U.S. Environmental Protection Agency Region 7

Little Medicine Creek Grundy, Sullivan, Putnam and Mercer Counties, Missouri

Total Maximum Daily Load

September, 2006

Approved by:

/s/	10/13/2006
William A. Spratlin	**Date**
Director	
Water, Wetlands, and Pesticides Division	

Total Maximum Daily Load (TMDL)
Little Medicine Creek
Pollutant: Sediment

Name: Little Medicine Creek (also listed as: West Fork Medicine Creek)

Downstream Location: Grundy County
Upstream Location: Mercer County

Hydrologic Unit Code (HUC):10280103

Water Body Identification (WBID): 623

Missouri Stream Class: The impaired segment of Little Medicine Creek is a Class P Stream[1].

Beneficial Uses[2]:

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

Size of Impaired Segment: 40 miles

Location of Impaired Segment[3]: From Section 9, 61N, 22W to State Line (refer to Table H 10 CSR 20-7)

Pollutant: Sediment

Pollutant Source: Agricultural Nonpoint Source

TMDL Priority Ranking: High

[1] Class P streams maintain permanent flow during drought conditions, see 10 CSR 20-7.031(1)(F).
[2] For Beneficial Uses see 10 CSR 20-7.031(1)(C) and Table H.
[3] See Table H 10 CSR 20-7.

1. Introduction

This Little Medicine Creek 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 Little Medicine Creek 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.

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 nonpoint 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

Little Medicine Creek is located in the Lower Grand River Basin near Harris, Missouri. The upstream and downstream counties include Mercer and Grundy, respectively. The primary cause of the sediment impairment to Little Medicine Creek has been identified as pollution caused by agricultural nonpoint 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 Little Medicine Creek 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 303d listing for this water at a later time to address new information on the impairment.

A combination of natural geology and land use in the prairie portions of the state (where Little Medicine Creek 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[4].

Little Medicine Creek was placed on the Missouri 303(d) list for sedimentation. This was primarily based on best professional judgment as 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 Little Medicine Creek 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, 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. In the case of Little Medicine Creek, the study measured habitat quality, water quality, and macro-invertebrate communities[5]. Invertebrate sampling was collected in spring for every year between 1996 and 2000, as well as 2004 and 2005, and fall 2003 and 2004. Invertebrate scores of 16 or greater are judged to indicate unimpaired streams while scores equal to or less than 14 are judged to be impaired. The scores for 10 of 34 samples are equal to or less than 14 (Table 2). Therefore, the biological assessment defined the stream as impaired based on aquatic invertebrate scores at various monitoring sites[6].

Table 1: Land Use Distribution for Little Medicine Creek

Type	Percent
Barren or Sparsely Vegetated	0.29%
Cropland	18.24%
Deciduous Forest	12.17%
Deciduous Woody/Herbaceous	3.24%
Evergreen Forest	0.06%
Grassland	59.05%
Herbaceous-Dominated Wetland	1.34%
High Density Urban	0.00%
Impervious	2.03%
Low Intensity Urban	0.17%

[4] Missouri Department of Natural Resources, 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.

[5] Biological Assessment and Habitat Study, Little Medicine Creek, Grundy and Putnam Counties, 1996-2005, Missouri Department of Natural Resources

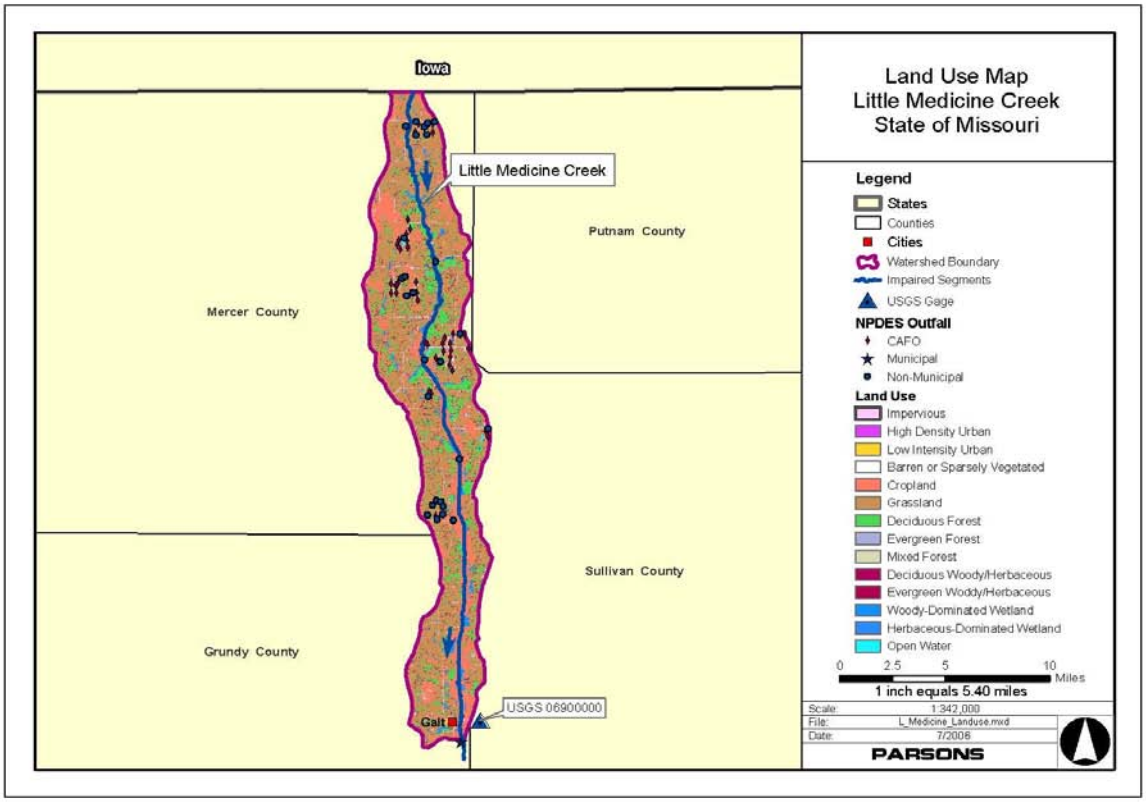
[6] Missouri Department of Natural Resources, 2006. Biological Assessment and Habitat Study, Little Medicine Creek, Grundy and Putnam Counties, 1996-2005.

Open Water	0.83%
Woody-Dominated Wetland	2.58%
Watershed Area = 106.21 mi²	**Sum: 100.00%**

Table 2: Invertebrate Data for Little Medicine Creek

Aquatic Invertebrate Scores ≤ 14			
Sampling Time	**Site 1**	**Site 2**	**Site 3**
Spring 1996	12		
Spring 1997	14, 14		
Spring 1999	14		
Spring 2000	14, 14, 14	14	
Spring 2004	14		14

Figure 1: Land Use Map for Little Medicine Creek Watershed



3. Description of Sources

3.1 Point Sources

Eight NPDES permitted facilities are located within the watershed (Table 3). Six of the facilities are Combined Animal Feeding Operations (CAFO). 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 permits are issued for facilities with more than 1,000 animal units. Total potential animal units (AU) for all facilities are approximately 16,113 AU. The actual number of animal units on site is variable, but typically less than potential numbers.

Galt Wastewater Treatment Facility (WWTF) is located in Grundy County, with a design flow of 0.04 MGD.

Table 3: Permitted Facilities

Facility - CAFOs	Permit number	County	Design Flow
Premium Standard Farms	MO-G010034	Mercer	Non discharging
PSF, Overlook Ranch	MO-G010037	Mercer	Non discharging
PSF, Summers Multipliers	MO-0118141	Mercer	Non discharging
PSF, Peach Perkins Farm	MO-0118150	Mercer	Non discharging
PSF, Somerset Farm	MO-0118168	Mercer	Non discharging
Premium Standard Farms	MO-0118745	Mercer	Non discharging
Facility - Construction			
PSF, Princeton Feed Mill	MO-R12A105	Mercer	N/A
Facility – Other			
Galt WWTF	MO-0095729	Grundy	0.04

3.2 Non-Point Sources

Most of the watershed is grassland (59%), woodland (18%), or cropland (18%). The cropland in the watershed appears to be concentrated near the main stem of Little Medicine Creek. Cropland that is adjacent to and drains into Little Medicine Creek could contribute to the sediment impairment. There are six NPDES-permitted CAFOs in the watershed (Table 3), as well as other livestock, including many horses, cattle, and hogs held in pastures and feedlots (Table 4). Overland runoff can easily carry sediment from agricultural land into the stream. Soil, from exposed land, runs into the creek, increasing the turbidity and concentration of total suspended solids and decreasing the transparency. Background levels of total suspended solids come from natural fluvial processes. Sediment becomes suspended during high flow events as soil along the banks is eroded

and bed sediment is re-suspended. Sediment loading in Little Medicine Creek watershed comes predominantly from nonpoint source pollution.

Table 4 – Livestock Estimates per County[7]

	Mercer	**Grundy**	**Putnam**
Cattle	**Animal Units**	**Animal Units**	**Animal Units**
Beef	15,206	10,644	20,647
Milk	62	927	451
Cow/Calf	27,412	20,462	52,930
Hogs/Pigs	(D)	13,250	(D)
Sheep/Lambs	559	2,038	485
Poultry			
Layers	866	1,019	737
Broilers	(D)	(D)	150

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

4. Description of the Applicable WQS and Water Quality Targets

4.1 Beneficial Uses

Little Medicine Creek has the following beneficial uses:

- Livestock and Wildlife Watering (LWW)
- Protection of Warm Water Aquatic Life
- Human Health associated with Fish Consumption (AQL)
- Whole Body Contact Recreation (WBC) - 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 Anti-degradation Policy

Missouri's WQS include the U.S. Environmental Protection Agency (EPA) "three-tiered" approach to anti-degradation, 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.

[7] 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

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 caters 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 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

The impairment of this waterbody is based on exceedence of the general, or narrative, criteria contained in Missouri's WQS, 10 CSR 20-7.031(3)(A), (C) and (G).

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

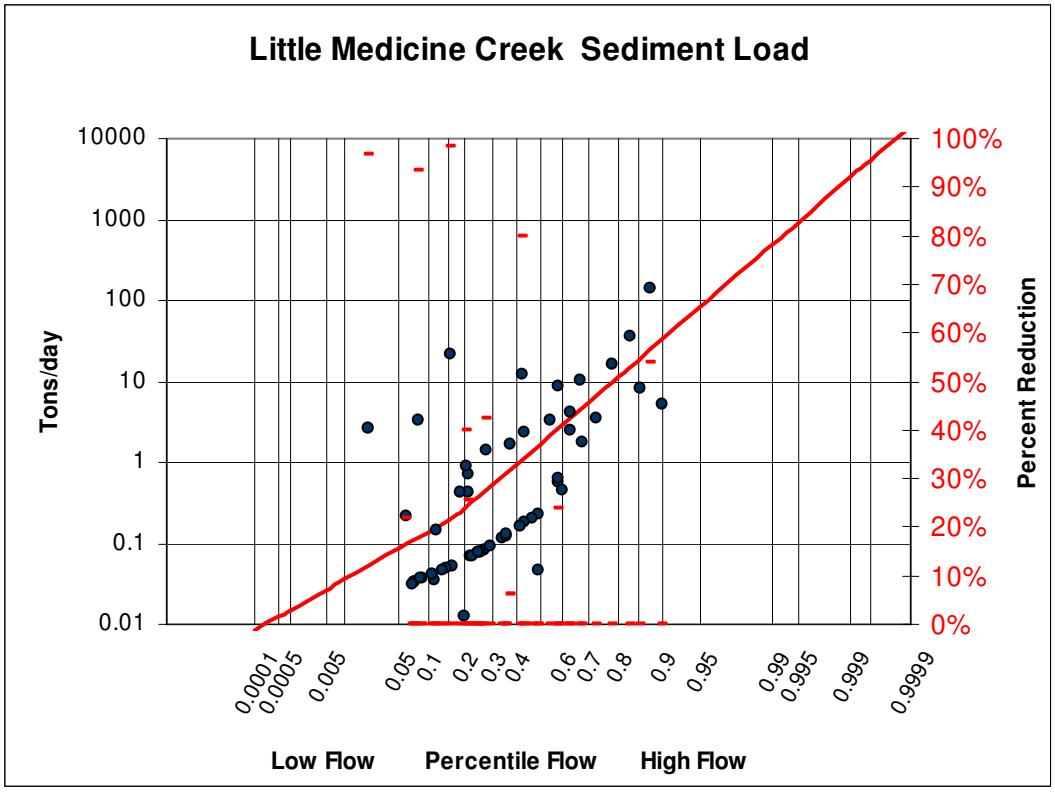
When the WQS is expressed as a narrative value, a measurable indicator of the pollutant may be selected to express the narrative as a numeric value. There are many quantitative indicators of sediment, such as, total suspended solids (TSS), turbidity, and bedload sediment, which are appropriate to describe sediment in rivers and streams.[8] 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.

[8] Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria, U.S. Environmental Protection Agency, EPA-822-R-06-001, May 2006.

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 defined as a curve over the range of flows for Little Medicine Creek, see Figure 2, where the solid (red) curve is the TMDL. The biological assessment (Table 2) showed that Little Medicine Creek is impaired for aquatic life use. Based on Figure 2, the TMDL is a 26% to 100% percent reduction in sediment load over the range of flows. Turbidity measurements taken during the biological assessment were used to estimate TSS concentrations using relationships developed by Doisey and Rabeni (2004)[9]. These estimates are shown in figure 1, where the solid (black) points are loads calculated from the estimated concentrations and the corresponding horizontal (red) bars are percent reduction to meet the TMDL.

Figure 2. TMDL Allocation and Percentage of Reduction for Little Medicine Creek



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 25th percentile of the current EDU condition calculated from all data available within the EDU in which

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

the waterbody is located. Therefore, the 25th percentile is targeted as the TMDL load duration curve. For a full description of the development of suspended sediment targets using reference load duration curves refer to Appendix B. Specific data sources for this TMDL and EDU-wide TSS data are listed in Appendix C. Table 5 shows estimates of discharge at flow percentiles.

Table 5: Estimated Flow for Range of Percentiles at the Impaired Segment Outlet

	Percent of Flow	Discharge (cubic feet per second)
Flow Estimate for Little Medicine Creek Based on Drainage Area and Synthetic Ecological Drainage Unit Flow	10	7.2
	30	20.9
	50	44.5
	70	96.7
	90	308

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 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. 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.

Grundy County has one small municipal WWTF that discharges treated effluent into Little Medicine Creek; if Galt WWTF discharges 80 mg/L of TSS (the monthly average permit limit) at design flow (0.04 MGD), then it would contribute an estimated 0.013 tons per day and the weekly average of 120 mg/L TSS would result in a load of 0.02 tons per day. In addition, stormwater runoff from all permitted facilities, also discharge to the stream. Based on the assessment of sources, point sources do not contribute to water quality impairment relative to sediment impacts on stream biology.

All six permitted livestock facilities (CAFOs) are non-discharging permits. The WLAs are set at zero.

Compliance with the Missouri Storm Water Permit will ensure construction sites meet the TMDL area weighted loadings. One facility with a Storm Water Permit for construction is shown in Table 3. The permittee will develop a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP ensures the design, implementation, and maintenance of Best Management Practices (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 construction sites at or below applicable targets.

7. Load Allocation (Nonpoint Source Loads)

LA is the allowable amount of the pollutant that can be assigned to nonpoint sources. The LA is set at 90% of the TMDL, leaving 10% of the TMDL as a MOS.

8. Margin of Safety

A Margin of Safety (MOS) is usually 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 loading capacity as a separate term in the TMDL.
(2) Implicit – Incorporate the MOS as part of the critical conditions for the waste load allocation and the load allocation calculations by making conservative assumptions in the analysis.

The MOS in this case is explicit (10%). The LA is set at 90% of the TMDL curve shown in Figure 3, for example, at the flow probability of 0.7, the TMDL is approximately 9.6 tons per day. The LA would therefore be 8.6 tons per day and the remaining 1.0 ton per day treated as a MOS.

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 load duration curve (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. Bioassessment data used in this TMDL was generated by MDNR's Environmental

Services Program (ESP). Field monitoring data were collected during both spring and fall seasons from 1996 to 2005 (Table 1).

10 Monitoring Plans for Little Medicine Creek

The department conducted a bioassessment and gathered chemistry data on Little Medicine Creek in 2003-2005. Limitations of time and personnel necessitated dividing the study into an upper and lower portion over a two-year interval. An upper 14-mile section of Little Medicine Creek was sampled in the fall of 2003 and spring of 2004. Sampling of the remaining 26 miles of stream was conducted in the fall of 2004 and spring of 2005. Macroinvertebrates and water quality were sampled each season. Habitat assessments were conducted during the fall.

No future monitoring has been scheduled for Little Medicine Creek 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. In addition, the USGS currently collects ambient water quality data once a month on the West Fork near Harris in Sullivan County. The survey gathers a variety of field and laboratory parameters at this site.

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 Little Medicine Creek on the EPA, Region 7, TMDL website: http://www.epa.gov/region07/water/tmdl_public_notice.htm. The response to comments and final TMDL will be available at: http://www.epa.gov/region07/water/apprtmdl.htm#Missouri.

This water quality limited segment of Little Medicine Creek in Grundy, Sullivan, Putnam and Mercer Counties, 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 Little Medicine Creek 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. The EPA public noticed this TMDL from August 25, to September 25, 2006, and the Summary of Response to Comment(s) is posted on the EPA website: http://www.epa.gov/region07/water/apprtmdl.htm#Missouri.

12. References

Kansas Department of Health and Environment, 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.

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

Missouri Department of Natural Resources, 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, 2006, Biological Assessment and Habitat Study, Little Medicine Creek, Grundy and Putnam Counties, 1996-2005.

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

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.

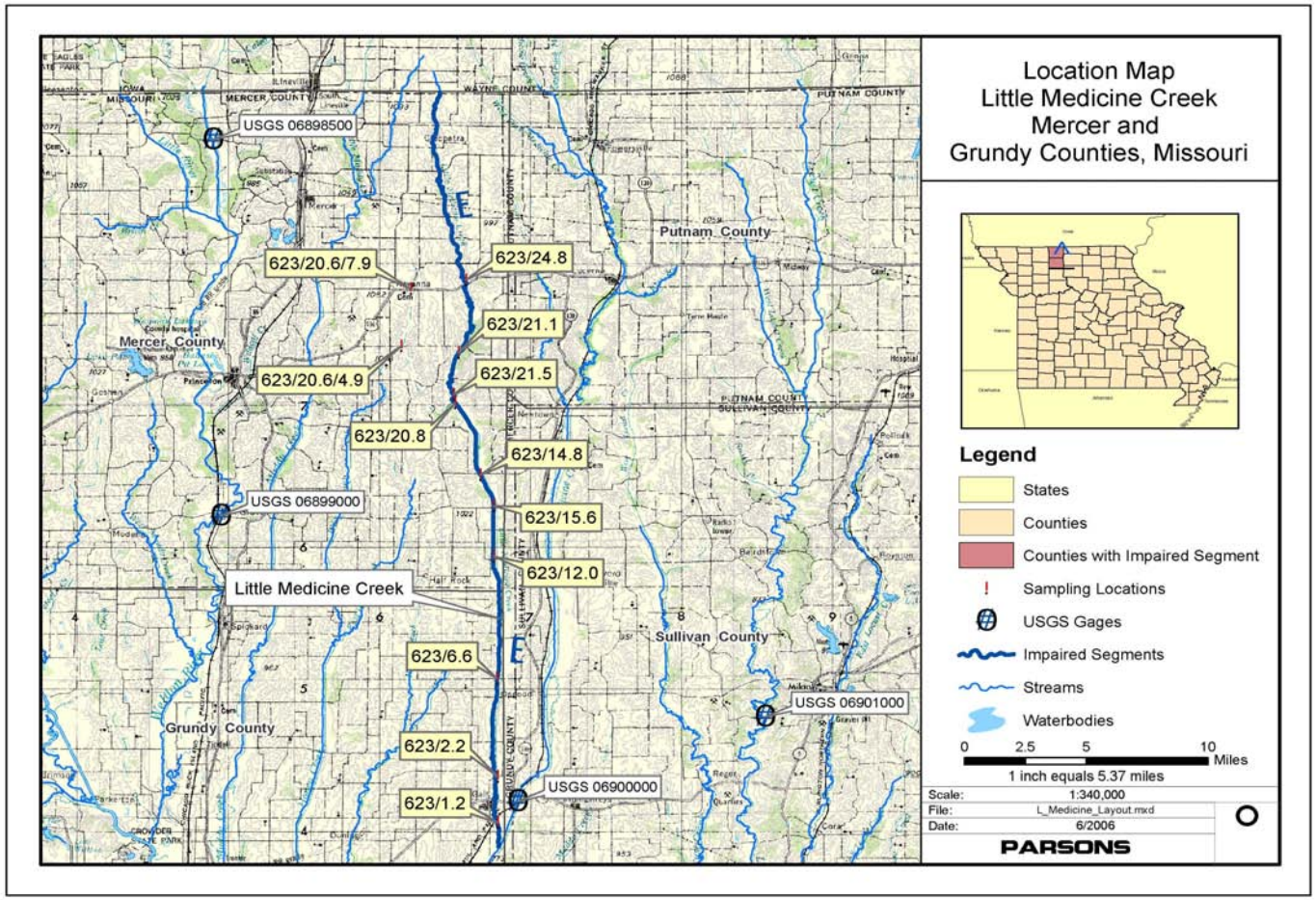
USEPA, 2006, Development of Suspended Sediment Targets using Reference Load Duration Curves, EPA Region 7, Kansas City, KS.

USEPA, May 2006, Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria, EPA-822-R-06-001.

13. Appendices

Appendix A: Location Map for Little Medicine Creek
Appendix B: Development of Suspended Sediment Targets using Reference Load Duration Curves
Appendix C: Data sources Used to Develop TMDL

Appendix A: Location Map for Little Medicine Creek



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 25th 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 75th percentile of reference lakes or the 25th 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 25th 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 25th 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 load calculated with this reference concentration.

Methodology

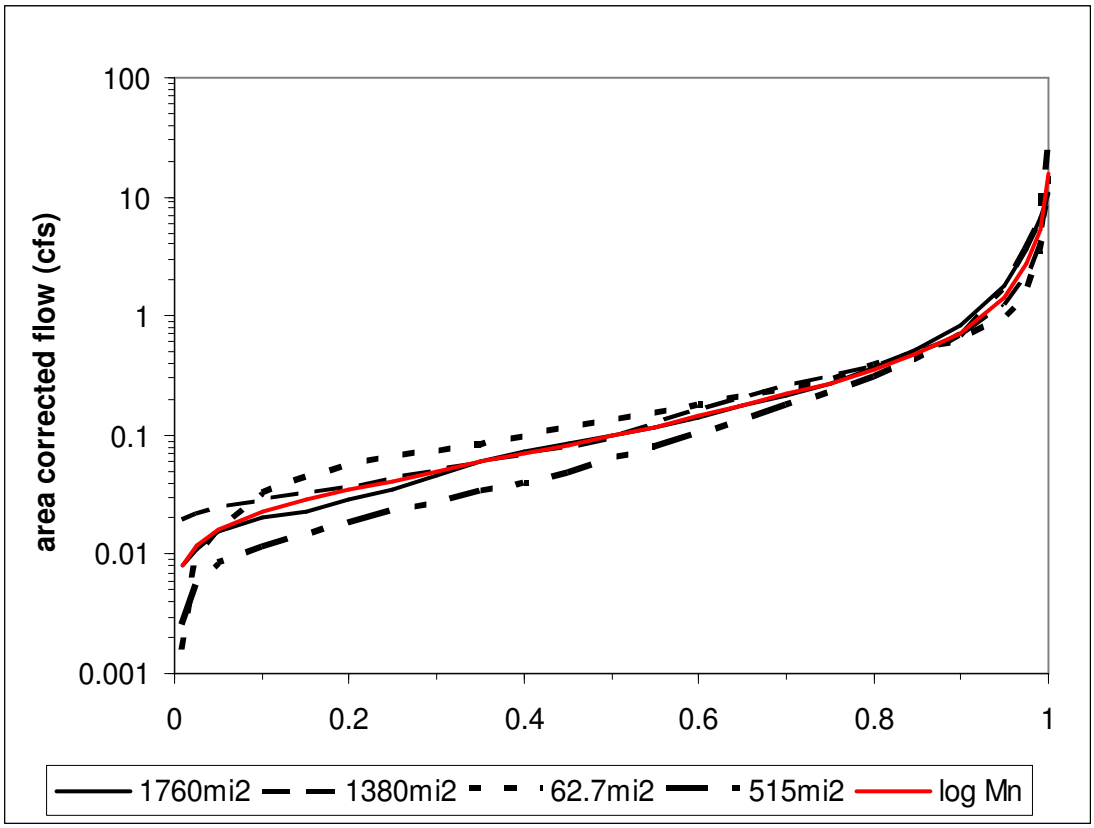
The first step in this procedure is to locate available pollutant data within the EDU of interest. These data along with the instantaneous flow measurement taken at the time of sample collection for the specific date are recorded to create the population from which to develop the load duration. Both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

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

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

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

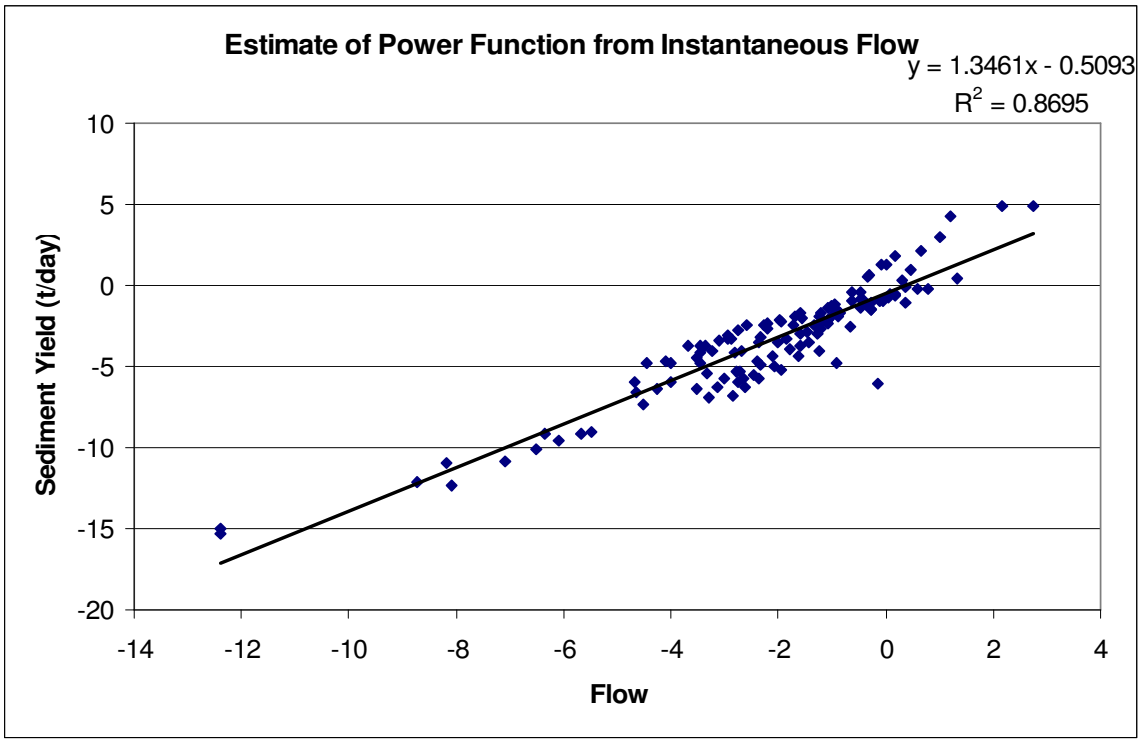
The watershed-size normalized data for the individual gages in the EDU were calculated and compared to a pooled data set including all of the gages. The results of this analysis is displayed in the following figure and table:



Gage	gage	area (mi^2)	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^2/day) and the instantaneous flow (cfs/mi^2.) The following graph shows the EDU relationship:



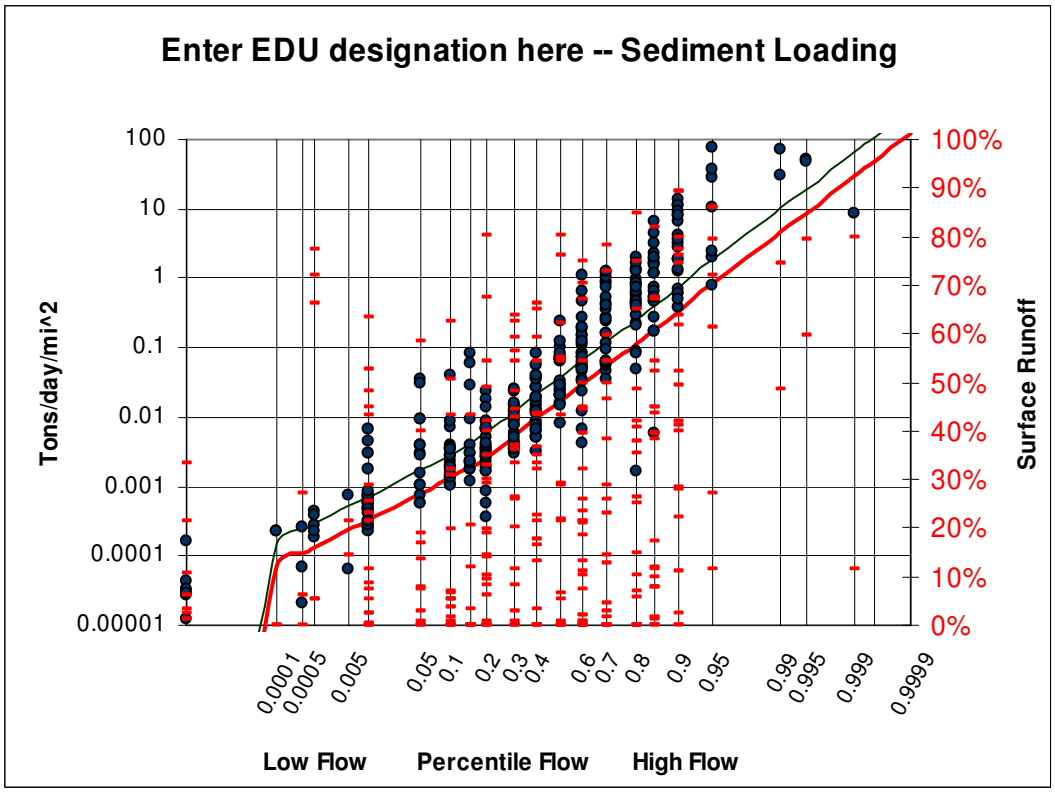
Further statistical analyses on this relationship are included in the following Table:

m	1.34608498	b	-0.509320019
Standard Error (m)	0.04721684	Standard Error (b)	0.152201589
r^2	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_{75} statistic times the standard error of (y). The resulting TMDL Equation is the following:

*Sediment yield (t/day/mi^2)=exp(1.34608498 * ln (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 5th Street
Kansas City, Kansas 66101
Website: http://www.epa.gov/region07/water/tmdl.htm

Appendix C

Data Sources Used To Develop TMDL

USGS stream gages used to generate synthetic flow

Grand River nr Gallatin	06897500
Thompson River at Trenton	06899500
Grand River nr Sumner	06902000
East Fork Little Chariton nr Huntsville	06906300
Mussel Fork nr Mussel Fork	06906000
East Fork Little Chariton nr Macon	06906200

USGS stream sample sites used to generate EDU TMDL

Chariton River nr Prairie Hill	06905500
Mussel Fork nr Mystic	06905725
Mussel Fork nr Mussel Fork	06906000
North River nr Dunlap	06899580
Thompson River nr Mount Moriah	06898100
Weldon River nr Princeton	06898800
Little Medicine Creek nr Harris	06900100
Locust Creek nr Unionville	06900900
East Fork Little Chariton nr Macon	06906200
East Fork Little Chariton nr Huntsville	06906300
Medicine Creek nr Harris	06899950