U.S. Environmental Protection Agency Region 7

Big Muddy Creek
Daviess County, 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)
For Big Muddy Creek

Pollutant: Sediment


Location of Big Muddy Creek Watershed and WBID 436

Name: Big Muddy Creek

Location: Daviess County

Hydrologic Unit Code (HUC): 10280101-180

Water Body Identifications (WBID): 436

Missouri Stream Classification: Class P[1]

Beneficial Uses[2]:

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

Impairment: Protection of Warm Water Aquatic Life

Size of Impaired Segment: 8 miles

Location of Impaired Segment: From (upstream) Section 33, T60N, R27W to its mouth at the Grand River in SE ¼, Section 36, T59N, R27W

Pollutant Source: Agricultural Nonpoint Sources

Pollutant: Sediment

TMDL Priority Ranking: High

[1] Class P streams are streams that maintain permanent flow even in drought periods. See Missouri Water Quality Standards (WQS) 10 Code of State Regulations 20-7.031(1)(F). The WQS can be found at the following uniform resource locator (URL): www.dnr.mo.gov/env/wpp/rules/index.html#Chap7

[2] For Beneficial uses see 10 CSR 20-7.031(1)(C) and Table (H)

1. Introduction

This Big Muddy 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 determined on the 1998 and 2002 303(d) lists of impaired waters that the water quality standards (WQS) for Big Muddy 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.

Big Muddy Creek was placed on the Missouri 303(d) list for sedimentation. Little sediment data exists to directly document sediment as a significant impact to the stream. General fisheries data and the effect of sediment on fish were the initial data used to consider Big Muddy Creek for 303(d) listing. For this TMDL, sediment targets were derived using generalized information from the ecological drainage unit (EDU).

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

Background

Big Muddy Creek is a small northwestern Missouri tributary of the Grand River. The headwaters of Big Muddy lie between Gilman City and Jameson in northern Daviess County. It flows south to the confluence with the Grand River, about 5 miles southeast of Gallatin, Missouri. Eight miles of lower Big Muddy Creek are listed as impaired by sediment. The Big Muddy Creek watershed is approximately 118 mi^2 with predominant landuse of approximately 43% cropland, 41% grassland and 8% deciduous forest (Appendix A). The basin is best characterized as rural with a declining population and no major urban areas. Land use is predominantly agricultural with cropland the largest component.

Big Muddy Creek watershed lies within the Grand River Basin, which lies within the Central Plains - Grand Chariton EDU. Average annual precipitation for the basin ranges from 32 inches in the northwest part of the basin to 36 inches in the southeast portion. Geology of the basin is described as follows in the Grand River Watershed Inventory and Assessment[3]:

[3] Grand River Watershed Inventory and Assessment, Northwest Regional Fisheries, Missouri. http://mdc.mo.gov/fish/watershed/grand/contents/140cotxt.htm

"The Missouri portion of the basin lies entirely within the Dissected Till Plain. The topography consists of broad, flat stream valleys and rolling to undulating (occasionally hilly) uplands. Pennsylvanian shales, sandstones, and limestones underlie the basin. The formations dip slightly to the northwest, exposing outcrops of successively younger formations from the mouth to the headwaters. The entire area was glaciated and later subjected to extensive loessial deposits. The predominating soils are derived from the glacial drift and loess, however, the soil types owe their characteristics more to the stage of weathering than the parent material. Loessial silt loam soils cover the greater part of the broad divides and gentle slopes. Glacial silt loams and silty clay loams, usually highly eroded, occur on the slopes. The alluvial soils consist principally of the Wabash series, of which silt loams are the most extensive and most important agriculturally. Generally, the soils are fine-grained and easily erodible."

Water Quality Problems

Big Muddy Creek was placed on the Missouri 303(d) list for stream habitat degradation due to sedimentation. The number one pollutant entering Missouri's waters is sediment, with about 59 million tons of soil eroding from Missouri's land each year.[4] 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 sunlight reaching aquatic plants, covers fish spawning areas and food supplies, and clogs the gills of fish. In addition, other pollutants like phosphorus, pathogens, and heavy metals are often attached to the soil particles and wind up in the streams with the sediment.[5] Since little sediment data exists to directly document sediment as a significant impact to Big Muddy Creek, Biological Assessments of Big Muddy Creek were conducted by MDNR's Environmental Services Program (ESP) in fall 2004 and spring 2005; the data is shown in Appendix B.

The quality and quantity of habitat for aquatic life have been affected generally in Missouri. A combination of natural geology and land use in the prairie portions of the state (where Big Muddy Creek is located) is believed to have reduced the amount and impaired the quality of habitat for aquatic life. The major problems are extensive channelization, vertical banks, and poor riparian zones. In many cases, row crops are planted to the edge of stream banks, thereby decreasing the quality of the riparian corridor and leading to unstable banks and loss of woody debris input to the stream. Channelization causes a loss of channel structure, habitat heterogeneity and changes in basin hydrology that increase flood flows and prolong low flow conditions. The lack of top predator fish has been shown to be related to channeled streams and the resulting lack of pools.[6] The most compelling evidence of loss or impairment of aquatic habitat is the historical change in distribution of fishes in Missouri. Many species of fish no longer appear in portions of the state where they once lived.

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.

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[4] Missouri Soil and Water Districts Commission, March 2003, Needs Assessment, Plan To Address Identified Needs & A Summary To Date, http://www.dnr.mo.gov/env/swcp/2003%20needs%20assessment.pdf.
[5] Agricultural Nonpoint Source (AgNPS), Special Area Land Treatment (SALT) Program, NPS Problems, http://www.dnr.mo.gov/env/swcp/service/Salt/nps_problems.htm#improper%20animal%20waste%20management.
[6] Grand River Watershed Inventory and Assessment, Northwest Regional Fisheries, Missouri. http://mdc.mo.gov/fish/watershed/grand/contents/140cotxt.htm

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 water body. However, the water quality condition for which Bid Muddy 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.

3. Description of Sources

Point Sources

Potential point sources of sediment include facilities with permits through the National Pollution Discharge Elimination System (NPDES). Big Muddy Creek watershed is rural, with less than 0.4% of the area classified as urban (Appendix A). There are six NPDES-permitted facilities within the Big Muddy Creek Watershed: Jameson Wastewater Treatment Facility (WWTF), Jamesport Water Treatment Plant, Landmark Manufacturing Corporation, ContiGroup Hickory Creek Farms, Barry Lane, and ContiGroup Campbell Creek Farm, see Tables 1 and 2.

Big Muddy Creek is identified on the 303d list as having large Concentrated Animal Feeding Operations (CAFO), see Table 2. CAFOs typically utilize earthen or concrete structures to contain and store manure prior to land application. NPDES permits are issued for facilities with more than 1,000 animal units. 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.

Table 1. NPDES-permitted facilities in Big Muddy Creek watershed.

Facility	NPDES Permit #	Design Flow (MGD)
Jameson WWTF	MO0118010	0.0229
Jamesport WTP	MOG640157	Water treatment plant filter backwash
Landmark Mfg Corp	MO0113671	0.056537

Table 2. NPDES-permitted CAFOs in Big Muddy Creek watershed.

CAFOs	NPDES permit #	Livestock	Design Animal Units
CG, Hickory Creek Farms	MOG010475	Swine	2,740
Barry Lane	MOG010490	Hogs	1,920
CG, Campbell Creek Farm	MO0118460	Hogs	32,000

Nonpoint Sources

The main source of sediment is believed to be runoff from agricultural nonpoint sources. Problems from agricultural runoff include turbidity, sedimentation, low dissolved oxygen (DO), high nitrogen and phosphorous concentrations, high ammonia and high fecal coliform counts.

The dominant land use in Big Muddy Creek watershed is agriculture. Much of the impaired segment of Big Muddy Creek is near or adjacent to cropland (Appendix A) which could contribute to sediment loading of the streams. The agricultural areas of the basin also contain livestock which are not held in permitted CAFOs, see Table 3. Most rainfall in the basin runs off the surface of the land rather than soaking into the soil due to a glacial till (a clayey material that greatly retards movement of water to the subsurface) that covers the basin. Unconfined livestock have free access to many smaller streams throughout the basin, which further contributes to stream bank instability and erosion.[7]

Table 3. Agriculture Census County Summary for Daviess County, 2002[8].

Livestock and Poultry	**Animal Units**
Cattle and calves	29,408
Beef cows	14,262
Milk cows	357
Hogs and pigs	(D)
Sheep and lambs	1,110
Layers 20 wks old and older	1,136
Broilers	(D)

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

Hydrology and channel form of streams in the basin has been altered. Although there are no major dams within the basin, channelization and levees are common for many of the streams. Big Muddy Creek was identified on the 303d list as having significant amounts of channelization. Several basin streams have been channelized for over half their length and lack a suitable riparian corridor. The combination of channel alterations and inadequate riparian corridors has resulted in tall stream banks that are rapidly eroding. Streams within the basin are typically turbid. Historical accounts indicate many basin streams have always been muddy. Most water quality problems are associated with nonpoint source pollutants such as soil erosion and manure runoff. Except in the uppermost portions of the watershed, nearly all stream bank erosion problems are too severe for biotechnical measures to be practical. Due to the severe stream bank erosion problem, Missouri Department of Conservation (MDC) considers their stream improvement efforts to have very limited application throughout the basin.[9]

[7] Grand River Watershed Inventory and Assessment, Northwest Regional Fisheries, Missouri. http://mdc.mo.gov/fish/watershed/grand/contents/140cotxt.htm

[8] Census of Agriculture, Volume 1 Chapter 2: Missouri County Level Data, 2002, http://www.nass.usda.gov/census/census02/volume1/mo/index2.htm

[9] Grand River Watershed Inventory and Assessment, Northwest Regional Fisheries, Missouri. http://mdc.mo.gov/fish/watershed/grand/contents/140cotxt.htm

4. Description of the Applicable Water Quality Standards and Numeric Water Quality Targets

Beneficial Uses

The designated uses of Big Muddy Creek, WBID 436, are:

- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life and Human Health Associated with 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

Anti-degradation Policy

Missouri's WQS include the U.S. Environmental Protection Agency's (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 instream 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.

Tier 2 – Protects the level of water quality necessary to support 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 antidegradation 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 (BMP) for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national 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).

Specific 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.

(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, total suspended solids (TSS), turbidity, and bedload sediment, which are appropriate to describe sediment in rivers and streams.[10] 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.

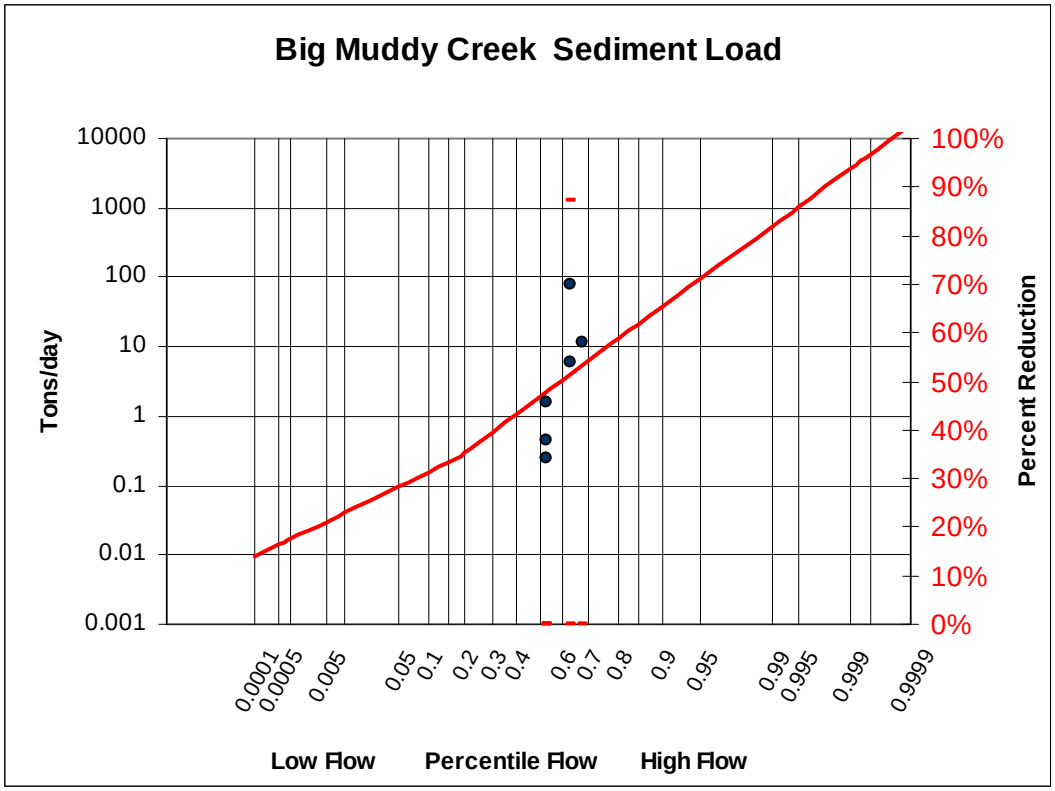
5. Calculation of Load Capacity

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 defined as a curve over the range of flows for Big Muddy Creek, see Figure 1, where the solid (red) curve is the TMDL. This sediment TMDL is set at no increase in the current sediment loading and a 10% reduction in the current condition is required as a MOS. Turbidity measurements taken during the biological assessment were used to estimate TSS concentrations using relationships developed by Doisey and Rabeni (2004)[11]. These estimates are shown in figure 1, where the round (black) points are loads calculated from the estimated concentrations and the corresponding horizontal bars (red) are percent reduction to meet the TMDL.

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

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

Figure 1. TMDL curve over the range of flows.



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 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 C. For Big Muddy Creek flow estimate and source data for the reference EDU refer to Appendix D.

6. 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. For example, at median flow (0.5 percentile flow) the TMDL is approximately 2 tons/day, so the LA would be approximately 1.8 tons/day.

7. 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. Table 4 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. All permitted CAFOs are non-discharging permits and therefore their WLAs are set at zero.

Table 4. WLAs for NPDES-permitted facilities in Big Muddy Creek watershed.

Facility	NPDES Permit #	WLA (tons/day) d/w/m*
Jameson WWTF	MO0118010	0.0105 / NA / 0.0067
Jamesport WTP	MOG640157	Max. daily SS** 1.0mL/L/Hr, and inclusion of BMPs
Landmark Mfg Corp	MO0113671	NA / 0.0259 / 0.0145
CG, Hickory Creek Farms	MOG010475	0
Barry Lane	MOG010490	0
CG, Campbell Creek Farm	MO0118460	0

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

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 Big Muddy Creek shows instances where load exceeds the TMDL (Figure 1). To account for uncertainties in the modeling an explicit 10% MOS is assigned to this TMDL.

9. Seasonal Variation

The TMDL curve represents all flow conditions, hence all seasons. Bioassessment data used in this TMDL was generated by MDNR's ESP; invertebrate sampling was collected for two seasons, fall 2004 and spring 2005 (Appendix B).

10. Monitoring

No future monitoring has been scheduled for Big Muddy Creek at this time. However, Missouri Department of Natural Resources 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, 40 CFR 130.7, require that TMDLs be subject to public review. EPA is providing public notice of this TMDL for Big Muddy Creek on the EPA, Region 7, TMDL website: http://www.epa.gov/region07/water/tmdl_public_notice.htm. The response to comments and final TMDL will be available at: http://www.epa.gov/region07/water/apprtmdl.htm#Missouri.

This water quality limited segment of Big Muddy Creek in Daviess County, Missouri, is included on the 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 will assist EPA by providing a distribution list of interested persons to which EPA will provide an announcement of the Big Muddy Creek TMDL. Groups that receive the public notice announcement will include the Missouri Clean Water Commission, the Missouri Water Quality Coordinating Committee, Stream Team Volunteers in the counties, county legislators, and potentially impacted cities, towns and facilities. The EPA public noticed this TMDL from August 25, 2006, 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

Grand River Watershed Inventory and Assessment, Northwest Regional Fisheries, Missouri. http://mdc.mo.gov/fish/watershed/grand/contents/140cotxt.htm

Biological Assessment and Habitat Study, Big Muddy Creek, Daviess County, 2004-2005. Department of Natural Resources, Environmental Services Program.

Agricultural Nonpoint Source (AgNPS), Special Area Land Treatment (SALT) Program, NPS Problems, http://www.dnr.mo.gov/env/swcp/service/Salt/nps_problems.htm#improper%20animal%20waste%20management

Missouri Soil and Water Districts Commission, March 2003, Needs Assessment, Plan to Address Identified Needs & a Summary to Date, http://www.dnr.mo.gov/env/swcp/2003%20needs%20assessment.pdf

Census of Agriculture, Volume 1 Chapter 2: Missouri County Level Data, 2002, http://www.nass.usda.gov/census/census02/volume1/mo/index2.htm

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

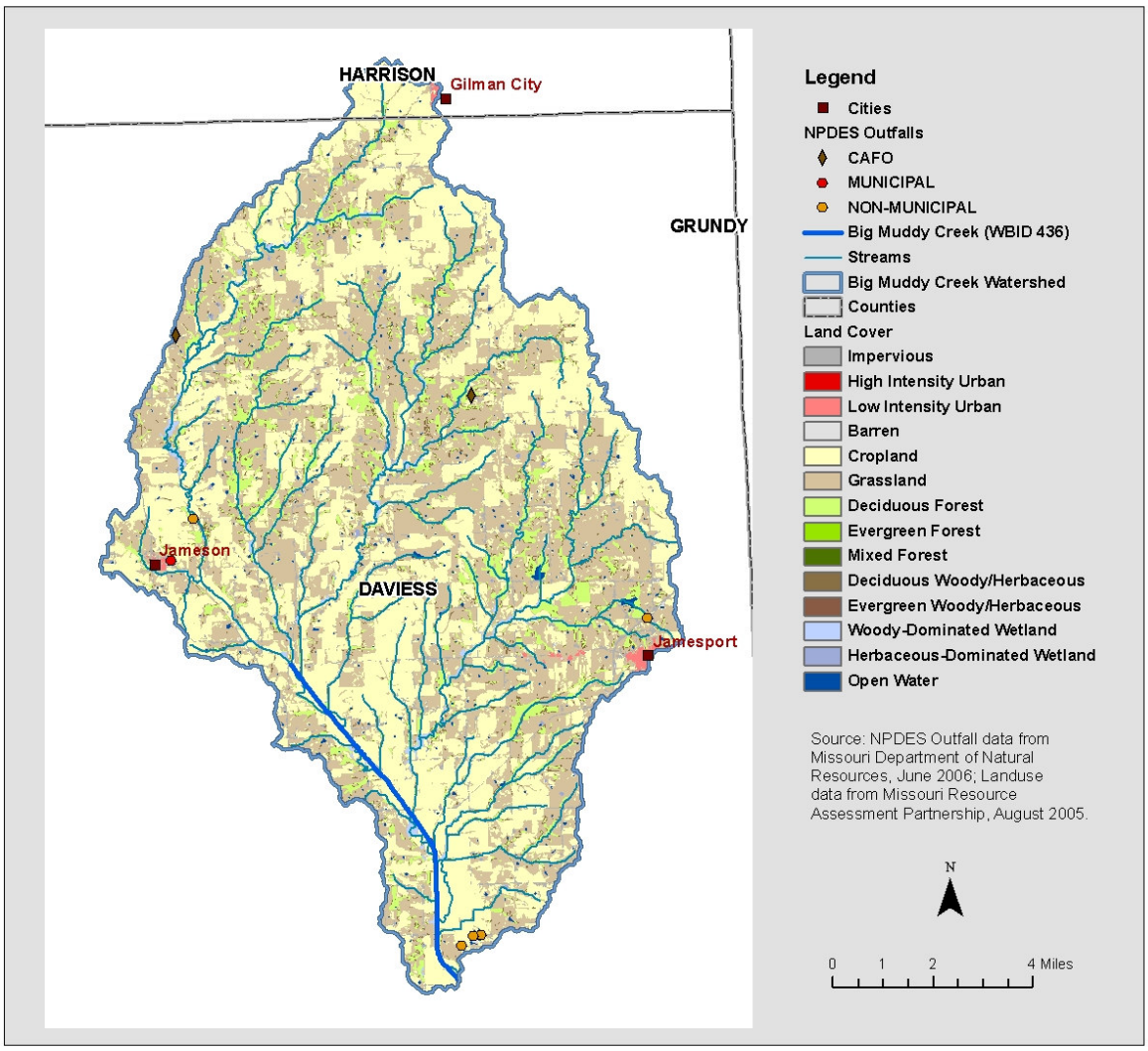
Effects of Suspended Sediment on Native Missouri Fishes: A Literature Review and Synthesis, K.E. Doisey and C.F. Rabeni, 2004, University of Missouri.

13. Appendices

Appendix A – Map of Big Muddy Creek Watershed And Impaired Segment – WBID 436
Appendix B – Big Muddy Creek Biological Assessment Data
Appendix C – Development of Pollutant Targets using Reference Load Duration Curves
Appendix D – Big Muddy Creek Flow Estimate and Source Data for Reference EDU
Appendix E – Missouri Department of Natural Resources Total Maximum Daily Load Information Sheet For Streams with Aquatic Habitat Loss that are Listed for Sediment

Appendix A

Map Of Big Muddy Creek Watershed And Impaired Segment – WBID 436



Appendix B

Big Muddy Creek Biological Assessment Data

Big Muddy Creek Invertebrate Data

Big Muddy Creek - WBID 436

Aquatic Invertebrate Data by MDNR

Site	Date	Score	Sinuosity	Avg.Width	Avg. Depth	Max. Depth
1	Fall 2004	20				
1	Spring 2005	18	1.06	62.8	0.9	1.83
2	Fall 2004	20				
2	Spring 2005	20	1.02	49.2	0.6	1.17
3	Fall 2004	20				
3	Spring 2005	16	1.03	34.7	0.5	1.5
Reference Streams in EDU				45.7	0.9	2.7

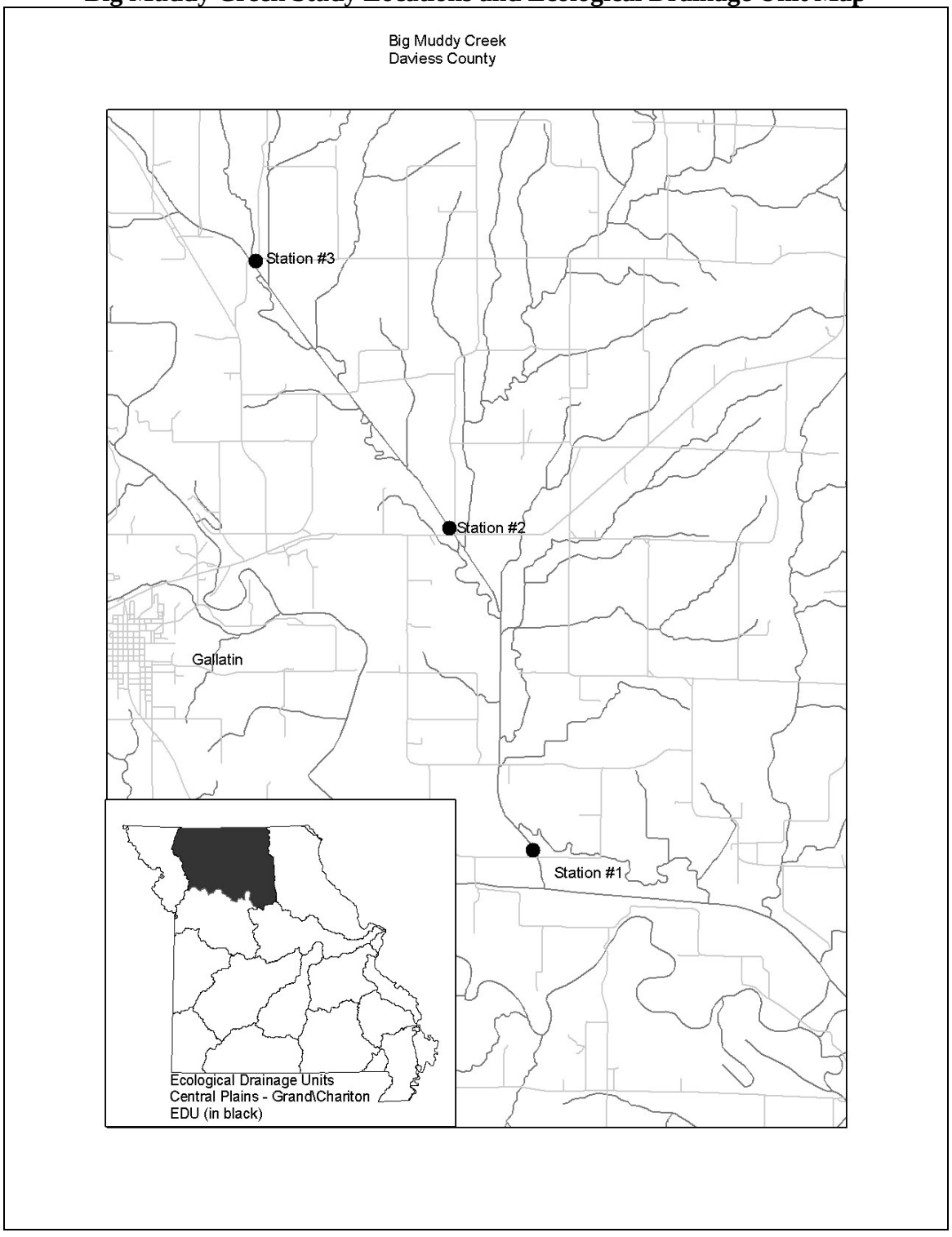
Site 1: Sec.36, 59N,27W. Site 2 Sec.11,59N,27W. Site 3 Sec.33,60N,27W

Note: Invertebrate scores of 16 or greater are judged to indicate unimpaired streams. Scores less than 16 are judged to be impaired.

Big Muddy Creek Water Chemistry Data

Site	Year	Mo	Day	Flow	C	DO	pH	SC	KJN	NH_3N	NO_3N	TP	Cl	Turbidity
Big Muddy Cr. 1	2004	9	16	21.4	19	7.98	7.6	369	0.69	<0.03	0.09	0.25	9.55	62.7
Big Muddy Cr. 2	2004	9	15	6.8	24	7.3	7.8	421	0.53	<0.03	0.02	0.22	9.09	45.3
Big Muddy Cr. 3	2004	9	15	19.3	22	7.11	7.6	314	1.53	<0.03	0.17	0.49	11.6	337
Big Muddy Cr. 1	2005	3	22	0.33	6	12.9	8.3	447	0.33	<0.03	0.04	0.09	13.3	8.19
Big Muddy Cr. 2	2005	3	22	7.9	6	13.7	8.4	453	0.22	<0.03	0.01	0.08	13	5.25
Big Muddy Cr. 3	2005	3	22	3.1	6	13	8.3	445	0.38	<0.03	0.02	0.08	14.9	22.8
WQS						5	6.5-9.0			2*			230	
The ammonia standard is temperature and pH dependent. 2.0 mg./L is estimated based on summer water.														

Big Muddy Creek Study Locations and Ecological Drainage Unit Map



Appendix C

Development of Pollutant 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

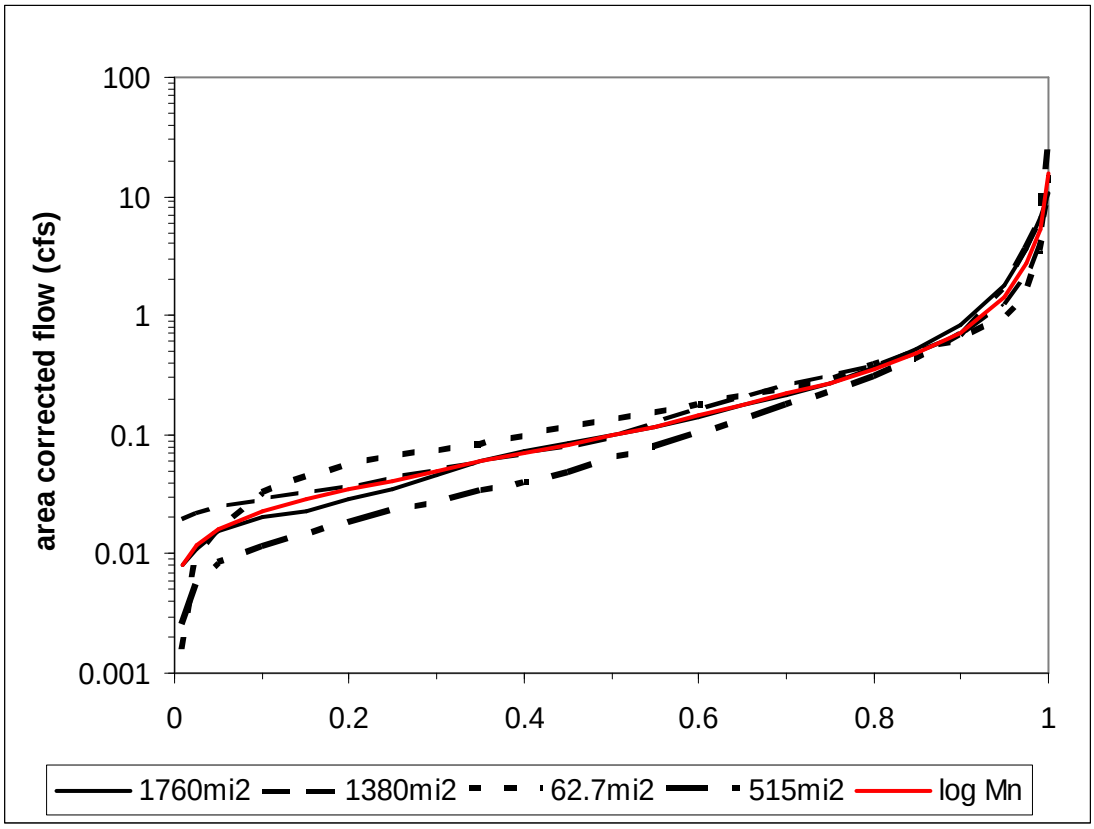
The first step in this procedure is to locate available pollutant data within the EDU of interest. These data along with the instantaneous flow measurement taken at the time of sample collection for the specific date are recorded to create the population from which to develop the load duration. Both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

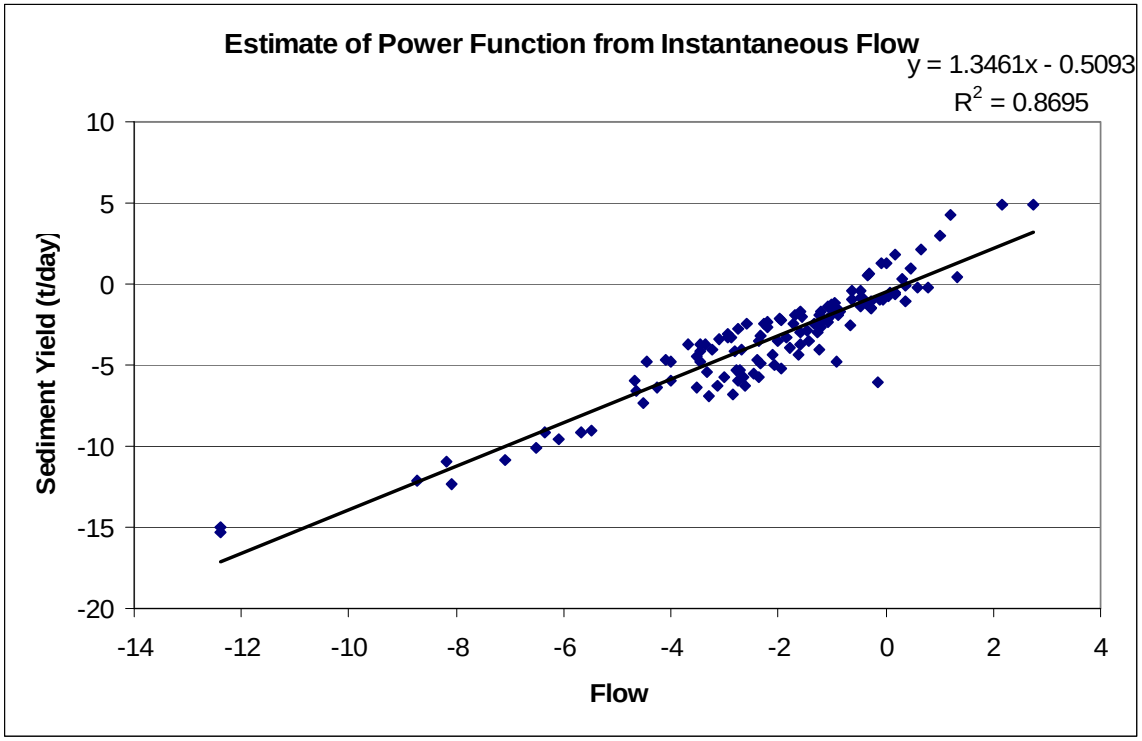
The watershed-size normalized data for the individual gages in the EDU were calculated and compared to a pooled data set including all of the gages. The results of this analysis is displayed in the following figure and table:



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:



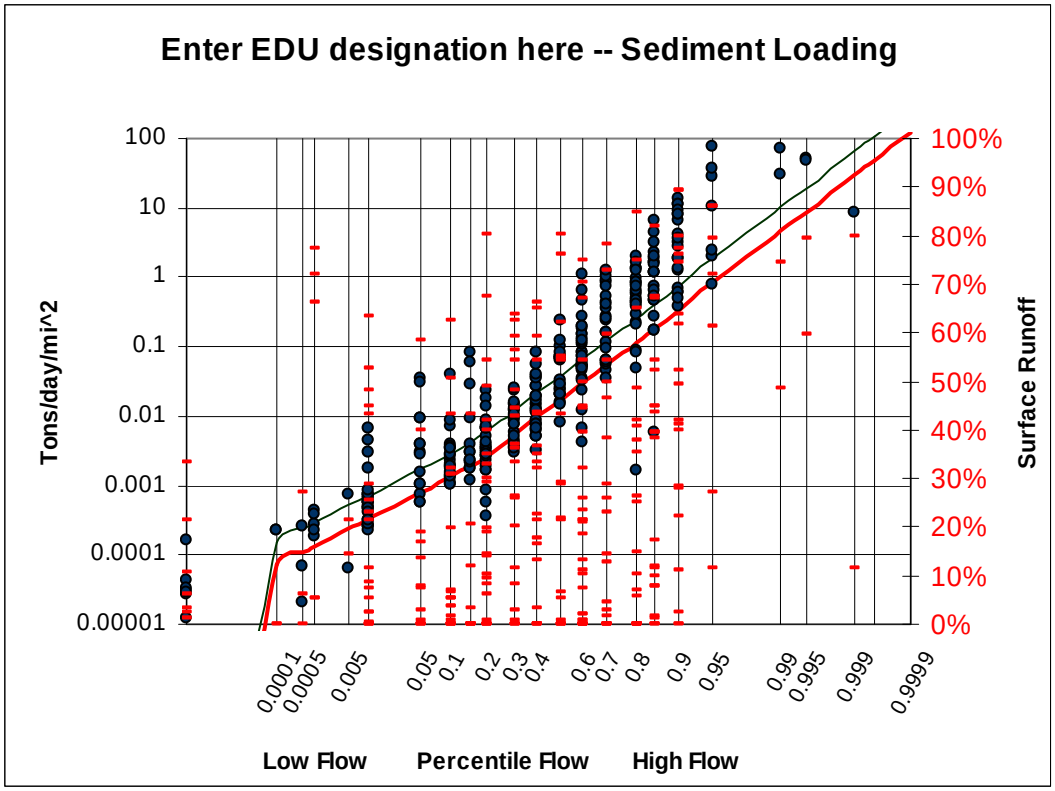
Further statistical analyses on this relationship are included in the following Table:

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 D

Big Muddy Creek Flow Estimate and Source Data for Reference EDU

Estimated Flow for Range of Percentiles at the Impaired Segment Outlet

	Percentile of Flow	Discharge (cubic feet per second)
Flow estimate for Big Muddy Creek based on drainage area and synthetic ecological drainage unit flow.	10	3.2
	30	9.5
	50	20.4
	70	45.2
	90	150

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

Appendix E

Missouri Department of Natural Resources

Total Maximum Daily Load Information Sheet

For Streams with Aquatic Habitat Loss that are Listed for Sediment

Waterbody Segment at a Glance:

Location: Streams in Northern and West Central Missouri and in the Mississippi Embayment of Southeast Missouri and the Missouri and Mississippi Rivers.

Impairment: In 1998 the Department of Natural Resources listed 38 streams with habitat impairment due to agricultural nonpoint source problems. Twelve of them were delisted because new data showed they were higher quality reference streams, not impaired by sediment. One of them was retained on the list for "unknown" pollutants. The other 25 of them appear on the 2002 US EPA 303(d) list for Missouri as being impaired by "sediment".

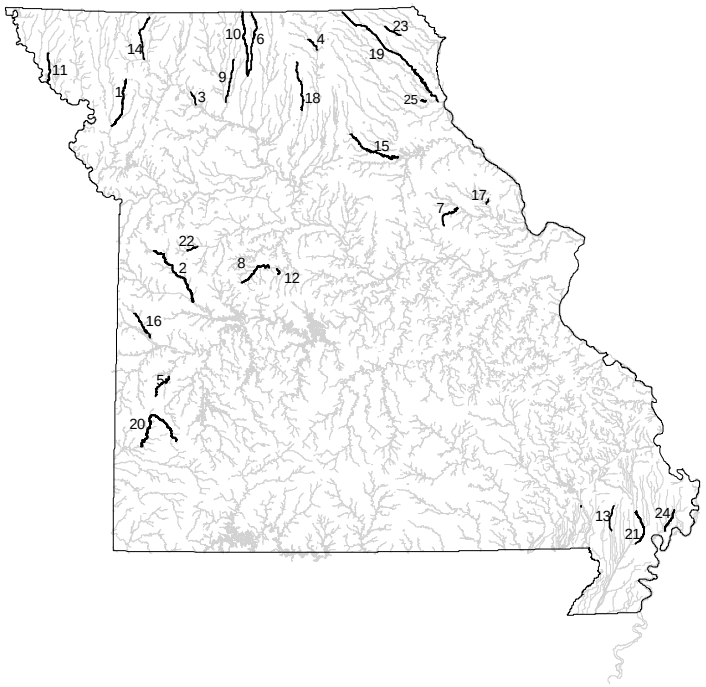
Description of the Problem

All of these waters, as per Missouri Water Quality Standards, must provide a suitable home for aquatic life. A combination of natural geology and land use in the prairie portions of the state and the Mississippi Embayment is believed to have reduced the amount and impaired the quality of aquatic habitat. The major problems are excessive rates of sediment deposition due to streambank 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 change in distribution of fishes in Missouri. Many species of fish no longer appear in portions of the state where they once lived.

The department proposed changing the listing of "sediment" to "habitat loss." This change was proposed because sediment is often an important, but certainly not the only, pollutant or condition causing degradation of aquatic habitat in these streams. With this proposed change, other problems such as channelization, alteration of streambanks and riparian zones, and alteration of normal flow regimes would be included as conditions contributing to impairment. The US Environmental Protection Agency denied this change because habitat loss is "pollution", not a specific "pollutant" that can be measured and calculated. This is necessary because a TMDL (Total Maximum Daily Load) is a numeric calculation.

The department is developing a sediment protocol to determine if sediment is actually the pollutant in these streams and a standard way to measure sediment.

Missouri Streams with Loss of Habitat due to Agricultural Nonpoint Source Pollution



#	Waterbody	County (lower section)	Miles affected		#	Waterbody	County (lower section)	Miles affected
1	3rd Fork Platte River	Buchanan	31.5		14	M. Fork Grand River	Gentry	25
2	Big Creek	Henry	49		15	M. Fork Salt River	Monroe	49
3	Big Muddy Creek	Daviess	8		16	Miami Creek	Bates	18
4	Clear Creek	Adair	10.5		17	Mill Creek	Lincoln	4
5	Clear Creek	Vernon	18		18	Mussel Fork	Macon	29
6	E. Fork Medicine Cr.	Grundy	36		19	N. Fabius River	Marion	82
7	Elkhorn Creek	Montgomery	19		20	N. Fork Spring River	Jasper	51.5
8	Flat Creek	Pettis	20		21	Old Channel Little R.	New Madrid	20
9	Honey Creek	Livingston	23		22	S. Fork Blackwater R.	Johnson	5
10	Little Medicine Creek	Grundy	40		23	S. Wyaconda River	Clark	9
11	Little Tarkio Creek	Holt	17.5		24	Spillway Ditch	New Madrid	13.5
12	Lake Creek	Pettis	5		25	Troublesome Creek	Marion	3.5
13	Lateral #2 Main Ditch	Stoddard	11.5					

For more information call or write:

Missouri Department of Natural Resources
Water Protection Program
P.O. Box 176, Jefferson City, MO 65102-0176
1-800-361-4827 or (573) 751-1300 office or (573) 751-9396 fax
Program Home Page: www.dnr.state.mo.us/deq/wpcp