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Sediment TMDL for the Yalobusha River

Yazoo River Basin

Prepared By

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Office of Pollution Control
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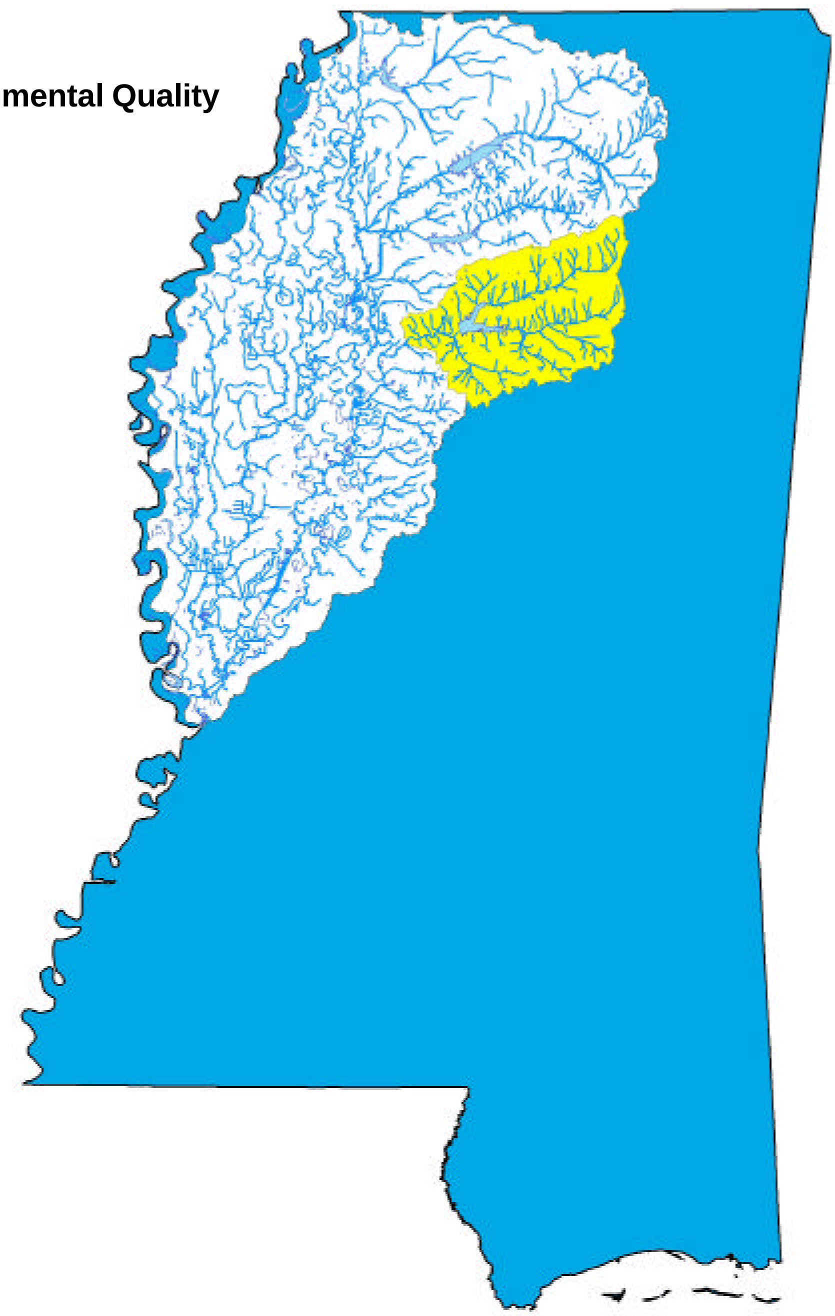
TMDL/WLA Section



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FOREWORD

This report contains one or more Total Maximum Daily Loads (TMDLs) for water body segments found on Mississippi's 1996 Section 303(d) List of Impaired Waterbodies. Because of the accelerated schedule required by the consent decree, many of these TMDLs have been prepared out of sequence with the State's rotating basin approach. The implementation of the TMDLs contained herein will be prioritized within Mississippi's rotating basin approach.

The amount and quality of the data on which this report is based are limited. As additional information becomes available, the TMDLs may be updated. Such additional information may include water quality and quantity data, changes in pollutant loadings, or changes in landuse within the watershed. In some cases, additional water quality data may indicate that no impairment exists.

Conversion Factors

To convert from	To	Multiply by	To convert from	To	Multiply by
mile^2	acre	640	acre	ft^2	43560
km^2	acre	247.1	days	seconds	86400
m^3	ft^3	35.3	meters	feet	3.28
ft^3	gallons	7.48	ft^3	gallons	7.48
ft^3	liters	28.3	hectares	acres	2.47
cfs	gal/min	448.8	miles	meters	1609.3
cfs	MGD	0.646	tonnes	tons	1.1
m^3	gallons	264.2	: g/l * cfs	gm/day	2.45
m^3	liters	1000	: g/l * MGD	gm/day	3.79

Fraction	Prefix	Symbol	Multiple	Prefix	Symbol
10^{-1}	deci	d	10	deka	da
10^{-2}	centi	c	10^{2}	hecto	h
10^{-3}	milli	m	10^{3}	kilo	k
10^{-6}	micro	:	10^{6}	mega	M
10^{-9}	nano	n	10^{9}	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f	10^{15}	peta	P
10^{-18}	atto	a	10^{18}	exa	E

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TMDL INFORMATION PAGE

Table i. Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Yalobusha River	MSYLBUSHM1	Grenada	08030205	Sediment/Siltation	Monitored
Near Grenada: From Grenada POTW outfall to confluence with Bakers Creek					
Yalobusha River	MSYLBUSHM2	Grenada	08030205	Sediment/Siltation	Monitored
Near Holcomb: From confluence with Bakers Creek to confluence with Cane Creek					
Yalobusha River	MSYLBUSHE	Grenada	08030205	Sediment/Siltation	Evaluated
Near Grenada: From Grenada Reservoir spillway to Grenada POTW outfall					

Table ii. Water Quality Standard

Parameter	Beneficial use	Narrative Water Quality Criteria
Sediment/ Siltation	Aquatic Life Support	Waters shall be free from materials attributable to municipal, industrial, agricultural, or other dischargers producing color, odor, taste, total suspended solids, or other conditions in such degree as to create a nuisance, render the waters injurious to public health, recreation, or to aquatic life and wildlife, or adversely affect the palatability of fish, aesthetic quality, or impair the waters for any designated uses.

Table iii. Total Maximum Daily Load

Segment	WLA	LA	MOS	TMDL
MSYLBUSHM1	8.8E-02 to 2.4E-01*	8.8E-02 to 2.4E-01*	implicit	8.8E-02 to 2.4E-01*
MSYLBUSHM2	8.8E-02 to 2.4E-01*	8.8E-02 to 2.4E-01*	implicit	8.8E-02 to 2.4E-01*
MSYLBUSHE	8.8E-02 to 2.4E-01*	8.8E-02 to 2.4E-01*	implicit	8.8E-02 to 2.4E-01*

*tons per acre per day at the effective discharge

EXECUTIVE SUMMARY

Yalobusha River segment 1 (MSYLBUSHM1) and Yalobusha River segment 2 (MSYLBUSHM2) are on the Mississippi 1998 Section 303(d) List of Impaired Waterbodies as impaired due to siltation. Yalobusha River evaluated segment (MSYLBUSHE) is on the Mississippi 1998 Section 303(d) List of Evaluated Waterbodies for siltation. The siltation cause was changed to sediment/siltation in 2002 to indicate a clean sediment issue. This TMDL is being completed for clean sediment. Certain contaminants may be associated with sediment such as pesticides and nutrients. However, these contaminants are not being addressed within this TMDL. These contaminants would also be controlled by the same best management practices (BMPs) that control the sediment.

The State of Mississippi *Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulation does not include a numerical water quality standard for aquatic life protection due to sediment (2002). The narrative standard for the protection of aquatic life is sufficient for justification of TMDL development, but does not provide a quantifiable TMDL target.

The estimated target for this TMDL was developed by the Channel and Watershed Processes Research Unit (CWPRU) at the National Sedimentation Laboratory (NSL). CWPRU was contracted by MDEQ and EPA Region 4 to develop reference sediment yields, or targets, for each ecoregion within Mississippi and Region 4. The reference load, or TMDL target, was derived from the empirical analysis of historical flow and sediment-transport data for stable streams in the appropriate ecoregion for the Yalobusha River, which is the Mississippi Valley Loess Plains (Ecoregion 74).

The Yalobusha River, shown in Photo 1, flows in a southwestern direction from its headwaters near Houston, MS. A dam near Grenada, MS on the Yalobusha River forms the Grenada Reservoir. The segments listed for sediment on the Yalobusha River are downstream from the dam and flow in a southwestern direction from below the Grenada Reservoir spillway to the confluence with Cane Creek. The listed segments, MSYLBUSHM1 and MSYLBUSHM2, are four and thirteen miles long respectively, and are within Grenada County.

The listed segments of the Yalobusha River are within United States Geologic Service (USGS) Hydrologic Unit Code (HUC) 08030205. The immediate drainage area of the listed segments of the Yalobusha River is 238,379 acres below the Grenada Reservoir spillway. The drainage area upstream of the reservoir also drains to the listed segments through the dam. However, the impact of activities above the dam would be mitigated by the dampening effect of storage in the reservoir. While this report contains information on both the immediate and the complete drainage areas, the immediate drainage area below the dam is considered the primary area of interest.

The Yalobusha River, upstream of the dam and listed segments, flows through Pontotoc, Chickasaw, Calhoun, Yalobusha, and Grenada Counties in north central Mississippi. The entire watershed is 1,074,021 acres and contains many landuse types including agricultural land, pastureland, and urban areas. However, the dominant landuse within the watershed is agriculture. The immediate watershed below the dam is 238,379 acres. The location of the complete and immediate Yalobusha River watersheds are provided in Figure 1 and Figure 2, respectively.

Photo 1. Yalobusha River looking upstream at Highway 35/8 near Holcomb, MS

The listed segments of the Yalobusha River for this TMDL are in the Mississippi Valley Loess Plains, Ecoregion 74. According to 40 CFR §130.2 (i), TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure. In this case, an "other appropriate measure" is used to express the TMDL as the tons of sediment that can be discharged from an acre of a subwatershed during a day (tons/acre/day) at the effective discharge and still attain the applicable water quality standard. This results in a range of acceptable reference yields of 8.8E-02 to 2.4E-01 tons per acre per day at the effective discharge in the immediate watershed. It is expected that all values within this range will result in attainment of water quality standards. The TMDL is expressed at the effective discharge, which is the channel forming flow that moves the most sediment. This TMDL is not applicable on an annual basis, because the effective discharge only occurs statistically once every one and a half years, not on a daily basis. However, because the effective discharge is the critical condition, compliance with the TMDL at effective discharge will result in the attainment of the water quality standards at all times.

It is appropriate to apply the same target yield to permitted (WLA) and unpermitted (LA) watershed areas. For load TMDLs the WLA and LA are summed to calculate the TMDL. Because this TMDL is expressed as a yield, as long as all activities, permitted or unpermitted, meet the same yield, the TMDL will be met, regardless of the relative load contribution. The methods used to develop the acceptable yields are described in detail in the reports titled, *"Reference" and "Impacted" Rates of Suspended-Sediment Transport for Use in Developing Clean Sediment TMDLs: Mississippi and the Southeastern United States* (Simon, et al., 2002b) and *Actual and Reference Sediment Yields for the James Creek Watershed – Mississippi* (Simon, et al., 2002a).

There are facilities in the Yalobusha River Watershed with National Pollutant Discharge Elimination System (NPDES) permits that are permitted for Total Suspended Solids (TSS). A list of facilities is not included because no changes are required in their permits due to this TMDL. This is considered appropriate since these sources provide negligible loadings of sediment to the receiving waters compared to wet weather sources (e.g., NPDES regulated construction activities, Municipal Separate Storm Sewer Systems [MS4s], and nonpoint sources). Also, the Total Suspended Solids (TSS) component of a NPDES permitted facility is different from the pollutant addressed within this TMDL because the TSS component of the permitted discharges is generally composed more of organic material, and therefore, provides less direct impact on the biologic integrity of a stream (through settling and accumulation) than would stream sedimentation due to soil erosion during wet weather events. The pollutant of concern for this TMDL is sediment from landuse runoff and in-channel processes.

Wet weather sources of sediment, which are discharged to a receiving waterbody as a result of the storm events, are considered to be the primary concern for this sediment TMDL. These wet weather sources can be broadly defined, for the purposes of this TMDL, into two categories: wet weather sources regulated by the NPDES program, and wet weather sources *not* regulated by NPDES. Wet weather sources regulated by the NPDES program include industrial activities (which includes certain construction activities), and discharges from MS4s. The wet weather NPDES regulated sources are provided a wasteload allocation (WLA) in this TMDL, and all other wet weather sources of sediment (those not regulated by NPDES) are provided a Load Allocation (LA).

The WLAs provided to NPDES municipal and industrial permitted dischargers will be implemented through the State's NPDES permit program and are not included in this TMDL. The wet weather WLAs provided to the NPDES-regulated construction activities and MS4s will be implemented through Best Management Practices (BMPs) as specified in Mississippi's General Stormwater Permits for Small Construction, Construction, and Phase I & II MS4 permits, which can be found on the MDEQ website (www.deq.state.ms.us). It is not technically feasible to incorporate numeric sediment limits into permits for these activities/facilities at this time. LAs for non-point sources will be achieved through the voluntary application of BMPs. Properly designed and well-maintained BMPs are expected to provide attainment of the wet weather WLAs and LAs.

For streams listed as impaired due to sediment or siltation in the Yazoo River Basin, including the Yalobusha River, suspended sediment data were either not available or were insufficient to calibrate a water quality model for prediction of existing sediment loads within these water bodies. Therefore, this TMDL does not provide an existing load specific to the Yalobusha River. However, a source assessment is included. In addition, the CWPRU estimated the typical range for unstable streams in this ecoregion is 1.9E-01 to 1.5 tons per acre per day at the effective discharge. This range is representative of the load that would be expected from the Yalobusha River watershed. The unstable yield range is approximately an order of magnitude larger than the target yield range, which indicates a reduction is necessary in the Yalobusha River watershed.

Figure 1. Location of the Yalobusha River Watershed (Complete Drainage Area)

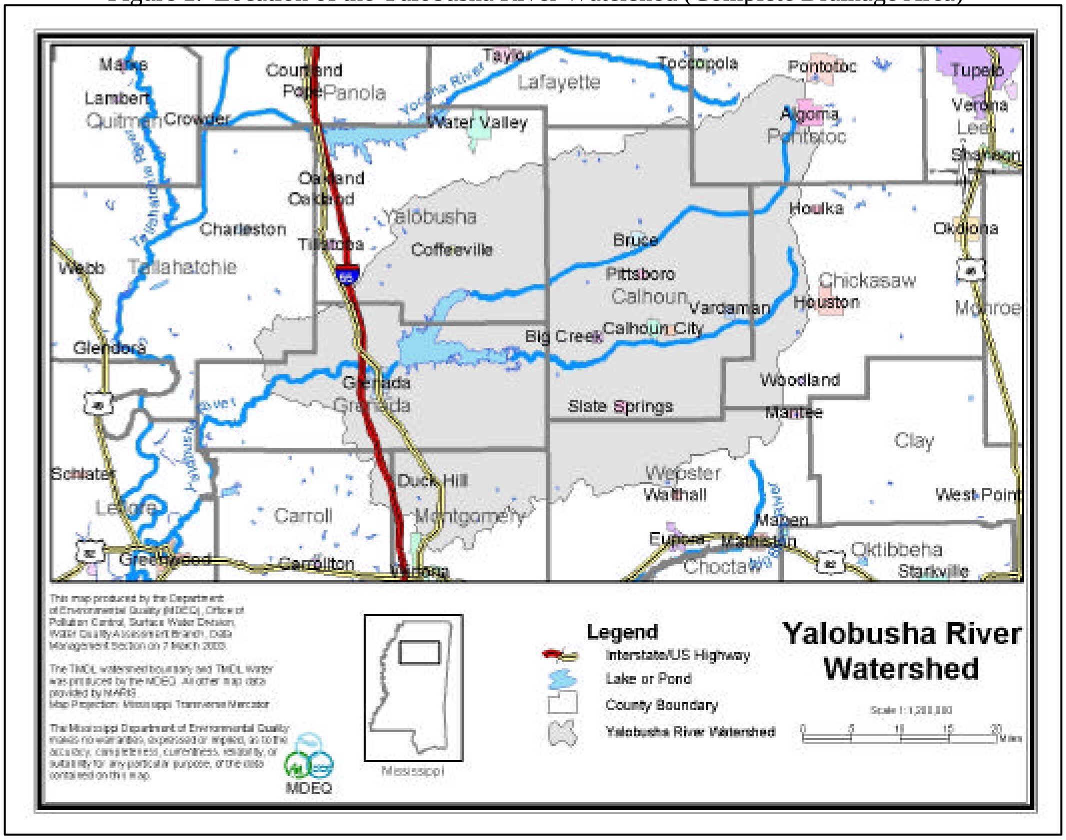
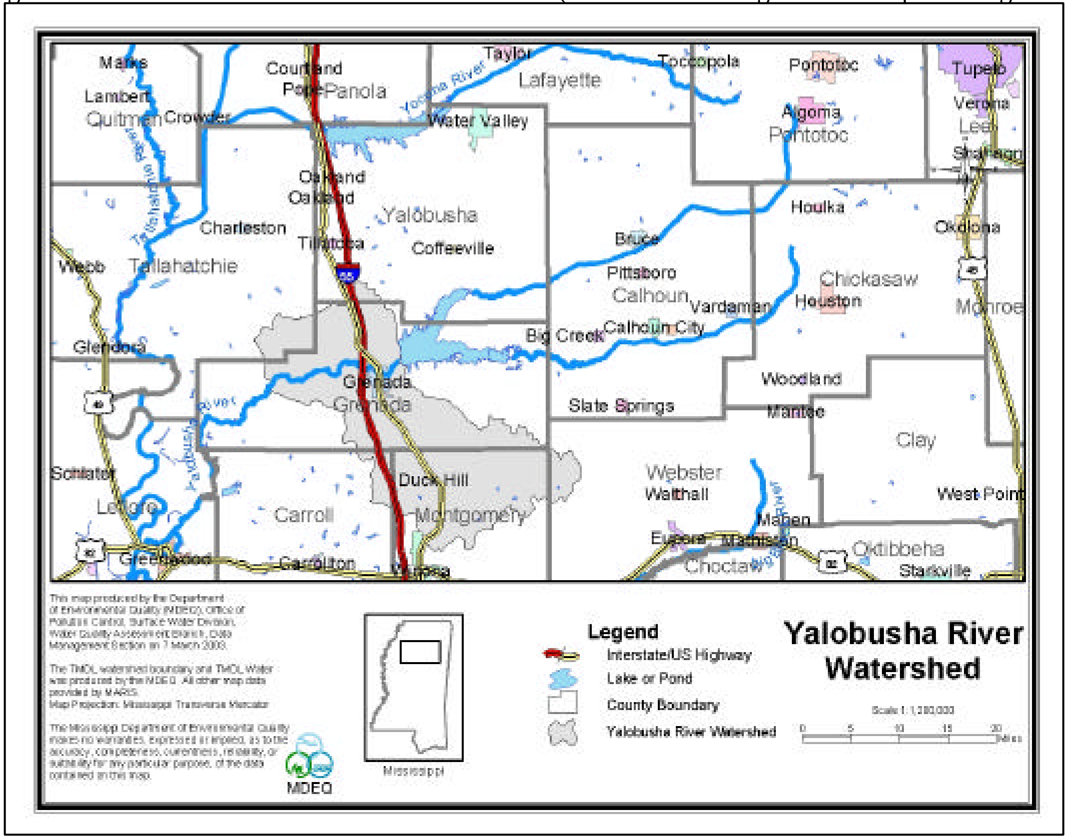


Figure 2. Location of the Yalobusha River Watershed (Immediate Drainage Area of Impaired Segments)



1.0 INTRODUCTION

1.1 Background

The identification of water bodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those water bodies are required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130). The TMDL process is designed to restore and maintain the quality of those impaired water bodies through the establishment of pollutant specific allowable loads. The pollutant of concern for this TMDL is sediment from landuse runoff and in-channel sediment processes.

The Yalobusha River is located in Pontotoc, Chickasaw, Calhoun, Yalobusha, and Grenada Counties in West Mississippi. The drainage area of the Yalobusha River lies within USGS HUC 08030205 and the Mississippi Valley Loess Plains Ecoregion (74). The monitored segments are four and thirteen mile segments that, combined, flow from below the Grenada Reservoir spillway to the confluence with Cane Creek. The evaluated segment begins at the spillway and continues to the beginning of the monitored segments just below the spillway.

The landuse distribution of the Yalobusha River watershed is provided in Tables 1 and 2 and in Figures 3 and 4. Table 1 and Figure 3 provide landuse information for the complete drainage area of the impaired segments. Table 2 and Figure 4 provide landuse information for the immediate drainage area of the impaired segments. The location of the 303(d) listed segments is shown in Figures 3 and 4.

Table 1. Yalobusha River Watershed Landuse Distribution (Complete Drainage Area)

	Forest	Urban	Barren	Wetland	Agriculture	Other	Total
Area (acres)	404,055	7,791	1,690	201,630	420,135	38,720	1,074,021
Percentage	37.6	0.7	0.2	18.8	39.1	3.6	100

Table 2. Yalobusha River Watershed Landuse Distribution (Immediate Drainage Area of Impaired Segments)

	Forest	Urban	Barren	Wetland	Agriculture	Other	Total
Area (acres)	97,890	5,137	1,294	47,822	85,460	776	238,379
Percentage	41.1	2.2	0.5	20.1	35.8	0.3	100

Figure 3. Yalobusha River Watershed 303(d) Listed Segments (Complete Drainage Area)

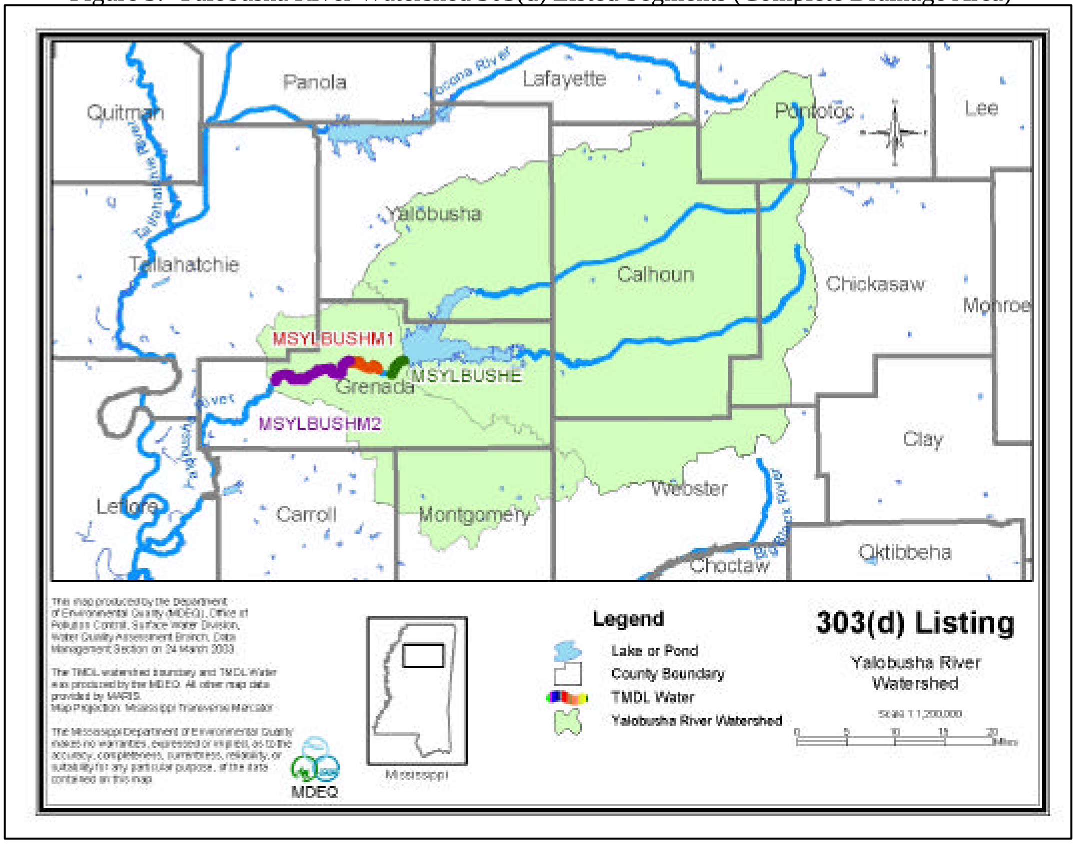
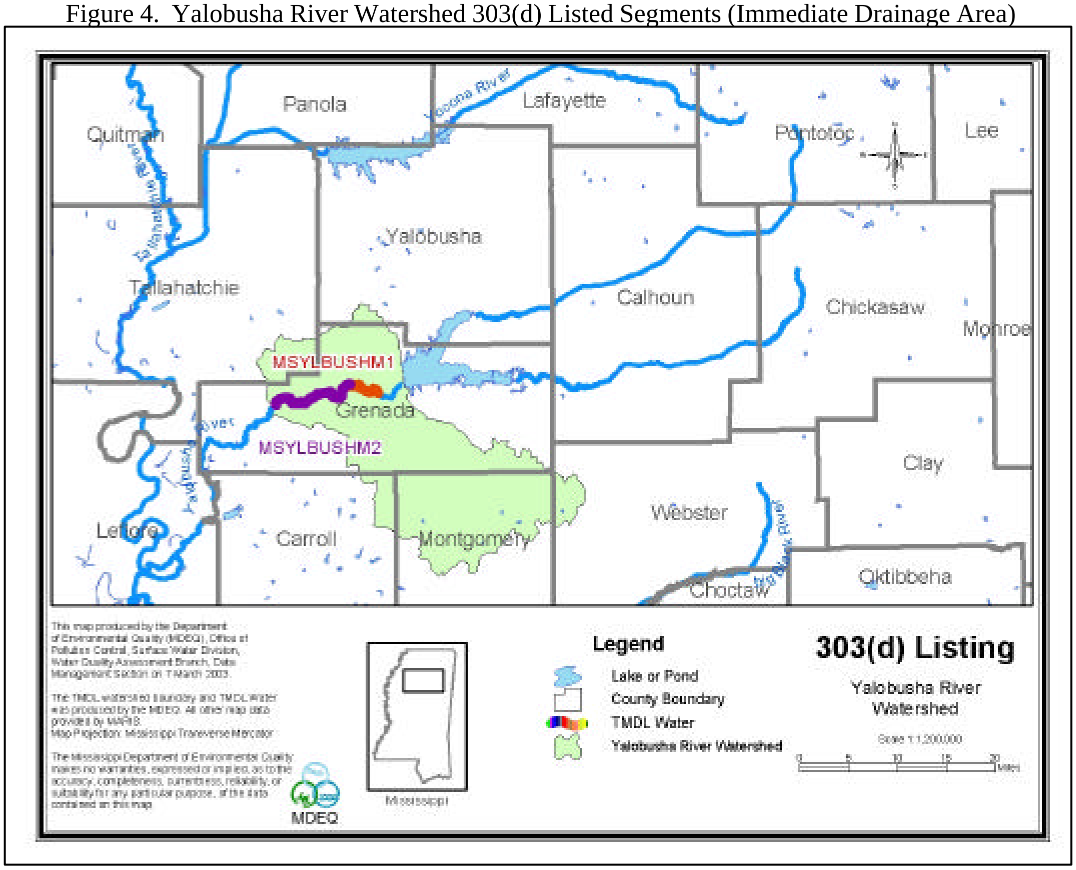


Figure 4. Yalobusha River Watershed 303(d) Listed Segments (Immediate Drainage Area)



1.2 Applicable Water Body Segment Use

The water use classification for the Yalobusha River, as established by the State of Mississippi in the *Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulation, is Fish and Wildlife Support. Waters with this classification are intended for fishing and propagation of fish, aquatic life, and wildlife. Waters that meet the Fish and Wildlife Support criteria should also be suitable for secondary contact, which is defined as incidental contact with water including wading and occasional swimming.

1.3 Applicable Water Body Segment Standard

The *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* do not include a water quality standard applicable to aquatic life protection due to sediment (2002). However, a narrative standard for the protection of aquatic life was interpreted to determine an applicable target for this TMDL. The narrative standard is that waters shall be free from materials attributable to municipal, industrial, agricultural, or other dischargers producing color, odor, taste, total suspended solids, or other conditions in such degree as to create a nuisance, render the waters injurious to public health, recreation, or to aquatic life and wildlife, or adversely affect the palatability of fish, aesthetic quality, or impair the waters for any designated uses.

2.0 TMDL ENDPOINT AND WATER QUALITY ASSESSMENT

2.1 Selection of a TMDL Endpoint and Critical Condition

One of the major components of a TMDL is the establishment of target endpoints, which are used to evaluate the attainment of acceptable water quality. Target endpoints, therefore, represent the water quality goals that are to be achieved by meeting the load and waste load allocations specified in the TMDL. The endpoints allow for a comparison between observed conditions and conditions that are expected to restore designated uses.

This sediment TMDL is expressed as an acceptable range of sediment loadings at the effective discharge. The range was developed from data measured at stable streams in the same ecoregion as the Yalobusha River. The target range for the Yalobusha River watershed is a sediment yield in the range from 8.8E-02 to 2.4E-01 tons of sediment per acre per day at the effective discharge. The discharge, which moves the most sediment, is known as the effective discharge, which has been selected as the critical condition for this TMDL (Simon, et al., 2002b). If the sediment target applicable for sediment in the Yalobusha River is maintained during critical conditions, then the health of the stream should improve.

3.0 SOURCE ASSESSMENT and LOAD ESTIMATION

An important part of the TMDL analysis is the identification of individual sources, source categories, or source subcategories of sedimentation in the watershed and the amount of pollutant loading contributed by each of these sources. Under the Clean Water Act, sources are broadly classified as either point or nonpoint sources. Under 40 CFR §122.2, a point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The National Pollutant Discharge Elimination System (NPDES) program regulates point source discharges. Point sources can be described by two broad categories: 1) NPDES regulated municipal and industrial wastewater treatment plants (WWTPs) and 2) NPDES regulated industrial activities (which includes construction activities) and municipal storm water discharges (Municipal Separate Storm Sewer Systems [MS4s]). For the purposes of this TMDL, all sources of sediment loading not regulated by NPDES are considered nonpoint sources. Potential sources of sediment in the Yalobusha River watershed were considered. Sources were characterized with the best available information, which is documented in this section.

3.1 Assessment of Point Sources

There are facilities in the Yalobusha River Watershed with National Pollutant Discharge Elimination System (NPDES) permits that are permitted for Total Suspended Solids (TSS). A list of facilities is not included because no changes are required in their permits due to this TMDL. This is considered appropriate since these sources provide negligible loadings of sediment to the receiving waters compared to wet weather sources (e.g., NPDES regulated construction activities, Municipal Separate Storm Sewer Systems [MS4s], and nonpoint sources). Also, the Total Suspended Solids (TSS) component of a NPDES permitted facility is different from the pollutant addressed within this TMDL because the TSS component of the permitted discharges is generally composed more of organic material, and therefore, provides less direct impact on the biologic integrity of a stream (through settling and accumulation) than would stream sedimentation due to soil erosion during wet weather events. The pollutant of concern for this TMDL is sediment from landuse runoff and in-channel processes.

Sediment loadings from NPDES regulated construction activities and Municipal Separate Storm Sewer Systems (MS4s) are considered point sources of sediment to surface waters. These discharges occur in response to storm events and are included in the WLA of this TMDL.

As of March 2003, discharge of storm water from construction activities disturbing between one and five acres must also be authorized by an NPDES permit in addition to the requirements already in place for larger construction sites. The purpose of these NPDES permits is to eliminate or minimize the discharge of pollutants from construction activities. Since construction activities at a site are of a temporary, relatively short term nature, the number of construction sites covered by the general permit at any instant of time varies. The target for these areas is the same range as the TMDL target of 8.8E-02 to 2.4E-01 tons per acre per day at the effective discharge. The WLAs provided to the NPDES regulated construction activities and MS4s will be implemented as Best Management Practices (BMPs) as specified in Mississippi's General Stormwater Permits for Small Construction, Construction, and Phase I & II MS4 permits. It is not technically feasible to incorporate numeric sediment limits into construction storm water or MS4 permits at this time. WLAs should not be construed as numeric permit limits for construction or MS4 activities. Properly designed and well-maintained BMPs are expected to provide attainment of WLAs.

3.2 Assessment of Nonpoint Sources

Nonpoint loading of sediment in a water body results from the transport of the material into receiving waters by the processes of mass wasting, head cutting, gullying, and sheet and rill erosion. Sources of sediment include:

- Agriculture
- Silviculture
- Rangeland
- Construction sites
- Roads
- Urban areas
- Mass wasting areas
- Gullies
- Surface mining
- In-channel and in-stream sources
- Historical landuse activities and channel alterations

The 1,074,021 acre complete drainage area and the 238,379 acre immediate drainage area of the Yalobusha River contain many different landuse types, including forest, cropland, pasture, barren, and wetlands as shown in Tables 3 and 4 and Figures 5 and 6. The landuse information for the watershed is based on the State of Mississippi's Automated Resource Information System (MARIS), 1997. This data set is based on Landsat Thematic Mapper digital images taken between 1992 and 1993. The MARIS data are classified on a modified Anderson level one and two system with additional level two wetland classifications.

Table 3. Yalobusha River Watershed Landuse Distribution (Complete Drainage Area)

	Forest	Urban	Barren	Wetland	Agriculture	Other	Total
Area (acres)	404,055	7,791	1,690	201,630	420,135	38,720	1,074,021
Percentage	37.6	0.7	0.2	18.8	39.1	3.6	100

Figure 5. Yalobusha River Watershed Landuse Distribution (Complete Drainage Area)

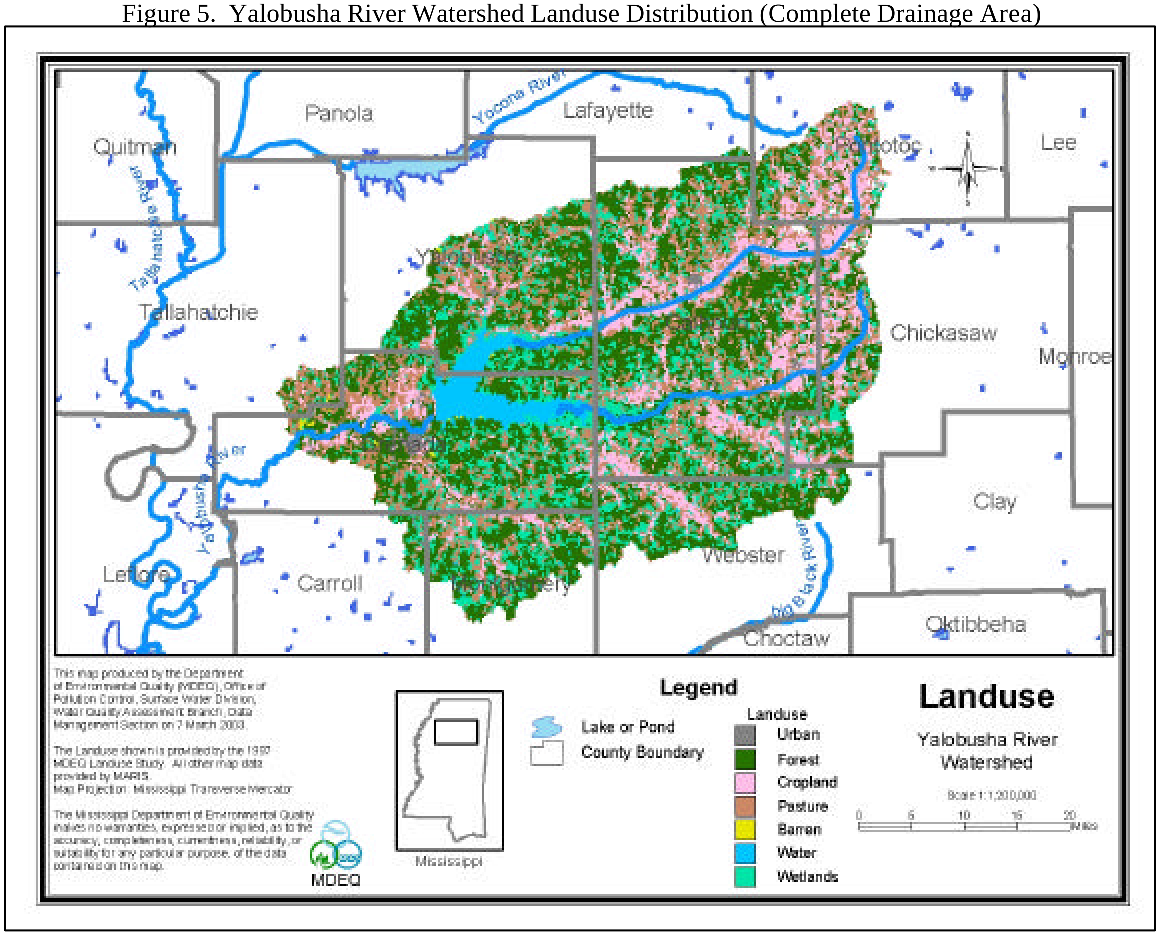
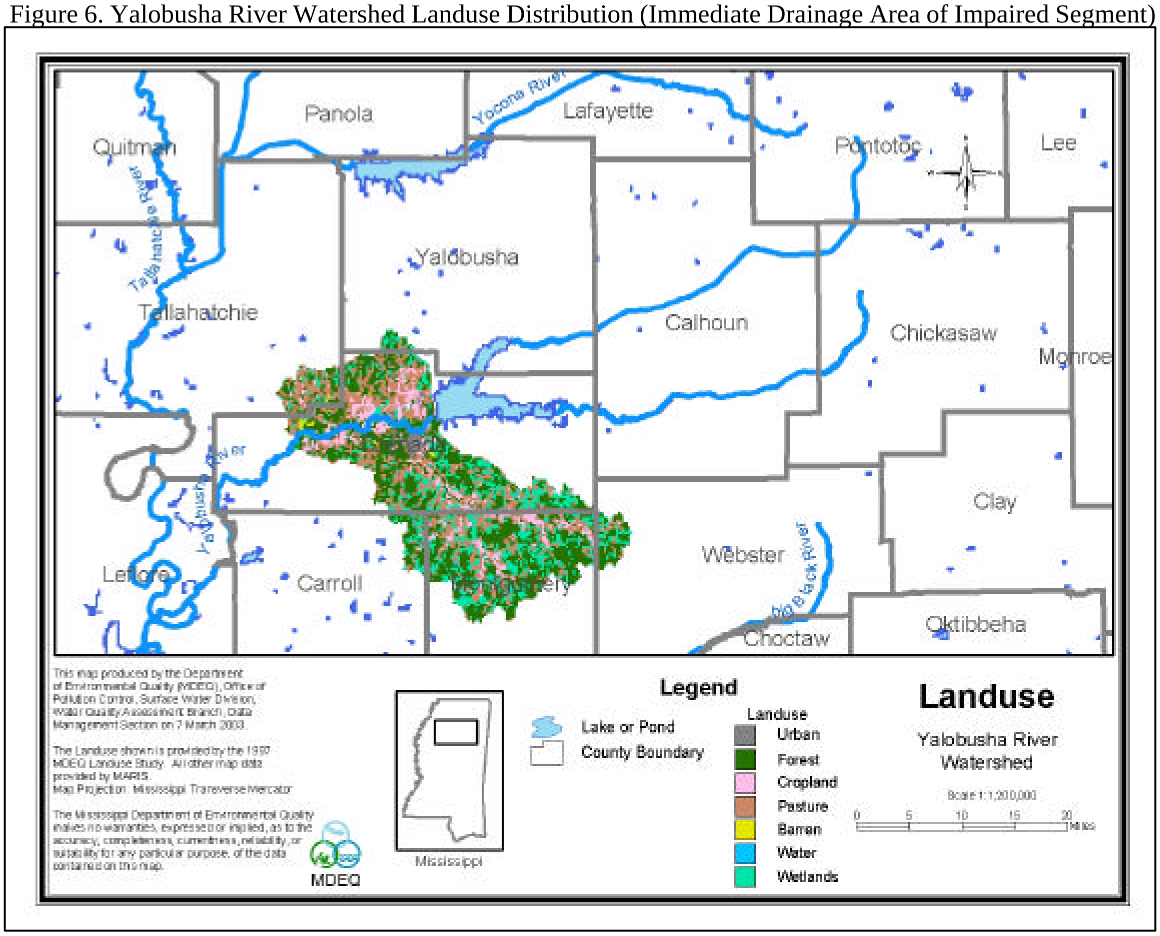


Table 4. Yalobusha River Watershed Landuse Distribution (Immediate Drainage Area of Impaired Segments)

	Forest	Urban	Barren	Wetland	Agriculture	Other	Total
Area (acres)	97,890	5,137	1,294	47,822	85,460	776	238,379
Percentage	41.1	2.2	0.5	20.1	35.8	0.3	100

Figure 6. Yalobusha River Watershed Landuse Distribution (Immediate Drainage Area of Impaired Segment)



3.3 Load Estimation

Due to lack of data for calibration it was determined that a modeling exercise to quantify the load from each source and estimate the total existing load would be inappropriate. However, the range of loads for other unstable streams with sufficient data in this ecoregion is 1.9E-01 to 1.5 tons per acre per day at the effective discharge. Similar sources are present in those watersheds. Therefore the existing load for Yalobusha River should be within this range.

4.0 DETERMINING THE TARGET SEDIMENT LOAD

The information and methodologies described in the following sections are based on research efforts conducted by the CWPRU of the National Sedimentation Laboratory in Oxford, Mississippi. The primary sources of the information presented in this section are:

- *Actual and Reference Sediment Yields for the James Creek Watershed – Mississippi* (Simon, et al., 2002a)

- *"Reference" and Impacted" Rates of Suspended-Sediment Transport for Use in Developing Clean Sediment TMDLs: Mississippi and the Southeastern United States* (Simon, et al., 2002b)

4.1 Selecting a Reference Condition (Simon, et al., 2002a)

Sediment loads (transport rates) in streams vary by orders of magnitude over time and by location. Controls such as geology and channel-boundary materials, land use, channel stability, and the type and timing of precipitation events make prediction of sediment loads difficult and complex. Still, in order to determine the amount of sediment that impairs a given waterbody (TMDL), one must first be able to determine the sediment load that would be expected in an unimpaired stream of a given type and location. However, baseline conditions of flow, sediment concentrations, and transport rates for streams in the wide variety of physiographic provinces and under a wide variety of land uses are poorly understood.

There is no reason to assume that "natural" or background rates of sediment transport will be consistent from one region to another. Within the context of clean sediment TMDLs, it follows that there is no reason to assume that "target" values should be consistent on a nationwide basis. Similarly, there is no reason to assume that channels within a given region will have consistent rates of sediment transport. For example, unstable channel systems or those draining disturbed watersheds will produce and transport more sediment than stable channel systems in the same region. This reflects differences in the magnitude and perhaps type of erosion processes that dominate a subwatershed or stream reach.

To be useful for TMDL practitioners sediment-transport relations must be placed within a conceptual and analytic framework such that they can be used to address sediment-related problems at sites where no such data exist. To accomplish this, sediment-transport characteristics and relations need to be regionalized according to attributes of channels and drainage basins that are directly related to sediment production, transport, and potential impairment. In a general way, these attributes include among others, physiography, geology, climate and ecology, differentiated collectively as an ecoregion.

In order to identify those sediment-transport conditions that represent impacted or impaired conditions, it is essential to first be able to define a non-disturbed, stable, or "reference" condition for the particular stream reach. In some schemes the "reference" condition simply means "representative" of a given category of classified channel forms or morphologies and as such, may not be analogous with a “stable”, “undisturbed”, or “background” rate of sediment production and transport.

The Rosgen (1985) stream classification system is widely used to describe channel form. In this classification system, stream types D, F, and G are by definition, unstable (Rosgen, 1996). These stream reaches, therefore, would be expected to produce and transport enhanced amounts of sediment and represent “impacted”, if not “impaired” conditions. Thus, although it may be possible to define a “representative” reach of stream types D, F, and G, for the purpose of TMDL development, a “reference” condition transporting “natural” or “background” rates of sediment will be difficult to find.

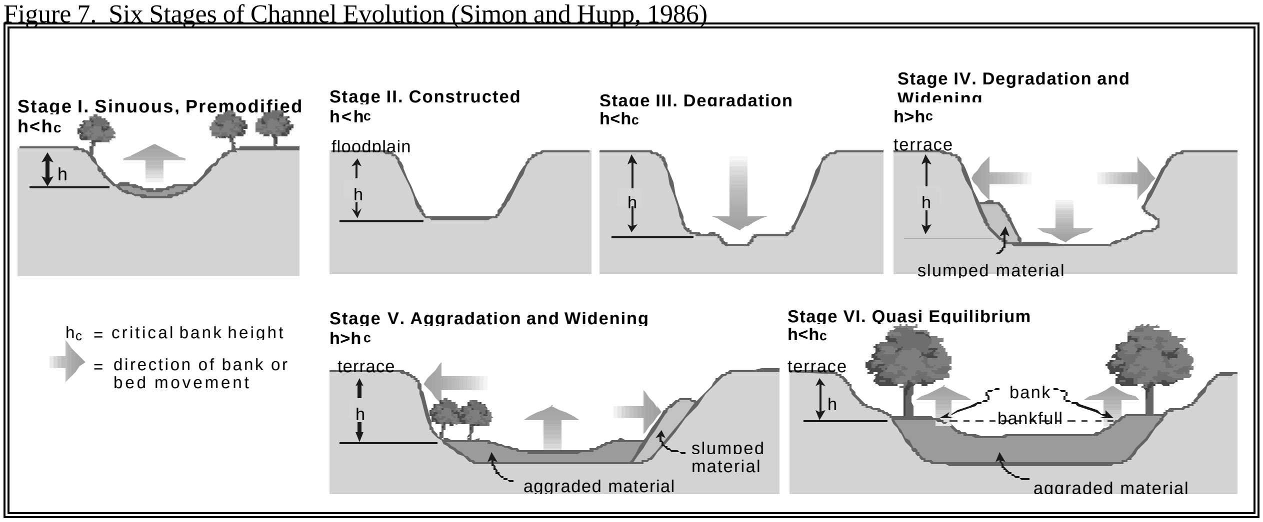
As an alternative scheme for TMDL practitioners, the channel evolution framework set out by Simon and Hupp (1986) is proposed (Figure 7). In most alluvial channels, disruption of the dynamic equilibrium generally results in a certain degree of upstream channel degradation and downstream aggradation. If the predisturbed channel is considered as the initial stage (stage I) of channel evolution and the disrupted channel as an instantaneous condition (stage II), rapid channel degradation can be considered stage III. Degradation flattens channel gradients and consequently reduces the available stream power for given discharges with time. Concurrently, bank heights are increased and bank angles are often steepened by fluvial undercutting and by pore-pressure induced bank failures near the base of the bank. Thus, the degradation stage (stage III) is directly related to destabilization of the channel banks and to channel widening by mass-wasting processes (stage IV) once bank heights and angles exceed the critical conditions of the bank material (as determined by shear-strength characteristics).

As degradation migrates further upstream, aggradation (stage V) becomes the dominant trend in previously degraded downstream sites because the flatter gradient and lower hydraulic radius at the degraded site cannot transport the heightened sediment loads originating from degrading reaches upstream. This secondary aggradation occurs at rates roughly 60% less than the associated degradation rate (Simon and Hupp, 1992). These reduced aggradation rates indicate that bed-level recovery will not be complete and that attainment of a new dynamic equilibrium will take place through (1) further channel widening, (2) the establishment of riparian vegetation that adds roughness elements and reduces the stream power for given discharges, and (3) further gradient reduction by meander extension and elongation.

The lack of complete bed-level recovery often results in a two-tiered channel configuration with the original floodplain surface becoming a terrace. Flood flows are, therefore, constrained within this enlarged channel below the terrace level. Without proliferation of riparian vegetation within the channel, this results in a given flow having greater erosive power than if an equivalent flow could dissipate energy by spreading across the floodplain. Where vegetation does re-establish, the additional roughness limits the erosive power of flood events within the incised channel and constrains shear-stress values to near bankfull levels. Aggrading conditions (stage V) are also common in reaches downstream from the area of maximum disturbance immediately after the disturbance is imposed on the stream channel.

With stages of channel evolution tied to discrete channel processes and not strictly to specific channel shapes, they have been successfully used to describe systematic channel-stability processes over time and space in diverse environments subject to various disturbances such as stream response to: channelization in the Southeast US Coastal Plain; volcanic eruptions in the Cascade Mountains; and dams in Tuscany, Italy (Rinaldi and Simon, 1998). Because the stages of channel evolution represent shifts in dominant channel processes, they are systematically related to suspended-sediment and bed-material discharge (Simon, 1989; Kuhnle and Simon, 2000), fish-community structure, rates of channel widening (Simon and Hupp, 1992), and the density and distribution of woody riparian vegetation (Hupp, 1992).

Figure 7. Six Stages of Channel Evolution (Simon and Hupp, 1986)



An advantage of a process-based channel-evolution scheme for use in TMDL development is that Stages I and VI represent two true "reference" conditions. In some cases, channels are unlikely to recover to Stage I, pre-modified conditions. Stage VI, re-stabilized conditions are a more likely target under the present regional landuse and altered hydrologic regimes and can be used as a "reference" condition. However, in pristine areas where disturbances have not occurred or where they are far less severe, Stage I conditions can be used as a "reference" condition.

4.2 Analysis of Available Suspended Sediment Data (Simon, et al., 2002a)

Analysis of suspended sediment transport data involves establishing a relation between flow and sediment concentration or load. Instantaneous concentration data combined with either an instantaneous flow value or flow data representing the value obtained from the stage-discharge relation at 15-minute intervals are best. Mean daily values of both flow and sediment loads, which are readily available from the USGS, tend to be biased towards lower flows, particularly in flashy basins. For establishing sediment-transport rating relations, instantaneous concentration and 15-minute flow data were used from USGS and

ARS gauging station records.

Because the "effective discharge" is that discharge or range of discharges that shape channels and perform the most geomorphic work (transport the most sediment) over the long term, it can serve as a useful indicator of regional suspended sediment transport conditions for "reference" and impacted sites. In many parts of the United States, the effective discharge is approximately equal to the peak flow that occurs about every 1.5 years ($Q_{1.5}$) and may be analogous to the bankfull discharge in stable streams.

The recurrence interval for the effective discharge was calculated for 10 streams in Mississippi. Calculating the effective discharge is a matter of integrating a flow-frequency curve with a sediment-transport rating to obtain the discharge (range of discharges) that transports the most sediment. This was accomplished at 10 sites where the complete 15-minute flow record was easily obtainable. For the 10 streams analyzed in Mississippi, the $Q_{1.5}$ is on average, a good approximation (Table 5). Therefore, the $Q_{1.5}$ was used as a measure of establishing the effective discharge at all sites.

The effective discharge ($Q_{1.5}$) was determined for all sites where the instantaneous sediment concentration data were available. This discharge was then applied to the sediment transport relation to obtain the sediment load at the effective discharge. To normalize the data for differences in basin size, the sediment load was divided by drainage area to obtain sediment yield (in $T/D/km^2$).

4.3 "Reference" or "Target" Sediment Yields

"Reference" or "Target" values for suspended sediment are based on the concept that stable channel conditions can be represented by channel evolution Stages I and VI. Therefore, the effective discharge sediment yields for Stage I and VI in a given ecoregion represent background or natural transport rates (Simon, et al., 2002b). The targeted sediment yield for an ecoregion is based on the sediment yield values obtained for Stage I and VI sites within that ecoregion. Based on this information, the targeted sediment yield range for Ecoregion 74 is 8.8E-02 to 2.4E-01 tons per acre per day at the effective discharge.

Ecoregion 74, the Mississippi Valley Loess Plains, produces the greatest amount of sediment per unit drainage area in the nation partly due to 1) the highly erodible nature of the silt sized sediment that dominates the region, and 2) the extensive channel dredging and straightening that has taken place in the region over the past century in response to land clearing and subsequent channel filling (Simon, et al., 2002c). Figure 8 provides a median of all of the data in each ecoregion, not the range of the central 50 percent of the distribution for the stable streams only, which is the way the target yield for this TMDL is provided. However, Figure 8 is useful to demonstrate why the target yield for Ecoregion 74 the Mississippi Valley Loess Plains, is much larger than the target yield for Ecoregion 73, the Mississippi Alluvial Plain. The Ecoregions of the Yazoo River Basin, 73 and 74, are shown in Figure 9.

Figure 8. Comparison of national median suspended-sediment yields at the Q1.5 for 84 ecoregions of the continental United States (Simon et al., 2002c)

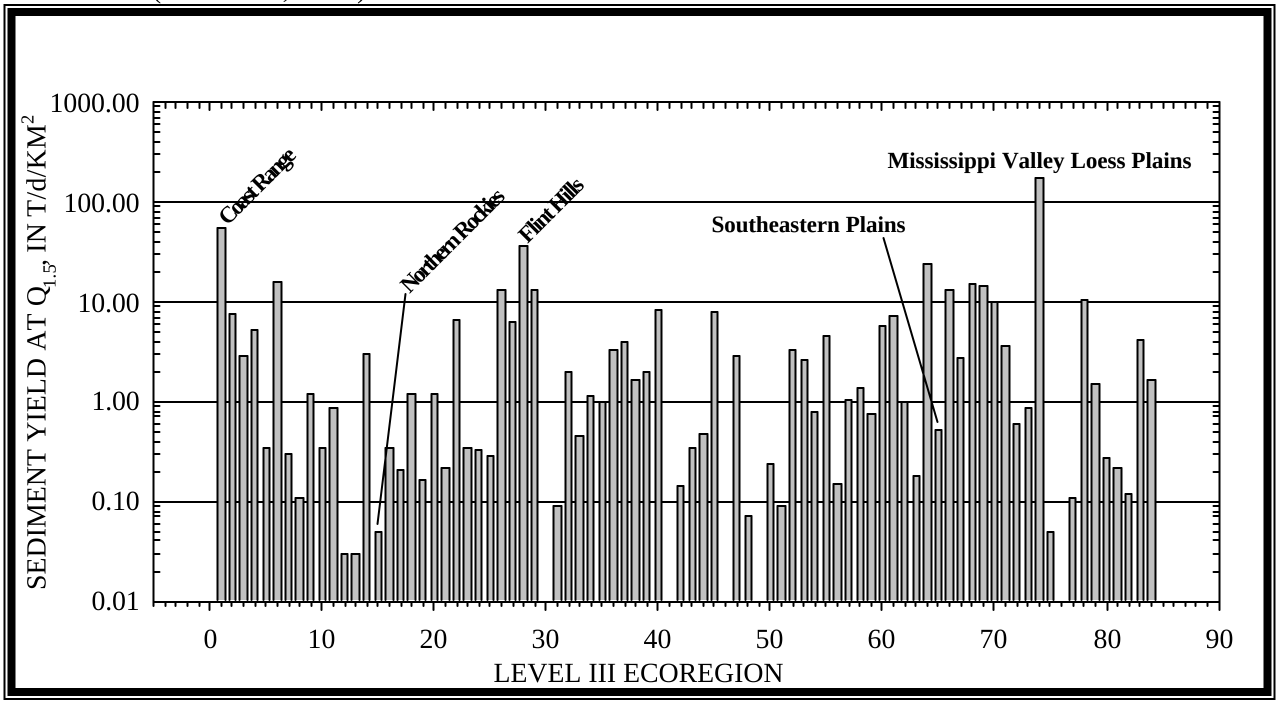
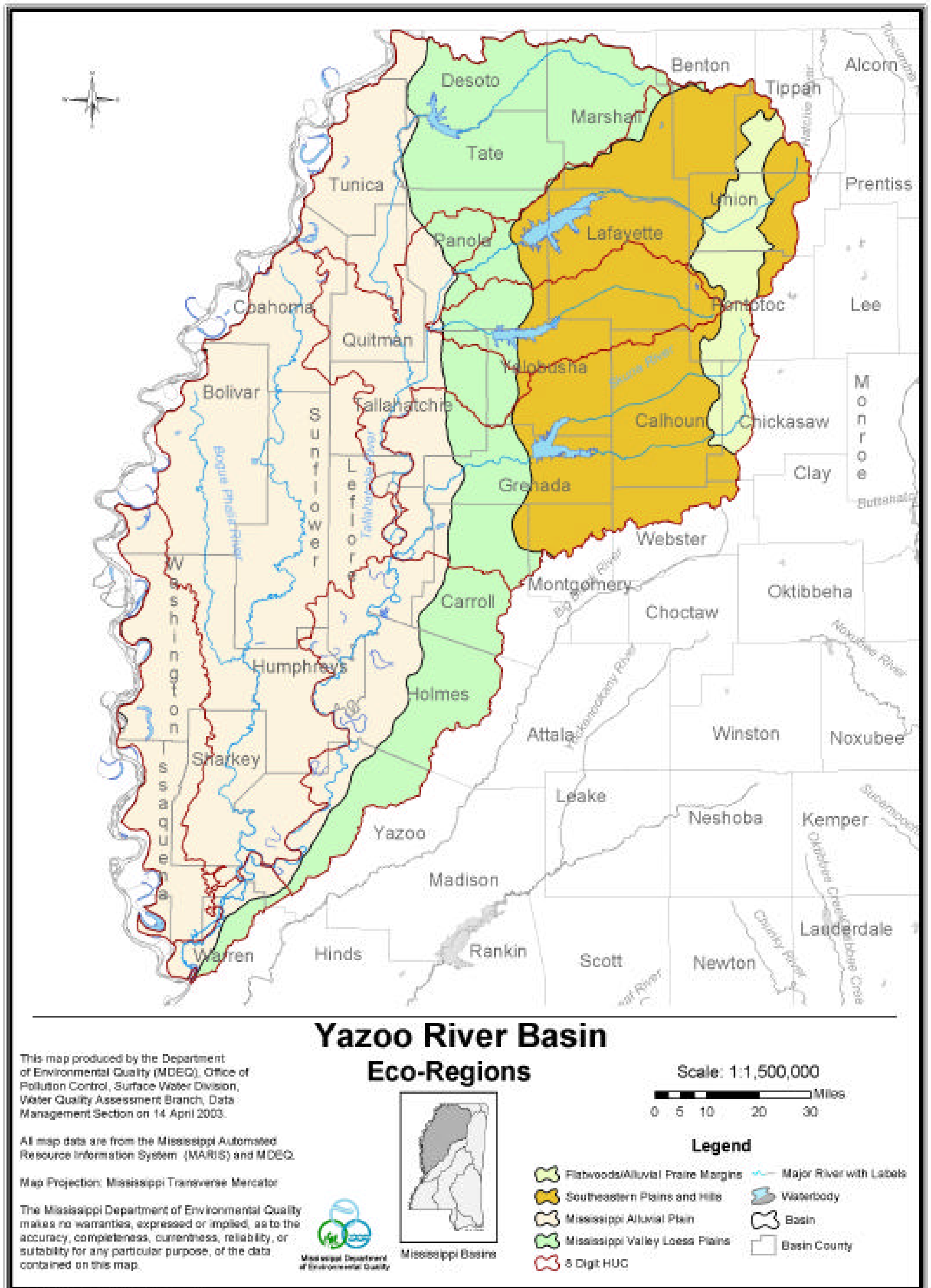


Figure 9. Ecoregions of the Yazoo River Basin



5.0 ALLOCATION

The allocation for this TMDL involves a waste load allocation (WLA) for permitted sources, a load allocation (LA) for unpermitted nonpoint sources, and an implicit margin of safety (MOS), which should result in attainment of water quality standards in the Yalobusha River. According to 40 CFR §130.2 (i), TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure. In this case, an "other appropriate measure" is used to express the TMDL as the tons of sediment that can be discharged from an acre of a subwatershed during a day (tons/acre/day) at the effective discharge and still attain the applicable water quality standard. It is appropriate to apply the same target yield to permitted (WLA) and unpermitted (LA) watershed areas. For load TMDLs the WLA and LA are summed to calculate the TMDL. Because this TMDL is expressed as a yield, as long as all activities, permitted or unpermitted, meet the same yield, the TMDL yield will be met, regardless of the relative load contribution. The methods used to develop these values are described in detail in the reports titled, *"Reference" and "Impacted" Rates of Suspended-Sediment Transport for Use in Developing Clean Sediment TMDLs: Mississippi and the Southeastern United States* (Simon, et al., 2002b) and *Actual and Reference Sediment Yields for the James Creek Watershed – Mississippi* (Simon, et al., 2002a).

5.1 Wasteload Allocations

The contribution from NPDES permitted facilities was considered negligible in the development of this TMDL. The Total Suspended Solids (TSS) component of any NPDES permitted facility is different from the pollutant addressed within this TMDL. The pollutant of concern for this TMDL is sediment from landuse runoff and in-channel processes.

Sediment loadings from NPDES regulated construction activities and Municipal Separate Storm Sewer Systems (MS4s) are considered point sources of sediment to surface waters. These discharges occur in response to storm events and are included in the WLA of this TMDL as the same target yield as the TMDL of 8.8E-02 to 2.4E-01 tons per acre per day at the effective discharge.

5.2 Load Allocations

The load allocation developed for this TMDL is an estimation of the acceptable contribution of all nonpoint sources in the watershed. Channel processes and upland sources both contribute to the sediment loading of the river. Forested areas that are subject to silviculture activities may exhibit elevated sediment contributions if Voluntary Best Management Practices for Forestry in Mississippi are not implemented. Best management practices (BMPs), as outlined in "Mississippi's BMPs: Best Management Practices for Forestry in Mississippi" (MFC, 2000), "Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater" (MDEQ, et. al, 1994), and "Field Office Technical Guide" (NRCS, 2000), would be the most effective means of reducing the load from the upland sources.

The calculated range of allowable loads of sediment for the impaired segments of the Yalobusha River without exceeding the applicable narrative water quality standard, as interpreted by MDEQ, is also a range of 8.8E-02 to 2.4E-01 tons per acre per day at the effective discharge.

5.3 Incorporation of a Margin of Safety (MOS)

The two types of MOS development are to implicitly incorporate the MOS using conservative assumptions or to explicitly specify a portion of the total TMDL as the MOS. The MOS selected for this TMDL is implicit. The use of conservative procedures provides a sufficient implicit MOS. These conservative procedures include the use of a stable stream as the target in an area where a majority of the streams are unstable and the use of the effective discharge flow, the flow that produces the most sediment transport.

5.4 Calculation of the TMDL

As stated above, the pollutant of concern for this TMDL is sediment from landuse runoff and in-channel processes. The load allocation includes the contributions from the channel and surface runoff from the watershed. The margin of safety for this TMDL is implicit and derived from the conservative assumptions incorporated into this methodology. This TMDL, expressed as an acceptable range of sediment yields, is the same for the WLA, LA and TMDL. For load TMDLs the WLA and LA are summed to calculate the TMDL. Because this TMDL is expressed as a yield, as long as all activities, permitted or unpermitted, meet the same yield as shown in Table 5, the TMDL yield will be met, regardless of the relative load contribution.

WLA= 8.8E-02 to 2.4E-01 tons of sediment per acre per day at the effective discharge

LA = 8.8E-02 to 2.4E-01 tons of sediment per acre per day at the effective discharge

MOS = Implicit

Table 5. TMDL Yields

Parameter	WLA	LA	MOS	TMDL
Sediment (tons/acre/day)*	8.8E-02 to 2.4E-01	8.8E-02 to 2.4E-01	Implicit	8.8E-02 to 2.4E-01

*at the effective discharge

5.5 Seasonality

The use of a data collected throughout the year at many stations in the ecoregion to set the target addresses seasonal variation. Instantaneous flow and suspended sediment data were used to develop the TMDL targets for each ecoregion. These data were collected throughout the year and would account for all seasons of the calendar year, changing atmospheric conditions (including rainy and dry seasons and high and low temperatures), and the periods representative of critical conditions.

6.0 CONCLUSION

The acceptable range of sediment yields was estimated to be 8.8E-02 to 2.4E-01 tons per acre per day at the effective discharge. The estimated range of yields for unstable streams in the same ecoregion is 1.9E-01 to 1.5 tons per acre per day at the effective discharge. Because the existing range for the Yalobusha River is estimated to be similar to that of other unstable streams in its ecoregion, there is a deviation of approximately one order of magnitude in the estimated existing range and the TMDL range. Therefore, it is recommended that the Yalobusha River watershed be considered a priority for streambank and riparian buffer zone restoration and any sediment reduction BMPs, especially for the road crossings, agricultural activities, and construction activities. The implementation of these BMP activities should reduce the sediment load entering the Yalobusha River. The reduction of the sediment load in the Yalobusha River watershed to equal that of a relatively stable stream will allow the river to approach stable conditions, which would provide improved habitat for the support of aquatic life in the river.

6.1 Future Activities

MDEQ has adopted the Basin Approach to Water Quality Management, a plan that divides Mississippi's major drainage basins into five groups. During each yearlong cycle, MDEQ resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Yazoo River Basin, the Yalobusha River watershed may receive additional monitoring to identify any changes or improvements in water quality. For land disturbing activities related to silviculture, construction, and agriculture, it is recommended that practices, as outlined in "Mississippi's BMPs: Best Management Practices for Forestry in Mississippi" (MFC, 2000), "Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater" (MDEQ, et. al, 1994), and "Field Office Technical Guide" (NRCS, 2000), be followed, respectively.

6.2 Public Participation

This TMDL will be published for a 30-day public notice. During this time, the public will be notified by publication in the statewide newspaper and a newspaper in the area of the watershed. The public will be given an opportunity to review the TMDL and submit comments. MDEQ also distributes all TMDLs at the beginning of the public notice to those members of the public who have requested to be included on a TMDL mailing list. TMDL mailing list members may request to receive the TMDL reports through either, email or the postal service. Anyone wishing to become a member of the TMDL mailing list should contact Greg Jackson at (601) 961-5098 or Greg_Jackson@deq.state.ms.us. At the end of the 30-day period, MDEQ will determine the level of interest in the TMDL and make a decision on the necessity of holding a public meeting.

All comments received during the public notice period and at any public meeting become a part of the record of this TMDL. All comments will be considered in the ultimate completion of this TMDL for submission of this TMDL to EPA Region 4 for final approval.

DEFINITIONS

Aggradation: The raising of the bed of a watercourse by the deposition of sediment.

Allocations: That portion of a receiving water's loading capacity that is attributed to one of its existing or future pollution sources (nonpoint or point) or to natural background sources.

Ambient Stations: A network of fixed monitoring stations established for systematic water quality sampling at regular intervals, and for uniform parametric coverage over a long-term period.

Anthropogenic: Pertains to the [environmental] influence of human activities.

Assimilative Capacity: The capacity of a body of water or soil-plant system to receive wastewater effluents or sludge without violating the provisions of the State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters and Water Quality regulations.

Background: The condition of waters in the absence of man-induced alterations based on the best scientific information available to MDEQ. The establishment of natural background for an altered water body may be based upon a similar, unaltered or least impaired, water body or on historical pre-alteration data.

Background Levels: Levels representing the chemical, physical, and biological conditions that would result from natural geomorphological processes such as weathering or dissolution.

Bank Full Stage: Stage of flow at which a stream fills its channel up to level of its bank. Recurrence interval averages 1.5 to 2 years.

Bedload Sediment: Portion of sediment load transported downstream by sliding, rolling, bouncing along the channel bottom. Generally consists of particles >1 mm.

Best Management Practices (BMPs): Methods, measures, or practices that are determined to be reasonable and cost effective means for a land owner to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.

Calibration: The process of adjusting model parameters within physically defensible ranges until the resulting predictions give a best possible good fit to observed data.

Channel: A natural stream that conveys water; a ditch or channel excavated for the flow of water.

Channel Improvement: The improvement of the flow characteristics of a channel by clearing, excavation, realignment, lining, or other means in order to increase its capacity. Sometimes used to connote channel stabilization.

Channel Stabilization: Erosion prevention and stabilization of velocity distribution in a channel using jetties, drops, revetments, vegetation, and other measures.

Clean Sediment: Sediment that is not contaminated by chemical substances. Pollution caused by clean sediment refers to the quantity of sediment, as opposed to the presence of pollutant-contaminated sediment.

Critical Condition: The critical condition can be thought of as the "worst case" scenario of environmental conditions in the water body in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc.) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence.

Cross-Sectional Area: Wet area of a waterbody normal to the longitudinal component of the flow.

Daily Discharge: The "discharge of a pollutant" measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. For pollutants with limitations expressed in units of mass, the "daily discharge" is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurement, the "daily average" is calculated as the average.

Designated Use: Use specified in water quality standards for each water body or segment regardless of actual attainment.

Discharge Monitoring Report: Report of effluent characteristics submitted by a NPDES permitted facility.

Dissolved Solids: Disintegrated organic and inorganic material in water. Excessive amounts will make water unfit to drink or use in industrial processes.

Diurnal: Actions or processes that have a period or a cycle of approximately one tidal-day or are completed within a 24-hour period and that recur every 24 hours.

Dynamic Model: A mathematical formulation describing and simulating the physical behavior of a system or a process and its temporal variability.

Ecoregion: A physical region that is defined by its ecology, which includes meteorological factors, elevation, plant and animal speciation, landscape position, and soils.

Effective Discharge: The discharge which moves the most sediment.

Effluent: Treated wastewater flowing out of the treatment facilities.

Effluent Standards and Limitations: All State or Federal effluent standards and limitations on quantities, rates, and concentrations of chemical, physical, biological, and other constituents to which a waste or wastewater discharge may be subject under the Federal Act or the State law. This includes, but is not limited to, effluent limitations, standards of performance, toxic effluent standards and prohibitions, pretreatment standards, and schedules of compliance.

Flood Plain: The lowland that borders a river, usually dry but subject to flooding.

Fluvial Geomorphology: The effect of rainfall and runoff on the form and pattern of riverbeds and river channels.

Geomorphology: The study of the evolution and configuration of landforms.

Gully Erosion: The erosion process whereby water accumulates in narrow channels and, over short periods, removes soil from this narrow are to considerable depths, ranging from 1-2 feet to as much as 75-100 feet.

Impaired Water body: Any water body that does not attain water quality standards due to an individual pollutant, multiple pollutants, pollution, or an unknown cause of impairment.

Land Surface Runoff: Water that flows into the receiving stream after application by rainfall or irrigation. It is a transport method for nonpoint source pollution from the land surface to the receiving stream.

Load Allocation (LA): The portion of a receiving water's loading capacity attributed to or assigned to nonpoint sources (NPS) or background sources of a pollutant. The load allocation is the value assigned to the summation of all direct sources and land applied fecal coliform that enter a receiving water body.

Loading: The total amount of pollutants entering a stream from one or multiple sources.

Mass Wasting: Downslope transport of soil and rocks due to gravitational stress.

NPDES Permit: An individual or general permit issued by the Mississippi Environmental Quality Permit Board pursuant to regulations adopted by the Mississippi Commission on Environmental Quality under Mississippi Code Annotated (as amended) §§ 49-17-17 and 49-17-29 for discharges into State waters.

Narrative Criteria: Nonquantitative guidelines that describe the desired water quality goals.

Natural Waters: Flowing water within a physical system that has developed without human intervention, in which natural processes continue to take place.

Nonpoint Source: Pollution that is not released through pipes but rather originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related to either land or water use including failing septic tanks, improper animal-keeping practices, forest practices, and urban and rural runoff.

Numeric Target: A measurable value determined for the pollutant of concern which, if achieved, is expected to result in the attainment of water quality standards in the listed water body.

Phased Approach: Under the phased approach to TMDL development, load allocations and wasteload allocations are calculated using the best available data and information recognizing the need for additional monitoring data to accurately characterize sources and loadings. The phased approach is typically employed when nonpoint sources dominate. It provides for the implementation of load reduction strategies while collecting additional data.

Point Source: Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial wastewater treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water stream or river.

Pollutant: Dredged soil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into a water. (CWA Section 502(6))

Pollution: Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, biological, chemical, and radiological integrity of water.

Reference Sites: Water bodies that are representative of the characteristics of the region and subject to minimal human disturbance.

Runoff: That part of precipitation, snow melt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into receiving waters.

Scour: To abrade and wear away. Used to describe the weathering away of a terrace or diversion channel or streambed. The clearing and digging action of flowing water, especially the downward erosion by stream water in sweeping away mud and silt on the outside of a meander or during flood events.

Sediment: Particulate organic and inorganic matter that accumulates in a loose, unconsolidated form on the bottom of natural waters.

Sediment Delivery: Contribution of transported sediment to a particular location or part of a landscape.

Sediment Production: Delivery of colluvium or bedrock from hillslope to stream channel. The production rate is evaluated as the sum of the rates of colluvial bank erosion and sediment transport across channel banks.

Sediment Yield: Amount of sediment passing a particular point (e.g., discharge point of the basin) in a watershed per unit of time.

Sedimentation: Process of deposition of waterborne or windborne sediment or other material; also refers to the infilling of bottom substrate in a waterbody by sediment (siltation).

Sheet Erosion: Also Sheetwash. Erosion of the ground surface by unconcentrated (i.e. not in rills) overland flow.

Sheetwash: Also Sheet Erosion. Erosion of the ground surface by unconcentrated (i.e. not in rills) overland flow.

Stage: The height of a water surface above an established datum plane.

Stream Restoration: Various techniques used to replicate the hydrological, morphological, and ecological features that have been lost in a stream due to urbanization, farming, or other disturbance.

Surface Runoff: Precipitation, snow melt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants.

Suspended Solids: Organic and inorganic particles (sediment) suspended in and carried by a fluid (water). The suspension is governed by the upward components of turbulence, currents, or colloidal suspension. Suspended sediment usually consists of particles <0.1 mm, although size may vary according to current hydrological conditions. Particles between 0.1 mm and 1 mm may move as suspended or be deposited (bedload).

Thalweg: Deepest part of a stream channel.

Topography: The physical features of a geographic surface area including relative elevations and the positions of natural and man-made features.

Total Maximum Daily Load or TMDL: The calculated maximum permissible pollutant loading to a water body at which water quality standards can be maintained. Also, the sum of the individual wasteload allocations for point sources, load allocations for nonpoint sources, and natural background, plus a margin of safety. TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standard.

Turbidity: A measure of opacity of a substance; the degree to which light is scattered or absorbed by a fluid.

Waste: Sewage, industrial wastes, oil field wastes, and all other liquid, gaseous, solid, radioactive, or other substances which may pollute or tend to pollute any waters of the State.

Wasteload Allocation (WLA): The portion of a receiving water's loading capacity attributed to or assigned to point sources of a pollutant.

Water Quality Standards: The criteria and requirements set forth in *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. Water quality standards are standards composed of designated present and future most beneficial uses (classification of waters), the numerical and narrative criteria applied to the specific water uses or classification, and the Mississippi antidegradation policy.

Water Quality Criteria: Elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports the present and future most beneficial uses.

Waters of the State: All waters within the jurisdiction of this State, including all streams, lakes, ponds, wetlands, impounding reservoirs, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface and underground, natural or artificial, situated wholly or partly within or bordering upon the State, and such coastal waters as are within the jurisdiction of the State, except lakes, ponds, or other surface waters which are wholly landlocked and privately owned, and which are not regulated under the Federal Clean Water Act (33 U.S.C.1251 et seq.).

Watershed: The area of land draining into a stream at a given location.

ABBREVIATIONS

ARS .... Agricultural Research Service

BMP .... Best Management Practice

CWA .... Clean Water Act

CWPRU .... Channel and Watershed Processes Research Unit

DA .... Drainage Area

DEM .... Digital Elevation Model

EPA .... Environmental Protection Agency

GIS .... Geographic Information System

HUC .... Hydrologic Unit Code

LA .... Load Allocation

MARIS .... Mississippi Automated Resource Information Service

MDEQ .... Mississippi Department of Environmental Quality

MFC .... Mississippi Forestry Commission

MOS .... Margin of Safety

NPDES .... National Pollution Discharge Elimination System

NPS .... Non-Point Source

NRCS .... Natural Resource Conservation Service

NSL .... National Sedimentation Laboratory

RF3 .... Reach File 3

TSS .... Total Suspended Solids

USGS .... United States Geological Survey

USLE .... Universal Soil Loss Equation

WLA .... Waste Load Allocation

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