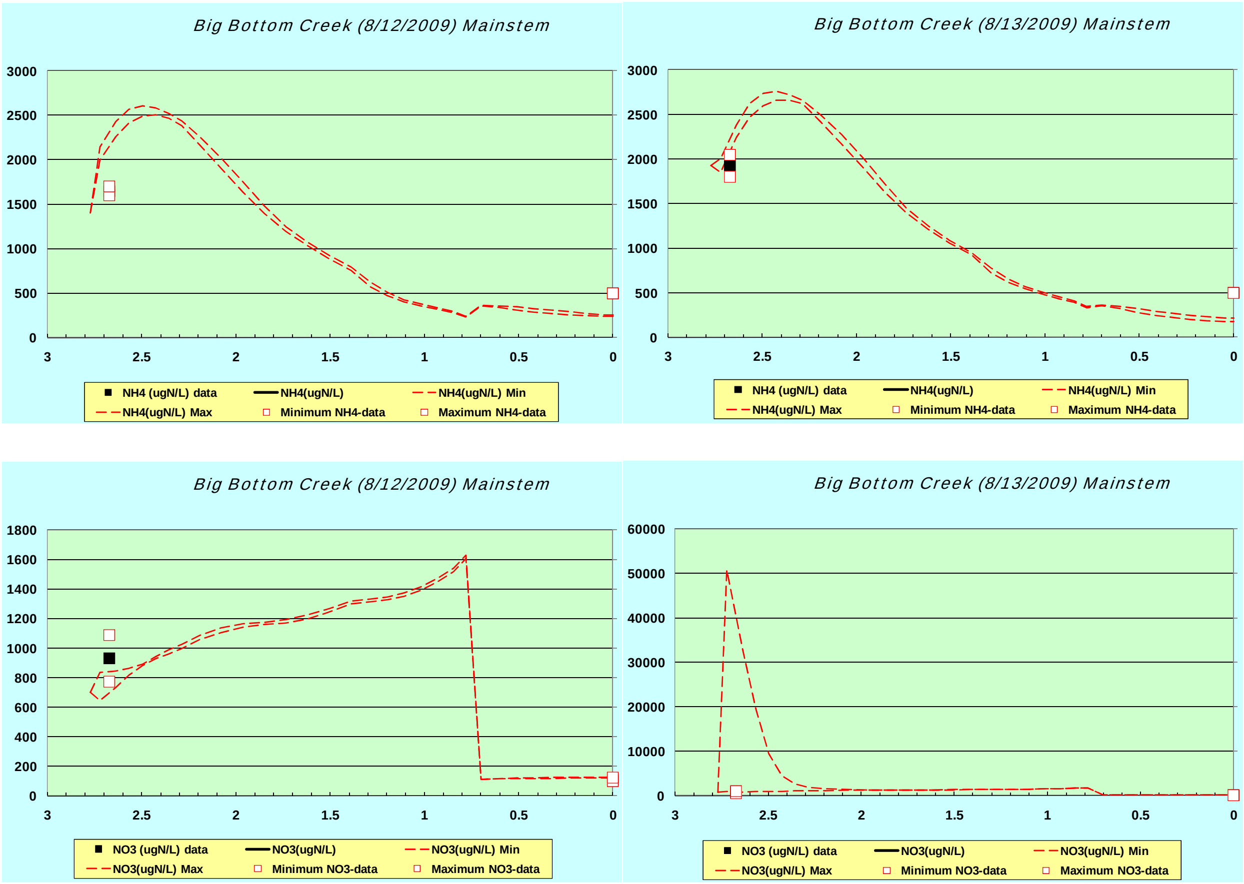

Figure B-16. Ammonium and nitrate validation in Big Bottom Creek

Note: Ammonium was below laboratory detection limits of 0.5 mg/L in the majority of samples. Based on four samples that had both NH_4-N and TKN results, a NH_4-N:TKN ratio of 0.49 was calculated. Because TKN had a lower detection limit (0.3 mg/L), the NH_4-N:TKN ratio was used to estimate the remaining NH_4-N observed data.

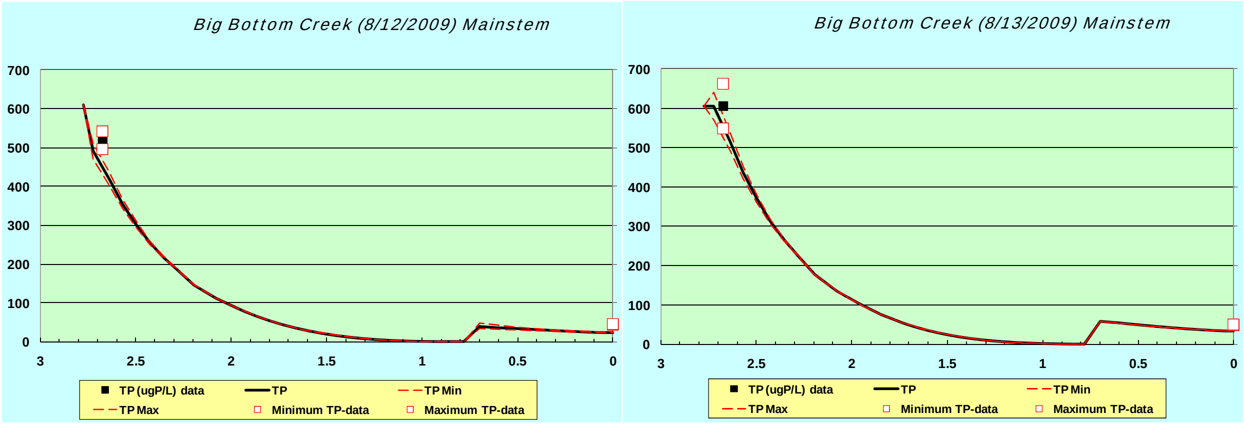

Figure B-17. TP validation in Big Bottom Creek

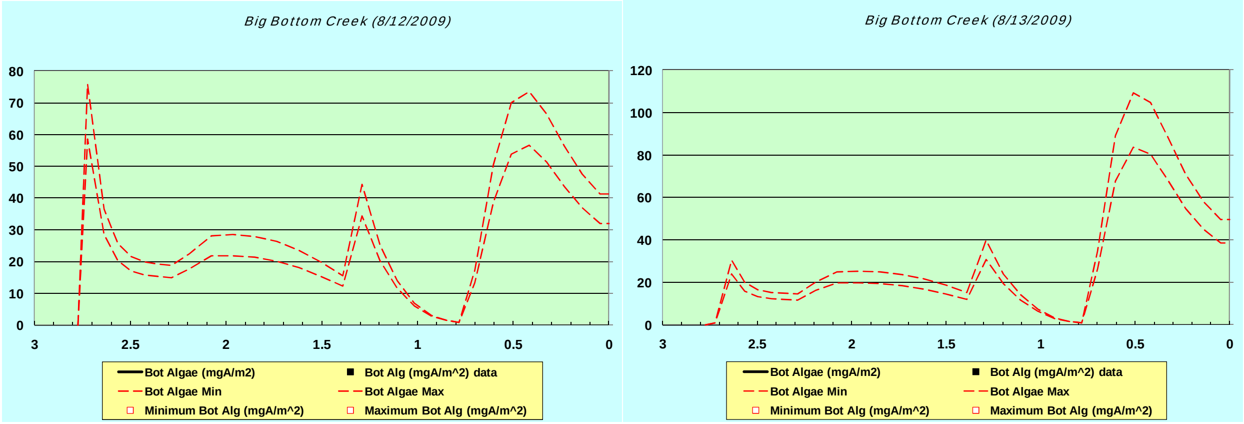

Figure B-18. Bottom algae from validation runs in Big Bottom Creek

Note: Bottom algae were not sampled in 2009 but were calibrated to diurnal DO variations measured in stream. The model validation runs used the same algae inputs and kinetics as the calibration runs.

B.5 Model Goodness of Fit Discussion

The calibration and validation periods were assessed both visually and statistically. The figures 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 statistical measures that were used to assess the model calibration and validation include the evaluation of coefficient of determination (R^2), root mean square error, percent bias, average error, relative error and residual error. Table B-10 reports the statistical measure and equation for each quantitative calibration metrics used to evaluate the calibration, and Table B-11 reports the calculated error statistics for the periods simulated.

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:

- Coefficient of determination (r^2) is high for all parameters and suggests a high degree of correlation between the simulated model results and observed water quality data.

- The root mean square error statistic (RMSE) for DO is near 1 mg/L for the average, minimum and maximum for all periods.

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

Table B-10. Quantitative metrics for calibration and validation

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

Table B-11. Summary statistics for calibration and validation runs

Statistic	Model Period	Flow	Avg. DO	Min DO	Max DO	CBOD	TN	TKN	NO_3	TP
RMSE	Calibration	0.004	0.6	1.0	1.0	2.1	0.5	0.4	0.3	0.1
	Validation	0.005	1.1	1.6	1.2	1.7	1.5	0.4	1.5	0.3
	Entire Period	0.004	0.8	1.2	1.0	1.8	1.0	0.4	0.9	0.2
R2	Calibration	1.00	0.9	0.9	0.8	1.0	0.9	1.0	0.1	1.0
	Validation	1.00	0.7	0.8	0.1	1.0	0.7	1.0	0.3	1.0
	Entire Period	1.00	0.9	0.9	0.7	0.9	0.7	1.0	0.3	1.0
PBIAS	Calibration	0.60	-0.3	-11.7	2.2	2.4	-6.5	-22.5	2.0	5.2
	Validation	-10.24	-20.4	-58.6	-17.9	23.7	-61.9	5.9	-344.5	18.9
	Entire Period	-1.51	-6.2	-24.1	-4.1	9.5	-40.1	-3.6	-150.7	14.8
Abs. Average Error	Calibration	0.003	0.3	0.8	0.8	3.6	0.2	0.2	0.1	0.0
	Validation	0.003	0.9	1.9	1.0	2.1	1.8	0.1	1.8	0.1
	Entire Period	0.003	0.6	1.2	0.9	3.0	0.9	0.1	0.8	0.0
Residual Error	Calibration	0.000	0.0	-0.7	0.2	3.6	-0.1	-0.2	0.0	0.0
	Validation	-0.003	-0.9	-1.9	-0.9	2.1	-1.6	0.1	-1.7	0.1
	Entire Period	-0.001	-0.4	-1.2	-0.3	3.0	-0.7	0.0	-0.7	0.0

References – Appendix B

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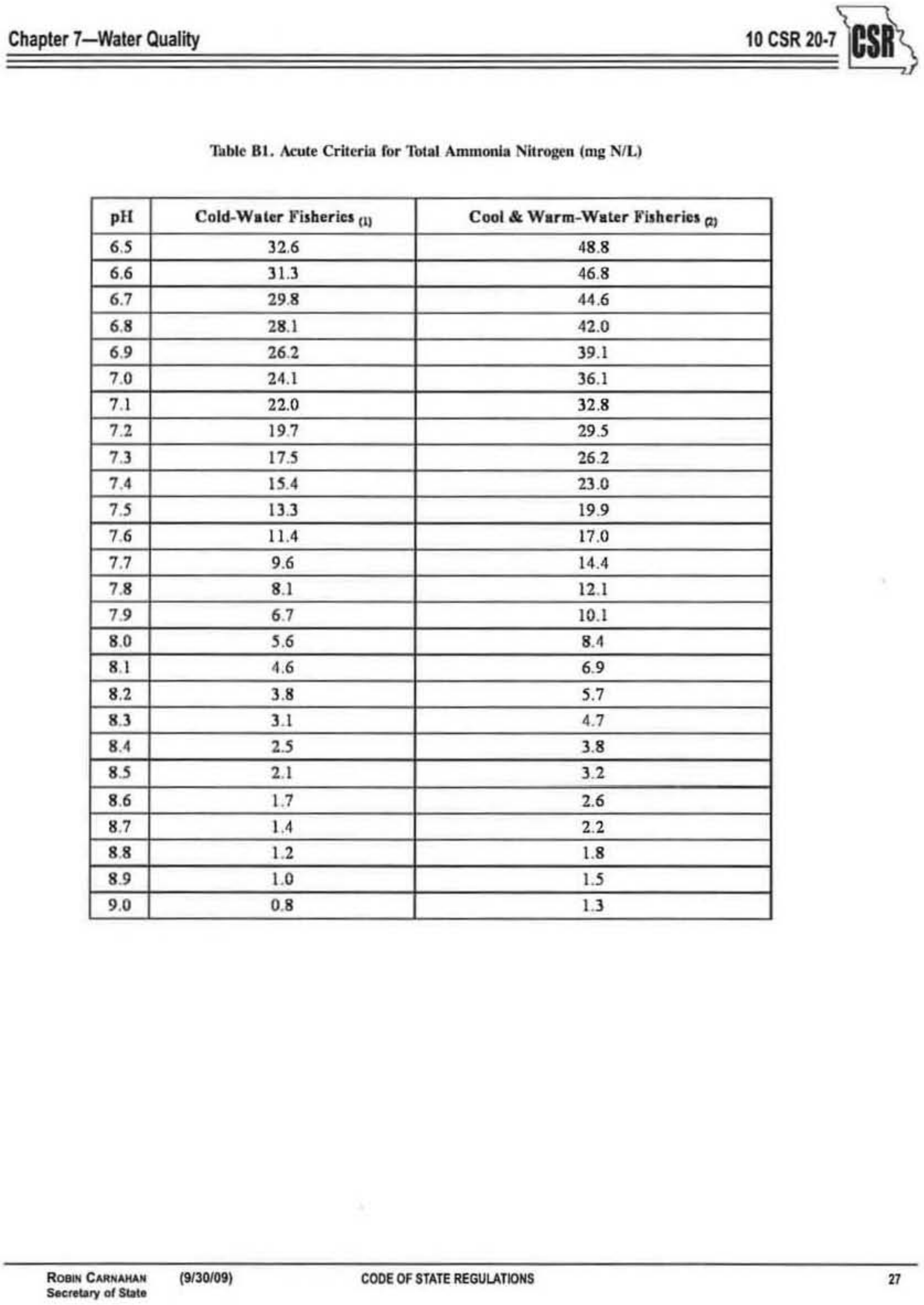
APPENDIX C - AMMONIA CRITERIA



Chapter 7—Water Quality

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Table B1. Acute Criteria for Total Ammonia Nitrogen (mg N/L)

pH	Cold-Water Fisheries (1)	Cool & Warm-Water Fisheries (2)
6.5	32.6	48.8
6.6	31.3	46.8
6.7	29.8	44.6
6.8	28.1	42.0
6.9	26.2	39.1
7.0	24.1	36.1
7.1	22.0	32.8
7.2	19.7	29.5
7.3	17.5	26.2
7.4	15.4	23.0
7.5	13.3	19.9
7.6	11.4	17.0
7.7	9.6	14.4
7.8	8.1	12.1
7.9	6.7	10.1
8.0	5.6	8.4
8.1	4.6	6.9
8.2	3.8	5.7
8.3	3.1	4.7
8.4	2.5	3.8
8.5	2.1	3.2
8.6	1.7	2.6
8.7	1.4	2.2
8.8	1.2	1.8
8.9	1.0	1.5
9.0	0.8	1.3

ROBIN CARNAHAN
Secretary of State

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Table B2. Chronic Criteria for Total Ammonia Nitrogen (mg N/L): Early Life Stage absent(3)(4)

	Temperature (°C)																
pH	**0-7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	**30**
6.5	10.8	10.1	9.5	8.9	8.3	7.8	7.3	6.8	6.4	6.0	5.3	4.6	4.1	3.6	3.1	2.8	2.4
6.6	10.7	9.9	9.3	8.7	8.2	7.7	7.2	6.7	6.3	5.9	5.2	4.6	4.0	3.5	3.1	2.7	2.4
6.7	10.5	9.8	9.2	8.6	8.0	7.5	7.1	6.6	6.2	5.8	5.1	4.5	3.9	3.5	3.0	2.7	2.3
6.8	10.2	9.5	8.9	8.4	7.9	7.4	6.9	6.5	6.1	5.7	5.0	4.4	3.8	3.4	3.0	2.6	2.3
6.9	9.9	9.3	8.7	8.1	7.6	7.2	6.7	6.3	5.9	5.5	4.8	4.3	3.7	3.3	2.9	2.5	2.2
7.0	9.6	9.0	8.4	7.9	7.4	6.9	6.5	6.1	5.7	5.3	4.7	4.1	3.6	3.2	2.8	2.4	2.1
7.1	9.2	8.6	8.0	7.5	7.1	6.6	6.2	5.8	5.4	5.1	4.5	3.9	3.5	3.0	2.7	2.3	2.0
7.2	8.7	8.2	7.6	7.2	6.7	6.3	5.9	5.5	5.2	4.9	4.3	3.7	3.3	2.9	2.5	2.2	1.9
7.3	8.2	7.7	7.2	6.7	6.3	5.9	5.6	5.2	4.9	4.6	4.0	3.5	3.1	2.7	2.4	2.1	1.8
7.4	7.6	7.2	6.7	6.3	5.9	5.5	5.2	4.8	4.5	4.3	3.7	3.3	2.9	2.5	2.2	1.9	1.7
7.5	7.0	6.6	6.2	5.8	5.4	5.1	4.8	4.5	4.2	3.9	3.4	3.0	2.6	2.3	2.0	1.8	1.6
7.6	6.4	6.0	5.6	5.3	5.0	4.6	4.3	4.1	3.8	3.6	3.1	2.7	2.4	2.1	1.9	1.6	1.4
7.7	5.8	5.4	5.1	4.7	4.0	4.2	3.9	3.7	3.4	3.2	2.8	2.5	2.2	1.9	1.7	1.5	1.3
7.8	5.1	4.8	4.5	4.2	4.4	3.7	3.5	3.2	3.0	2.8	2.5	2.2	1.9	1.7	1.5	1.3	1.1
7.9	4.5	4.2	3.9	3.7	3.5	3.2	3.1	2.8	2.7	2.5	2.2	1.9	1.7	1.5	1.3	1.1	1.0
8.0	3.9	3.7	3.4	3.2	3.0	2.8	2.6	2.5	2.3	2.2	1.9	1.7	1.5	1.3	1.1	1.0	0.8
8.1	3.4	3.1	2.9	2.8	2.6	2.4	2.3	2.1	2.0	1.9	1.6	1.4	1.2	1.1	1.0	0.8	0.7
8.2	2.9	2.7	2.5	2.4	2.2	2.1	1.9	1.8	1.7	1.6	1.4	1.2	1.1	0.9	0.8	0.7	0.6
8.3	2.4	2.3	2.1	2.0	1.9	1.7	1.6	1.5	1.4	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.5
8.4	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.7	0.7	0.6	0.5	0.4
8.5	1.7	1.6	1.5	1.4	1.3	1.2	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4
8.6	1.4	1.4	1.3	1.2	1.1	1.0	1.0	0.9	0.8	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3
8.7	1.2	1.1	1.1	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2
8.8	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2
8.9	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2
9.0	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1

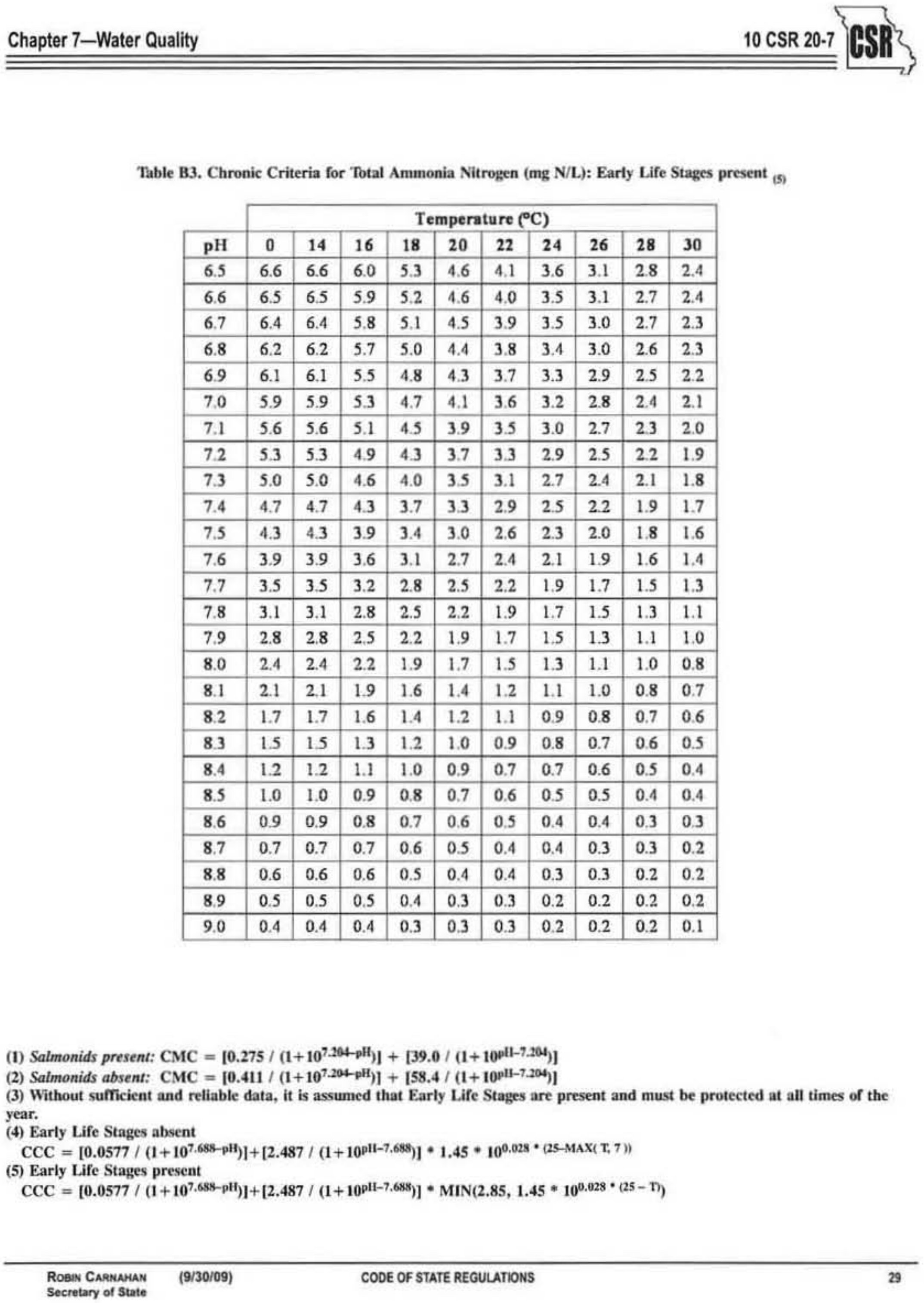

Table B3. Chronic Criteria for Total Ammonia Nitrogen (mg N/L): Early Life Stages present (5)

	Temperature (°C)									
pH	0	14	16	18	20	22	24	26	28	30
6.5	6.6	6.6	6.0	5.3	4.6	4.1	3.6	3.1	2.8	2.4
6.6	6.5	6.5	5.9	5.2	4.6	4.0	3.5	3.1	2.7	2.4
6.7	6.4	6.4	5.8	5.1	4.5	3.9	3.5	3.0	2.7	2.3
6.8	6.2	6.2	5.7	5.0	4.4	3.8	3.4	3.0	2.6	2.3
6.9	6.1	6.1	5.5	4.8	4.3	3.7	3.3	2.9	2.5	2.2
7.0	5.9	5.9	5.3	4.7	4.1	3.6	3.2	2.8	2.4	2.1
7.1	5.6	5.6	5.1	4.5	3.9	3.5	3.0	2.7	2.3	2.0
7.2	5.3	5.3	4.9	4.3	3.7	3.3	2.9	2.5	2.2	1.9
7.3	5.0	5.0	4.6	4.0	3.5	3.1	2.7	2.4	2.1	1.8
7.4	4.7	4.7	4.3	3.7	3.3	2.9	2.5	2.2	1.9	1.7
7.5	4.3	4.3	3.9	3.4	3.0	2.6	2.3	2.0	1.8	1.6
7.6	3.9	3.9	3.6	3.1	2.7	2.4	2.1	1.9	1.6	1.4
7.7	3.5	3.5	3.2	2.8	2.5	2.2	1.9	1.7	1.5	1.3
7.8	3.1	3.1	2.8	2.5	2.2	1.9	1.7	1.5	1.3	1.1
7.9	2.8	2.8	2.5	2.2	1.9	1.7	1.5	1.3	1.1	1.0
8.0	2.4	2.4	2.2	1.9	1.7	1.5	1.3	1.1	1.0	0.8
8.1	2.1	2.1	1.9	1.6	1.4	1.2	1.1	1.0	0.8	0.7
8.2	1.7	1.7	1.6	1.4	1.2	1.1	0.9	0.8	0.7	0.6
8.3	1.5	1.5	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.5
8.4	1.2	1.2	1.1	1.0	0.9	0.7	0.7	0.6	0.5	0.4
8.5	1.0	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4
8.6	0.9	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3
8.7	0.7	0.7	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2
8.8	0.6	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2
8.9	0.5	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2
9.0	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1

(1) *Salmonids present:* $\mathrm{CMC} = [0.275 / (1+10^{7.204-\mathrm{pH}})] + [39.0 / (1+10^{\mathrm{pH}-7.204})]$

(2) *Salmonids absent:* $\mathrm{CMC} = [0.411 / (1+10^{7.204-\mathrm{pH}})] + [58.4 / (1+10^{\mathrm{pH}-7.204})]$

(3) Without sufficient and reliable data, it is assumed that Early Life Stages are present and must be protected at all times of the year.

(4) Early Life Stages absent

$\mathrm{CCC} = [0.0577 / (1+10^{7.688-\mathrm{pH}})]+[2.487 / (1+10^{\mathrm{pH}-7.688})] * 1.45 * 10^{0.028 * (25-\mathrm{MAX}(T, 7))}$

(5) Early Life Stages present

$\mathrm{CCC} = [0.0577 / (1+10^{7.688-\mathrm{pH}})]+[2.487 / (1+10^{\mathrm{pH}-7.688})] * \mathrm{MIN}(2.85, 1.45 * 10^{0.028 * (25-T)})$

APPENDIX D - DEVELOPMENT OF TSS TARGETS USING REFERENCE LDC

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 excluding large rivers that originate outside of the EDU, such as the Mississippi River. 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. In order to develop a synthetic flow record, calculate an average of the log discharge per square mile of USGS gaged rivers for which the drainage area is entirely contained within the EDU. Selection of these gages is based on location, land use/soil/topography similarities to the Big Bottom Creek watershed and the availability of flow data of sufficient age and duration. From this synthetic record a flow duration curve was developed which was used to build a load duration curve (LDC) for the pollutant.

From this population of load durations follow the reference method used in setting nutrient 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 total maximum daily load (TMDL). For most cases available pollutant data for reference streams is also not likely to be available. Therefore, follow the alternative method and target the 25th percentile of load duration of the available data within the EDU as the TMDL LDC. During periods of low flow the actual pollutant concentration may be more important than load. To account for this during periods of low flow the LDC uses the 25th percentile of EDU concentration at flows where surface runoff is less than 1 percent of the stream flow. This result in an inflection point in the curve below which the TMDL is calculated using load calculated with this reference concentration.

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 Big Bottom Creek EDU (Ozark/Apple/Joachim 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.

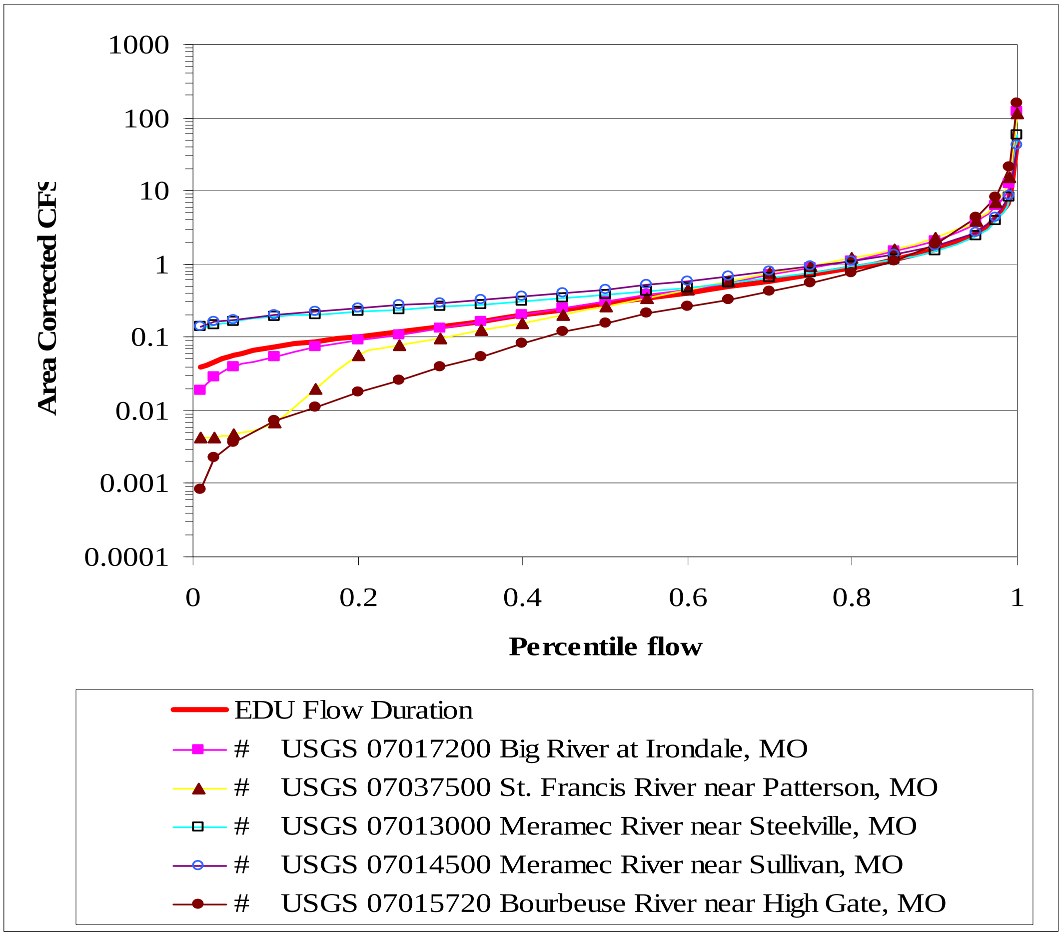

Figure D-1. Synthetic Flow Development in the Ozark/Apple/Joachim EDU

Table D-1. Stream Flow Stations Used to Estimate Flows in Big Bottom Creek

River/Station Name	Data Source	Station Number	Drainage Area (mi^2)	Lognormal Nash-Sutcliffe
Big River at Irondale, MO	USGS	07017200	175	63%
St. Francis River near Patterson, MO	USGS	07037500	956	68%
Meramec River near Steelville, MO	USGS	07013000	781	98%
Meramec River near Sullivan, MO	USGS	07014500	1,475	96%
Bourbeuse River near High Gate, MO	USGS	07015720	135	51%

The next step is to calculate pollutant-discharge relationships for the EDU, these are log transformed data for the yield (tons/mi^2/day) and the instantaneous flow (cfs/mi^2). Figure D-2 shows the EDU relationship. Further statistical analyses on this relationship are included in Table D-2.

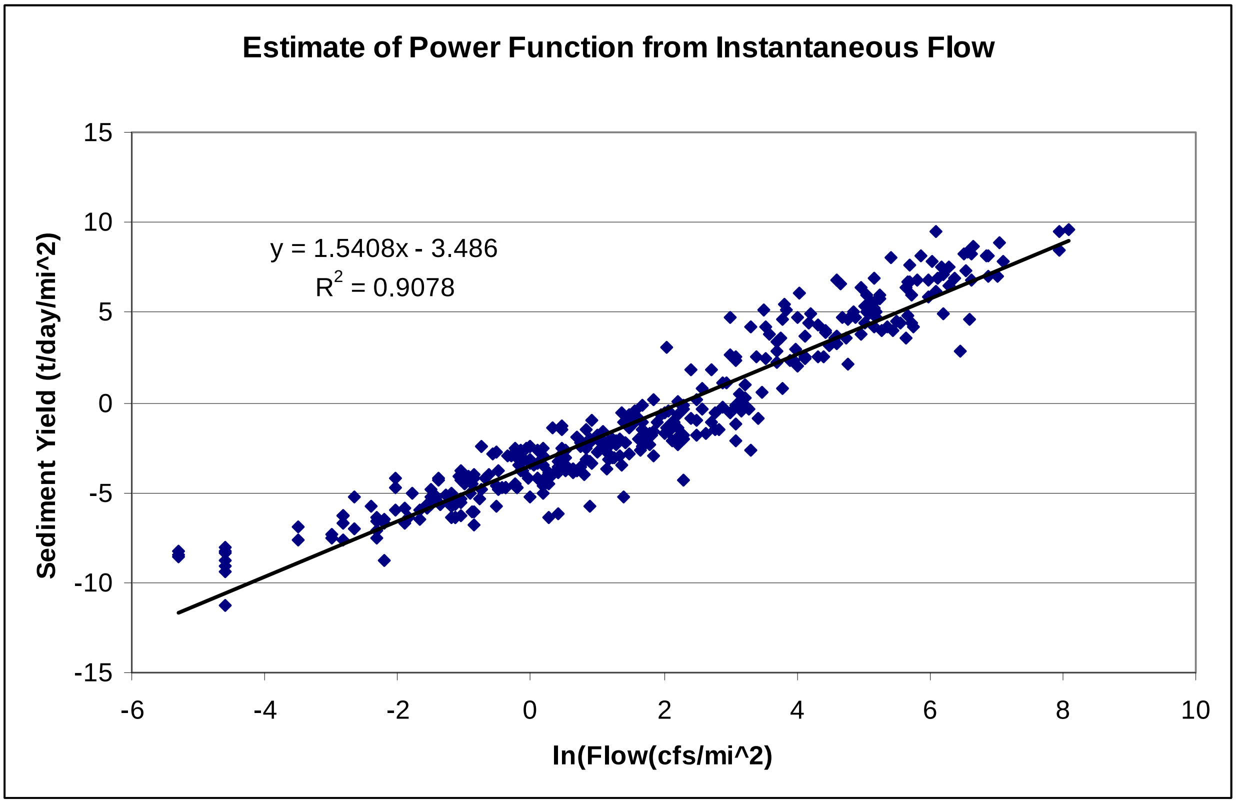

Figure D-2. Estimate of Power Function from Instantaneous Flow in the Ozark/Apple/Joachim EDU

Table D-2. Ozark/Apple/Joachim EDU Flow and Sediment Statistics

m	1.54079899	b	-3.485986392
Standard Error (m)	0.02549522	Standard Error (b)	0.082872781
r2	0.90778871	Standard Error (y)	1.377724534
F	3652.36846	DF	371
SSreg	6932.65148	SSres	704.2043347

The standard error of y was used to estimate the 25th percentile level for the TMDL line. This was done by adjusting the intercept (b) by subtracting the product of the one-sided Z_{75} statistic times the standard error of (y). The resulting TMDL equation is the following:

Sediment yield (t/day/mi2) = exp (1.54079899 * ln (flow) -3.485986392)

A resulting pooled TMDL of all data in the watershed is shown in the following graph:

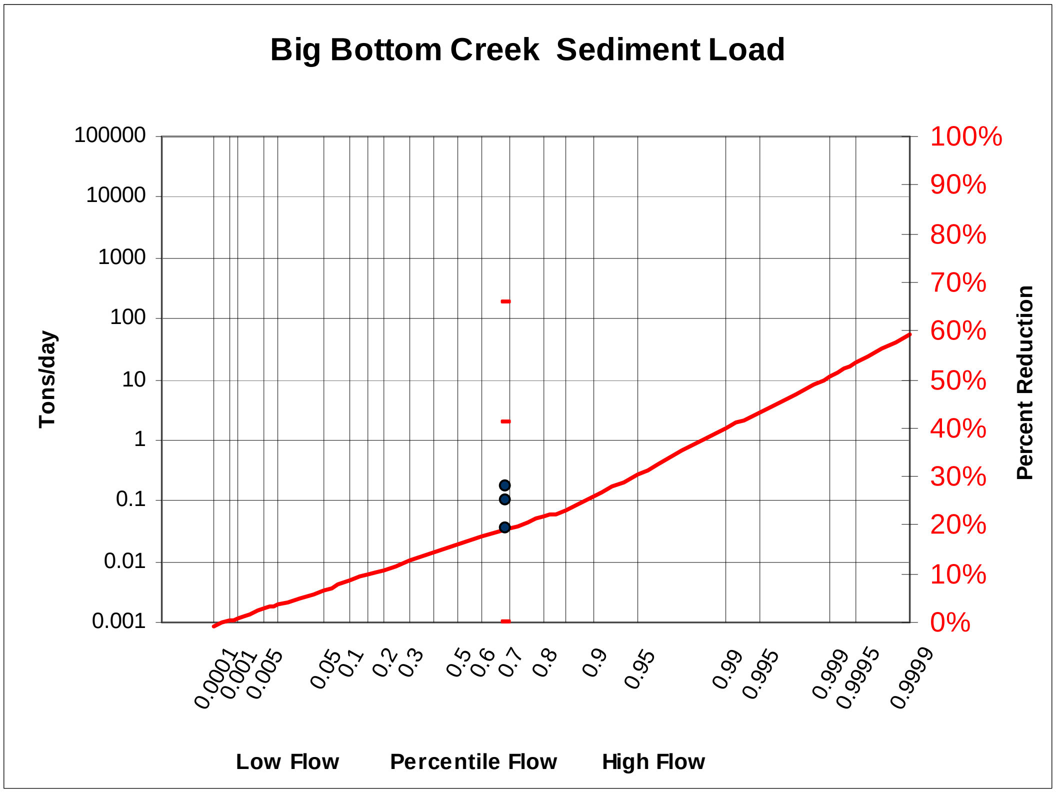

Figure D-3. TMDL LDC for TSS

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 (tons/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 Big Bottom Creek the 25th percentile TSS concentration target is 10 mg/L. The TMDL, LA and WLA were calculated based on this concentration.

For more information contact:

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 -DEVELOPMENT OF NUTRIENT TARGETS USING ECOREGION NUTRIENT CRITERIA WITH LDCS

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 EPA-approved state numeric criteria for the impaired stream is not available a reference approach is used. The target for pollutant loading is the U. S. Environmental Protection Agency (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 U. S. Geological Survey (USGS) gaged rivers for which the drainage area is contained within the Ecological Drainage Unit (EDU). Selection of these gages is based on location, land use/soil/topography similarities to the Big Bottom Creek watershed and the availability of flow data of sufficient age and duration. From this synthetic record develop a flow duration and build a load duration curve (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.

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/Apple/Joachim 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 E-1, Table E-1). Table E-1 demonstrates the pooled data set can confidently be used as a surrogate for the EDU analyses.

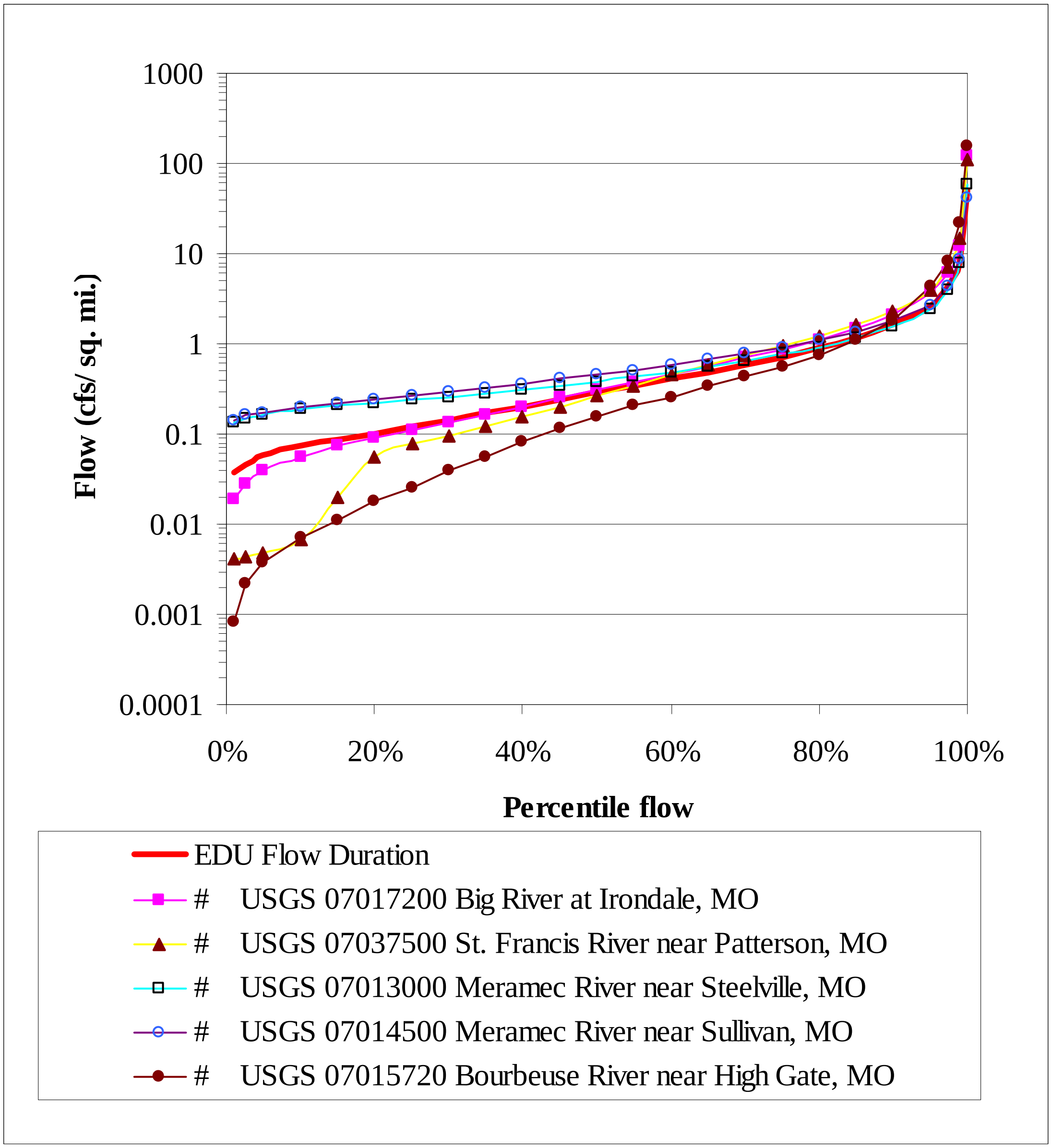

Figure E-1. Synthetic Flow Development in the Ozark/Apple/Joachim EDU

Table E-1. Stream Flow Stations Used to Estimate Flows in Big Bottom Creek

River/Station Name	Data Source	Station Number	Drainage Area (mi2)	Lognormal Nash-Sutcliffe
Big River at Irondale, MO	USGS	07017200	175	63%
St. Francis River near Patterson, MO	USGS	07037500	956	68%
Meramec River near Steelville, MO	USGS	07013000	781	98%
Meramec River near Sullivan, MO	USGS	07014500	1,475	96%
Bourbeuse River near High Gate, MO	USGS	07015720	135	51%

The next step was to collect previously measured water quality data from within the ecoregion. Measured total nitrogen (TN) concentrations are adjusted so their median is equal to the EPA recommended ecoregion TN criterion. This is accomplished by subtracting the difference between the EPA recommended ecoregion TN criterion and 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. Where this adjustment would result in a negative concentration the minimum measured concentration is substituted. Figure E-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.

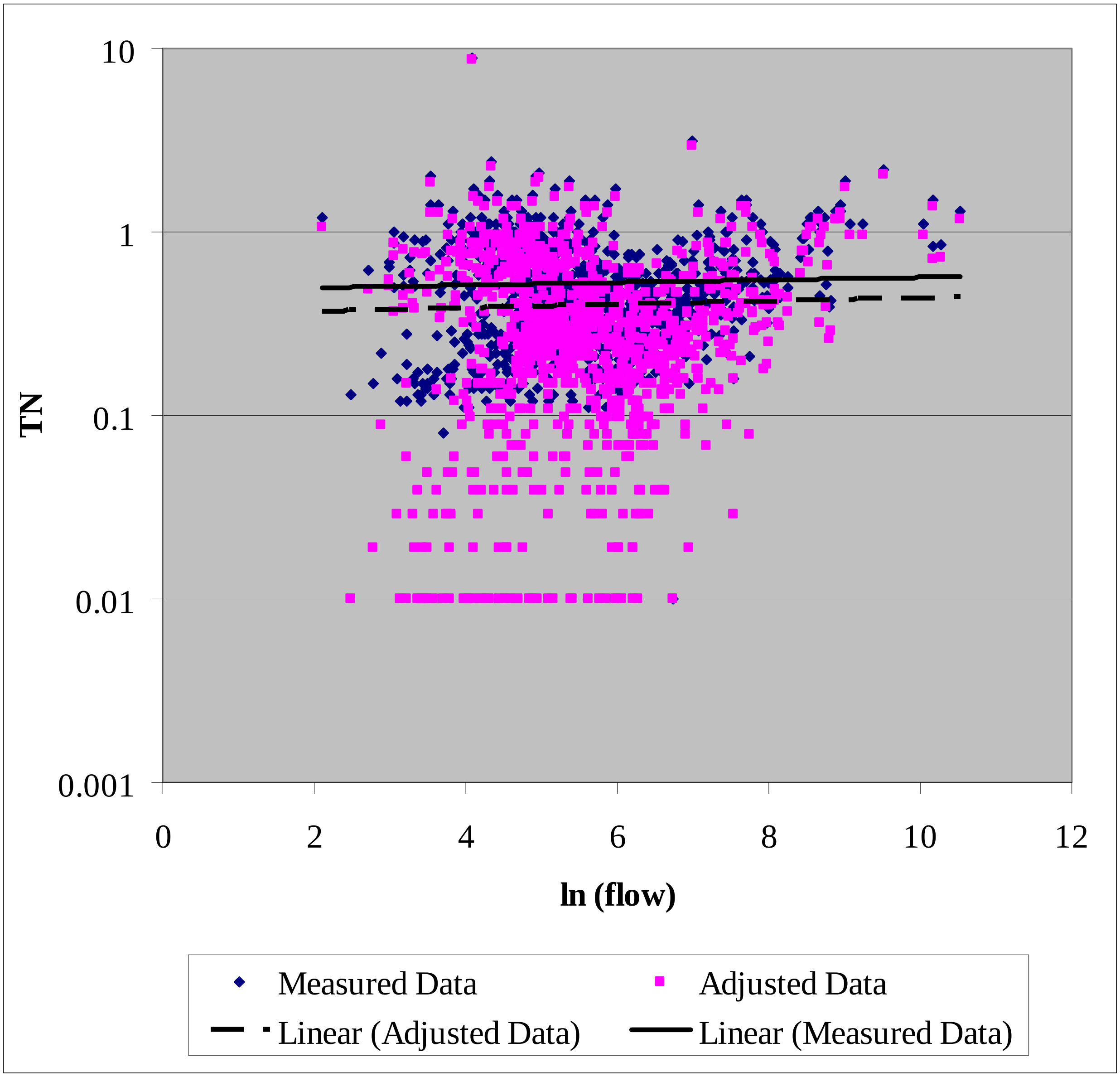

Figure E-2. Graphic Representation of Data Adjustment in Ozark/Apple/Joachim EDU

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 yield (pounds/mi^2/day) and the instantaneous flow (cfs/mi^2). Figure E-3 shows this relationship for this TMDL.

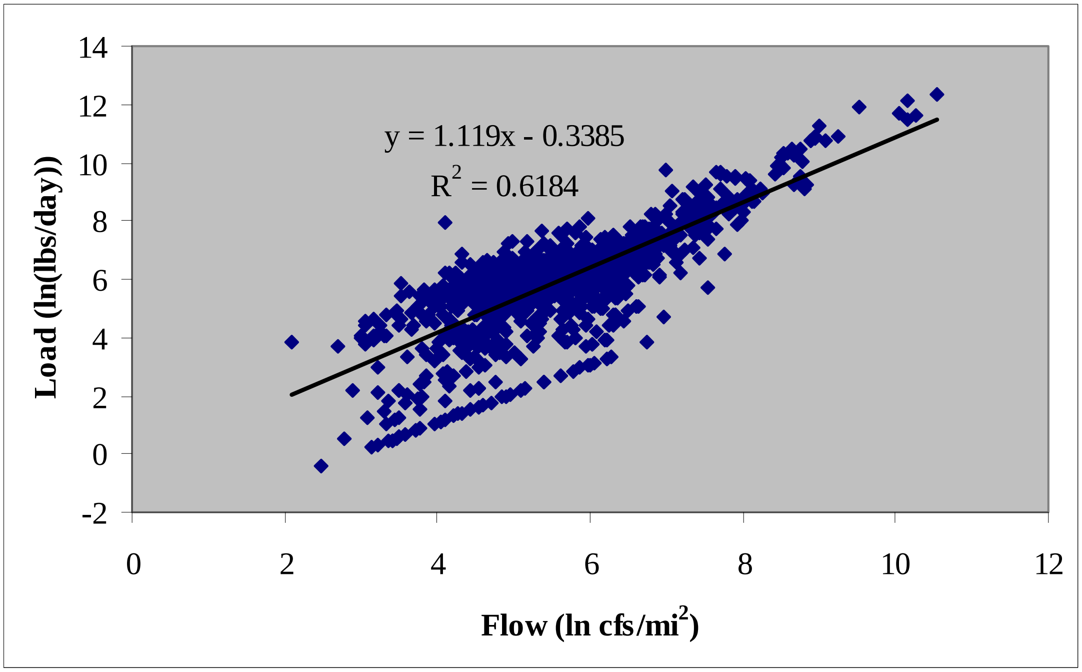

Figure E-3. TN Load and Flow Relationship Used to Set TN TMDL Targets

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 E-4).

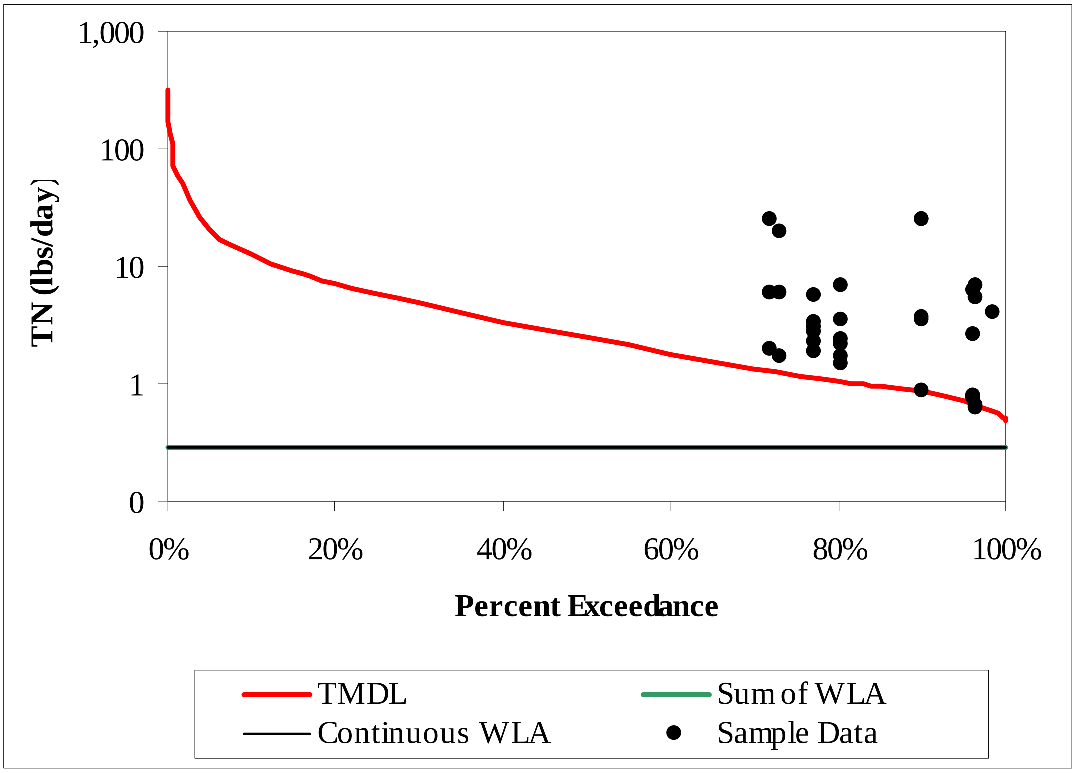

Figure E-4. Example of TMDL LDC Using This Method

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:

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 F - STREAM FLOW AND WATER QUALITY STATIONS USED TO DEVELOP TMDLS IN THE BIG BOTTOM CREEK WATERSHED

Table F-1. Stations Used to Develop Water Quality Data Targets in Big Bottom Creek

USGS/ MDNR Station	Station Name
06930800	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
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
1708/1.2/0.6	Watkins Creek @ Fry Lane
1709/1.0	Maline Creek @ Bellefontaine Rd.
1711/1.0/7.0	River des Peres @ Harlan Park
1711/1.2	River des Peres @ St. Louis
1711/1/3.5/1.5/0.5	Black Creek near Brentwood
1711/1/3.7/0.6	Deer Creek @ Maplewood, MO
1711/1/3.7/4	Deer Creek @ LaDue
1711/1/5.3/1.9	Engelholm Creek near Wellston
1713/1.7	Gravois Creek @ Green Park Rd, Mehlville
1714/0.8	Rock Creek @ Hwy K in Kimmswick
1716/3.4	Glaize Creek near Barnhardt
1755/1.8	Pickle Creek @ Hawn State Park

Table F-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
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

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
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

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

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

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

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

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

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

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

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

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

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

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

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

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
370905091204001	10/10/2001	0.39	109
370905091204001	10/10/2001	0.4	109
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
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

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7066110	10/23/1991	0.01	166
7066110	11/12/1992	0.13	2200
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
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

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

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

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

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

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

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

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

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

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

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

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

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

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7014500	11/9/2005	0.21	581
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
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

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7061600	1/13/2009	0.02	136
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
7014200	5/9/2002	0.07	3250
7014200	2/14/2007	0.04	264

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

	Sample	TP	Flo

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

	Sample	TP	Flow

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

	Sample	TP	Flow

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

	Sample	TP	Flow

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

	Sample	TP	Flow

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

	Sample	TP	Flow

MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)		MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)
1708/1.2/0.6	12/09/1999	160	40		1711/1.2	06/09/2003	0.499	2.4
1708/1.2/0.6	01/06/2000	20	0.25		1711/1.2	08/11/2003	2	0.32
1708/1.2/0.6	02/29/2000	13	0.54		1711/1.2	10/09/2003	588	2860
1708/1.2/0.6	05/26/2000	280	40		1711/1.2	12/04/2003	14	8.6
1708/1.2/0.6	06/19/2000	17	0.42		1711/1.2	02/18/2004	9	7.9
1708/1.2/0.6	08/01/2000	32	0.86		1711/1.2	03/04/2004	433	969
1708/1.2/0.6	12/01/1998	10	1.7		1711/1.2	05/17/2004	4	9
1708/1.2/0.6	02/10/1999	12	3.6		1711/1.2	08/03/2004	4.99	2.1
1708/1.2/0.6	02/11/1999	1400	47		1711/1.2	10/04/2004	4.99	14
1708/1.2/0.6	04/15/1999	80	50		1711/1.2	10/12/2004	147	177
1708/1.2/0.6	06/17/1999	22	0.82		1711/1.2	04/25/2005	14	3.2
1708/1.2/0.6	08/03/1999	25	0.13		1711/1.2	06/21/2005	27	23
1708/1.2/0.6	12/15/1997	2	0.32		1711/1.2	08/10/2005	11	26
1708/1.2/0.6	02/24/1998	2	1		1711/1.2	10/04/2005	4.99	1.7

MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)		MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)
1708/1.2/0.6	04/03/1998	350	75		1711/1.2	10/31/2005	108	489
1708/1.2/0.6	04/13/1998	1500	142		1711/1.2	04/04/2006	12	7.7
1708/1.2/0.6	06/23/1998	22	2.72		1711/1.2	04/06/2006	168	289
1708/1.2/0.6	08/26/1997	31	1		1711/1.2	06/06/2006	4.99	1.9
1708/1.2/0.6	09/02/1997	3300	100		1711/1.2	08/22/2006	4.99	3.8
1708/1.2/0.6	12/18/2000	16	0.87		1711/1.2	10/03/2006	4.99	0.62
1708/1.2/0.6	02/09/2001	760	55		1711/1.2	10/16/2006	58	81
1708/1.2/0.6	02/27/2001	16	2.1		1711/1.2	01/16/2007	19	24
1708/1.2/0.6	04/10/2001	11160	439		1711/1.2	02/05/2007	4.99	8.4
1708/1.2/0.6	05/30/2001	15	0.39		1711/1.2	03/19/2007	15	22
1708/1.2/0.6	08/27/2001	44	0.13		1711/1.2	04/23/2007	51	731
1708/1.2/0.6	10/23/2001	37	12		1711/1.2	04/24/2007	9.99	635
1708/1.2/0.6	12/11/2001	2	0.43		1711/1.2	05/22/2007	49.99	280
1708/1.2/0.6	02/05/2002	3	3.1		1711/1.2	06/19/2007	19	6.7
1708/1.2/0.6	03/09/2002	937	158		1711/1.2	07/23/2007	4.99	1.3
1708/1.2/0.6	05/29/2002	43	4.4		1711/1.2	08/08/2007	10	1.2
1708/1.2/0.6	08/08/2002	49	1.6		1711/1.2	09/12/2007	4.99	1.1
1708/1.2/0.6	10/29/2002	131	54		1711/1/3.5/1.5/0.5	12/03/2003	4	0.35
1708/1.2/0.6	12/17/2002	4	0.32		1711/1/3.5/1.5/0.5	02/17/2004	6	0.4
1708/1.2/0.6	02/04/2003	16	1.2		1711/1/3.5/1.5/0.5	03/26/2004	298	43
1708/1.2/0.6	03/28/2003	131	34		1711/1/3.5/1.5/0.5	04/24/2004	239	61
1708/1.2/0.6	06/09/2003	14	0.62		1711/1/3.5/1.5/0.5	05/18/2004	13	0.84
1708/1.2/0.6	08/12/2003	23	0.25		1711/1/3.5/1.5/0.5	08/03/2004	4.99	1.1
1708/1.2/0.6	10/14/2003	162	30		1711/1/3.7/0.6	05/21/2001	150	100
1708/1.2/0.6	12/04/2003	4	1.9		1711/1/3.7/0.6	05/30/2001	10	1.2
1708/1.2/0.6	02/10/2004	26	10		1711/1/3.7/0.6	08/27/2001	3	1.2
1708/1.2/0.6	03/26/2004	2830	57		1711/1/3.7/0.6	10/05/2001	133	247
1708/1.2/0.6	05/17/2004	9	2.8		1711/1/3.7/0.6	12/10/2001	3	1.3
1708/1.2/0.6	08/04/2004	4.99	1.5		1711/1/3.7/0.6	02/04/2002	6	5.3
1709/1.0	12/09/1999	99	307		1711/1/3.7/0.6	03/09/2002	337	392
1709/1.0	01/06/2000	67	0.47		1711/1/3.7/0.6	05/29/2002	19	13
1709/1.0	02/29/2000	25	3		1711/1/3.7/0.6	08/05/2002	27	0.75
1709/1.0	04/07/2000	2600	300		1711/1/3.7/0.6	10/25/2002	114	143
1709/1.0	06/15/2000	22	5.4		1711/1/3.7/0.6	12/17/2002	25	1.1
1709/1.0	08/01/2000	31	4.2		1711/1/3.7/0.6	02/04/2003	17	2.9
1709/1.0	12/01/1998	12	6.3		1711/1/3.7/0.6	03/28/2003	27	118
1709/1.0	02/10/1999	12	12		1711/1/3.7/0.6	06/09/2003	7	1.7
1709/1.0	02/11/1999	2000	749		1711/1/3.7/0.6	08/11/2003	20	0.89
1709/1.0	05/04/1999	970	492		1711/1/3.7/0.6	10/09/2003	378	1110
1709/1.0	06/17/1999	19	2.7		1711/1/3.7/0.6	12/03/2003	2	1.2
1709/1.0	08/03/1999	19	1.6		1711/1/3.7/0.6	12/09/2003	50	55
1709/1.0	12/15/1997	9	2.7		1711/1/3.7/0.6	02/17/2004	5	3.5
1709/1.0	02/24/1998	9	5.4		1711/1/3.7/0.6	03/03/2004	134	98

MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)		MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)
1709/1.0	04/15/1998	1400	478		1711/1/3.7/0.6	04/23/2004	76	52
1709/1.0	06/23/1998	28	7		1711/1/3.7/0.6	05/18/2004	3	3.9
1709/1.0	12/11/1996	10	5		1711/1/3.7/0.6	08/03/2004	4.99	1.4
1709/1.0	03/05/1997	9	8		1711/1/3.7/4	05/21/2001	80	62
1709/1.0	05/25/1997	2900	779		1711/1/3.7/4	05/30/2001	10	0.01
1709/1.0	06/10/1997	30	5		1711/1/3.7/4	08/28/2001	6	0.01
1709/1.0	08/26/1997	28	2		1711/1/3.7/4	10/05/2002	64	18
1709/1.0	09/02/1997	2300	1150		1711/1/3.7/4	12/10/2002	9	0.01
1709/1.0	08/01/1996	24	4.6		1711/1/3.7/4	02/05/2002	8	0.28
1709/1.0	09/23/1996	1300	940		1711/1/3.7/4	03/09/2002	221	85
1709/1.0	12/18/2000	19	2.2		1711/1/3.7/4	05/30/2002	31	1
1709/1.0	02/09/2001	2100	173		1711/1/3.7/4	08/05/2002	12	0.01
1709/1.0	02/27/2001	43	9		1711/1/3.7/4	10/25/2002	40	25
1709/1.0	04/10/2001	3700	351		1711/1/3.7/4	12/17/2002	19	0.00499
1709/1.0	05/29/2001	18	0.34		1711/1/3.7/4	02/04/2003	6	1.3
1709/1.0	08/27/2001	37	0.56		1711/1/3.7/4	04/06/2003	18	44
1709/1.0	10/24/2001	69	61		1711/1/3.7/4	06/09/2003	15	0.00499
1709/1.0	12/10/2001	15	1.7		1711/1/3.7/4	08/11/2003	14	0.00499
1709/1.0	02/05/2002	68	6.4		1711/1/3.7/4	10/09/2003	437	536
1709/1.0	03/09/2002	575	171		1711/1/3.7/4	12/03/2003	0.499	0.01
1709/1.0	05/30/2002	6	6		1711/1/3.7/4	12/10/2003	235	180
1709/1.0	08/08/2002	56	3.9		1711/1/3.7/4	02/17/2004	3	0.1
1709/1.0	10/29/2002	305	180		1711/1/3.7/4	03/04/2004	450	307
1709/1.0	12/17/2002	7	3.2		1711/1/3.7/4	04/24/2004	97	90
1709/1.0	02/04/2003	22	9		1711/1/3.7/4	05/18/2004	38	0.6
1709/1.0	04/16/2003	2300	416		1711/1/3.7/4	08/03/2004	4.99	0.1
1709/1.0	06/09/2003	11	6		1711/1/5.3/1.9	01/06/2000	2	0.3
1709/1.0	08/12/2003	29	0.84		1711/1/5.3/1.9	02/18/2000	5000	224
1709/1.0	10/09/2003	1300	541		1711/1/5.3/1.9	02/29/2000	6	0.21
1709/1.0	12/04/2003	5	17		1711/1/5.3/1.9	05/07/2000	1000	7.7
1709/1.0	02/09/2004	6	9.9		1711/1/5.3/1.9	06/15/2000	14	0.17
1709/1.0	03/04/2004	2190	706		1711/1/5.3/1.9	07/31/2000	11	0.37
1709/1.0	05/17/2004	6	9		1711/1/5.3/1.9	12/01/1998	6	0.95
1709/1.0	08/04/2004	13	3.5		1711/1/5.3/1.9	02/11/1999	4	1.2
1709/1.0	10/05/2004	25	0.35		1711/1/5.3/1.9	02/11/1999	2700	105
1709/1.0	10/26/2004	465	127		1711/1/5.3/1.9	05/12/1999	450	36
1709/1.0	03/22/2005	872	398		1711/1/5.3/1.9	06/17/1999	5	0.26
1709/1.0	04/25/2005	4.99	5.2		1711/1/5.3/1.9	08/03/1999	3	0.19
1709/1.0	06/20/2005	20	2.4		1711/1/5.3/1.9	12/16/1997	4	0.16
1709/1.0	08/08/2005	14	3		1711/1/5.3/1.9	02/24/1998	11	0.51
1709/1.0	10/03/2005	15	5.3		1711/1/5.3/1.9	04/13/1998	1900	33
1709/1.0	10/31/2005	118	256		1711/1/5.3/1.9	06/22/1998	6	0.6
1709/1.0	04/04/2006	49	4.8		1711/1/5.3/1.9	08/19/1997	85	40

MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)		MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)
1709/1.0	05/01/2006	404	441		1711/1/5.3/1.9	08/26/1997	8	0.3
1709/1.0	06/06/2006	13	2.3		1711/1/5.3/1.9	12/19/2000	7	0.13
1709/1.0	08/21/2006	4.99	1.1		1711/1/5.3/1.9	02/24/2001	880	27
1709/1.0	10/02/2006	10	0.88		1711/1/5.3/1.9	02/27/2001	13	0.42
1709/1.0	10/16/2006	114	214		1711/1/5.3/1.9	04/03/2001	211	22
1709/1.0	01/16/2007	62	13		1711/1/5.3/1.9	05/29/2001	6	0.1
1709/1.0	02/05/2007	11	8.5		1711/1/5.3/1.9	08/27/2001	3	0.06
1709/1.0	03/19/2007	20	4.4		1711/1/5.3/1.9	10/24/2001	825	44
1709/1.0	04/03/2007	785	1220		1711/1/5.3/1.9	12/11/2001	0.499	0.11
1709/1.0	04/10/2007	10	6.2		1711/1/5.3/1.9	02/05/2002	4	0.46
1709/1.0	05/21/2007	61	5.3		1711/1/5.3/1.9	04/08/2002	169	22
1709/1.0	06/18/2007	10	3.6		1711/1/5.3/1.9	05/29/2002	38	0.79
1709/1.0	07/26/2007	61	1.6		1711/1/5.3/1.9	08/08/2002	2	0.1
1709/1.0	08/08/2007	32	0.93		1711/1/5.3/1.9	10/25/2002	213	11
1709/1.0	09/12/2007	65	1.4		1711/1/5.3/1.9	12/17/2002	3	0.15
1711/1.0/7.0	01/06/2000	6	0.03		1711/1/5.3/1.9	02/04/2003	6	0.22
1711/1.0/7.0	02/18/2000	1400	964		1711/1/5.3/1.9	04/20/2003	255	20
1711/1.0/7.0	02/29/2000	12	0.06		1711/1/5.3/1.9	06/09/2003	2	0.35
1711/1.0/7.0	06/15/2000	12	0.06		1711/1/5.3/1.9	08/12/2003	7	0.15
1711/1.0/7.0	08/01/2000	5	0.35		1711/1/5.3/1.9	10/09/2003	697	34
1711/1.0/7.0	12/01/1998	6	0.47		1711/1/5.3/1.9	12/03/2003	1	0.42
1711/1.0/7.0	02/11/1999	5	0.68		1711/1/5.3/1.9	02/18/2004	2	0.59
1711/1.0/7.0	02/11/1999	1000	333		1711/1/5.3/1.9	03/26/2004	1990	45
1711/1.0/7.0	06/17/1999	4	0.11		1711/1/5.3/1.9	05/18/2004	5	0.64
1711/1.0/7.0	08/03/1999	4	0.01		1711/1/5.3/1.9	08/03/2004	4.99	0.31
1711/1.0/7.0	12/16/1997	9	0.22		1713/1.7	12/09/1999	320	117
1711/1.0/7.0	02/24/1998	4	0.05		1713/1.7	01/05/2000	17	2.4
1711/1.0/7.0	04/03/1998	84	231		1713/1.7	02/28/2000	19	2.1
1711/1.0/7.0	06/22/1998	10	0.41		1713/1.7	05/26/2000	210	151
1711/1.0/7.0	08/19/1997	60	75		1713/1.7	11/30/1998	21	32
1711/1.0/7.0	08/26/1997	12	0.03		1713/1.7	02/07/1999	1600	3300
1711/1.0/7.0	12/19/2000	14	0.35		1713/1.7	02/10/1999	14	11
1711/1.0/7.0	02/27/2001	4	0.81		1713/1.7	05/12/1999	810	460
1711/1.0/7.0	03/15/2001	610	190		1713/1.7	06/16/1999	54	2.5
1711/1.0/7.0	04/09/2001	1000	288		1713/1.7	08/03/1999	25	1.2
1711/1.0/7.0	05/29/2001	13	0.09		1713/1.7	10/13/1997	61	19
1711/1.0/7.0	08/27/2001	3	0.01		1713/1.7	12/16/1997	4	2
1711/1.0/7.0	10/24/2001	633	593		1713/1.7	02/23/1998	3	6.4
1711/1.0/7.0	12/11/2001	28	0.07		1713/1.7	04/15/1998	2200	679
1711/1.0/7.0	02/04/2002	0.499	1.3		1713/1.7	06/22/1998	28	7.9
1711/1.0/7.0	03/09/2002	380	157		1713/1.7	08/01/1996	34	2.32
1711/1.0/7.0	05/30/2002	4	0.81		1713/1.7	09/23/1996	1800	2800
1711/1.0/7.0	08/08/2002	12	0.06		1713/1.7	06/19/2000	21	2.4

MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)		MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)
1711/1.0/7.0	10/29/2002	159	15		1713/1.7	08/23/2000	13	3.8
1711/1.0/7.0	12/17/2002	13	0.22		1713/1.7	11/06/2000	93	100
1711/1.0/7.0	02/04/2003	27	0.71		1713/1.7	12/18/2000	14	3.4
1711/1.0/7.0	03/19/2003	322	161		1713/1.7	02/24/2001	530	153
1711/1.0/7.0	06/09/2003	4	0.3		1713/1.7	02/27/2001	16	18
1711/1.0/7.0	08/12/2003	8	0.06		1713/1.7	05/29/2001	14	1.6
1711/1.0/7.0	10/09/2003	784	691		1713/1.7	08/27/2001	5	0.3
1711/1.0/7.0	12/17/2003	2	0.41		1713/1.7	10/15/2001	118	115
1711/1.0/7.0	02/18/2004	11	1.04		1713/1.7	12/10/2001	0.499	1.5
1711/1.0/7.0	03/03/2004	721	68		1713/1.7	02/04/2002	9	7.4
1711/1.0/7.0	05/18/2004	7	1.5		1713/1.7	03/09/2002	982	297
1711/1.0/7.0	08/03/2004	4.99	0.19		1713/1.7	05/28/2002	28	7.4
1711/1.0/7.0	10/05/2004	4.99	0.07		1713/1.7	08/05/2002	12	1.1
1711/1.0/7.0	10/12/2004	383	177		1713/1.7	10/03/2002	778	191
1711/1.0/7.0	03/22/2005	375	109		1713/1.7	12/17/2002	9	1.5
1711/1.0/7.0	04/25/2005	13	1		1713/1.7	02/03/2003	7	2.3
1711/1.0/7.0	06/22/2005	4.99	0.26		1713/1.7	04/04/2003	325	133
1711/1.0/7.0	08/08/2005	4.99	1.3		1713/1.7	06/24/2003	10	3.2
1711/1.0/7.0	10/03/2005	4.99	0.29		1713/1.7	08/11/2003	15	1
1711/1.0/7.0	10/20/2005	610	184		1713/1.7	10/09/2003	790	278
1711/1.0/7.0	04/02/2006	2030	20		1713/1.7	12/04/2003	14	8.5
1711/1.0/7.0	04/03/2006	4.99	1.9		1713/1.7	02/18/2004	10	4.1
1711/1.0/7.0	06/06/2006	4.99	0.68		1713/1.7	03/03/2004	231	85
1711/1.0/7.0	08/22/2006	4.99	0.68		1713/1.7	05/17/2004	15	5.4
1711/1.0/7.0	10/02/2006	4.99	0.05		1713/1.7	08/02/2004	4.99	4.4
1711/1.0/7.0	10/16/2006	104	193		1714/0.8	03/12/2007	4.99	9.8
1711/1.0/7.0	01/16/2007	4.99	3.4		1714/0.8	05/21/2007	31	9.8
1711/1.0/7.0	02/05/2007	4.99	1.3		1716/3.4	03/12/2007	4.99	12
1711/1.0/7.0	03/19/2007	4.99	1.8		1716/3.4	05/21/2007	4.99	10
1711/1.0/7.0	04/03/2007	475	65		1755/1.8	01/28/1997	3	2
1711/1.0/7.0	04/10/2007	4.99	16		1755/1.8	06/18/1997	2	13
1711/1.0/7.0	05/21/2007	4.99	0.8		1755/1.8	01/17/1996	0.499	2.8
1711/1.0/7.0	06/18/2007	8.499	0.24		1755/1.8	06/24/1996	1	0.73
1711/1.0/7.0	07/23/2007	4.99	0.21		1755/1.8	01/11/1995	4	5.5
1711/1.0/7.0	08/08/2007	4.99	0.26		1755/1.8	05/08/1995	10	2.7
1711/1.0/7.0	09/12/2007	4.99	0.11		1755/1.8	01/27/1994	32	27
1711/1.2	10/29/2002	79	314		1755/1.8	06/24/1994	10	1
1711/1.2	12/17/2002	6	2.4		1755/1.8	11/10/1992	10	1.6
1711/1.2	02/03/2003	5	3.2		1755/1.8	01/20/1993	10	10
1711/1.2	03/19/2003	444	752		1755/1.8	03/16/1993	0.499	7.5
					1755/1.8	05/18/1993	13	6.2
					1755/1.8	07/07/1993	5	3.6
					1755/1.8	09/29/1993	8	1.7

Appendix G – Supplemental Implementation Plan

States are not required under Section 303(d) of the CWA to develop TMDL implementation plans and EPA does not approve or disapprove them. However, 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 Big Bottom Creek TMDL.

This TMDL will be implemented through permit action. The current Lake Forest Estates Subdivision WWTP (MO0035742) permit was issued December 1, 2006, with limits for BOD of 60/30 mg/L (weekly/monthly averages) and monitoring only for ammonia. New limits for ammonia went into effect Nov 30, 2009. They are 3.7 mg/L daily maximum/1.9 mg/L monthly average for summer and 7.5/3.7 mg/L in the winter. However, the permit also states that a new water quality review will be conducted after three years to determine if recent upgrades were sufficient to bring about a recovery of the receiving stream. The permit also includes instream monitoring requirements, as stated above in Section 12. Monitoring Plan. Due to the development of new WLAs for the Lake Forest Estates WWTP, future permit renewals will contain the requirements found in this TMDL to ensure attainment of the protection of aquatic life designated use.

This TMDL was developed using the most recent and accurate data available. Should new data, information, criteria, targets or WQS become available, that may change the LC or allocations contained within this TMDL, the TMDL may be revised or modified by MDNR at any time (40 CFR 130.7).