United States Environmental Protection Agency
Region 7
Total Maximum Daily Load
For Unknown Pollutants

Willow Branch (MO_0654U-01)
Putnam County, Missouri

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

9-1-10
Date

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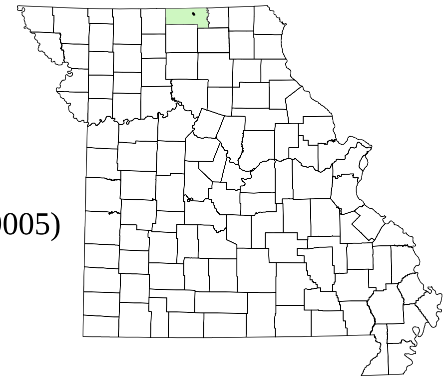
Total Maximum Daily Load (TMDL)
For Willow Branch
Pollutant: Unknown



Name: Willow Branch

Location: Putnam County, Missouri

Hydrologic Unit Code (HUC): 10280201-0502

Water Body Identification (WBID): 0654U-01 (a.k.a. 9005)

Missouri Stream Class: Unclassified (U)

Designated Beneficial Uses: General Criteria[1]

Location of Segment: Located in Putnam County, northeast of Unionville, Missouri. Segment begins at Township 66 North Range 18 West Section 16 and ends at Township 66 North Range 18 West Section 28.

Size of Segment: 2 miles[2]

Location of Impaired Segment: Located in Putnam County, northeast of Unionville, Missouri. Segment begins at Township 66 North Range 18 West Section 16 and ending at Township 66 North Range 18 West Section 28. The impaired length includes the entire unclassified headwater portion of Willow Branch.[3]

Size of Impaired Segment: 0.6 U miles[2]

Pollutants: Unknown

Identified Source on 303(d) List: Unknown

TMDL Priority Ranking: Medium

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[1] There are no designated beneficial uses for unclassified waters.
[2] Mileage associated with the 2008 303(d) List is 0.6 U miles; however, the stream length listed corresponds to geospatial data available in "Missouri 's 2004/2006 Section 303(d) List - Rivers and Streams" developed by the Missouri Department of Natural Resources, Division of Environmental Quality, Water Protection Program. This information is available online at: ftp://msdis.missouri.edu/pub/state/st_imprd_2006_s.zip.
[3] Willow Branch is an unclassified segment which means there is no official location description in MO WQS Table H, but the TMDL as described encompasses the entire reach referred to in the Missouri 2008 303(d) List.

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ACRONYMS AND ABBREVIATIONS

Σ	Sum of
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
Ck	Creek
Cl	Chloride
CSR	Code of State Regulations
CWA	Clean Water Act
DO	Dissolved Oxygen
e.g.	For Example
EDU	Ecological Drainage Unit
EPA	Environmental Protection Agency
Gal / year	Gallons per year
GIS	Geographic Information System
HUC	Hydrologic Unit Code
LA	Load Allocation
LC	Loading Capacity
LDC	Load Duration Curve
MDC	Missouri Department of Conservation
mg	Milligrams
mg/L	Milligrams per Liter
MGD	Million Gallons per Day
MO	Missouri
MDNR	Missouri Department of Natural Resources
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
MSWDC	Missouri Soil and Water Districts Commission
N	North
NA	Not Applicable
NASS	National Agricultural Statistics Service
NESC	National Environmental Service Center
NH_3	Ammonia Nitrogen
NO_2	Nitrite Nitrogen
NO_3	Nitrate Nitrogen
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PCS	Permit Compliance System
PSF	Premium Standard Farms

ACRONYMS AND ABBREVIATIONS (CONTINUED)

SWPPP	Storm Water Pollution Prevention Plan
TKN	Total Kjeldahl Nitrogen
Temp	Temperature
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
U	Unclassified
URS	URS Group
US	United States
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WBID	Water Body Identification
WLA	Waste load Allocation
WQBELs	Water Quality Based Effluent Limitations
WQS	Water Quality Standards
WWTP	Wastewater Treatment Plant

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1 INTRODUCTION

The Willow Branch 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 (US) Environmental Protection Agency (EPA) approved Missouri 2008 303(d) List and is identified as impaired due to unknown pollutants and sources. Total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP) measurements in Willow Branch have shown each parameter to be present at elevated levels and linked to the impaired beneficial use of the water body. This report addresses the Willow Branch impairment by establishing TSS, TN and TP TMDLs in accordance with Section 303(d) of the CWA. EPA is establishing this TMDL to meet the milestones of the 2001 Consent Decree, *American Canoe Association, et al. v. EPA*, No. 98-1195-CV-W in consolidation with No. 98-4282-CV-W, February 27, 2001.

Section 303(d) of the CWA and Federal Chapter 40 of the Code of Federal Regulations (CFR) Part 130 requires states to develop TMDLs for waters not meeting designated beneficial uses. The TMDL process quantitatively assesses the impairment factors so that states can establish water-quality based controls to reduce pollution and restore and protect the quality of their water resources. The purpose of a TMDL is to determine the maximum amount of a pollutant (the load) that a water body can assimilate without causing violations of the water quality standards (WQS). WQS are benchmarks used to assess the quality of 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 in-stream water quality conditions. The TMDL consists of a waste load 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 receiving water impacts. This is often associated with model assumption and data limitations.

The goal of the TMDL program is to restore designated beneficial uses to water bodies. In addition to establishing a TMDL for Willow Branch, this report provides a summary of information, results and recommendations related to the impairment based on a broad analysis of watershed information and detailed analysis of water quality, flow data and comparison to a reference stream condition in the same ecoregion or ecological drainage unit (EDU) in which Willow Branch is located.

Section 2 of this report provides background information on the Willow Branch watershed and Section 3 describes potential sources of concern. Section 4 presents the applicable WQS and Section 5 describes the modeling that was done to support the TMDL. Sections 6 to 10 present the required TMDL elements (LC, WLA, LA, MOS, seasonal variation) and Sections 11 to 13 summarize the follow-up monitoring plan, reasonable assurances and public participation. A summary of the administrative record is presented in Section 14.

2 BACKGROUND

This section of the report provides information on Willow Branch and its watershed.

2.1 THE SETTING

Willow Branch is located in the Central Plains / Grand River / Chariton Ecological Drainage Unit (EDU). Willow Branch originates in Putnam County (T66N R18W Section 18) and flows south to its confluence with North Blackbird Creek, a tributary of the Chariton River. The Willow Branch watershed covers an area of approximately 3.6 square miles with a river distance of approximately two miles. The elevation of the impaired segment ranges from 940 feet (upstream) to 900 feet (downstream) and has an average stream slope of 0.0038 feet/feet (USDI, 1997).

In 2002, EPA placed Willow Branch on the Missouri 303(d) List for unknown pollutants, based on two state reports, Monitoring Report on 26 Waters and Visual/Benthic Low Flow Surveys, published by the Missouri Department of Natural Resources (MDNR). Willow Branch has been greatly impaired by stream habitat degradation resulting from numerous environmental factors including poorly forested riparian buffers and management, sedimentation or siltation and stream bank erosion. Approximately 60 percent of stream banks were considered moderately unstable, with less than 50 percent of their surface covered with vegetation (Versar, 2008). In 2009, MDNR gathered data six times under varying flow regimes to supplement existing data so a TMDL could be developed for Willow Branch (MDNR, 2009b).

All waters of the state, as per Missouri WQS, must protect aquatic life. A combination of natural geology and land use in the prairie portions of the state where Willow Branch is located is believed to have reduced the amount and impaired the quality of habitat for aquatic life. The major water quality problems are excessive nutrients and increased rates of sediment deposition due to stream bank erosion and sheet erosion from agricultural lands, loss of stream length and stream channel heterogeneity due to channelization and changes in basin hydrology that have increased flood flows and prolonged low flow conditions. The number one pollutant entering Missouri's waters is sediment, with about 59 million tons of soil eroding from Missouri's land each year (MSWDC, 2003). Sedimentation occurs when wind or water runoff carries soil particles from an area and transports them to a stream or lake. Excessive sedimentation clouds the water, which reduces the amount of sunlight reaching aquatic plants, covers fish spawning areas and food supplies and clogs the gills of fish. In addition, other pollutants like nitrogen, phosphorus, pathogens and heavy metals are often attached to soil particles and move into streams with the sediment (MDNR, 2009a). TMDLs are not written to address habitat, but are written to correct water quality conditions. To address the unknown pollutant, this TMDL targets nutrients and sediment.

There are many quantitative indicators of sediment, such as TSS, turbidity and bedload sediment, which are appropriate to describe sediment in rivers and streams. TSS was selected as the numeric target for sediment in this TMDL because it enables the use of the highest quality data available, including permit conditions and monitoring data. To address nutrients both TN and TP are selected because both nutrients are generally elevated by both point and nonpoint sources.

2.2 PHYSIOGRAPHIC LOCATION, GEOLOGY AND SOILS

Willow Branch is located within the Northern Plains; a region within the Dissected Till Plains. The Dissected Till Plains are a physiographic region of the Central Lowlands Province, which are in turn part of the Interior Plains physiographic division of the United States (MDC, 2010). The Dissected Till Plains are characterized by moderately dissected, glaciated, flat-to-rolling terrain that slopes gently toward the Missouri and Mississippi River Valleys. Willow Branch is a tributary to North Blackbird Creek in the Chariton River watershed. The Willow Branch watershed is located in the Middle Pennsylvanian Middle Series-Desmonian Stage. Predominant rock types include shale and limestone (Stoeser *et al.,* 2005).

Table 1 provides a summary of soil types in the impaired Willow Branch watershed. The dominant soil type C, covers approximately 82.4 percent of the 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. Approximately 16 percent of soils in the impaired watershed are categorized as Group D. Group D soils include clay loam, silty clay loam, sandy clay, silty clay or clay. This hydrologic 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 and soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material (Purdue Research Foundation, 2009). The soils hydrologic group relates to the rate at which water enters the soil profile, which in turn affects the amount of water that enters the stream as direct runoff.

Table 1. Willow Branch Watershed Soils Summary (NRCS, 2009)

Soil Type	Hydrologic Soil Group	Acres	Percent (%)
Adair Loam	C	263.6	11.5
Armstrong Clay Loam	C	336.0	14.6
Gara Loam	C	603.1	26.2
Keswick Loam	C	138.2	6.0
Vigar-Zook-Nodaway Complex	C	164.6	7.2
Winnegan Loam	C	389.4	16.9
Subtotal	**C**	**1894.9**	**82.4**
Clarinda Silty Clay Loam	D	104.4	4.5
Edina Silt Loam	D	73.4	3.2
Pershing Silty Clay Loam	D	50.6	2.2
Seymour Silty Clay Loam	D	141.2	6.1
Subtotal	**D**	**369.6**	**16.0**
Other[4]	B/C/D	35.4	1.5

2.3 RAINFALL AND CLIMATE

The Unionville weather station is located in Putnam County within 10 miles of the Willow Branch watershed (Figure 1). It records daily precipitation, maximum and minimum temperature, snowfall and snow depth. Figure 2 provides a summary of rainfall and climate data for the Unionville Station based on 30 year totals (1971 – 2000) (NOAA, 2009). The annual average precipitation and temperature over the 30 year period is 37.5 inches and 49.8 degrees Fahrenheit, respectively. Weather stations provide useful information for developing a general understanding of the watershed. Precipitation is related to stream flow and runoff events that are related to erosion. Thus, an understanding of annual and monthly precipitation patterns is useful when considering the load duration curve (LDC) approach (see Section 5) to TMDLs.

[4] Other soil types that make up less than one percent of the total watershed area include: Colo silt loam (Hydrologic Soil Group B/D), Gorin silt loam (Hydrologic Soil Group C), Humeston silty clay loam (Hydrologic Soil Group C/D) and Lamoni clay loam (Hydrologic Soil Group C).

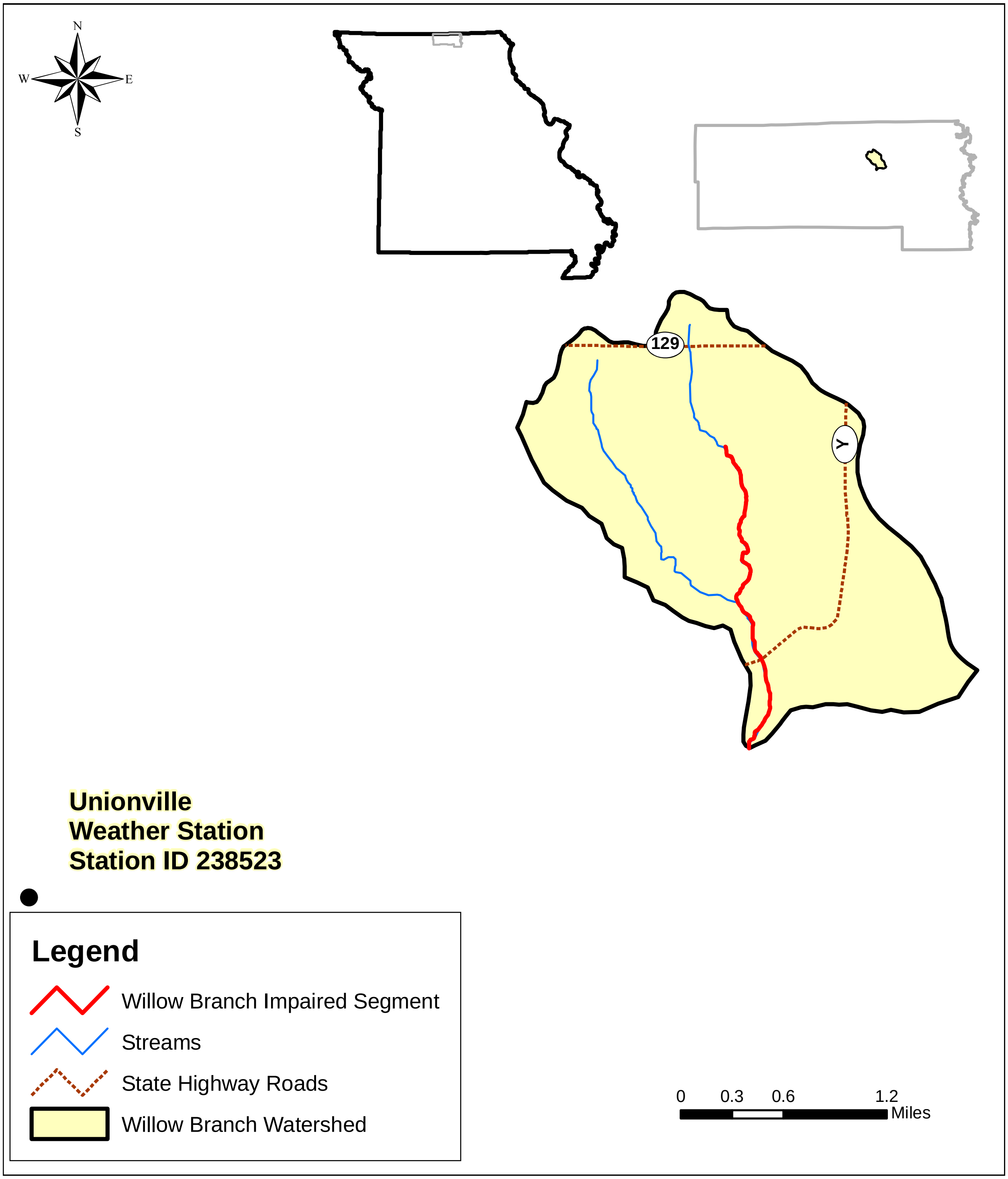

Figure 1. Location of Willow Branch Watershed with Weather Station

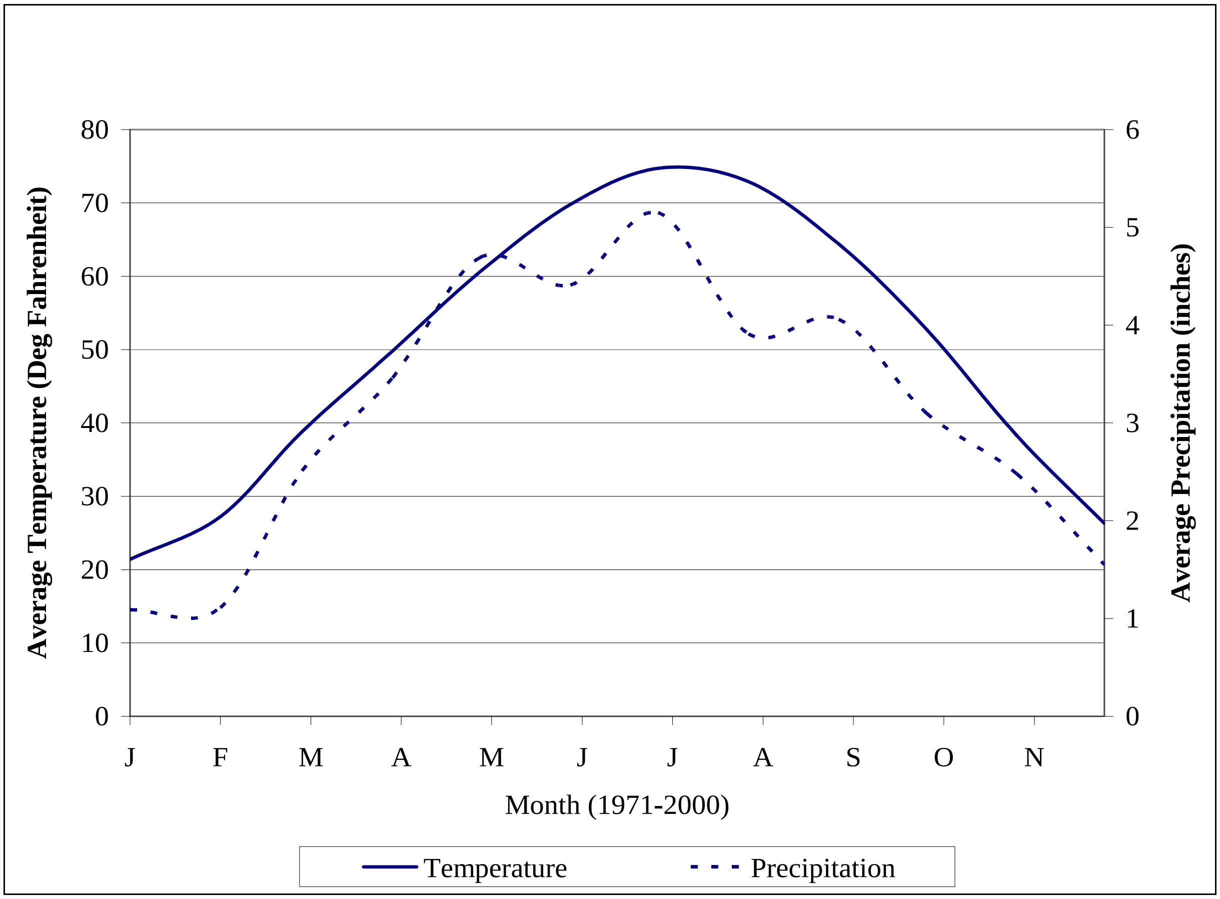

Figure 2. Thirty Year Monthly Temperature and Precipitation Averages for Unionville Weather Station

2.4 POPULATION

Population data for the Willow Branch watershed is not directly available. However, the Census reports that the 2000 population (in Putnam County) for all areas was 5,223 (US Census Bureau, 2000). The rural population of the watershed can be estimated based on the proportion of the watershed compared to Putnam County. Putnam County covers an area of 519.66 square miles and has a population of 5,223. The rural population in Putnam County is approximately 2,801 people (total county population minus the sum of Powersville, Lucerne, Unionville, Livonia and Worthington) and the rural county area is 516.46 square miles (total county area minus county urban area). The Willow Branch watershed rural area was estimated to be 5 persons; calculated by dividing the rural watershed area (3.6 square miles) by the Putnam County rural area (516.46 square miles) and multiplying the product by the Putnam County rural population (2,801). An overall population density for the Willow Branch watershed was calculated to be 1 person per square mile (5 persons divided by 3.6 square miles).

2.5 LAND USE AND LAND COVER

The land use and land cover of the Willow Branch watershed is shown in Figure 3 and summarized in Table 2 (MoRAP, 2005). The primary land uses/land covers are grassland (58 percent), cropland (15 percent) and forest (14 percent). Herbaceous, wetlands, impervious, barren and water occupy the remaining 13 percent of the watershed area.

Table 2. Land Use/Land Cover in the Willow Branch Watershed (MoRAP, 2005)

	Watershed Area		
Land Use/Land Cover	**Acres**	**Square Miles**	**Percent (%)**
Impervious[5]	66.7	0.10	2.9
Barren or Sparsely Vegetated	33.1	0.05	1.4
Cropland	354.5	0.55	15.4
Grassland	1330.4	2.08	57.9
Forest	324.3	0.51	14.1
Herbaceous[5]	101.4	0.16	4.4
Wetland	2.7	0.00	0.1
Open Water	84.3	0.13	3.7
Total	**2297.4**	**3.6**	**100**

[5] Impervious land use includes non-vegetated, impervious surfaces including areas dominated by streets, parking lots and buildings while herbaceous land use includes shrublands, young woodlots and open woodlands (MoRAP, 2005).

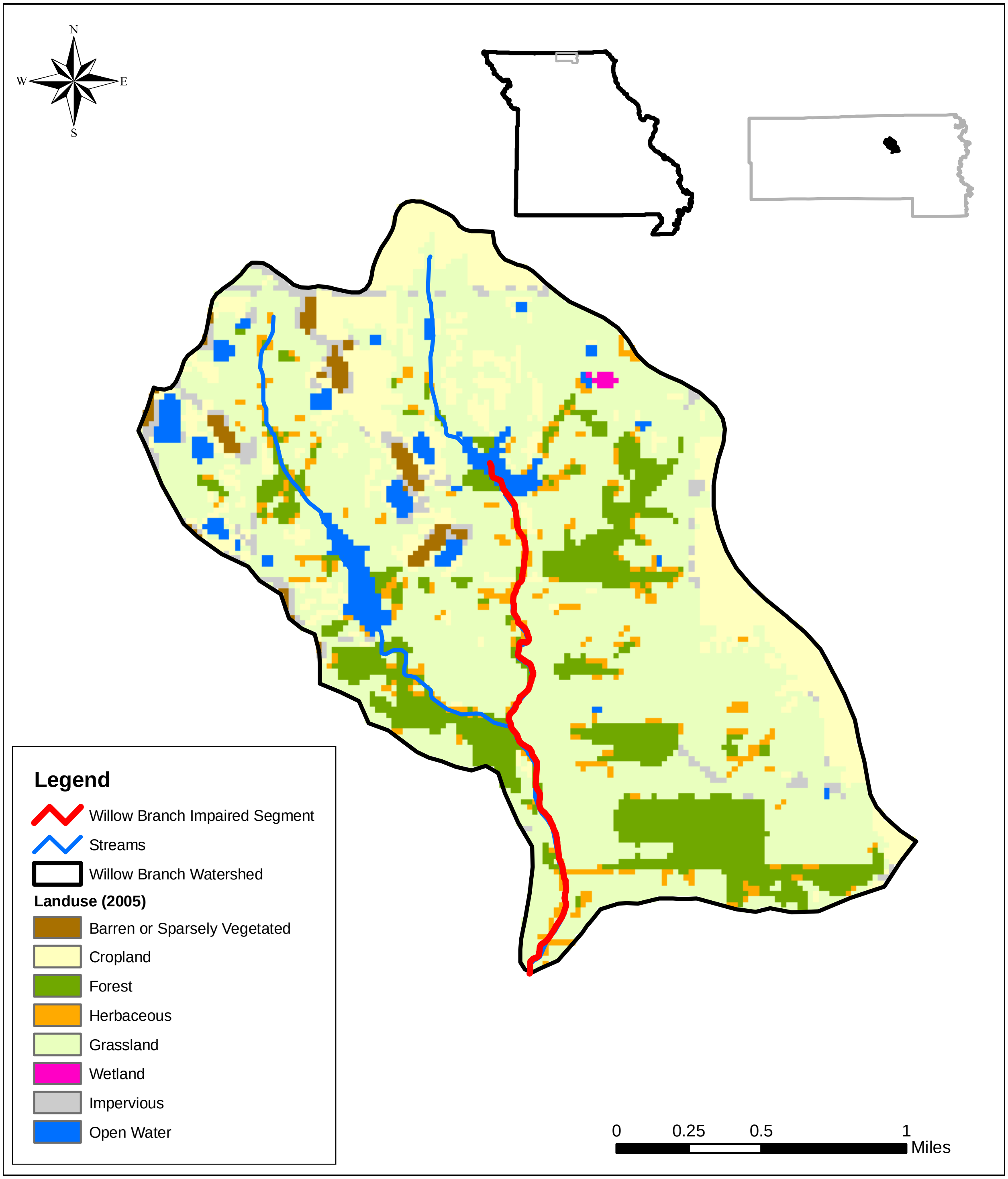

Figure 3. Land Use/Land Cover in the Willow Branch Watershed (MoRAP, 2005)

3 SOURCE INVENTORY

A source assessment is used to identify and characterize the known and suspected sources contributing to impairment in Willow Branch. 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. Sediment is considered to be the primary contributor to impairment of aquatic communities in Willow Branch. Water quality data used to identify and assess sources in Willow Branch are presented in Appendix A.

3.1 POINT SOURCES

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

- Municipal and industrial wastewater treatment plants (WWTP),
- Concentrated animal feeding operations (CAFOs),
- Storm water runoff from Municipal Separate Storm Sewer Systems (MS4s) and
- General permitted facilities (e.g. including storm water runoff from construction and industrial sites)

General permits (as opposed to site specific permits) are issued to activities that are similar enough to be covered by a single set of requirements. Storm water permits are issued to activities that discharge only in response to precipitation events. Point sources in Willow Branch were identified by consulting EPA's Permit Compliance System (PCS) website[6] (EPA, 2009a) and MDNR's Geographic Information System (GIS) inventory[7] of NPDES permitted facilities covered under storm water or general permits.

The sole point source permit for the Willow Branch watershed is a CAFO which has several outfalls. They are listed in Table 3 and shown in Figure 4. This CAFO permit is a site specific permit that reflects the rural nature of the area. The permit is related to agricultural production.

There is one permitted CAFO located in the watershed. Premium Standard Farms (PSF), LLC; Whitetail Finishing Site (MO0117421) includes a combined design flow of 0.09668 million gallons per day (MGD). This is a hog finishing facility and is designed for finishing of

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

52,992 hogs per year. It is a "no discharge" permit (e.g. effluent is land applied) and would only discharge in the event of an extreme storm event. Wastewater is stored in the lagoons and land applied based on the available nitrogen approach. This facility has a waste management system designed to minimize runoff entering the facility and detain runoff emanating from the operation. In addition, it is designed to retain a 25-year, 24-hour rainfall/runoff event as well as an anticipated two weeks of normal wastewater from their operations. Typically, this rainfall event coincides with stream flow that occurs less than 1 to 5 percent of the time. The potential number of animals associated with the CAFO in the watershed is 52,992 head. The actual number of animals at the feedlot operation is typically less than the number allowed by the facility's permit. A recent letter to MDNR (dated December 21, 2009) indicates that PSF decided to temporarily close and depopulate the Whitetail Farm. Since the Whitetail Farm is a no discharge facility and has temporarily closed since 2009, this facility does not impose any water quality impact during the critical low flow periods.

Countywide data from the National Agriculture Statistics Service (NASS) (USDA, 2007) were combined with the land cover data for the Willow Branch watershed to estimate approximately 273 cattle in the watershed[8]. The cattle are most likely located on the approximate 2.08 square miles of grassland / pastureland in the watershed. The density of cattle in the Willow Branch watershed (75.96 cattle per square mile or 273 cattle in the entire watershed) suggests they are a potential source of TSS and nutrients to the stream. NASS also reports there were 964 sheep and lambs and 374 chickens (layers) in Putnam County in 2007. There was no county level data available for hogs and pigs in Putnam County; however, permit MO0117421 lists 52,992 finishing hogs as the facility's design capacity. Grazing densities within the watershed are estimated at approximately 134 head of cattle per square mile. The high percentage of grassland and pasture in the watershed may serve as ideal seasonal grazing lands for livestock during the winter months, which may account for highly variable livestock populations within the watershed from one year to the next.

Based on these conditions, nutrients within the watershed may be attributed to fertilizer or manure application to the agricultural lands being utilized for pasture, hay, or crop production. Of particular concern are lands near the riparian areas that are subject to livestock grazing or watering and fertilizer applications. The animal wastes, from manure applications, for both confined and unconfined feeding sites are considered a major potential source of nutrient loading going into Willow Branch.

Illicit straight pipe discharges of household waste are also potential point sources of suspended sediment and nutrients in rural areas. Illicit discharges drain directly or indirectly to streams 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 Willow Branch watershed; however, illicit straight pipe discharges are not known or expected to be a significant source of suspended sediment and nutrients in Willow Branch. Critical periods for impacts from illicit straight pipe connections would be low flow periods, not wet weather conditions.

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[8] According to the NASS there are approximately 46,700 head of cattle in Putnam County (USDA, 2007). According to the 2005 MoRAP there are 356 square miles of grasslands in Putnam County (MoRAP, 2005). These values result in a cattle density of approximately 134 cattle per square mile of grasslands in Putnam County. This density was multiplied by the number of grassland square miles in the Willow Branch Watershed to estimate the number of cattle in the watershed.

Table 3. Permitted Facilities in the Willow Branch Watershed

Facility ID and Name	Outfall Type	Receiving Stream[1]	Outfall Number	Design Flow (Gal/Year)[2]	Reporting Requirements[3]	Permit Expiration	Classification /Description
MO0117421, Premium Standard Farms, LLC; Whitetail Finishing Site	Anaerobic Lagoon/ Secondary Containment	N. Blackbird Ck.	001	6,162,660	Flow, DO, NH_3, BOD, pH, Cl, Temp., TKN, TP, $NO_3 + NO_2$, Solids	2009	Hogs
			003	5,267,680			
			004	6,187,480			
			006	6,168,135			
			007	6,210,840			
			008	5,289,580			
	Domestic Wastewater	N. Blackbird Ck.	013	NA	Flow, DO, NH_3, BOD, pH, Cl, Temp.		
	Fresh Water Lake Monitoring	Tributary to N. Blackbird Ck.	015		Flow, pH, NH_3, $NO_3 + NO_2$, TP, Temp, TSS		
			016				

[1] "N" = North, "Ck." = Creek
[2] "Gal/Year" = Gallons per year. Total facility permitted flow = 53,046,780 gallons per year or 0.145 million gallons per day (MGD) while the allowable permitted flows for the watershed is 35,286,375 Gal/year (or 0.09668 MGD). "NA" = Not Applicable (no design flow).
[3] "DO" = Dissolved Oxygen, "NH_3" = Ammonia Nitrogen, "BOD" = Biochemical Oxygen Demand, "Cl" = Chloride, "Temp" = Temperature, "TKN"= Total Kjeldahl Nitrogen, "TP" = Total Phosphorus, "NO_3" = Nitrate Nitrogen, "NO_2" = Nitrite Nitrogen, "TSS" = Total Suspended Solids.

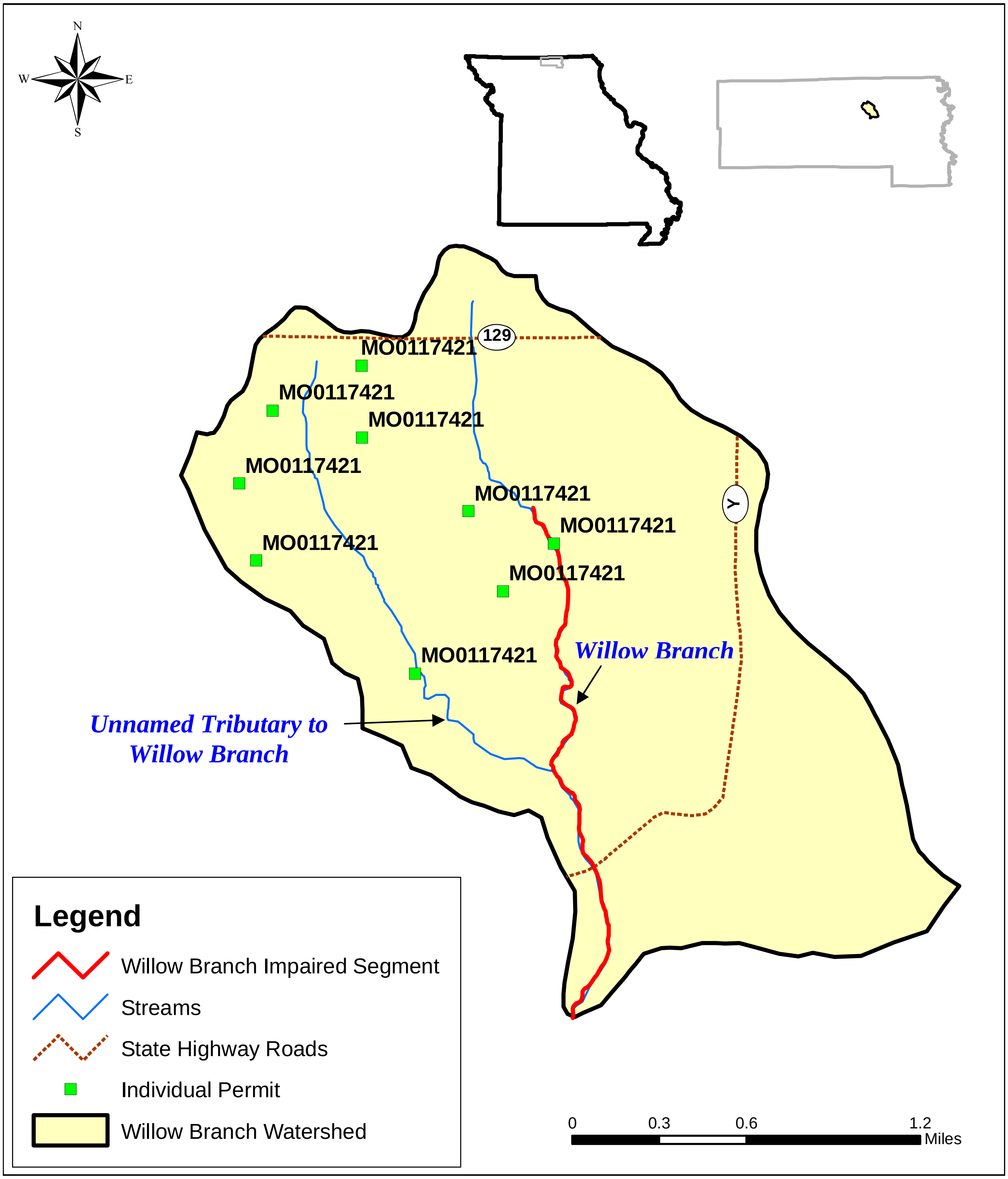

Figure 4. Locations of Permitted Facility in the Willow Branch Watershed

3.2 NONPOINT SOURCES

Nonpoint sources include all other categories not classified as point sources. According to the recent stressor identification study conducted by Versar (2008), the major stressors causing the impaired aquatic communities in Willow Creek are excessive sediment deposition, unstable stream banks, lack of vegetative protection on the stream banks and poor riparian cover and management. Therefore, runoff from agricultural areas such as cropland pasture, non-regulated animal feeding areas and onsite wastewater treatment systems are considered the potential nonpoint sources that contribute to the impairment in the stream. Each of these contributing factors is discussed in detail in the following sections.

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

3.2.1 Runoff from Agriculture Areas

The 2005 land use/land cover data (MoRAP, 2005) indicates there are 354 cropland acres in the watershed, which comprises 15.4 percent of the entire watershed and 1,330 acres (58 percent) grassland acres in the watershed (Table 2). Fifty seven percent of the riparian[9] buffer is classified as grassland (see Table 4 in Section 3.2.4). Lands used for agricultural purposes can be a source of sediment, 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 and irrigation water. Sediment can be dislodged from the soil matrix by agricultural animals in confined spaces and pastures and stream bank erosion can occur when cattle access streams for drinking water. Runoff from these areas can be potential sources of nutrients, sediment 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. Since the watershed is dominated by grassland and pasture the number of smaller animal feeding operations that are not registered is presumably high, particularly during seasonal feeding months in the winter. 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. Several agricultural facilities covered by NPDES permits are present in the watershed. Additional discussion on CAFOs in the Willow Branch watershed is provided in Section 3.1 of this report.

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

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.

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.

3.2.2 Runoff from Urban Areas

Since none of the Willow Branch watershed is classified as urban and only 2.9 percent of the watershed is identified as impervious it is unlikely that runoff from urban areas is a significant source of pollutants in the watershed. However, storm water runoff from impervious and urban areas can contribute pollutants during precipitation events. A general description of potential impacts from urban runoff is provided below.

Storm water runoff from urban areas can be a significant source of sediment, bacteria, nutrients and oxygen consuming substances, such as organic material and chemicals (pesticides and fertilizers). Lawn fertilization can lead to high nutrient loads; pet wastes can contribute both nutrient loads and organic material. For example, 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 dissolved oxygen saturation capacity of the stream. Excessive discharge of suspended solids from urban areas can also lead to streambed siltation problems. Since there is very little impervious area in the watershed and no urban land uses, it is unlikely that runoff from urban areas is a significant source of TSS, TN or TP to Willow Branch.

3.2.3 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 (Horsley and Witten, 1996). 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 systems in the Willow Branch watershed is unknown. However, the National Environmental Service Center (NESC) reports there are 4,747 septic systems, in the Upper Chariton watershed (HUC10280201), with an average population per septic system of 2.1 (EPA, 2009b). As discussed in Section 2.4, the estimated rural population of the Willow Branch watershed is approximately 157 persons. Based on this population and an average density of 2.1 persons per septic system an estimate of approximately 75 systems in the watershed is obtained. An EPA study reports that the statewide failure rate of onsite wastewater systems in Missouri is 30 to 50 percent (EPA, 2002). At this failure rate there would potentially be 21 to 35 failing systems in the watershed. No information was identified that would suggest failing onsite wastewater systems are a significant problem in the Willow Branch watershed. Based on this information, onsite wastewater treatment systems are considered a potential, albeit not significant, source of nutrients.

3.2.4 Riparian Habitat Conditions

Riparian (streamside) habitat conditions can have a strong influence on in-stream water quality and habitat. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the detention, removal and assimilation of pollutants from runoff. Therefore, a stream with good riparian habitat is better able to moderate the impacts of high pollutant loads than a stream with poor riparian cover. Wooded riparian buffers can also provide shading that reduces stream temperatures and increases the dissolved oxygen saturation capacity of the stream.

As indicated in Table 4, over 56 percent of the land in the Willow Branch riparian corridor (defined as a 30-meter strip on either side of Willow Branch) is classified as grassland (which may include pasture areas), 19 percent is herbaceous and 17 percent is forest (MoRAP, 2005). Compared to wooded areas, grasslands provide less shading and higher pollutant loads due to livestock and related agricultural activity.

Table 4. Percentage Land Use/Land Cover Within Riparian Buffer, 30-Meter

Land Use/Land Cover	Percent (%)
Cropland	0.5
Forest	17.4
Herbaceous	18.8
Grassland	56.8
Open Water	6.5
Total	100

4 APPLICABLE WATER QUALITY STANDARDS AND NUMERIC WATER QUALITY TARGETS

Section 303(d) of the CWA and Chapter 40 of the CFR Part 130 require states to develop TMDLs for waters not meeting designated uses. The TMDL process quantitatively assesses the impairment factors so that states can establish water-quality based controls to reduce pollution 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, 2008]). 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).

4.1 DESIGNATED BENEFICIAL USES

The impaired Willow Branch segment (WBID 0654U-01 also listed as WBID 9005) is two miles in length. This segment is unclassified and thus numeric WQS do not apply; however, general narrative criteria pertaining to the protection of aquatic life do apply.

4.2 CRITERIA

Water quality monitoring has not revealed violation of a specific WQS; however, elevated levels of TSS, TN and TP have been identified as potential contributors to impairment. These parameters are being used as surrogate water quality targets that, if met, are protective of the impaired use. In the 2008 Missouri 303(d) List, Willow Branch is listed as impaired due to unknown pollutants.

All water bodies in Missouri are protected by the general criteria (standards) contained in Missouri's WQS, 10 CSR 20-7.031(3). These criteria are also called narrative criteria, since they do not contain specific numerical limits. The narrative criteria not being met in Willow Branch are (3)(A), (D) and (G):

- 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 or conditions in sufficient amounts to result in toxicity to human, animal or aquatic life.
- Waters shall be free from physical, chemical or hydrologic changes that would impair the natural biological community.

In the absence of Missouri numeric standards for nutrients in freshwater streams, ambient water quality criteria recommendations provided by the EPA (2000) are used to quantify TN and TP LCs in Ecoregion 40 and Willow Branch. Reference conditions for TN and TP in level III Ecoregion 40 streams are as follows: TN = 0.855 milligrams per liter (mg/L) and TP = 0.092 mg/L. For this TMDL, recommended TN and TP ecoregion criteria are used directly in developing LCs for TN and TP. There are many quantitative indicators of sediment, such as TSS, turbidity and bedload sediment, which are appropriate to describe sediment in rivers and streams (EPA, 2006). A concentration of TSS was selected to represent the numeric target for this TMDL because it enables the use of the highest quality available data and is included in monitoring data. Additional discussion on watershed-specific targets used to develop LCs for TSS, TN and TP is provided in Section 5.1 of this report.

4.3 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 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 US. 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 (BMPs) 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 designated 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 waters of exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality.

5 MODELING APPROACH

When stream flow gage information is available, a LDC is useful in identifying and differentiating between storm-driven and steady-input sources (Cleland, 2002 and Cleland, 2003). For Willow Branch, the LDC approach was used to: 1) Provide a visual representation of stream flow conditions under which TSS, TN and TP criteria exceedances have occurred, 2) Assess critical conditions and 3) Quantify the level of reduction necessary to meet the surface water quality targets for TSS, TN and TP in the stream.

A limited amount of flow data is available in the Willow Branch watershed (Appendix A), which was inadequate for developing a LDC. To develop a synthetic flow record and a flow duration curve for Willow Branch, information from six United States Geological Survey (USGS) gaging stations (Table 5) in the same region of the state were used to establish a daily flow per square-mile estimate. Average daily flow per square-mile from the six stations was calculated for each day of record and multiplied by the watershed area (3.6 square miles) of the "Willow Branch at Highway Y" station. In Willow Branch, no permitted continuous or storm water flows are present. This approach was used to estimate average daily flow for each day during the period from July 20, 1978 to December 7, 2009. A detailed discussion of methods used to develop the TSS, TN and TP LDCs is presented in Appendix B and Appendix C.

Table 5. Stream Flow Stations Used to Estimate Flows in Willow Branch at Highway Y

River/Station Name	Data Source	Station Number	Drainage Area (mi^2)	Discharge Record	Latitude/ Longitude
East Fork Little Chariton River near Macon, MO	USGS	06906200	112	1971–2009	39°45'05.2", 92°31'08.2"
East Fork Little Chariton River near Huntsville, MO	USGS	06906300	220	1962-2009	39°27'17.7", 92°34'06.6"
Thompson River at Trenton, MO	USGS	06899500	1,720	1928–2009	40°04'09.5", 93°38'16.9"
Grand River near Gallatin, MO	USGS	06897500	2,250	1920–2009	39°55'37", 93°56'33"
Mussel Fork near Musselfork, MO	USGS	06906000	267	1948–2009	39°31'24.7", 92°56'58.7"
Grand River near Sumner, MO	USGS	06902000	6,880	1924-2009	39°38'24.1", 93°16'25.3"

5.1 CRITERION TO SUPPORT THE TMDL

In Willow Branch, where narrative standards are targeted for the impaired segment, a reference approach was used to define TMDL targets. The TSS, TN and TP were developed as surrogates for the impaired use and are protective of the stream's general uses. Missouri does not have a numeric criterion for TSS, TN and TP; therefore a statistical approach is used to develop a target for TSS and EPA's (2000) ecoregion nutrient criteria are used for TN and TP. LDCs are used to establish TMDLs for each of these pollutants. The methods used to establish the TSS target differs from the method used to establish the TN and TP targets. Each method is described below.

The TSS target was derived based on a reference approach by targeting the 25th percentile of TSS measurements (USGS, non-filterable residue) in the geographical region in which Willow Branch is located (see Appendix D for a list of sites and data). In this approach, the target for pollutant loading is the 25th percentile of the current EDU condition calculated from all data available within the EDU in which the water body is located. Therefore, the 25th percentile is targeted as the TMDL LDC. A detailed discussion of the method used to develop the TSS target is provided in Appendix B.

TN and TP TMDL targets and LCs are based on EPA recommended Ecoregion 40 criteria and water quality observations at locations throughout the ecoregion. For this analysis, the 25th percentile of data for all seasons is used as the target. This value is calculated by taking the median of the four seasonal 25th percentiles of data within an ecoregion (EPA, 2000). TN and TP concentrations from monitoring locations within Missouri and in Ecoregion 40 are plotted with flow to define the relationship between load and flow unique to Missouri streams in this ecoregion. In developing this relationship, individual water quality measurements are "corrected" based on the ecoregion target such that the median of the dataset is equal to the ecoregion target. Allowable pollutant loads are calculated for all flow conditions by multiplying flow by either the EPA-recommended ecoregion target concentration or the concentration established using the Missouri Ecoregion 40 streams; whichever concentration is higher. Reference conditions for TN and TP in level III Ecoregion 40 streams are provided in Table 3e of *Ambient Water Quality Criteria Recommendations, Information Supporting the Development of State and Tribal Nutrient Criteria for Rivers and Streams in Nutrient Ecoregion IX* (EPA, 2000) and in Section 4.2 of this report. A detailed discussion of the method used to develop the TN and TP targets is provided in Appendix C. Criteria used as targets in developing TSS, TN and TP TMDLs are presented in Table 6.

Table 6. Criteria Used to Develop TSS, TN and TP TMDLs[1]

	TSS EDU Target (mg/L)	TN Ecoregion Criteria (mg/L)	TP Ecoregion Criteria (mg/L)
EDU and Ecoregion Targets and Criteria	5.75	0.855	0.092

[1] The TSS target is based on the 25th percentile of the EDU condition calculated from all data available from 1997 to 2009 (see Appendix D) within the Central Plains/Grand/Chariton EDU (12) in which Willow Branch is located. TN and TP criteria are based on the 25th percentile of data for all seasons in Ecoregion 40. This value is calculated as the median of the four seasonal 25th percentiles of data within an ecoregion (EPA, 2000).

6 CALCULATION OF LOAD CAPACITY

LC is defined as the greatest amount of a pollutant that a water body can assimilate without violating WQS. The TMDL quantifies and allocates the LC to known point and nonpoint sources in the form of WLAs, LAs, a MOS and natural background conditions. The MOS accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition is represented by Equation 1.

$$LC = \Sigma\ WLAs + \Sigma\ LAs + MOS \quad \textbf{Equation 1}$$

Where:

LC = Load Capacity

WLA = Waste Load Allocations (point source)

LA = Load Allocations (nonpoint 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 CFR (40 CFR § 130.2 (1)) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For Willow Branch, TSS, TN and TP TMDLs are expressed as pounds per day using a LDC (Figure 5, Figure 6, Figure 7, Table 7, Table 8 and Table 9). The LDC represents the LC as a solid red line over the range of flow conditions present in the creek. Water quality measurements, shown as round (black) points, are loads calculated from TSS, TN and TP concentrations collected in Willow Branch at Highway Y.

As presented in Figure 5, excursions to the TSS threshold occurred primarily under high flow conditions. A minimal amount of data are available for TN and TP (Figure 6 and Figure 7); however, of the data available, one of four TN values and two of four TP values were found to be above the EPA-recommended Ecoregion 40 criteria. The remainder of TN and TP measurements were found to be below EPA recommended Ecoregion 40 criteria.

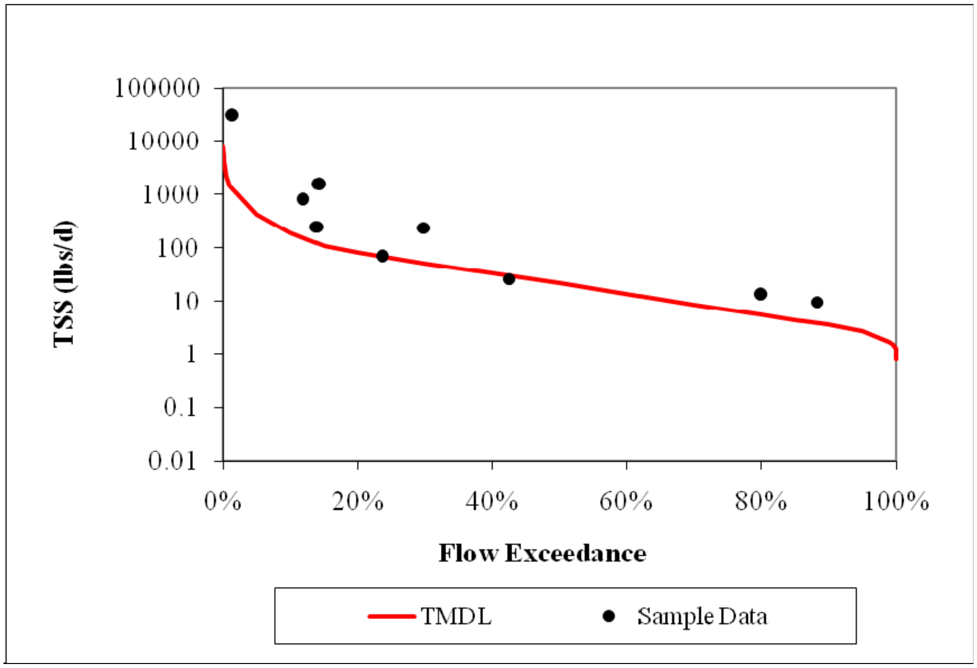

Figure 5. TSS LDC for Willow Branch at Highway Y

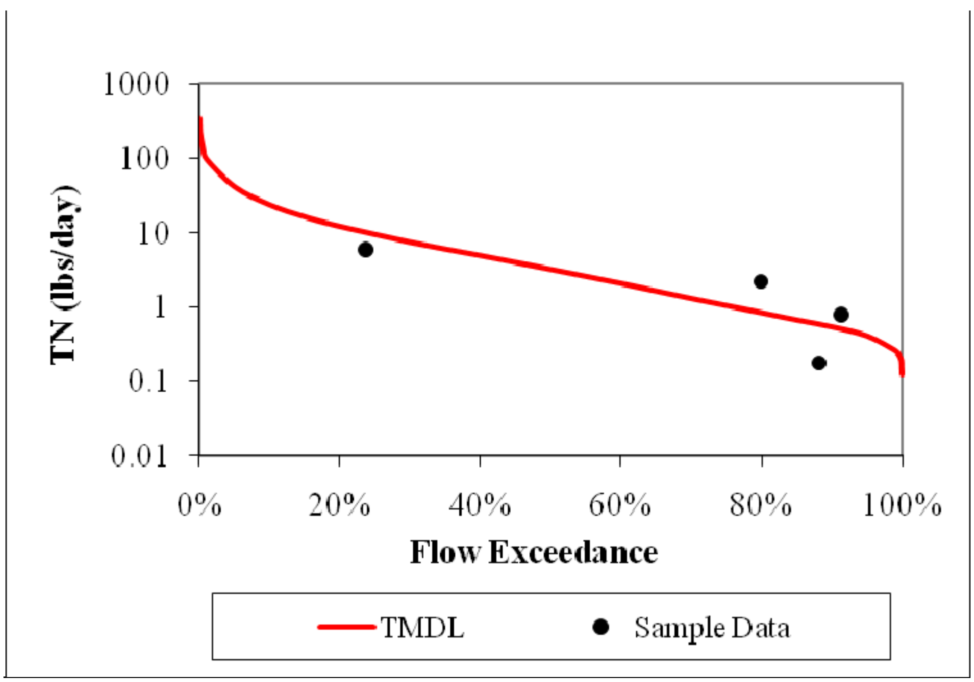

Figure 6. TN LDC for Willow Branch at Highway Y

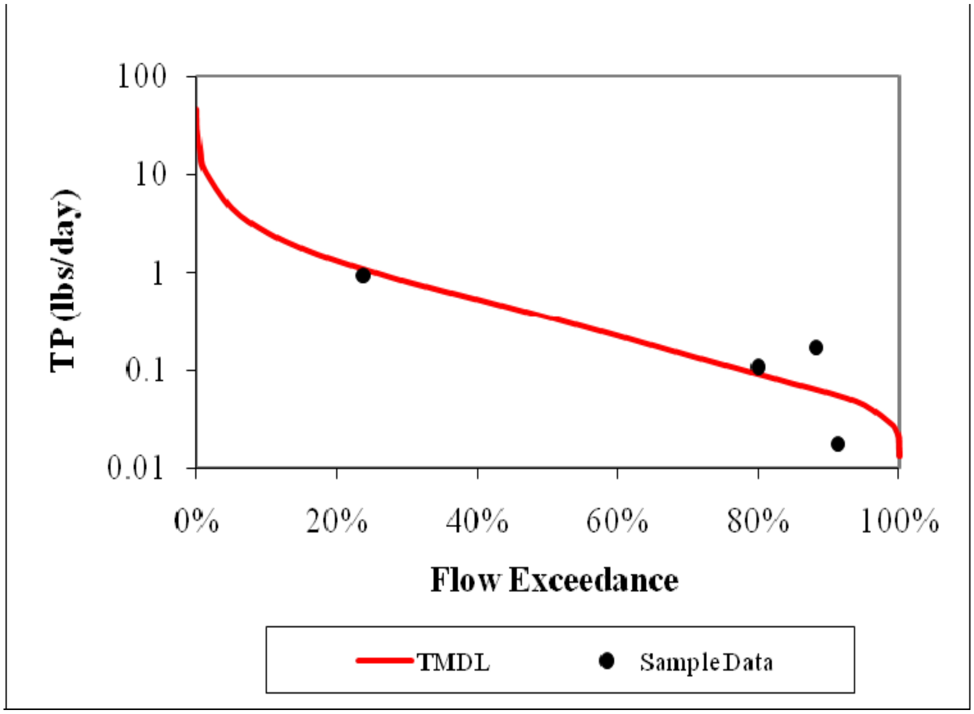

Figure 7. TP LDC for Willow Branch at Highway Y

Table 7. TSS TMDL Under a Range of Flow Conditions in Willow Branch

Flow Exceedance	Estimated Flow (cfs)	TSS TMDL (lbs/day)	TSS LA (lbs/day)	TSS WLA (lbs/day)
95%	0.09	2.73	2.73	0
90%	0.12	3.61	3.61	0
70%	0.28	8.71	8.71	0
50%	0.69	21.53	21.53	0
30%	1.61	49.90	49.90	0
10%	5.13	189.64	189.64	0
5%	8.95	420.13	420.13	0

Table 8. TN TMDL Under a Range of Flow Conditions in Willow Branch

Flow Exceedance	Estimated Flow (cfs)	TN TMDL (lbs/day)	TN LA (lbs/day)	TN WLA (lbs/day)
95%	0.09	0.41	0.41	0
90%	0.12	0.54	0.54	0
70%	0.28	1.29	1.29	0
50%	0.69	3.20	3.20	0
30%	1.61	7.42	7.42	0
10%	5.13	23.65	23.65	0
5%	8.95	41.29	41.29	0

Table 9. TP TMDL Under a Range of Flow Conditions in Willow Branch

Flow Exceedance	Estimated Flow (cfs)	TP TMDL (lbs/day)	TP LA (lbs/day)	TP WLA (lbs/day)
95%	0.09	0.044	0.044	0
90%	0.12	0.058	0.058	0
70%	0.28	0.139	0.139	0
50%	0.69	0.344	0.344	0
30%	1.61	0.798	0.798	0
10%	5.13	2.545	2.545	0
5%	8.95	4.443	4.443	0

7 WASTE LOAD ALLOCATION (POINT SOURCE LOADS)

The WLA is the allowable amount of the pollutant that can be assigned to point sources. The WLA is set to the lesser of current permit limits or technology based effluent limits (TBELs). Typically, NPDES permit limits are the most stringent of TBELs or water quality-based effluent limitations (WQBELs) for a given pollutant. TBELs are based upon the expected capability of a treatment method to reduce the pollutant to a certain concentration. WQBELs represent the most stringent concentration of a pollutant that a receiving stream can assimilate without exceeding applicable WQS or criteria at a specific location. The permitted facilities in the watershed are all "no discharge" facilities. Thus, the waste generated on site is not directly discharged to the stream, instead it is land applied. The "no discharge" permits only discharge in the event of a large storm event that exceeds the wastewater storage capacity of the facility.

PSF operates the White Tail Finishing Site under permit MO0117421. The facility is classified as a CAFO. There are six anaerobic lagoons with secondary containment structures that capture wastewater, irrigation water, storm water runoff and domestic wastewater (see Table 3). This is a no discharge facility for process waste. Wastewater is stored in the lagoons and land applied based on the available nitrogen approach. The PSF facilities are "no discharge" permits and would only discharge in the event of an extreme storm event. Since this facility is no discharge and would not cause or contribute to the TSS, TN and TP impairments, WLAs for this facility are set to zero.

EPA assumes that construction activities in the watershed will be conducted in compliance with Missouri's Storm Water permit including monitoring and discharge limitations. As required under the permit, Storm Water Pollution Prevention Plans (SWPPP) ensures the design, implementation and maintenance of BMPs. Compliance with the SWPPP should result in sediment loading from construction sites at or below applicable targets.

The WLAs listed in this TMDL do not preclude the establishment of future point sources of sediment or nutrient loading in the watershed (Table 10). Any future point sources should be evaluated in light of the TMDL established and the range of flows into which any additional load will impact.

Table 10. TSS, TN and TP WLAs for Site Specific Permitted Facilities in the Willow Branch Watershed

Facility ID	Facility Name [1]	Outfall Number[2]	Receiving Stream [3]	WLA for TSS, TN and TP (tons per day) d/w/m [4]
MO0117421	PSF, Whitetail Finishing	001	N. Blackbird Ck.	0.0
MO0117421	PSF, Whitetail Finishing	003	N. Blackbird Ck.	0.0
MO0117421	PSF, Whitetail Finishing	004	N. Blackbird Ck.	0.0
MO0117421	PSF, Whitetail Finishing	006	N. Blackbird Ck.	0.0
MO0117421	PSF, Whitetail Finishing	007	N. Blackbird Ck.	0.0
MO0117421	PSF, Whitetail Finishing	008	N. Blackbird Ck.	0.0
MO0117421	PSF, Whitetail Finishing	013	N. Blackbird Ck.	0.0
MO0117421	PSF, Whitetail Finishing	015	N. Blackbird Ck. tributary	0.0
MO0117421	PSF, Whitetail Finishing	016	N. Blackbird Ck. tributary	0.0

[1] PSF = "Premium Standard Farms"
[2] Only outfalls within the Willow Branch watershed are listed.
[3] "N." = North, "Ck." = Creek
[4] Permit limits based on current design loads where d = daily, w = weekly, m = monthly average.

8 LOAD ALLOCATION (NONPOINT SOURCE LOADS)

LA is the allowable amount of the pollutant that can be assigned to nonpoint sources. The TMDL curve is set at an estimate of expected reference conditions over the range of flows. The LA is set at the remainder for the TMDL loading curve after removing allowances for the point source WLA and MOS. Because all point sources in the watershed received a zero WLA and the MOS is implicit, the total LC is allocated to nonpoint sources as LA. TSS, TN and TP LAs are provided in Table 11.

Table 11. TSS, TN and TP LAs in Willow Branch Watershed

Flow Exceedance	Estimated Flow (cfs)	TSS LA (lbs/day)	TN LA (lbs/day)	TP LA (lbs/day)
95%	0.09	2.73	0.41	0.044
90%	0.12	3.61	0.54	0.058
70%	0.28	8.71	1.29	0.139
50%	0.69	21.53	3.20	0.344
30%	1.61	49.90	7.42	0.798
10%	5.13	189.64	23.65	2.545
5%	8.95	420.13	41.29	4.443

9 MARGIN OF SAFETY

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

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

An implicit MOS was incorporated into the TMDL based on conservative assumptions used in the development of the LDCs. The use of ecoregion targets in lieu of national or state-wide targets serves to ensure that implementation will result in either pristine or minimally impacted stream systems. The 25th percentile is considered a surrogate for establishing a reference population of the pristine systems (EPA 2000).

TN and TP targets are conservative because they are based on the 25th percentile of all TN and TP data gathered from subecoregion 40 of Aggregate Nutrient Ecoregion IX, where data are not directly influenced by permitted dischargers. In the case of nutrients the targets are the median calculated from the four seasonal 25th percentile values. As a result, both high concentrations seen during the periods of spring runoff and winter flow from snowmelt (and low concentrations seen during low flow conditions in both summer and fall) do not effectively affect the annual reference targets.

In the case of sediment, the approach used was to target the 25th percentile of all concentration data available in the EDU in which Willow Branch is located (see Appendix B and D). The use of these refined and/or EDU specific data ensures that all local geological and landscape conditions are addressed in this TMDL.

10 CRITICAL CONDITIONS AND SEASONAL VARIATION

The TMDL curve represents flow under all seasonal conditions. The LA and TMDL (expressed as concentrations) are applicable at all flow conditions, hence 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. Although there were insufficient water quality data to determine any seasonal pattern that may be occurring in the Willow Branch watershed, exceedances to the water quality criteria were present under both low and high flow conditions (Figure 5, Figure 6 and Figure 7).

11 MONITORING PLANS

A stressor study was conducted on Willow Branch in 2005-2006 by Versar, Inc. (2008). No future monitoring has been scheduled for Willow Branch at this time. However, MDNR routinely examines 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.

12 REASONABLE ASSURANCES

MDNR has the authority to issue and enforce 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 unknown pollutants will implement measures to reduce their contribution in the future will not be found in this section.

13 PUBLIC PARTICIPATION

EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). EPA is providing public notice of this draft TMDL for Willow Branch 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 Willow Branch in Putnam County, Missouri, is included on the EPA approved 2008 303(d) List for Missouri. 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.

14 ADMINISTRATIVE RECORD AND SUPPORTING DOCUMENTS

An administrative record on the Willow Branch TMDL has been assembled and is being kept on file with EPA.

APPENDICES

Appendix A – Willow Branch Water Quality Data
Appendix B – Development of TSS Targets Using Reference LDCs
Appendix C – Development of Nutrient Targets Using Ecoregion Nutrient Criteria with LDCs
Appendix D – Stream Flow and Water Quality Stations Used to Develop TMDLs in Willow Branch
Appendix E – Supplemental Implementation Plan

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Appendix A

Willow Branch Water Quality Data

Project Name[1]	Agency	Site	Site Name[1]	Date	Flow (cfs)	TP (mg/L)	TN (mg/L)	TSS (mg/L)	TSS Method
Willow Br.	MDNR	654/13.8/0.6	Willow Br. at Hwy Y	2/17/2006	0.25	0.03	1.33		
Willow Br.	Versar	654/13.8/0.6	Willow Br. at Hwy Y	10/17/2006	0.03	0.25	0.2598	14	SM 2540D
Willow Br.	Versar	654/13.8/0.6	Willow Br. at Hwy Y	3/27/2007	0.3	0.08	0.4999	6	SM 2540D
Willow Br.	Versar	654/13.8/0.6	Willow Br. at Hwy Y	9/16/2007	0.08	0.11	2.26	14	SM 2540D
Willow Br.	MDNR	654/13.8/0.6	Willow Br. at Hwy Y	2/18/2009	0.5			5	SM 2540D
Willow Br.	MDNR	654/13.8/0.6	Willow Br. at Hwy Y	2/27/2009	1			27	SM 2540D
Willow Br.	MDNR	654/13.8/0.6	Willow Br. at Hwy Y	3/11/2009	2.5			302	SM 2540D
Willow Br.	MDNR	654/13.8/0.6	Willow Br. at Hwy Y	4/20/2009	1			12	SM 2540D
Willow Br.	MDNR	654/13.8/0.6	Willow Br. at Hwy Y	5/6/2009	2			79	SM 2540D
Willow Br.	MDNR	654/13.8/0.6	Willow Br. at Hwy Y	5/26/2009	3.5			35	SM 2540D

[1] Br. = Branch, Hwy = Highway

Appendix B

Development of TSS Targets Using Reference LDCs

Overview

This procedure is used when a lotic[10] 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 EDU in which the water body is located. Additionally, it is also unlikely that a flow record for the impaired stream is available. If this is the case, a synthetic flow record is needed. 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 Willow Branch watershed and the availability of flow data of sufficient age and duration. From this synthetic record develop flow duration from which to build a LDC for the pollutant within the EDU.

From this population of load durations follow the reference method used in setting nutrient targets for streams and rivers in Nutrient Ecoregion IX (EPA, 2000). In this methodology the average concentration of either the 75th percentile of reference streams or the 25th percentile of all streams in the region is targeted in the 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

[10] Lotic = pertaining to moving water

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 Willow Branch EDU (Central Plains/Grand River/Chariton 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 B-1, Table B-1).

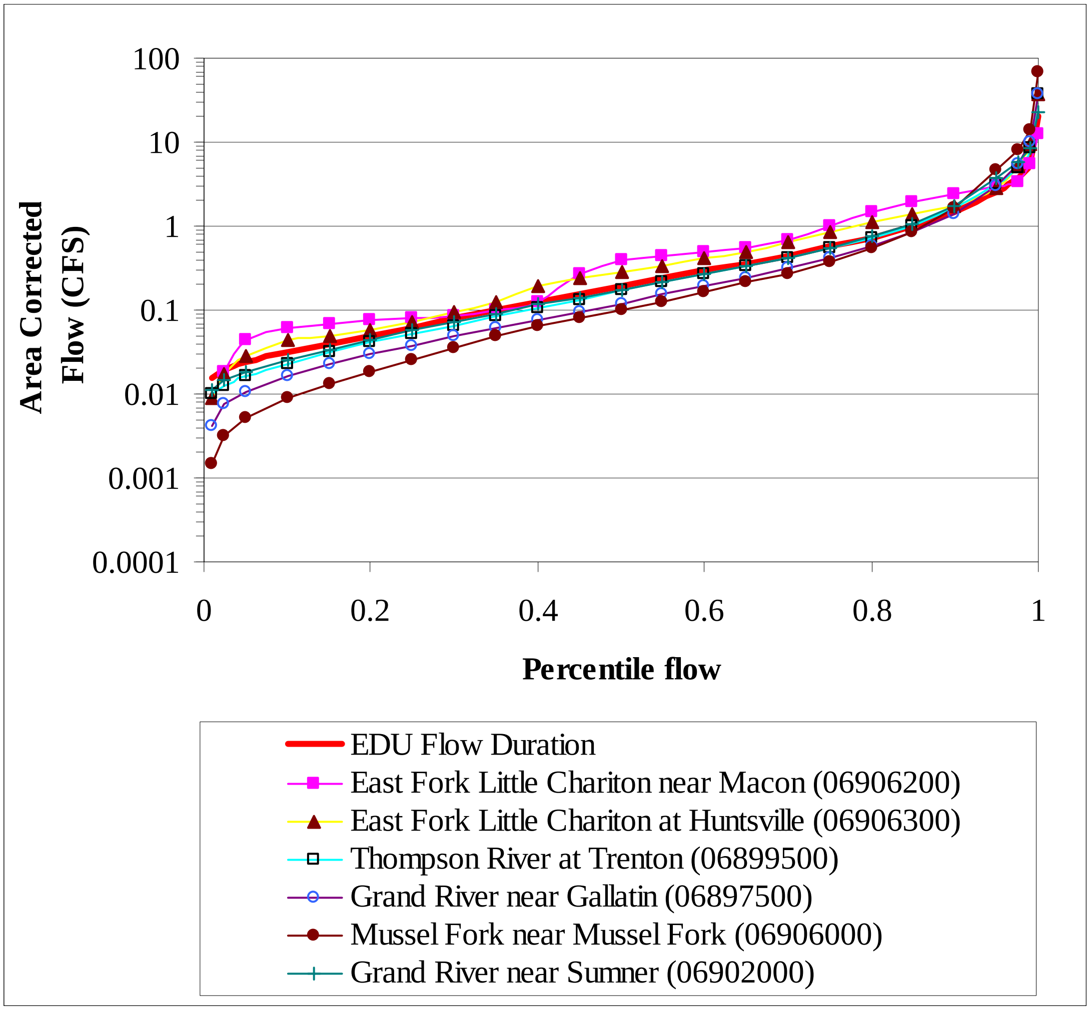

Figure B-1. Synthetic Flow Development in the Central Plains/Grand River/Chariton EDU

Table B-1. Stream Flow Stations Used to Estimate Flows in Willow Branch

River/Station Name	Data Source	Station Number	Drainage Area (mi^2)	Lognormal Nash-Sutcliffe
East Fork Little Chariton River near Macon, MO	USGS	06906200	112	60%
East Fork Little Chariton River near Huntsville, MO	USGS	06906300	220	78%
Thompson River at Trenton, MO	USGS	06899500	1,720	79%
Grand River near Gallatin, MO	USGS	06897500	2,250	76%
Mussel Fork near Mussel Fork, MO	USGS	06906000	267	47%
Grand River near Sumner, MO	USGS	06902000	6,880	96%

Table B-1 demonstrates the pooled data set can confidently be used as a surrogate for the EDU analyses.

The next step is to calculate sediment discharge relationship for the EDU. These are log transformed data for the sediment yield (lbs/day) and the instantaneous streamflow (cfs). Figure B-2 shows the EDU sediment flow relationship. To derive the TMDL curve, the synthetic (or normalized) flow values are multiplied by the watershed area and then applied the sediment-streamflow relationship to calculate the desirable reference stream sediment loads for various flow conditions (see Figure 5).

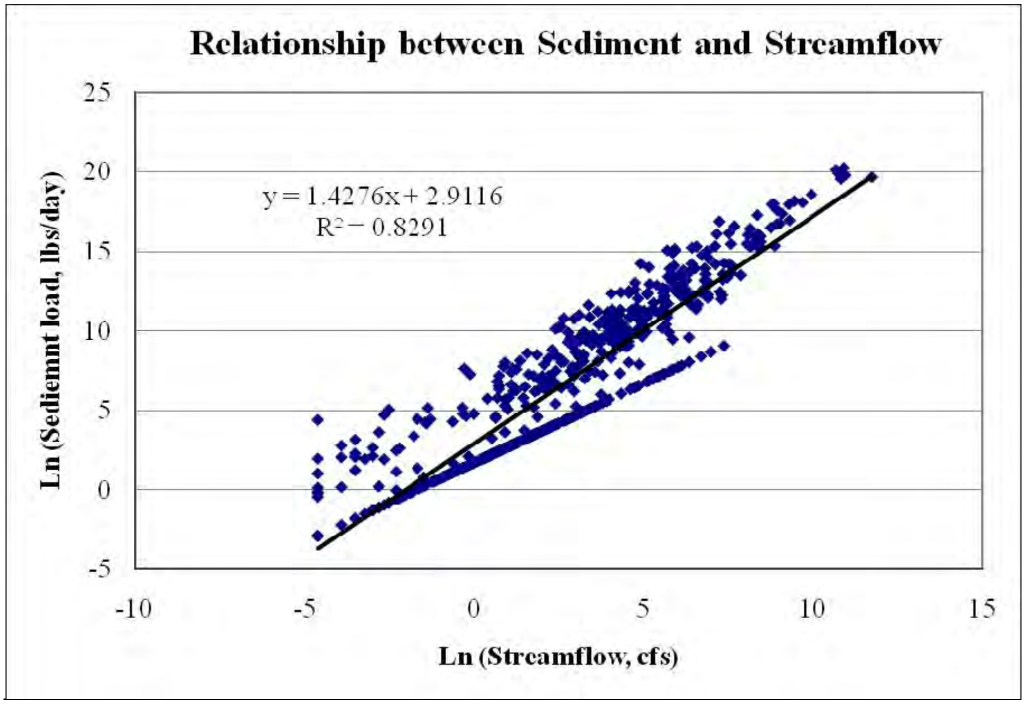

Figure B-2. Estimate of Power Function from Instantaneous Flow in the Central Plains/Grand River/Chariton EDU

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 C

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 pollution 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 EPA recommended ecoregion nutrient criterion for the specific ecoregion in which the water body is located (EPA, 2000). If a flow record for the impaired stream is not available a synthetic flow record is needed. To develop a synthetic flow record a user should calculate an average of the log discharge per square mile of USGS gaged rivers for which the drainage area is contained within the EDU. Selection of these gages is based on location, land use/soil/topography similarities to the Willow Branch watershed and the availability of flow data of sufficient age and duration. From this synthetic record develop a flow duration and build a LDC for the pollutant within the EDU.

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

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 Central Plains/Grand River/Chariton EDU. Watershed-size normalized data for the individual gages in the EDU were calculated and compared to a pooled data set of all the gages (Figure C-1, Table C-1). Table C-1 demonstrates the pooled data set can confidently be used as a surrogate for the EDU analyses.

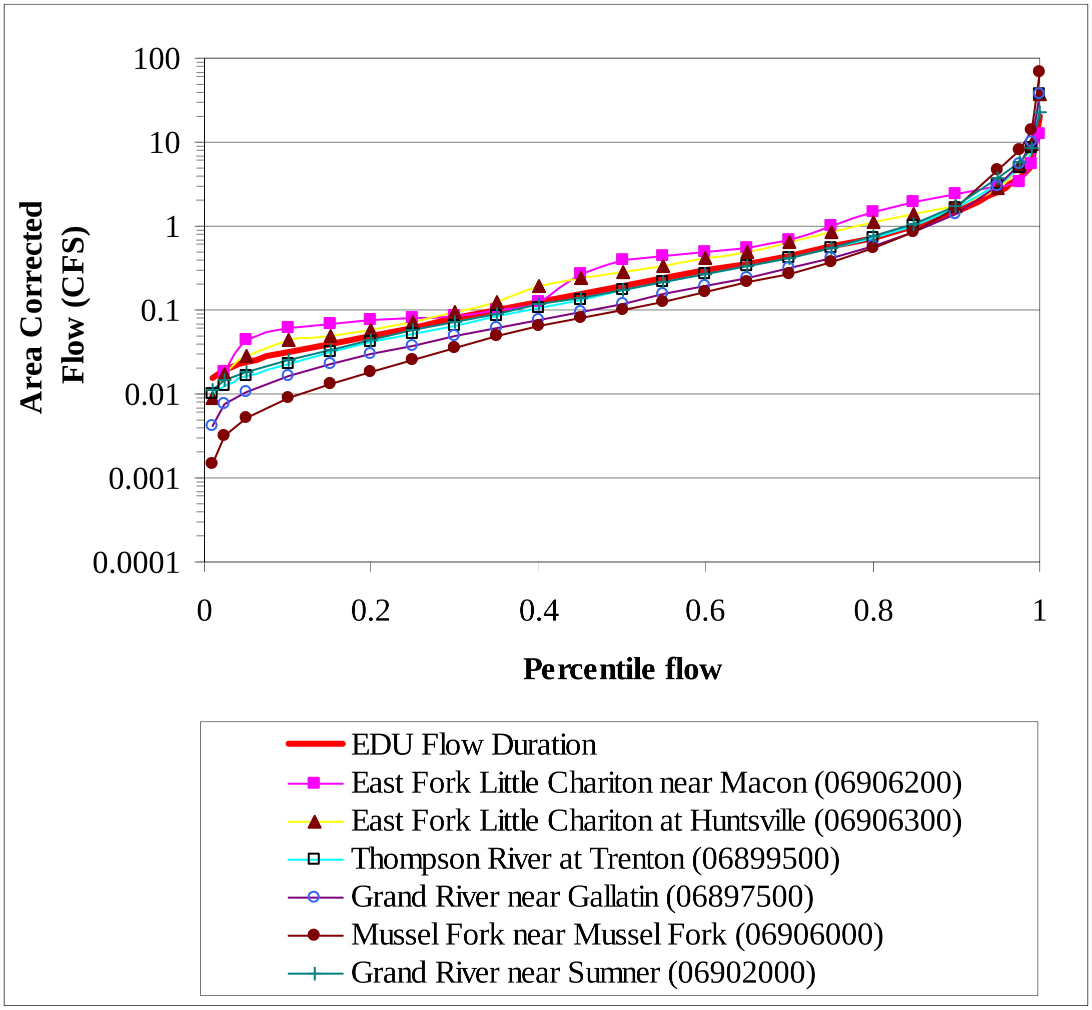

Figure C-1. Synthetic Flow Development in the Central Plains/ Grand River/Chariton EDU

Table C-1. Stream Flow Stations Used to Estimate Flows in Willow Branch

River/Station Name	Data Source	Station Number	Drainage Area (mi^2)	Lognormal Nash-Sutcliffe
East Fork Little Chariton River near Macon, MO	USGS	06906200	112	60%
East Fork Little Chariton River near Huntsville, MO	USGS	06906300	220	78%
Thompson River at Trenton, MO	USGS	06899500	1,720	79%
Grand River near Gallatin, MO	USGS	06897500	2,250	76%
Mussel Fork near Mussel Fork, MO	USGS	06906000	267	47%
Grand River near Sumner, MO	USGS	06902000	6,880	96%

The next step was to collect previously measured water quality data from within the ecoregion. Measured 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 C-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.

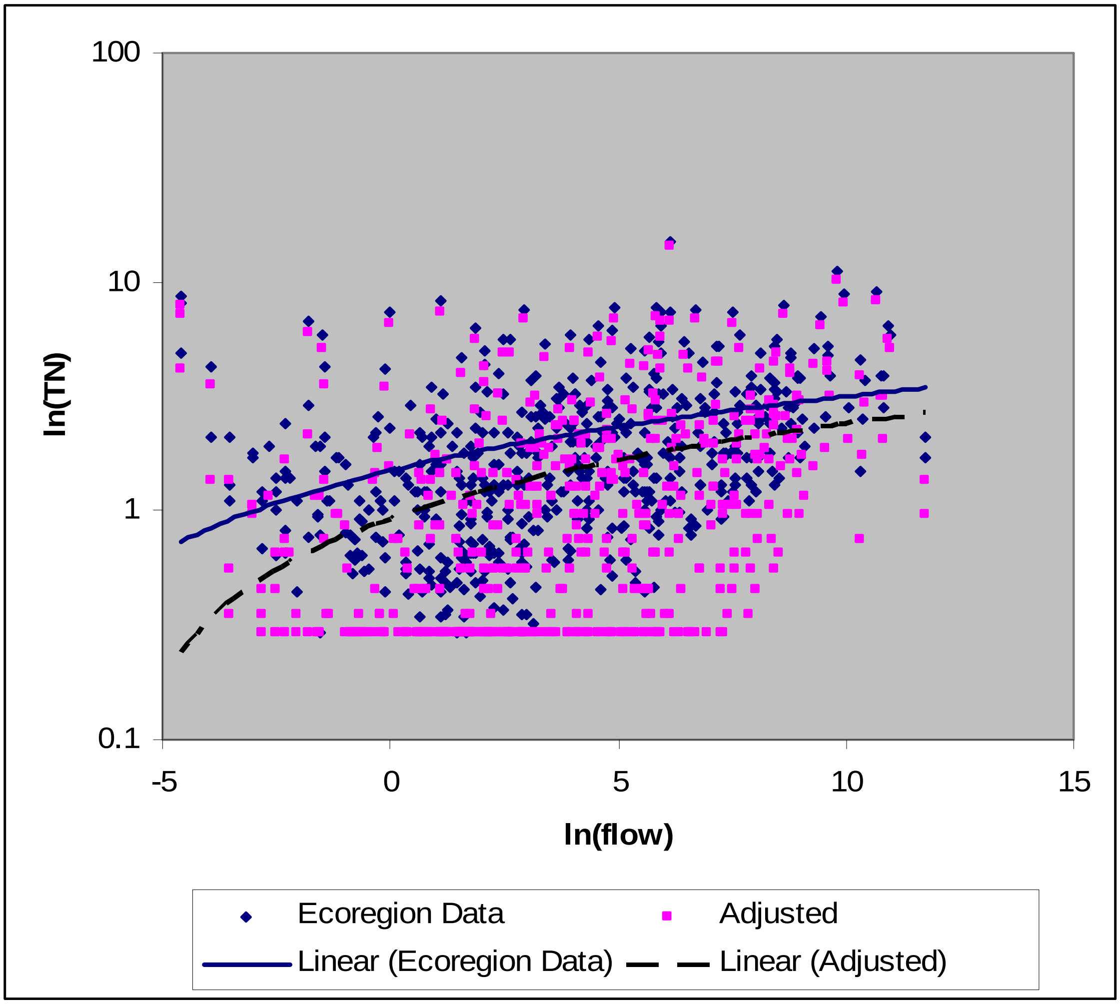

Figure C-2. Graphic Representation of Data Adjustment in Central Plains/ Grand River/Chariton EDU

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/day) and the instantaneous flow (cfs). Figure C-3 shows this relationship for this TMDL.

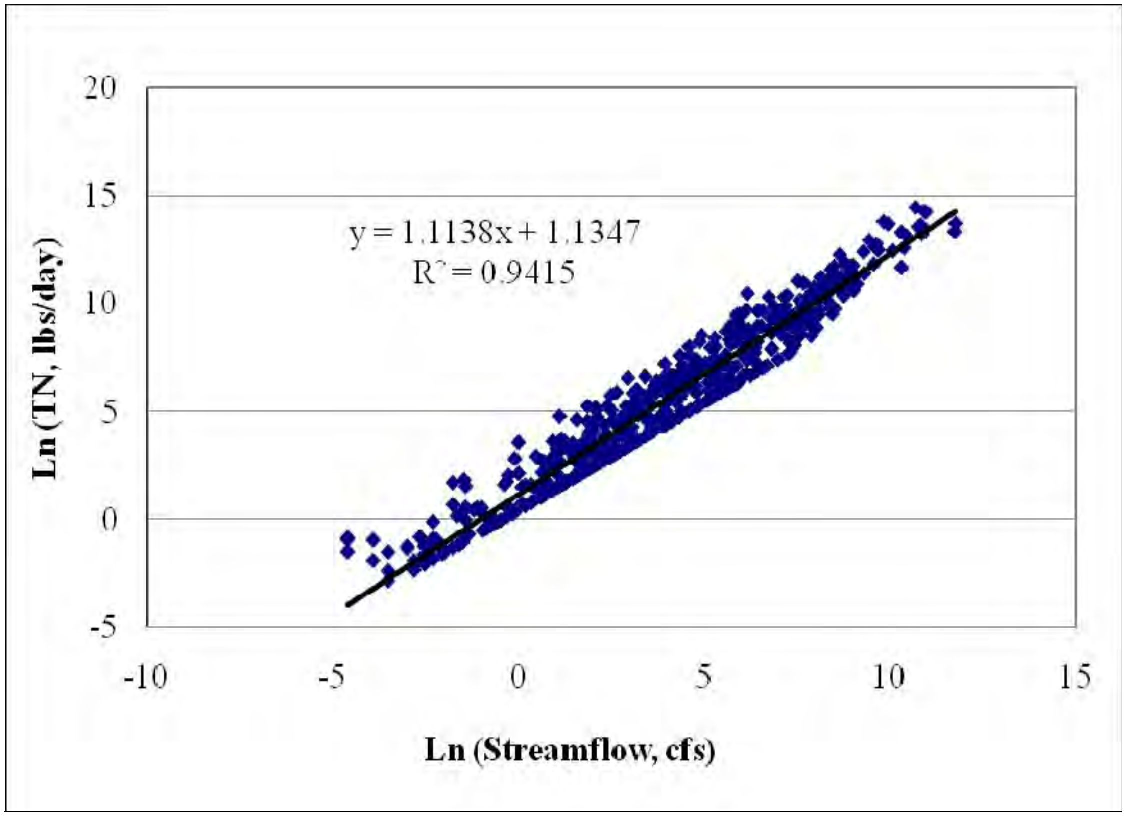

Figure C-3. Load / Flow Relationship Used to Set LDC TMDL

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

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

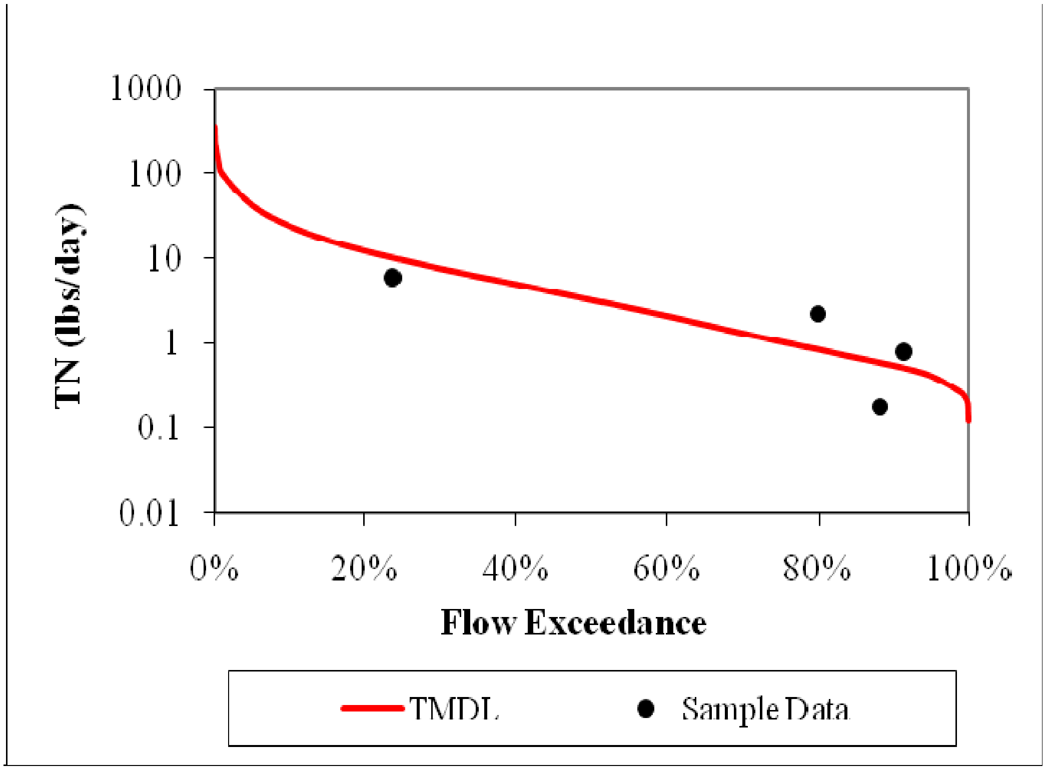

Figure C-4. Example of TMDL LDC Using This Method

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 D

Stream Flow and Water Quality Stations Used to Develop TMDLs in Willow Branch

Table D-1. Stream Flow Stations Used to Estimate Flows in Willow Branch

River/Station Name	Data Source	Station Number	Drainage Area (mi^2)
East Fork Little Chariton River near Macon, MO	USGS	6906200	112
East Fork Little Chariton River near Huntsville, MO	USGS	6906300	220
Thompson River at Trenton, MO	USGS	6899500	1,720
Grand River near Gallatin, MO	USGS	6897500	2,250
Mussel Fork near Mussel Fork, MO	USGS	6906000	267
Grand River near Sumner, MO	USGS	6902000	6,880

Table D-2. Stations Used to Develop Water Quality Data Targets in Willow Branch

USGS Gage Number	Station Name	Drainage Area (mi^2)
6898100	Thompson River at Mount Moriah, MO	891
6898800	Weldon River near Princeton, MO	452
6899580	NO Creek near Dunlap, MO	34
6899585	NO Creek at Farmersville, MO	67.4
6899950	Medicine Creek near Harris, MO	192
6900100	Little Medicine Creek near Harris, MO	66.5
6901500	Locust Creek near Linneus, MO	550
6902000	Grand River near Sumner, MO	6880
6905725	Mussel Fork near Mystic, MO	24

Table D-3. Water Quality Data Used in TMDL Development

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6898100 - Thompson River at Mount Moriah, MO					
6898100	11/9/1999	22	527		0.86
6898100	1/13/2000	8.6		0.7	E 0.04
6898100	3/23/2000	33			0.26
6898100	5/18/2000	19	27		0.14
6898100	7/13/2000	49			0.2
6898100	9/6/2000	10			0.53
6898100	11/28/2000	15	< 10	0.77	E 0.03
6898100	1/3/2001	7.5		0.75	< 0.06
6898100	3/15/2001	4860		5.6	1.92
6898100	5/2/2001	276	156	1.7	0.26
6898100	7/13/2001	126			0.16
6898100	9/20/2001	53		E 0.67	0.11

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6898100	11/8/2001	41	14		E 0.06
6898100	1/17/2002	14	< 10	0.74	E 0.03
6898100	3/14/2002	91	43	1.9	0.1
6898100	5/9/2002	223	347	1.8	0.39
6898100	8/1/2002	26	30		0.12
6898100	9/3/2002	17	176		0.3
6898100	11/7/2002	18	< 10		0.05
6898100	1/15/2003	15	< 10		E 0.04
6898100	3/28/2003	50	11	0.68	0.07
6898100	5/22/2003	196	107	5.1	0.22
6898100	7/15/2003	76	66	1.4	0.28
6898100	8/29/2003	6.1	< 10		0.08
6898100	9/4/2003	10	146		0.34
6898100	11/4/2003	325	644	4	1.08
6898100	1/23/2004	23	< 10	0.82	E 0.04
6898100	3/25/2004	268	186	5	0.3
6898100	5/20/2004	E 837	593	7.6	1.03
6898100	7/9/2004	118	17	2.8	0.28
6898100	9/10/2004	259	82	1.2	0.26
6898100	11/8/2004	70	132		0.24
6898100	1/21/2005	31	< 10	0.95	E 0.03
6898100	3/3/2005	144	42	2.4	0.09
6898100	5/25/2005	342	292	3.8	0.39
6898100	7/8/2005	96	67		0.19
6898100	9/16/2005	23	< 10	E 0.32	0.05
6898100	11/10/2005	12	< 10		0.04
6898100	1/20/2006	23	< 10		0.04
6898100	3/31/2006	23	< 10		0.04
6898100	5/25/2006	81	100		0.22
6898100	7/27/2006	15	23		0.1
6898100	9/8/2006	44	28		0.13
6898100	11/9/2006	23	< 10		0.05
6898100	1/4/2007	381	333	7.4	0.77
6898100	2/14/2007	24	< 10	3.9	E 0.03
6898100	3/21/2007	291	218	3.4	0.32
6898100	4/6/2007	394	192	3.2	0.3
6898100	5/23/2007	298	63	3.3	0.17
6898100	6/20/2007	133	82	2.1	0.18
6898100	7/25/2007	54	17		0.09
6898100	9/19/2007	132	26	E 0.83	0.1
6898100	11/16/2007	137	48	2.1	0.14
6898100	1/24/2008	200	20	2.4	0.07
6898100	3/12/2008	682	328	2.9	0.55
6898100	5/29/2008	481	196	3.4	0.29
6898100	7/10/2008	1280	1440	5.2	1.52
6898100	9/17/2008	569	300	1.7	0.43

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6898100	10/22/2008	1380	2930	5.2	2.44
6898100	1/14/2009	235	74	1.7	0.09
6898100	3/5/2009	264	254	2.2	0.35
6898100	5/7/2009	614	336	3.1	0.45
6898100	7/16/2009	1220	718	3.2	0.64
6898100	9/3/2009	288	109	1.2	0.25
6898800 - Weldon River near Princeton, MO					
6898800	11/9/1999	5.3		0.29	0.043
6898800	1/11/2000	10		0.38	< 0.05
6898800	3/21/2000	13			E 0.03
6898800	5/16/2000	2.4	< 10		< 0.05
6898800	7/11/2000	9.4			0.09
6898800	9/6/2000	1.8			0.07
6898800	11/30/2000	5.2	< 10	0.6	< 0.060
6898800	1/5/2001	8.1		0.54	< 0.06
6898800	3/15/2001	2840		3.9	1.28
6898800	5/2/2001	152	119	2.5	0.24
6898800	7/11/2001	63			0.13
6898800	9/18/2001	18		E 0.35	< 0.06
6898800	11/6/2001	36	18	0.6	0.1
6898800	1/15/2002	20	< 10	0.57	< 0.06
6898800	3/12/2002	101	114	2.6	0.21
6898800	5/7/2002	527	210	2.3	0.5
6898800	7/30/2002	17	14		0.07
6898800	8/15/2002	8.7	20		0.07
6898800	9/5/2002	3.3	13		E 0.04
6898800	10/24/2002	5	< 10	E 0.34	E 0.03
6898800	11/5/2002	6.5	< 10		< 0.04
6898800	12/10/2002	4.3	< 10	E 0.29	E 0.02
6898800	1/14/2003	1.9	< 10		E 0.02
6898800	3/7/2003	8.6	< 10	0.64	E 0.03
6898800	3/26/2003	7.3	< 10		0.04
6898800	5/20/2003	168	264	1.7	0.33
6898800	7/17/2003	6.1	19		0.08
6898800	9/5/2003	0.73	52		< 0.04
6898800	11/6/2003	99	120	4.5	0.5
6898800	1/21/2004	30	19	2.5	0.13
6898800	3/23/2004	90	39	1.7	0.12
6898800	5/18/2004	473	267	15	1.73
6898800	7/7/2004	44	14		0.08
6898800	9/8/2004	166	85	0.86	0.2
6898800	11/10/2004	20	< 10	E 0.35	E 0.03
6898800	1/19/2005	11	< 10	0.59	< 0.04
6898800	3/1/2005	80	51	1.1	0.07
6898800	5/23/2005	128	266	2.2	0.34
6898800	7/6/2005	23	< 10		E 0.04

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6898800	9/14/2005	6	10		0.05
6898800	11/8/2005	6.5	21		0.04
6898800	1/18/2006	9.4	< 10		< 0.04
6898800	3/31/2006	117	750	3	0.8
6898800	5/23/2006	6.1	12		0.04
6898800	7/25/2006	1.5	60		0.11
6898800	9/6/2006	9.2	42		0.08
6898800	11/7/2006	5.5	< 10		0.06
6898800	1/4/2007	82	44	3.7	0.23
6898800	2/16/2007	7.2	< 10	0.42	E 0.03
6898800	3/23/2007	625	1250	5.5	1.52
6898800	4/6/2007	174	86	1.4	0.15
6898800	5/23/2007	97	28	1	0.09
6898800	6/20/2007	35	31		0.12
6898800	7/25/2007	19	15		0.07
6898800	9/19/2007	42	24		0.07
6898800	11/14/2007	24	13	E 0.46	0.06
6898800	1/24/2008	60	140	1.6	0.26
6898800	3/12/2008	615	472	1.9	0.48
6898800	5/29/2008	166	79	1.2	0.17
6898800	7/10/2008	307	426	2.8	0.6
6898800	9/17/2008	325	364	1.4	0.41
6898800	10/22/2008	6480	1850	4.9	1.93
6898800	1/14/2009	78	< 15	0.92	E 0.04
6898800	3/6/2009	121	112	0.76	0.14
6898800	5/7/2009	260	126	1.2	0.21
6898800	7/16/2009	98	54		0.16
6898800	9/3/2009	274	145	1.1	0.26
6899580 - No. Creek near Dunlap, MO					
6899580	1/22/1998	3.7	1		
6899580	6/2/1998	3.2	51		
6899580	3/30/1999	4.4		0.48	E 0.05
6899580	4/22/1999	14		0.77	0.13
6899580	6/21/1999	0.25	70		0.14
6899580	10/25/1999	0.01		8.6	0.19
6899580	11/29/1999	0.01	73		0.24
6899580	12/20/1999	0.1			0.09
6899580	1/24/2000	0.1	28	1.4	0.12
6899580	2/23/2000	0.06			0.14
6899580	4/20/2000	0.81			0.16
6899580	5/9/2000	0.17	54	6.7	0.3
6899580	6/14/2000	6.4		6.3	0.46
6899580	6/22/2000	0.4		1.3	0.18
6899580	7/25/2000	0.11	45	1.4	0.15
6899580	10/24/2000	0.37		1.6	0.67
6899580	11/15/2000	0.68	21	2.1	0.14

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6899580	12/19/2000	0.08		E 1.4	E 0.06
6899580	1/24/2001	1.6	18	2.9	0.1
6899580	2/15/2001	40		2.8	0.34
6899580	3/27/2001	10		1.6	0.12
6899580	4/24/2001	19		1.3	0.18
6899580	5/22/2001	9.9	41	1.3	0.15
6899580	6/19/2001	2.7		1.6	0.23
6899580	6/25/2001	5.2		1.1	0.18
6899580	7/26/2001	59	290	1.7	0.35
6899580	8/9/2001	0.47		E 0.75	0.12
6899580	9/13/2001	0.1		E 2.4	0.15
6899580	10/23/2001	38	386	2.3	0.72
6899580	11/29/2001	0.28	78		0.19
6899580	12/13/2001	1	20		0.1
6899580	2/28/2002	1.7	22	1.2	0.07
6899580	3/21/2002	2.1	< 10		E 0.03
6899580	4/18/2002	4.3	36	0.75	0.12
6899580	5/23/2002	2.4	< 10	E 0.51	0.07
6899580	6/13/2002	0.53	20	0.64	0.1
6899580	6/28/2002	0.07	40		0.11
6899580	7/23/2002	0.01	< 10	E 8.0	0.17
6899580	8/22/2002	1	44	7.3	0.91
6899580	12/19/2002	0.01	37		0.16
6899580	3/13/2003	0.41	< 10		0.17
6899580	3/20/2003	0.34	12		0.15
6899580	4/25/2003	2.1	82	1.2	0.22
6899580	4/30/2003	0.62	12		0.14
6899580	5/6/2003	6.4	164	3.5	0.38
6899580	6/12/2003	3	68	8.2	0.24
6899580	7/9/2003	0.01	43	4.9	0.27
6899580	9/19/2003	0.26	144	1.1	0.28
6899580	10/23/2003	0.03	70		0.28
6899580	11/18/2003	0.1	23		0.22
6899580	12/11/2003	22	120	3.7	0.43
6899580	1/8/2004	1	17	2.3	0.11
6899580	2/27/2004	5.8	14	1.9	0.11
6899580	3/18/2004	52	117	2	0.25
6899580	4/20/2004	2.7	33		0.1
6899580	5/11/2004	1.3	< 10		0.08
6899580	6/22/2004	9.1	49	1.1	0.17
6899580	7/16/2004	0.41	23	E 0.78	0.14
6899580	8/23/2004	0.72	67	E 0.77	0.14
6899580	9/14/2004	0.76	520	E 2.6	0.79
6899580	10/26/2004	1	< 10		0.28
6899580	11/16/2004	3.7	< 10	0.46	0.06
6899580	12/14/2004	6.2	18	0.65	0.08

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6899580	1/25/2005	0.08	18	1.2	0.14
6899580	2/10/2005	21	138	1.4	0.16
6899580	3/17/2005	2.9	< 10		E 0.04
6899580	4/5/2005	3.6	< 10		0.04
6899580	5/12/2005	2	52		0.14
6899580	6/30/2005	0.86	24	0.73	0.12
6899580	7/13/2005	0.03	< 10		0.06
6899580	8/19/2005	0.02	33		0.09
6899580	9/21/2005	0.05	53		0.12
6899580	10/5/2005	0.08	380		0.49
6899580	11/3/2005	0.01	1510		1.94
6899580	12/14/2005	0.1	44	E 1.5	0.19
6899580	1/25/2006	0.03	43		0.11
6899580	2/14/2006	0.01	22		0.1
6899580	3/9/2006	0.2	< 10		0.07
6899580	4/12/2006	2.1	72	0.95	0.16
6899580	5/9/2006	2.8	44	0.93	0.13
6899580	6/15/2006	0.23	24	5.8	0.13
6899580	7/19/2006	0	152		0.59
6899580	8/10/2006	3.1	147	1.6	0.34
6899580	9/21/2006	0.02	170	E 4.3	0.31
6899580	10/25/2006	0.02	93	E 2.1	0.35
6899580	12/13/2006	0.52	17	0.92	0.12
6899580	1/26/2007	0.84	< 10	1	E 0.04
6899580	2/20/2007	56	162	3.8	0.68
6899580	3/15/2007	8.1	37	1.2	0.09
6899580	4/27/2007	76	225	2.9	0.38
6899580	5/10/2007	18	110	2.7	0.23
6899580	6/28/2007	19	485	7.6	0.64
6899580	7/19/2007	E 0.03	165	E 1.3	0.21
6899580	8/23/2007	0.24	75	1.5	0.21
6899580	9/27/2007	0.19	105		0.25
6899580	10/16/2007	0.06	136	E 1.2	0.36
6899580	11/8/2007	0.01	16		0.28
6899580	12/20/2007	3.1	20	2.2	0.14
6899580	1/10/2008	22	58	2	0.23
6899580	2/26/2008	E 65	86	2.9	0.35
6899580	3/25/2008	8.3	34	0.95	0.1
6899580	4/16/2008	11	102	1.2	0.18
6899580	5/22/2008	2.1	138	E 1.0	0.22
6899580	6/17/2008	13	74	1.3	0.22
6899580	7/15/2008	0.8	46	1.1	0.14
6899580	8/12/2008	0.55	24	E 0.54	0.1
6899580	9/23/2008	3	< 10	0.44	0.09
6899580	10/28/2008	6.6	< 15	0.65	0.13
6899580	11/18/2008	11	< 15	0.65	0.1

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6899580	12/2/2008	5.8	< 15	0.54	0.07
6899580	1/27/2009	1.9	< 15	E 0.34	E 0.04
6899580	2/24/2009	3	16		0.05
6899580	3/12/2009	16	250	2.1	0.34
6899580	4/24/2009	6.5	16	E 0.48	0.08
6899580	5/15/2009	29	730	2.7	0.65
6899580	6/23/2009	20	< 150	1.8	0.27
6899580	8/18/2009	56	266	2	0.38
6899585 - No Creek at Farmersville, MO					
6899585	11/16/2006	0.13	< 10	0.44	0.26
6899950 - Medicine Creek near Harris, MO					
6899950	10/26/1999	2.3			E 0.045
6899950	11/30/1999	3	6		< 0.05
6899950	12/21/1999	0.1		0.65	< 0.05
6899950	1/25/2000	0.5	3		< 0.05
6899950	2/22/2000	15			E 0.04
6899950	3/27/2000	8.7			E 0.03
6899950	4/18/2000	4			E 0.03
6899950	5/10/2000	10	< 10		0.05
6899950	6/21/2000	6		0.87	0.08
6899950	7/26/2000	6.6	37		0.11
6899950	9/20/2000	3.4		0.54	0.07
6899950	10/26/2000	6.1			0.07
6899950	11/14/2000	5.8	< 10	0.93	0.09
6899950	12/18/2000	3.1		E 0.34	< 0.06
6899950	1/25/2001	12	< 10	3.2	0.11
6899950	2/13/2001	131		2.8	0.3
6899950	3/29/2001	100		2	0.21
6899950	4/26/2001	76		1	0.21
6899950	5/24/2001	52	68	1.3	0.18
6899950	6/19/2001	79		1.5	0.33
6899950	6/26/2001	60		1.1	0.18
6899950	7/25/2001	353	1610	3.2	1.34
6899950	8/8/2001	13		E 0.55	0.09
6899950	9/12/2001	7.4		0.5	0.07
6899950	10/25/2001	33	118	2.6	0.37
6899950	11/28/2001	3.4	12	E 0.35	E 0.03
6899950	12/12/2001	6.2			< 0.06
6899950	1/3/2002	4.6	< 10	0.55	< 0.06
6899950	1/8/2002	5	< 10	E 0.45	< 0.06
6899950	2/27/2002	9.9	12	1.3	0.07
6899950	3/19/2002	18	< 10		0.06
6899950	4/17/2002	68	130	1.4	0.24
6899950	5/21/2002	38	38	1	0.1
6899950	6/28/2002	5.6	13		E 0.06
6899950	7/24/2002	3.6	< 10		0.08

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6899950	8/21/2002	17	41		0.14
6899950	9/10/2002	1.4	< 10		E 0.05
6899950	10/17/2002	1.4	< 10		E 0.03
6899950	11/19/2002	2	< 10		E 0.03
6899950	12/18/2002	2.8	< 10		0.04
6899950	1/30/2003	0.9	< 10		E 0.03
6899950	2/20/2003	3.4	< 10		E 0.03
6899950	3/12/2003	3.9	< 10		0.1
6899950	4/23/2003	14	12		0.25
6899950	5/8/2003	27	104	2.9	0.29
6899950	6/11/2003	51	282	5.8	0.47
6899950	7/10/2003	65	161	1.5	0.3
6899950	8/25/2003	0.61	< 10		0.06
6899950	9/17/2003	4.5	49	1.4	0.36
6899950	10/22/2003	1.3	< 10		0.05
6899950	11/20/2003	3	< 10		0.06
6899950	12/10/2003	368	E 692	5.5	2.81
6899950	1/7/2004	6.2	< 10	1.7	0.06
6899950	2/26/2004	55	66	2.4	0.34
6899950	3/16/2004	71	53	1.7	0.22
6899950	4/22/2004	21	12		0.06
6899950	5/13/2004	11	< 10		0.05
6899950	6/23/2004	42	49	1.2	0.18
6899950	7/14/2004	32	76	1.3	0.24
6899950	8/25/2004	378	1700	4.9	1.77
6899950	9/16/2004	25	15		0.1
6899950	10/27/2004	50	131	1.5	0.31
6899950	11/18/2004	16	< 10		0.04
6899950	12/16/2004	26	< 10	0.82	0.05
6899950	1/27/2005	169	280	2.3	0.53
6899950	2/9/2005	105	165	2.2	0.25
6899950	3/16/2005	28	< 10		0.06
6899950	4/8/2005	77	79		0.21
6899950	5/11/2005	24	15		0.08
6899950	6/29/2005	77	620	5.6	1.27
6899950	7/12/2005	5.7	< 10		0.05
6899950	8/17/2005	6.2	< 10	0.71	0.06
6899950	9/20/2005	3.6	14	E 0.37	0.05
6899950	10/5/2005	2.8	11		0.04
6899950	11/2/2005	2	< 10		E 0.03
6899950	12/15/2005	4.4	< 10		E 0.02
6899950	1/26/2006	2.6	< 10		E 0.03
6899950	2/17/2006	1.3	< 10		0.04
6899950	3/8/2006	9.8	< 10		0.06
6899950	4/13/2006	12	15		0.08
6899950	5/10/2006	18	20	0.59	0.07

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6899950	6/14/2006	2.4	< 10		0.04
6899950	7/18/2006	4.8	16		0.13
6899950	8/9/2006	16	150	1.5	0.38
6899950	9/20/2006	1.4	< 10		< 0.04
6899950	10/24/2006	3	< 10		0.08
6899950	11/15/2006	2.6	< 10		0.09
6899950	12/14/2006	4.4	24	1.5	0.07
6899950	1/25/2007	8	< 10	1.3	0.06
6899950	2/21/2007	460	379	7.4	1.37
6899950	3/14/2007	60	72	2	0.2
6899950	4/27/2007	971	660	4.5	1.19
6899950	5/9/2007	349	424	2.8	0.63
6899950	6/27/2007	10	19	0.65	0.08
6899950	7/18/2007	4.6	10		0.08
6899950	8/21/2007	57	763	3.2	0.93
6899950	9/25/2007	9.8	< 20		0.08
6899950	10/16/2007	46	84	1.2	0.25
6899950	11/6/2007	14	< 10	0.49	0.09
6899950	12/19/2007	57	35	1.7	0.13
6899950	1/9/2008	483	406	2.6	0.56
6899950	2/27/2008	202	140	3.5	0.45
6899950	3/26/2008	64	49	0.97	0.12
6899950	4/16/2008	119	170	1.5	0.27
6899950	5/21/2008	36	19		0.1
6899950	6/18/2008	112	148	1.4	0.28
6899950	7/16/2008	19	35		0.14
6899950	8/13/2008	25	46		0.1
6899950	9/24/2008	98	536	2.6	0.61
6899950	10/29/2008	60	39	0.92	0.17
6899950	11/19/2008	75	42	0.83	0.12
6899950	12/3/2008	49	16	0.61	0.06
6899950	1/28/2009	19	< 15	0.72	0.04
6899950	2/25/2009	34	22	0.61	0.06
6899950	3/11/2009	715	1180	4.9	1.37
6899950	4/22/2009	61	85	0.92	0.17
6899950	5/13/2009	377	1900	6.5	2.37
6899950	6/24/2009	75	220	2.4	0.42
6899950	7/22/2009	20	24		0.1
6899950	8/20/2009	180	455	2.2	0.54
6900100 - Little Medicine Creek near Harris, MO					
6900100	1/22/1998	8.7	1		
6900100	6/2/1998	11	26		
6900100	1/5/1999	4.8	5	0.67	< 0.05
6900100	3/31/1999	12		0.37	E 0.03
6900100	4/21/1999	35		1.1	0.16
6900100	6/22/1999	4.7	30	0.97	0.11

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6900100	8/25/1999	0.62		0.56	E 0.04
6900100	10/26/1999	0.67			E 0.03
6900100	11/30/1999	0.73	1		< 0.05
6900100	12/21/1999	0.1		0.82	0.06
6900100	1/25/2000	0.5	4		< 0.05
6900100	2/22/2000	1.8			E 0.04
6900100	3/27/2000	1.1			< 0.05
6900100	4/18/2000	2			E 0.04
6900100	5/10/2000	1.4	< 10		E 0.03
6900100	6/21/2000	1.2		1.5	0.07
6900100	7/26/2000	1.6	< 10		0.07
6900100	9/20/2000	1.6			0.05
6900100	10/26/2000	1.8			0.08
6900100	11/14/2000	1.8	< 10	1	E 0.06
6900100	12/19/2000	0.91		0.44	E 0.04
6900100	1/25/2001	3.2	< 10	3.2	E 0.04
6900100	2/13/2001	46		3.2	0.42
6900100	3/29/2001	35		1.9	0.14
6900100	4/26/2001	18		0.87	0.15
6900100	5/24/2001	16	31	1.4	0.12
6900100	6/19/2001	17		1.9	0.26
6900100	6/26/2001	13		0.92	0.09
6900100	7/25/2001	11	444	4	0.48
6900100	8/8/2001	1.4		0.59	E 0.05
6900100	9/12/2001	1.2		0.79	0.07
6900100	10/25/2001	7.5	54	2.2	0.2
6900100	11/28/2001	1.5	< 10		< 0.06
6900100	12/12/2001	1.7	< 10		< 0.06
6900100	1/8/2002	0.38	< 10	0.8	< 0.06
6900100	2/27/2002	1.8	< 10	1.2	E 0.03
6900100	3/19/2002	2	< 10		< 0.06
6900100	4/17/2002	13	66	1	0.13
6900100	5/21/2002	9.1	14	0.67	0.07
6900100	6/28/2002	2	< 10	E 0.44	E 0.04
6900100	7/24/2002	0.59	< 10		E 0.04
6900100	8/21/2002	3.1	< 10	0.62	0.1
6900100	9/10/2002	0.15	< 10		E 0.04
6900100	10/17/2002	0.31	< 10		E 0.03
6900100	11/19/2002	0.41	< 10		0.06
6900100	12/18/2002	0.64	< 10		E 0.02
6900100	1/29/2003	0.11	< 10		0.05
6900100	2/20/2003	0.64	< 10		E 0.03
6900100	3/12/2003	1.4	< 10		< 0.04
6900100	4/23/2003	0.47	< 10	0.61	0.04
6900100	5/8/2003	3.5	127	2.4	0.19
6900100	6/11/2003	30	344	5.4	0.51

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6900100	7/10/2003	138	E 2060	7.7	1.76
6900100	8/25/2003	0.08	13	E 0.64	0.1
6900100	9/18/2003	0.48	20	0.65	0.07
6900100	10/22/2003	0.3	< 10		0.07
6900100	11/20/2003	0.52	< 10		0.05
6900100	12/10/2003	98	470	6.5	0.93
6900100	1/7/2004	0.73	16	2.2	E 0.03
6900100	2/26/2004	10	36	2.2	0.11
6900100	3/16/2004	25	56	1.7	0.14
6900100	4/22/2004	4.6	< 10		0.04
6900100	5/13/2004	8.9	102	1.2	0.18
6900100	6/23/2004	12	33	1.3	0.13
6900100	7/14/2004	6	37	1.3	0.15
6900100	8/25/2004	2150	1400	5.8	1.91
6900100	9/16/2004	5.8	64	0.65	0.17
6900100	10/27/2004	16	146	1.3	0.29
6900100	11/18/2004	5.2	< 10		E 0.04
6900100	12/17/2004	4.6	< 10	0.85	E 0.03
6900100	1/27/2005	24	51	2.6	0.37
6900100	2/10/2005	7	48	1.8	0.11
6900100	3/16/2005	7.6	< 10		0.04
6900100	4/8/2005	15	18		0.07
6900100	5/12/2005	8.6	38	E 0.66	0.1
6900100	6/30/2005	6	20	E 0.73	0.1
6900100	7/12/2005	1.4	< 10	E 0.53	0.06
6900100	8/17/2005	0.42	< 10	0.64	0.06
6900100	9/20/2005	0.64	< 10		0.05
6900100	10/5/2005	0.22	< 10	E 0.29	E 0.04
6900100	11/2/2005	0.15	< 10		0.05
6900100	12/15/2005	1.6	< 10		E 0.03
6900100	1/26/2006	0.73	< 10		E 0.03
6900100	2/17/2006	0.37	< 10		E 0.04
6900100	3/8/2006	2.2	< 10		0.04
6900100	4/13/2006	1.5	15		0.07
6900100	5/10/2006	2.3	19		0.05
6900100	6/14/2006	0.43	< 10	0.53	0.05
6900100	7/19/2006	0.22	< 10	0.79	0.08
6900100	8/9/2006	3	122	1.2	0.25
6900100	9/20/2006	0.16	< 10		E 0.03
6900100	10/24/2006	0.35	< 10		0.06
6900100	11/16/2006	0.45	< 10		0.09
6900100	12/14/2006	1.1	13	1.5	0.06
6900100	1/25/2007	2.2	< 10	1.2	< 0.04
6900100	2/21/2007	E 130	59	6.2	1.16
6900100	3/15/2007	14	64	1.8	0.13
6900100	4/25/2007	1830	1070	7.3	2.42

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6900100	5/10/2007	52	184	2.3	0.33
6900100	6/27/2007	1.4	10	0.56	0.06
6900100	7/18/2007	0.53	13		0.06
6900100	8/21/2007	14	663	5.6	0.92
6900100	9/25/2007	1.5	< 20	E 0.43	0.09
6900100	10/17/2007	13	424	2.2	0.81
6900100	11/8/2007	1	< 10		0.1
6900100	12/19/2007	13	31	2.2	0.15
6900100	1/10/2008	68	88	2.7	0.34
6900100	2/27/2008	58	82	3.2	0.37
6900100	3/26/2008	21	43	0.95	0.11
6900100	4/16/2008	33	88	1.4	0.21
6900100	5/21/2008	7.3	< 10		0.08
6900100	6/18/2008	20	74	1.3	0.21
6900100	7/16/2008	3	10	0.51	0.07
6900100	8/13/2008	3.3	13	0.48	0.08
6900100	9/24/2008	300	2200	5.7	1.81
6900100	10/29/2008	18	23	0.65	0.11
6900100	11/19/2008	30	33	1	0.11
6900100	12/3/2008	17	< 15	0.68	0.05
6900100	1/28/2009	4.5	< 15	0.73	E 0.03
6900100	2/25/2009	12	18	0.57	0.05
6900100	3/11/2009	118	490	3.4	0.56
6900100	4/22/2009	15	15	0.41	0.06
6900100	5/13/2009	352	1760	7.8	2.21
6900100	6/24/2009	26	160	2	0.29
6900100	7/22/2009	2.5	< 15	0.47	0.05
6900100	8/20/2009	176	1290	3.8	1.15
6901500 - Locust Creek near Linneus, MO					
6901500	8/26/2003	0.8	<10		0.05
6902000 - Grand River near Sumner, MO					
6902000	11/8/1989	373		1	0.13
6902000	1/18/1990	851		2.2	0.34
6902000	5/9/1990	5480		2.3	0.42
6902000	7/11/1990	1430		1.3	0.35
6902000	11/7/1990	1310		3.6	0.3
6902000	1/9/1991	452		2	0.24
6902000	5/17/1991	14200		2.6	0.39
6902000	7/16/1991	2510		3.2	0.41
6902000	11/6/1991	470		1.7	0.31
6902000	1/15/1992	2720		1.7	0.34
6902000	7/8/1992	340			0.11
6902000	11/12/1992	7780		2.2	0.22
6902000	12/2/1992	4980		1.4	0.28
6902000	1/6/1993	8980		1.9	0.47
6902000	2/17/1993	2510		1.4	0.25

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6902000	3/17/1993	3220		1.5	0.28
6902000	4/8/1993	29800		1.5	0.22
6902000	5/12/1993	33700		3.7	0.2
6902000	6/16/1993	18400		11	1
6902000	7/27/1993	128000		2.1	0.55
6902000	8/25/1993	2820		1.3	
6902000	9/16/1993	23600		2.8	0.34
6902000	10/27/1993	1700		1.1	0.04
6902000	11/16/1993	3300		1.7	0.25
6902000	12/8/1993	1140			0.03
6902000	1/5/1994	755		0.92	0.05
6902000	2/3/1994	1200		2.7	0.18
6902000	3/16/1994	1750		1.8	0.18
6902000	3/30/1994	750		0.78	0.09
6902000	4/27/1994	900			0.12
6902000	5/10/1994	3700		2.6	0.28
6902000	6/14/1994	4500		5.2	1.2
6902000	8/23/1994	250			
6902000	9/14/1994	270			0.11
6902000	10/26/1994	136			0.13
6902000	11/30/1994	1200		2	0.15
6902000	12/14/1994	1140		1.8	0.2
6902000	1/5/1995	350		1.4	0.03
6902000	2/8/1995	2060		2.7	0.27
6902000	3/30/1995	2720		3.5	0.13
6902000	4/18/1995	5660		7.9	0.41
6902000	5/24/1995	51600		2.8	0.4
6902000	6/14/1995	4450		1.5	0.2
6902000	7/12/1995	6100		2.8	0.14
6902000	8/2/1995	2030		1.8	0.39
6902000	9/5/1995	496			0.13
6902000	10/24/1995	235			0.11
6902000	11/6/1995	595		1.2	0.1
6902000	12/13/1995	216		0.49	0.04
6902000	1/22/1996	430		1.1	0.08
6902000	2/14/1996	3050		2.5	1
6902000	3/26/1996	1480		2.4	0.31
6902000	4/16/1996	520			0.16
6902000	5/20/1996	4660		3.6	0.57
6902000	6/19/1996	14500		4.8	0.83
6902000	7/17/1996	1050			0.16
6902000	8/14/1996	906			0.12
6902000	9/11/1996	1170		1.6	0.14
6902000	10/9/1996	527			0.1
6902000	11/20/1996	4930		3.3	0.18
6902000	1/22/1997	466		1.4	0.07

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6902000	2/12/1997	1620		2.2	0.16
6902000	3/17/1997	2510		1.7	0.28
6902000	4/23/1997	29800		4.6	0.28
6902000	5/27/1997	2130		E 2.9	0.44
6902000	6/17/1997	15100		5.2	0.25
6902000	7/29/1997	395			0.12
6902000	8/19/1997	511		0.98	0.18
6902000	9/9/1997	286		1.2	0.15
6902000	11/17/1997	415	6		
6902000	1/15/1998	1590	16		
6902000	6/9/1998	4290	452		
6902000	8/18/1998	587	60		
6902000	11/16/1998	4640	264	1.3	0.15
6902000	12/1/1998	6620		2.4	0.8
6902000	1/25/1999	4150	231	2.4	0.31
6902000	2/23/1999	3040		1.2	0.16
6902000	3/23/1999	2740		3.2	0.25
6902000	4/13/1999	3460		2.5	0.47
6902000	5/19/1999	31900		2.5	0.7
6902000	6/15/1999	6840	1800		
6902000	7/27/1999	429			0.17
6902000	8/10/1999	639	80		0.22
6902000	9/13/1999	365			0.21
6902000	10/26/1999	130			0.1
6902000	11/30/1999	240	10		< 0.05
6902000	12/21/1999	157		0.83	0.06
6902000	1/4/2000	198	16	0.75	0.07
6902000	2/1/2000	123		0.61	0.05
6902000	3/7/2000	565		1.7	0.27
6902000	4/3/2000	301		0.83	0.19
6902000	5/2/2000	308	95		0.22
6902000	6/12/2000	217			0.22
6902000	7/11/2000	924	180	1.3	0.32
6902000	8/2/2000	465			0.23
6902000	9/12/2000	129			0.22
6902000	10/2/2000	341			0.28
6902000	11/21/2000	220	12	1.2	0.08
6902000	12/5/2000	207		1.3	0.08
6902000	1/3/2001	E 203	< 10	1.5	E 0.03
6902000	2/14/2001	5880		3.3	0.53
6902000	3/6/2001	8040		3.8	0.79
6902000	4/17/2001	7800		3	0.76
6902000	5/1/2001	1740	90		0.22
6902000	6/19/2001	6690		4.7	1.33
6902000	7/10/2001	1830	174	1.2	0.26
6902000	8/13/2001	572			0.17

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6902000	9/5/2001	404			0.17
6902000	10/17/2001	3210	555	2.4	0.65
6902000	11/6/2001	416	18		0.1
6902000	12/4/2001	323	16	0.46	0.12
6902000	1/8/2002	179	< 10	0.61	E 0.05
6902000	2/5/2002	347	12	0.95	0.08
6902000	3/6/2002	573	12	0.99	E 0.05
6902000	4/10/2002	4220	1440	3.8	1.16
6902000	5/7/2002	43700	2420	9.1	3.12
6902000	6/10/2002	841			0.2
6902000	7/16/2002	393	145	1.8	0.54
6902000	8/13/2002	175	< 10		0.17
6902000	9/4/2002	145	65		0.18
6902000	10/22/2002	97	39		0.11
6902000	11/27/2002	115	10		0.07
6902000	12/12/2002	102	< 10	0.45	0.05
6902000	2/12/2003	121	< 10	1.3	0.06
6902000	2/25/2003	E 130	< 10	0.52	0.08
6902000	3/21/2003	354	29	0.9	0.09
6902000	4/11/2003	163	46		0.12
6902000	5/2/2003	1940	524	3.3	0.76
6902000	6/20/2003	516	114	2	0.28
6902000	7/29/2003	130	19		0.19
6902000	8/21/2003	66	81		0.23
6902000	9/9/2003	85	58		0.18
6902000	10/21/2003	96	44		0.2
6902000	11/5/2003	75	26		0.09
6902000	12/15/2003	888	89	3.1	0.32
6902000	1/7/2004	E 275	< 10	1.6	0.08
6902000	2/3/2004	E 165	< 10	1.4	0.08
6902000	3/2/2004	997	112	2.8	0.26
6902000	4/6/2004	2040	136	2.4	0.25
6902000	5/19/2004	21000	1070	8.8	2.37
6902000	6/28/2004	1910	158	1.3	0.28
6902000	7/15/2004	7510	475	3.8	1.22
6902000	8/16/2004	715	49		0.19
6902000	9/2/2004	E 125000	543	1.7	0.57
6902000	10/12/2004	900	132	1.3	0.26
6902000	11/9/2004	1410	56	0.93	0.17
6902000	12/1/2004	813	22	0.86	0.11
6902000	1/24/2005	1530	90	1.8	0.22
6902000	2/14/2005	55000	2160	6.4	1.83
6902000	3/8/2005	1460	43	1.2	0.12
6902000	4/4/2005	992	55		0.11
6902000	5/3/2005	1530	117	1.7	0.21
6902000	6/22/2005	1600	203	1.8	0.34

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6902000	7/12/2005	513	135		0.26
6902000	8/22/2005	909	252	1.9	0.41
6902000	9/7/2005	301	55		0.18
6902000	10/12/2005	315	34	1.1	0.12
6902000	11/2/2005	220	< 10	0.54	0.07
6902000	12/19/2005	272	< 10	1	0.04
6902000	1/4/2006	459	14	1.1	0.07
6902000	2/7/2006	357	< 10	0.79	0.07
6902000	3/7/2006	267	12	E 0.44	0.07
6902000	4/10/2006	1010	415	2.7	0.53
6902000	5/3/2006	12500	1180	7.1	1.48
6902000	6/21/2006	386	154		0.3
6902000	7/6/2006	259	41		0.2
6902000	8/2/2006	131	138		0.23
6902000	9/6/2006	432	170		0.34
6902000	10/10/2006	121	51		0.1
6902000	11/6/2006	289	43	1.2	0.15
6902000	12/5/2006	546	76	2.8	0.26
6902000	1/4/2007	3400	767	4.9	1.05
6902000	2/14/2007	272	< 10	1.6	0.05
6902000	3/7/2007	3450	258	3.4	0.48
6902000	4/3/2007	7510	1120	3.9	1.1
6902000	5/2/2007	4620	360	3.4	0.51
6902000	6/6/2007	4600	200	3.1	0.43
6902000	7/10/2007	447	104		0.2
6902000	8/14/2007	1230	242	2	0.37
6902000	9/11/2007	736	52		0.17
6902000	10/23/2007	3100	340	2.9	0.6
6902000	11/6/2007	569	27	1.5	0.12
6902000	12/4/2007	702	45	0.84	0.14
6902000	1/9/2008	16000	850	3.9	1.11
6902000	2/14/2008	1900	100	1.9	0.22
6902000	3/5/2008	50600	1180	3.9	1.43
6902000	4/16/2008	7050	144	2.8	0.64
6902000	6/2/2008	10700	1120	5.1	1.31
6902000	7/9/2008	4230	384	1.8	0.49
6902000	8/4/2008	8200	452	1.7	0.47
6902000	9/2/2008	803	80		0.16
6902000	10/21/2008	1940	106	1.4	0.27
6902000	11/24/2008	2600	75	1.1	0.15
6902000	12/9/2008	1500	48	0.94	0.11
6902000	2/2/2009	1080	< 15	1	0.06
6902000	3/10/2009	57300	1300	5.9	1.77
6902000	4/1/2009	10900	418	2.3	0.55
6902000	5/5/2009	8690	780	2.5	0.68
6902000	6/2/2009	3960	312	2.9	0.42

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6902000	7/28/2009	986	62		0.18
6902000	8/17/2009	46900	1790	3.9	1.52
6902000	9/1/2009	6300	454	1.7	0.53
6905725 - Mussel Fork near Mystic, MO					
6905725	1/23/1998	1.6	12		
6905725	6/3/1998	1.2	22		
6905725	1/6/1999	1.9	4	0.56	< 0.05
6905725	3/31/1999	2.4		0.54	E 0.04
6905725	4/21/1999	8.4		0.98	0.11
6905725	6/23/1999	0.54	47	0.89	0.09
6905725	10/25/1999	0.01			0.07
6905725	11/30/1999	0.01	11		0.05
6905725	12/20/1999	0.1			< 0.05
6905725	1/24/2000	0.1	24		0.05
6905725	4/20/2000	0.16			0.07
6905725	5/11/2000	0.07	< 10		0.07
6905725	6/14/2000	8.3		3.3	0.44
6905725	6/15/2000	7.3		2.7	0.25
6905725	6/20/2000	0.22		1.9	0.11
6905725	7/27/2000	0	10		E 0.04
6905725	10/25/2000	0.03			0.28
6905725	11/15/2000	0.1	< 10		0.08
6905725	12/20/2000	0.02			0.06
6905725	1/24/2001	0.24	10	4.3	0.17
6905725	2/14/2001	59		3.2	0.42
6905725	3/28/2001	4.3		2.2	0.12
6905725	4/25/2001	4.1			0.12
6905725	5/22/2001	1.1		1.1	0.08
6905725	5/23/2001	0.82	11	1.1	0.08
6905725	6/18/2001	7.6		1.4	0.21
6905725	6/28/2001	2.5			0.11
6905725	7/26/2001	4.8	228	4.7	0.4
6905725	8/9/2001	0.13		E 1.1	0.1
6905725	9/11/2001	0.03		E 1.1	0.1
6905725	10/24/2001	3.5	50	2.4	0.42
6905725	11/29/2001	0.17	< 10		E 0.06
6905725	12/13/2001	0.83	20		E 0.05
6905725	1/9/2002	0.2	10	0.97	E 0.05
6905725	2/28/2002	1.4	18	1.4	0.09
6905725	3/20/2002	0.97	< 10		E 0.04
6905725	4/18/2002	1.6	17		0.07
6905725	5/22/2002	2.2	20		0.12
6905725	6/27/2002	0.06	10	E 0.69	E 0.04
6905725	8/22/2002	0.17	22	E 0.77	0.08
6905725	2/21/2003	0.05	< 10	1.7	0.15
6905725	3/13/2003	2.5	37		0.2

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6905725	3/19/2003	0.3	14	E 1.7	0.14
6905725	4/24/2003	0.19	26	1.9	0.1
6905725	4/30/2003	1.9	32	2.2	0.2
6905725	5/7/2003	2.5	44	2.1	0.23
6905725	6/12/2003	0.72	16	E 1.2	0.09
6905725	7/9/2003	E 0.00	11		0.1
6905725	9/17/2003	0.33	15	1.7	0.14
6905725	11/19/2003	E 0.01	38		0.27
6905725	12/11/2003	7.9	84	5	0.41
6905725	1/8/2004	0.24	19	2.1	0.17
6905725	2/20/2004	41	81	3.5	0.52
6905725	3/17/2004	25	60	1.8	0.18
6905725	4/21/2004	1.6	15		0.06
6905725	5/12/2004	0.55	< 10		0.07
6905725	6/24/2004	1.9	31	1.6	0.21
6905725	7/13/2004	11	52	1.6	0.21
6905725	8/24/2004	0.25	21	1.1	0.07
6905725	9/15/2004	0.52	< 10	E 1.1	0.09
6905725	10/28/2004	2	< 10		0.14
6905725	11/17/2004	1.8	< 10	0.67	0.06
6905725	12/17/2004	2.4	< 10	0.71	0.05
6905725	1/26/2005	18	46	1.8	0.22
6905725	2/8/2005	22	65	2.6	0.18
6905725	3/17/2005	2.9	< 10		0.13
6905725	4/7/2005	2.9	< 10		0.06
6905725	5/11/2005	11	10		0.07
6905725	6/29/2005	1.7	21		0.08
6905725	7/14/2005	0.02	< 10		0.04
6905725	8/18/2005	0.08	22	E 1.8	0.12
6905725	9/21/2005	0.05	74		0.23
6905725	10/4/2005	0.9	316	4.2	0.59
6905725	11/1/2005	0.04	22		0.16
6905725	12/13/2005	0.01	< 10		0.06
6905725	1/27/2006	0.12	< 10		0.05
6905725	2/15/2006	0.17	15	2.9	0.07
6905725	3/9/2006	0.3	< 10		0.04
6905725	4/14/2006	1.3	18		0.08
6905725	5/12/2006	1.1	10		0.07
6905725	6/15/2006	0.11	< 10		0.06
6905725	7/17/2006	0	34	1.5	0.15
6905725	8/8/2006	2.4	203	1.9	0.36
6905725	9/21/2006	0.06	11	1.1	0.06
6905725	10/23/2006	0.03	20	2.1	0.14
6905725	11/15/2006	0.03	82		0.2
6905725	12/15/2006	0.2	< 10	0.95	0.1
6905725	1/24/2007	0.62	11	1	0.1

USGS Gage Number	Sample Date	Flow (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
6905725	2/22/2007	8	< 10	4.4	0.58
6905725	3/13/2007	6.5	25	2.3	0.17
6905725	4/24/2007	1.7	< 50		0.08
6905725	5/8/2007	74	176	2	0.36
6905725	6/28/2007	12	444	5.6	0.6
6905725	7/17/2007	0.06	26		0.08
6905725	8/22/2007	2.5	245	3.5	0.53
6905725	9/26/2007	0.04	54		0.18
6905725	10/17/2007	0.07	312	1.9	0.37
6905725	11/7/2007	0.05	11		0.16
6905725	12/18/2007	2.8	20	2.5	0.2
6905725	1/9/2008	40	68	3.1	0.28
6905725	2/26/2008	39	180	3.1	0.57
6905725	3/25/2008	6.2	21	1.4	0.1
6905725	4/17/2008	5.8	28	1.1	0.11
6905725	5/22/2008	1.2	10		0.07
6905725	6/19/2008	2.5	25	1.5	0.15
6905725	7/18/2008	0.4	16		0.1
6905725	8/14/2008	3.9	182	1.9	0.28
6905725	9/23/2008	2.1	14		0.12
6905725	10/28/2008	1.5	< 15	1.3	0.12
6905725	11/20/2008	4.8	< 15	1.3	0.1
6905725	12/4/2008	3.5	< 15	0.6	0.05
6905725	1/29/2009	0.89	< 15	0.62	0.06
6905725	2/26/2009	4.8	< 15	0.62	0.05
6905725	3/12/2009	25	170	2.3	0.28
6905725	4/23/2009	5.4	< 15	E 0.64	0.07
6905725	5/14/2009	47	214	2.4	0.34
6905725	6/26/2009	5	< 150	1.8	0.16
6905725	7/21/2009	0.32	< 15		0.05
6905725	8/19/2009	2	106	2.1	0.23

Note: Blank cells indicate that there was no data for that particular parameter on that date.

Appendix E – Supplemental Implementation Plan

This implementation plan is not a requirement of the Federal CWA. However, the contractor included it as part of the TMDL preparation. 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 Willow Branch TMDL.

The pollutants targeted by the TMDL to address the unknown water quality impairment of Willow Branch are TSS, total nitrogen and total phosphorus. Potential sources of these pollutants do not include any regulated point sources. Therefore, any practices used to implement this TMDL will focus on nonpoint sources.

Point Sources

The WLA for Willow Branch has been set at zero for the existing permit. It is assumed that construction activities in the watershed will be conducted in compliance with Missouri's Storm Water Permit, including monitoring and discharge limitations. As required under the permit, Storm Water Pollution Prevention Plans (SWPP) ensures the design, implementation and maintenance of BMPs. Compliance with the SWPP should result in sediment loading from construction sites at or below applicable targets.

The WLAs listed in this TMDL do not preclude the establishment of future point sources of sediment or nutrient loading in the watershed. Any future point sources should be evaluated in the light of the TMDL established and the range of flows into which any additional load will impact.

Nonpoint Sources

Nonpoint sources of sediment and nutrients are not regulated in Missouri. However, with cropland and grassland accounting for approximately 73 percent of the land area in the watershed, agricultural runoff is likely a major component of nonpoint source contributions to the impaired segment. Contributions of sediment and nutrients from agricultural areas should be reduced to meet the TMDL targets.

To reduce the loading and effect of sediment on Willow Branch, efforts should be made to encourage agricultural producers in the watershed to adopt erosion control BMPs. The concept of BMPs is one of a voluntary and site specific approach to water quality problems. In the Willow Branch watershed, agricultural BMPs should focus on erosion control measures such as grassy swales, contour farming, the expansion or enhancement of riparian zones, off-stream watering of livestock and rotational grazing practices.

To reduce the loading and effect of nutrients on Willow Branch, efforts should be made to encourage agricultural producers in the watershed to adopt nutrient management practices. Management practices should focus on the proper management of nutrients from manure, previous crops and commercial fertilizers. Soil testing of croplands prior to fertilizer applications should be encouraged and education on cultural techniques such as identifying signs of plant need should be provided. Education on proper manure storage and timing of manure applications may also provide benefits for restoring the impaired water body.

In an effort to most effectively implement voluntary BMPs, MDNR may work with the NRCS, local university extension offices and the local Soil and Water Conservation District to encourage area land owners to implement these practices. An additional approach may be to work with these agencies to form a watershed group comprised of local stakeholders to promote the use of erosion control practices.