



**Total Maximum Daily Load (TMDL)  
South Fork Blackwater River  
Pollutant: Sediment**

**Name:** South Fork Blackwater River

**Downstream Location:** Johnson County, Missouri

**Hydrologic Unit Code (HUC):** 10300104

**Water Body Identification (WBID):** 921

**Missouri Stream Class:** The impaired segment of South Fork Blackwater River is a Class P Stream<sup>1</sup>.

**Beneficial Uses<sup>2</sup>:**

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

**Size of Impaired Segment:** 5 miles

**Location of Impaired Segment<sup>3</sup>:** From 12, 46N, 27W to 19, 46N, 27W (refer to Table H 10 CSR 20-7)

**Pollutant:** Sediment

**Pollutant Source:** Agricultural Non-point Source

**TMDL Priority Ranking:** High

## **1 Introduction**

This South Fork Blackwater River Total Maximum Daily Load (TMDL) for sediment is being established in accordance with Section 303(d) of the Clean Water Act, because the State of Missouri determined on the 1998 and 2002 303(d) lists of impaired waters that the water quality standards (WQS) for South Fork Blackwater River were exceeded due to sediment. 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, EPA is establishing this TMDL.

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<sup>1</sup> Class P streams maintain permanent flow during drought conditions. See 10 CSR 20-7.031(1)(F)

<sup>2</sup> For Beneficial Uses see 10 CSR 20-7.031(1)(C) and Table H

<sup>3</sup> See Table H 10 CSR 20-7

The purpose of a TMDL is to determine the pollutant loading a waterbody can assimilate without exceeding the WQS for that pollutant. The TMDL also establishes the pollutant load allocation necessary to meet the WQS established for each waterbody based on the relationship between pollutant sources and in-stream water quality conditions. The TMDL consists of a wasteload allocation (WLA), a load allocation (LA), and margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources. The LA is the fraction of the total pollutant load apportioned to non-point sources. The MOS is a percentage of the TMDL that accounts for the uncertainty associated with the model assumption and data inadequacies.

## **2 Background and Water Quality Problems**

South Fork Blackwater River is located in the Blackwater River Basin in Johnson County, Missouri. The primary cause of the sediment impairment to South Fork Blackwater River has been identified as pollution caused by agricultural non-point sources.

All waters of the State, as per Missouri WQS, must provide suitable conditions for aquatic life. The conditions include both the physical habitat and the quality of the water. TMDLs are not written to address habitat, but are written to correct water quality conditions. Because the water body addressed by this TMDL was assessed as to its biological function, many factors may have contributed to the impairment. The state of Missouri continues to do field evaluation and in the future, may define the role sediment is playing in the potential biological impairment of this waterbody. However, the water quality condition for which South Fork Blackwater River is currently listed is sedimentation; therefore, this TMDL addresses sediment. The state of Missouri may submit and EPA may approve another TMDL or a modified 303(d) listing for this water at a later time to address new information on the impairment.

A combination of natural geology and land use (Figure 1 and Table 1) in the prairie portions of the state, where South Fork Blackwater River is located, is believed to have reduced the amount and impaired the quality of habitat for aquatic life. The major problems are excessive rates of sediment deposition due to stream bank erosion and sheet erosion from agricultural lands, loss of stream length and loss of stream channel heterogeneity due to channelization, and changes in basin hydrology that have increased flood flows and prolonged low flow conditions. Loss of tree cover in riparian zones has caused elevated water temperatures in summer and a reduction in woody debris, a critical aquatic habitat component in prairie streams. The most compelling evidence of loss or impairment of aquatic habitat is the historical changes in the distribution of fishes in Missouri. Many species of fish no longer appear in portions of the state where they once lived.<sup>4</sup>

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<sup>4</sup> Missouri Department of Natural Resources (MDNR) (2005). Total Maximum Daily Load (TMDL) Information Sheet For Streams with Aquatic Habitat Loss that are Listed for Sediment, <http://www.dnr.mo.gov/env/wpp/tmdl/info/habitat-info.pdf>

The South Fork Blackwater River was placed on the Missouri 303(d) list for sedimentation. This was primarily based on best professional judgment because little sediment data exists to directly document sediment impacts to the stream. General fisheries data and the effect of sediment on fish were the initial data used to consider South Fork Blackwater River for 303(d) listing. For this TMDL, sediment targets were derived using generalized information from the ecological drainage unit (EDU). Since the 303(d) listing, Missouri Department of Natural Resources (MDNR) has developed a sediment protocol to determine if sediment is actually the pollutant in the streams listed and to arrive at a standard way to measure sediment. The first step of that protocol is a biological assessment to see if the biological community is actually impaired. A completed biological assessment was not yet available for this waterbody.

**Table 1: Land Use Distribution for South Fork Blackwater River**

<b>Type</b>	<b>Percent</b>
Barren or Sparsely Vegetated	0.2%
Cropland	21.3%
Deciduous Forest	18.4%
Deciduous Woody/Herbaceous	3.1%
Grassland	49.0%
Herbaceous-Dominated Wetland	0.2%
High Density Urban	<0.1%
Impervious	4.2%
Low Intensity Urban	1.4%
Open Water	1.7%
Woody-Dominated Wetland	0.6%
<b>Watershed Area = 181 mi<sup>2</sup></b>	

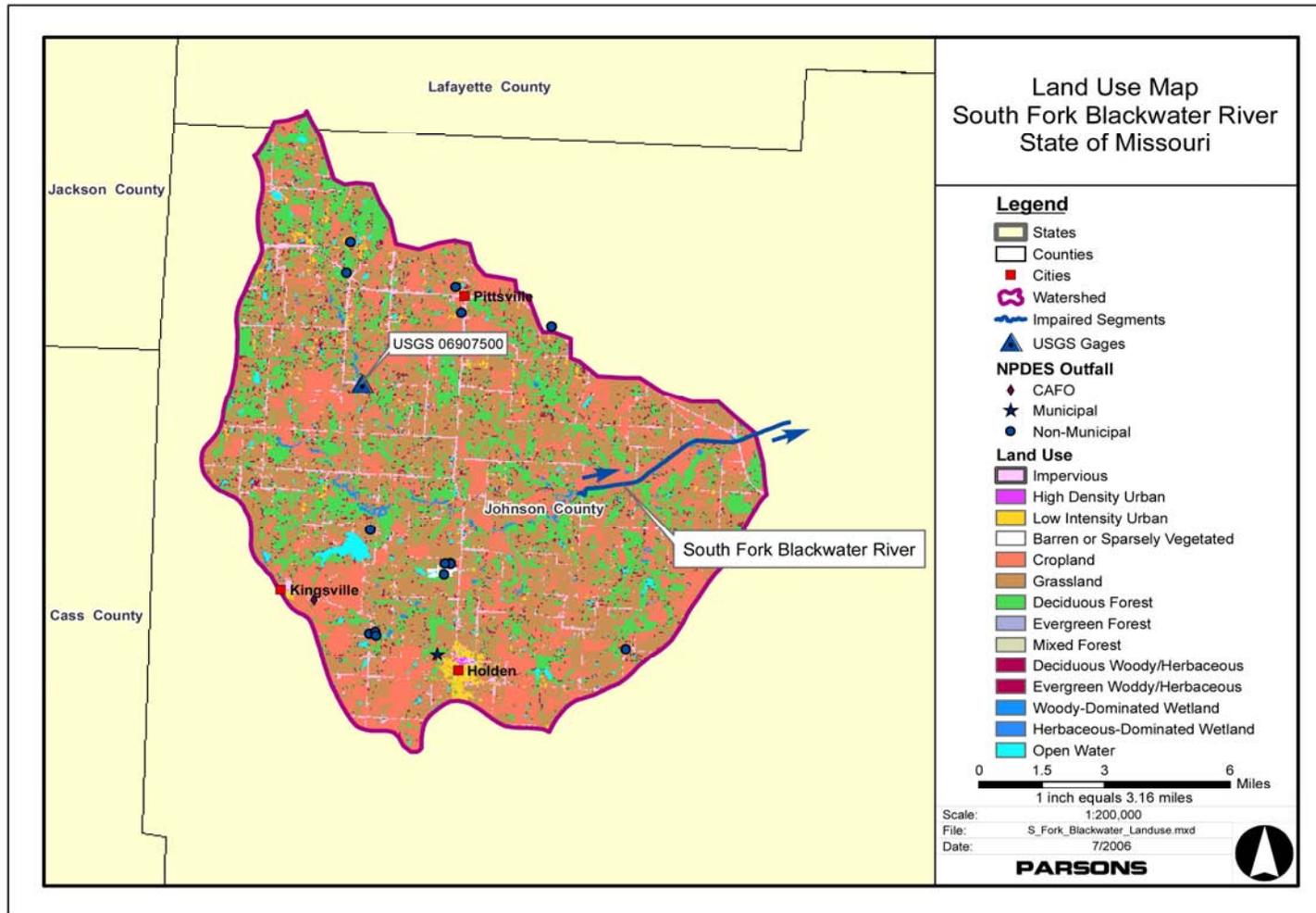
### **3 Description of Sources**

#### **3.1 Point Sources**

Thirteen National Pollutant Discharge Elimination System (NPDES) permitted facilities are located within the watershed (Table 2). Eight of these facilities have site specific permits while the rest are covered under general permits.

Livestock in the watershed include many horses, cattle, and hogs held in pastures, feedlots, and Concentrated Animal Feeding Operations (CAFO). One operation is registered, certified or permitted within the watershed. CAFOs are animal feeding operations in which animals are confined to areas that are totally roofed. CAFOs typically utilize earthen or concrete structures to contain and store manure prior to land application.

All permitted livestock facilities have waste management systems designed to minimize runoff entering their operations or detaining runoff emanating from their areas. Such systems are designed for the 25-year, 24-hour rainfall/runoff event. NPDES



**Figure 1: Land Use Map for South Fork Blackwater River**

permits, also non-discharging, are issued for facilities with more than 1,000 animal units (AU). For all facilities, total potential numbers are approximately 1,290 AU. The actual number on site is variable, but typically less than potential numbers.

**Table 2: Permitted Facilities**

<b>Facility - CAFOs</b>	<b>Permit number</b>	<b>County</b>	<b>Design Flow</b>
Kingsville Livestock Auction	MO-G010563	Johnson	Non discharging
<b>Facility – Other</b>			
Holden Municipal WWTP	MO-0057908	Johnson	0.29
Powell Gardens WWTF	MO-0123501	Johnson	0.007
Elm Quick Mart	MO-0124729	Johnson	0.01
Integrity Correctional CT	MO-0124885	Johnson	0.024
AECI, Holden Power Plant (Outfall 01, 02 and 03)	MO-0126560	Johnson	0.048
Maplewood Estates WWTF	MO-0127167	Johnson	0.0104
Miss Kitty’s Saloon	MO-0128228	Johnson	0.00084
Parkwood Estates	MO-0130931	Johnson	0.031
Limpus Quarries Inc. #4	MO-G490096	Johnson	storm water discharge
Whistle Redi-Mix Inc. – HO	MO-G490795	Johnson	storm water discharge
Holden WTP	MO-G640092	Johnson	filter back wash discharge
XMAA 8in Pipeline	MO-G670347	Johnson	hydrostatic test water discharge

### 3.2 Non-Point Sources

Most of the watershed is grassland (49%), cropland (21%), or deciduous forest (18%). Cropland appears to be spread evenly throughout the watershed. Cropland that is adjacent to and drains into South Fork Blackwater River, could contribute to the sediment impairment. In addition to the one NPDES-permitted CAFO in the watershed (Table 2), there are other livestock (Table 3). Overland runoff can easily carry sediment into the stream. Soil, from exposed land, runs into the creek, increasing the turbidity and concentration of total suspended solids (TSS) and decreasing the transparency. Background levels of TSS come from natural fluvial processes. Sediment becomes suspended during high flow events as soil along the banks is eroded and bed sediment is resuspended. Sediment loading in the South Fork Blackwater River watershed comes predominantly from nonpoint source pollution.

**Table 3: Livestock Estimates (AU) per County<sup>5</sup>**

	<b>Camden</b>	<b>Johnson</b>
<b>Cattle</b>		
<b>Beef</b>	13,209	39,195
<b>Milk</b>	784	1,306
<b>Cow/Calf</b>	27,605	78,942
<b>Hogs/Pigs</b>	8,492	4,835
<b>Sheep/Lambs</b>	530	1,161
<b>Poultry</b>		
<b>Layers</b>	1,343	(D)
<b>Broilers</b>	11,100	2,354

(D) Withheld to avoid disclosing data for individual farms.

## **4 Description of the Applicable WQS and Water Quality Targets**

### **4.1 Beneficial Uses**

South Fork Blackwater River has the following beneficial uses:

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

The stream classifications and designated uses may be found at 10 CSR20-7.031(1)(C) and (F) and Table H.

Use that is impaired:

- Protection of Warm Water Aquatic Life

### **4.2 Antidegradation Policy**

Missouri’s WQS include the EPA “three-tiered” approach to antidegradation, and may be found at 10 CSR 20-7.031(2).

Tier 1 – Protects existing uses and provides the absolute floor of water quality for all waters of the United States. Existing in-stream water uses are those uses that were attained on or after November 29, 1975, the date of EPA’s first WQS Regulation, or uses for which existing water quality is suitable unless prevented by physical problems such as substrate or flow.

<sup>5</sup> USDA- NASS Quick Stats (Livestock) 2002 Census of Agriculture, Volume 1 Chapter 2: Missouri County Level Data [http://www.nass.usda.gov/census/census02/volume1/mo/st29\\_2\\_001\\_001.pdf](http://www.nass.usda.gov/census/census02/volume1/mo/st29_2_001_001.pdf)

Tier 2 – Protects the level of water quality necessary to support the propagation of fish, shellfish, and wildlife and recreation in and on the water in waters that are currently of higher quality than required to support these uses. 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 economical or 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 non-point sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the “fishable/swimmable” uses and other existing uses.

Tier 3 – Protects the quality of outstanding national resources, 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 (with the exception of some limited activities that result in temporary and short-term changes in water quality).

#### **4.3 Narrative Criteria**

General or narrative criteria are contained in Missouri’s WQS 10 CSR 20-7.030 (3)(A)(C) and (G). These criteria state:

- (A) 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;
- (C) Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor or prevent full maintenance of beneficial uses;
- (G) Waters shall be free from physical, chemical or hydrologic changes that would impair the natural biological community.

When the WQS is expressed as a narrative value, a measurable indicator of the pollutant may be selected to express the narrative as a numeric value. There are many quantitative indicators of sediment, such as, TSS, turbidity, and bedload sediment, which are appropriate to describe sediment in rivers and streams.<sup>6</sup> TSS was selected as the numeric target for this TMDL because it enables the use of the highest quality data available, including permit conditions and monitoring data.

## **5. Calculation of Load Capacity**

Load capacity (LC) is defined as the maximum pollutant load that a waterbody can assimilate and still attain WQS. This total load is then divided among a WLA for point sources, a LA for nonpoint sources and a MOS. The LC for this TMDL has been

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<sup>6</sup> Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria, U.S. Environmental Protection Agency, EPA-822-R-06-001, May 2006.

defined as a curve over the range of flows for South Fork Blackwater River, see Figure 2, where the solid (red) curve is the TMDL. Turbidity measurements taken during field sampling for a biological assessment (report in preparation) were used to estimate TSS concentrations using relationships developed by Doisey and Rabeni (2004)<sup>7</sup>. These estimates are shown in Figure 2, where the round (black) points are loads calculated from the estimated concentrations and the corresponding horizontal (red) bars are the percent reduction required to meet the TMDL.

### 5.1 Modeling Approach

In cases where pollutant data for the impaired stream is not available a reference approach is used. In this approach, the target for pollutant loading is the 25<sup>th</sup> percentile of the current EDU condition calculated from all data available within the EDU in which the waterbody is located. Therefore, the 25<sup>th</sup> percentile is targeted as the TMDL load duration curve (LDC). For a full description of the development of suspended sediment targets using reference LDC refer to Appendix B. Specific data sources for this TMDL's flow and EDU-wide TSS data are listed in Appendix C. Table 4 shows estimates of discharge at flow percentiles.

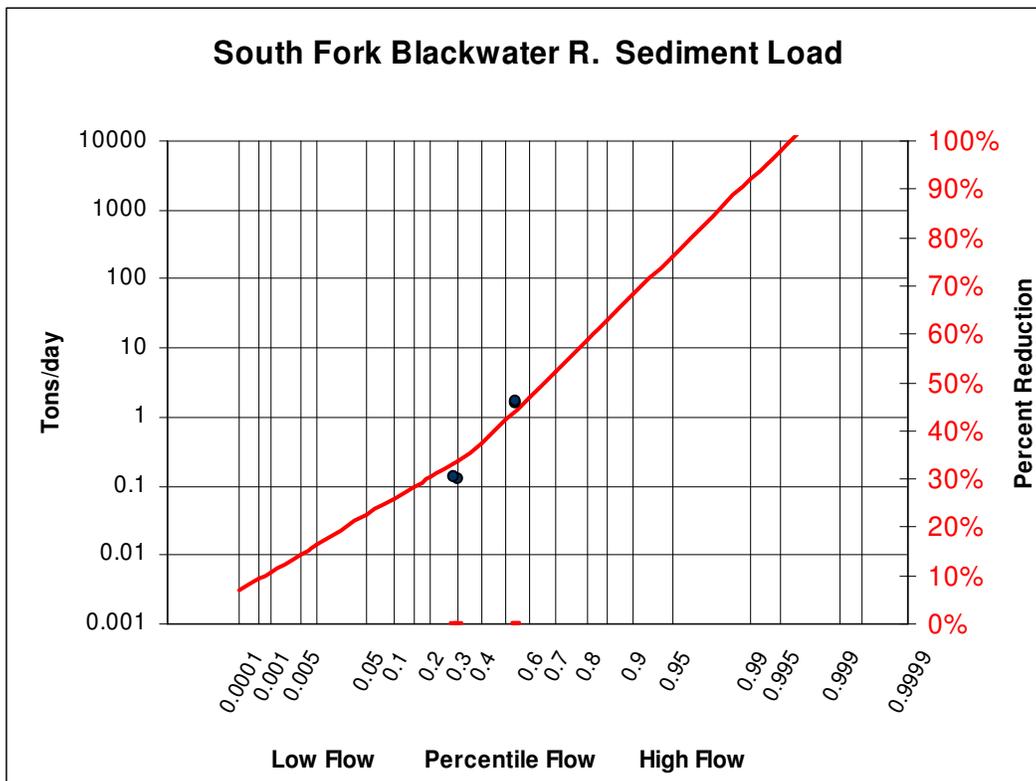


Figure 2: TMDL for South Fork Blackwater River

<sup>7</sup> Effects of Suspended Sediment on Native Missouri Fishes: A Literature Review and Synthesis, K.E. Doisey and C.F. Rabeni, 2004, University of Missouri.

**Table 4: Estimated Flow for Range of Percentiles at the Impaired Segment Outlet**

	Percent of Flow Occurrence	Discharge (cubic feet per second)
Flow Estimate for South Fork Blackwater River Based on Drainage Area and Synthetic Ecological Drainage Unit Flow	10	2.29
	30	7.96
	50	20.1
	70	53.7
	90	249

## **6 Waste Load Allocation (Point Source Loads)**

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). TBELs are defined in a permit based on facility type. Mechanical waste water treatment facilities' (WWTFs') permit limits are a weekly average TSS concentration of 45 mg/L and a monthly average TSS concentration of 30 mg/L. Secondary equivalent WWTFs' permit limits are a weekly average TSS concentration of 60 mg/L and a monthly average TSS concentration of 45 mg/L. Waste water treatment lagoon facilities' permit limits are up to a weekly average TSS concentration of 120 mg/L and a monthly average TSS concentration of 80 mg/L. Additionally, permits can be written to target lower limits if the specific facility is capable of performance exceeding TBELs. Table 5 lists the permitted point sources in the watershed and WLAs based on their current permit limits and permitted design flows. In addition any general permits need evaluation to determine if a site specific permit is needed to address sediment loading. Based on the assessment of sources, point sources do not contribute to water quality impairment relative to sediment impacts on stream biology. Thus, the WLAs are zero percentage net reduction in sediment load. These facilities' WLAs are set at the current permit limits and conditions. The WLAs listed in this TMDL do not preclude the establishment of future point sources of sediment loading in the watershed. 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 5. WLAs for permitted facilities.**

Facility - CAFOs	Permit number	WLA (tons/day) d/w/m*
Kingsville Livestock Auction	MO-G010563	0/0/0
<b>Facility – Other</b>		
Holden Municipal WWTP	MO-0057908	NA/0.07/0.05
Powell Gardens WWTF	MO-0123501	NA/0.001/0.0009
Elm Quick Mart	MO-0124729	NA/0.005/0.003
Integrity Correctional CT	MO-0124885	NA/0.004/0.003
AECI, Holden Power Plant (Outfall 01, 02 and 03)	MO-0126560	
Maplewood Estates WWTF	MO-0127167	NA/0.005/0.003
Miss Kitty’s Saloon	MO-0128228	NA/0.006/0.004
Parkwood Estates	MO-0130931	NA/0.0002/0.0001
Limpus Quarries Inc. #4	MO-G490096	non-storm water discharges TSS 70 mg/L, storm water discharges settleable solids daily maximum 1.5 mL/L/hr, inclusion of BMPs
Whistle Redi-Mix Inc. – HO	MO-G490795	non-storm water discharges TSS 70 mg/L, storm water discharges settleable solids daily maximum 1.5 mL/L/hr, inclusion of BMPs
Holden WTP	MO-G640092	Maximum daily settleable solids 1.0 ml/L/hr, inclusion of BMPs
XMAA 8in Pipeline	MO-G670347	Maximum TSS concentration 100 mg/L

\*Permit limits based on current design loads where d=daily, w=weekly average, m=monthly average.

Stormwater runoff from all permitted facilities also discharges to the stream. Compliance with the Missouri Storm Water Permit will ensure construction sites meet the TMDL area weighted loadings. The permittee will develop a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP ensures the design, implementation, and maintenance of BMPs. EPA assumes that construction activities in the watershed will be conducted in compliance with Missouri’s Storm Water Permit including monitoring and discharge limitations. Compliance with this permit should lead to sediment loadings from the construction site at or below applicable targets.

## **7 Load Allocation (Non-point Source Loads)**

LA is the allowable amount of the pollutant that can be assigned to non-point sources. The TMDL curve in Figure 2 is set at an estimate of reference conditions over the range of flows. The LA is set at 90% of the TMDL.

## **8 Margin of Safety**

A MOS is added to a TMDL to account for the uncertainties inherent in the calculations and data gathering. 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.

Available data for South Fork Blackwater River shows loading at or near the TMDL (Figure 2). To account for uncertainties in the modeling an explicit 10% MOS is assigned to this TMDL. For example, at the flow probability of 0.5 (median flow), the TMDL is approximately 1.4 tons/day and the MOS would be 0.14 tons/day.

## **9 Seasonal Variation**

The TMDL curve represents flow under all seasonal conditions. The LA and TMDL are applicable at all flow conditions, hence all seasons. The advantage of LDC approach is to avoid the constraints associated with using a single-flow critical condition during the development of a TMDL. Therefore, all flow conditions including seasonal variation are taken into account for TMDL calculations.

## **10 Monitoring Plans for South Fork Blackwater River**

MDNR scheduled a biocriteria study on South Fork Blackwater River in the 2006. No future monitoring has been scheduled for South Fork Blackwater River at this time. However, the department will routinely examine physical habitat, water quality, invertebrate community, 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.

## **11 Public Participation**

EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). EPA is providing public notice of this TMDL for South Fork Blackwater River on the EPA, Region 7, TMDL website: [http://www.epa.gov/region07/water/tmdl\\_public\\_notice.htm](http://www.epa.gov/region07/water/tmdl_public_notice.htm). The EPA public noticed this TMDL from September 29, 2006, to October 29, 2006, and the Summary of Response to Comments is posted on the EPA website: <http://www.epa.gov/region07/water/apprtmdl.htm#Missouri>.

This water quality limited segment of South Fork Blackwater River in Johnson County, Missouri, is included on the EPA approved 1998 and 2002 303(d) lists for Missouri. This TMDL is being produced 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 fulfill the *American Canoe* consent decree obligations. Missouri may submit and EPA may approve another TMDL for this water at a later time.

As part of the public notice process, MDNR assists EPA by providing a distribution list of interested persons to which EPA will provide an announcement of the South Fork Blackwater River TMDL. Groups that receive the public notice announcement include the Missouri Clean Water Commission, the Missouri Water Quality Coordinating Committee, Stream Team Volunteers in the county, county legislators, and potentially impacted cities, towns and facilities. EPA will respond to comments on this draft TMDL after public notice ends on September 29, 2006, and will post the response to comments on the EPA website:  
<http://www.epa.gov/region07/water/apprtmdl.htm#Missouri>.

## References

Missouri Department of Natural Resources (MDNR) (2005). Total Maximum Daily Load (TMDL) Information Sheet For Streams with Aquatic Habitat Loss that are Listed for Sediment, <http://www.dnr.mo.gov/env/wpp/tmdl/info/habitat-info.pdf>

Missouri Department of Natural Resources (MDNR) (2007). Quality Assurance Project Plan for Wasteload Allocations/Special Studies

Kansas Department of Health and Environment (KDHE) (2000). Upper Wakarusa River TMDL (Sediment Impact on Aquatic Life), <http://www.kdheks.gov/tmdl/klr/UpWakaTSS.pdf> and Little Arkansas River TMDL (Sediment Impact on Aquatic Life), <http://www.kdheks.gov/tmdl/la/LittleArkSed.pdf>

USDA (2002). NASS Quick Stats (Livestock) Census of Agriculture, Volume 1 Chapter 2: Missouri County Level Data  
[http://www.nass.usda.gov/census/census02/volume1/mo/st29\\_2\\_001\\_001.pdf](http://www.nass.usda.gov/census/census02/volume1/mo/st29_2_001_001.pdf)

USEPA (2006). Development of Suspended Sediment Targets using Reference Load Duration Curves, EPA Region 7, Kansas City, KS

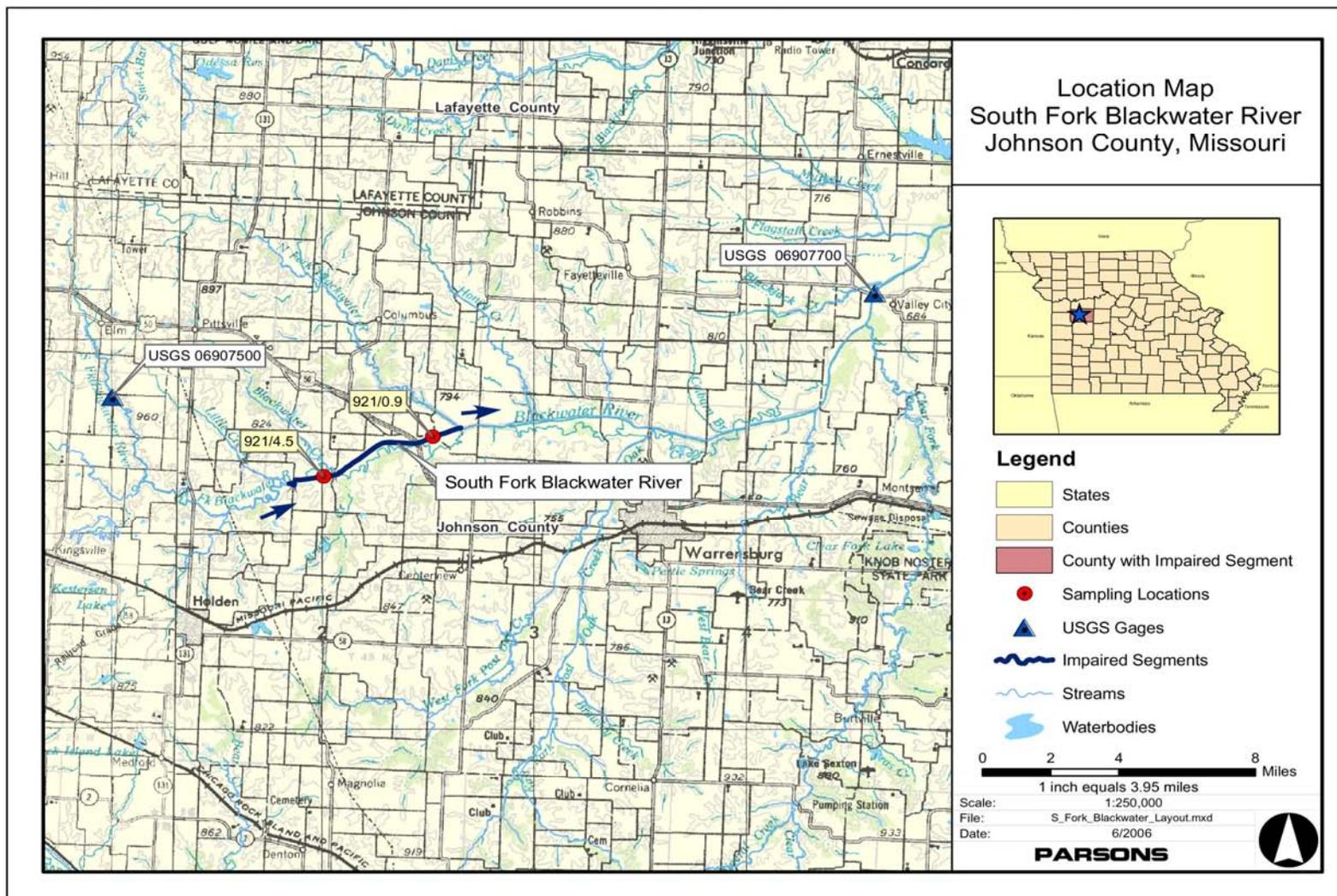
Effects of Suspended Sediment on Native Missouri Fishes: A Literature Review and Synthesis, K.E. Doisey and C.F. Rabeni, 2004, University of Missouri.

## **Appendices**

Appendix A: Location Map for South Fork Blackwater River

Appendix B: Development of Suspended Sediment Targets using Reference Load Duration Curves

Appendix C: Data Sources Used to Develop the TMDL



**Appendix A: Location Map for South Fork Blackwater River**

## **Appendix B**

### **Development of Suspended Sediment Targets using Reference Load Duration Curves**

#### **Overview**

This procedure is used when a lotic system is placed on the 303(d) impaired waterbody 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 25<sup>th</sup> percentile calculated from all data available within the ecological drainage unit (EDU) in which the waterbody 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. From this synthetic record develop a flow duration from which to build a load duration curve for the pollutant within the EDU.

From this population of load durations follow the reference method used in setting nutrient targets in lakes and reservoirs. In this methodology the average concentration of either the 75<sup>th</sup> percentile of reference lakes or the 25<sup>th</sup> percentile of all lakes 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 25<sup>th</sup> percentile of load duration of the available data within the EDU as the TMDL load duration curve. 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 load duration curve uses the 25<sup>th</sup> percentile of EDU concentration at flows where surface runoff is less than 1% of the stream flow. This results in an inflection point in the curve below which the TMDL is calculated using this reference concentration.

#### **Methodology**

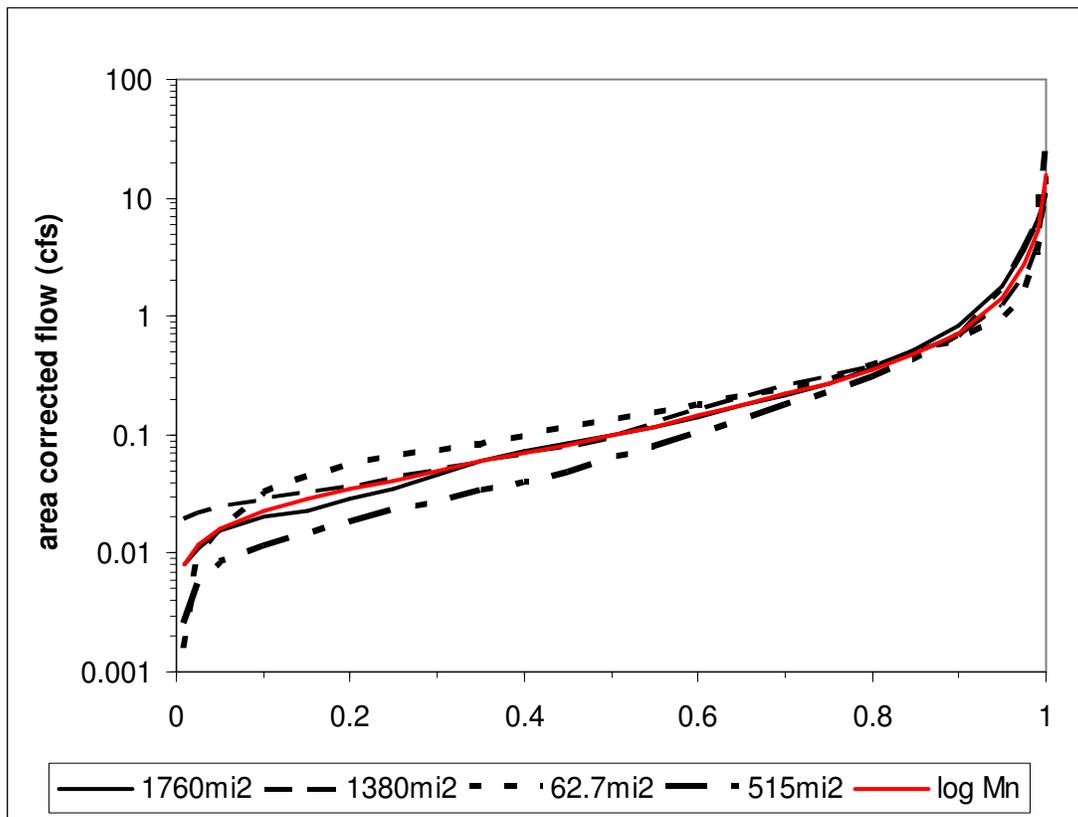
The first step in this procedure is to locate available pollutant data within the EDU of interest. These data along with the instantaneous flow measurement taken at the time of sample collection for the specific date are recorded to create the population from which to develop the load duration. Both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

Secondly, collect average daily flow data for gages with a variety of drainage areas for a period of time to cover the pollutant record. From these flow records normalize the flow to a per square mile basis. Average the log transformations of the average daily discharge for each day in the period of record. For each gage record used to build this synthetic flow record calculate the Nash-Sutcliffe statistic to determine if the

relationship is valid for each record. This relationship must be valid in order to use this methodology. This new synthetic record of flow per square mile is used to develop the load duration for the EDU. The flow record should be of sufficient length to be able to calculate percentiles of flow.

The following examples show the application of the approach to one Missouri EDU.

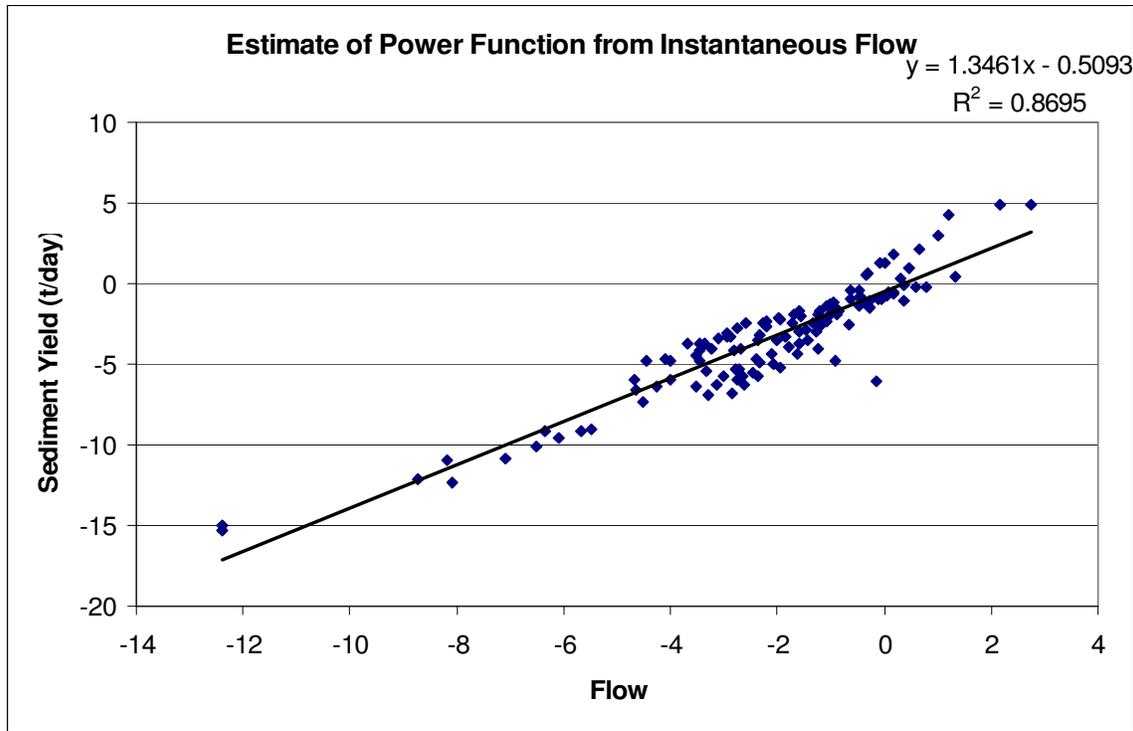
The watershed-size normalized data for the individual gages in the EDU were calculated and compared to a pooled data set including all of the gages. The result of this analysis is displayed in the following figure and table:



Gage	gage	area (mi <sup>2</sup> )	normal Nash-Sutcliffe	lognormal Nash-Sutcliffe
Platte River	06820500	1760	80%	99%
Nodaway River	06817700	1380	90%	96%
Squaw Creek	06815575	62.7	86%	95%
102 River	06819500	515	99%	96%

This demonstrates the pooled data set can confidently be used as a surrogate for the EDU analyses.

The next step is to calculate pollutant-discharge relationships for the EDU, these are log transformed data for the yield (tons/mi<sup>2</sup>/day) and the instantaneous flow (cfs/mi<sup>2</sup>.) The following graph shows the EDU relationship:



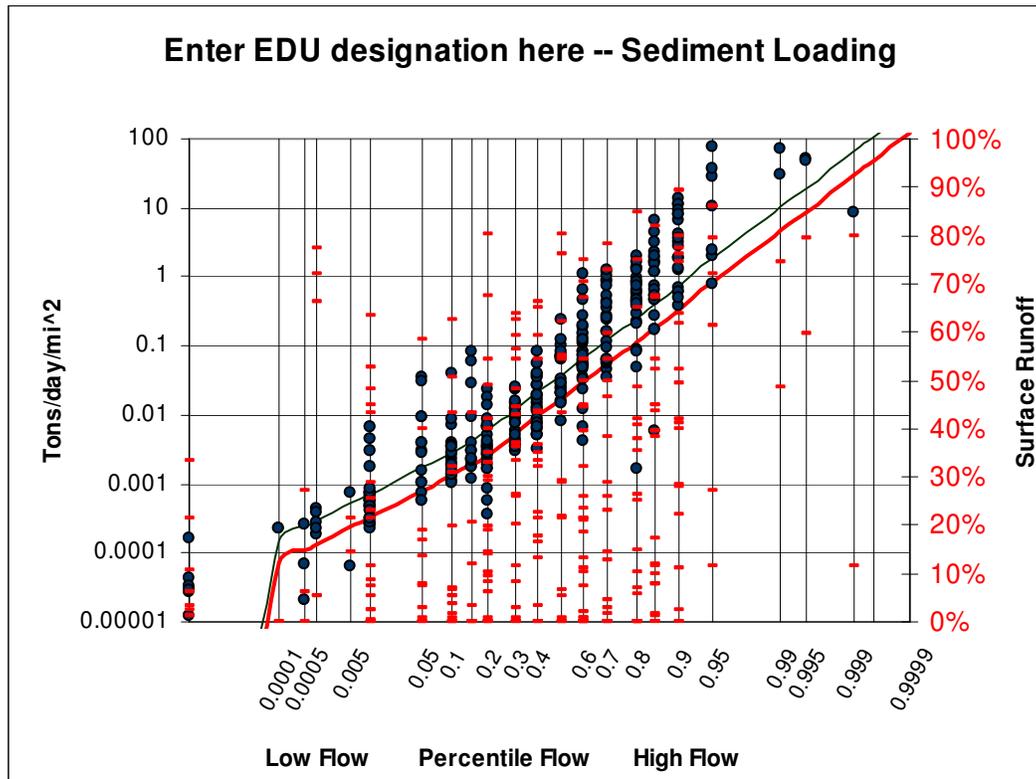
Further statistical analyses on this relationship are included in the following Table:

m	1.34608498	b	-0.509320019
Standard Error (m)	0.04721684	Standard Error (b)	0.152201589
r <sup>2</sup>	0.86948229	Standard Error (y)	1.269553159
F	812.739077	DF	122
SSreg	1309.94458	SSres	196.6353573

The standard error of y was used to estimate the 25%ile level for the TMDL line. This was done by adjusting the intercept (b) by subtracting the product of the one-sided Z<sub>75</sub> statistic times the standard error of (y). The resulting TMDL Equation is the following:

$$\text{Sediment yield (t/day/mi}^2\text{)} = \exp(1.34608498 * \ln(\text{flow}) - 1.36627)$$

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



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

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

## **Appendix C**

### **Data Sources Used to Develop the TMDL**

USGS stream gages used to generate synthetic flow

Lamine River nr Otterville	06906800
Blackwater R at Blue Lick	06908000

USGS stream sample sites used to generate EDU TMDL

Blue River nr Stanley KS	06893080
Blue River at Kenneth Road, OP KS	06893100
Lamine River near Pilot Grove, MO	06907300
Lamine River near Blackwater, MO	06908800