FINAL REPORT
October 2002
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Fecal Coliform TMDL for the Big Sunflower River

Yazoo River Basin

Sunflower, Coahoma, Washington, and Humphreys Counties, Mississippi

Prepared By

Mississippi Department of Environmental Quality
Office of Pollution Control
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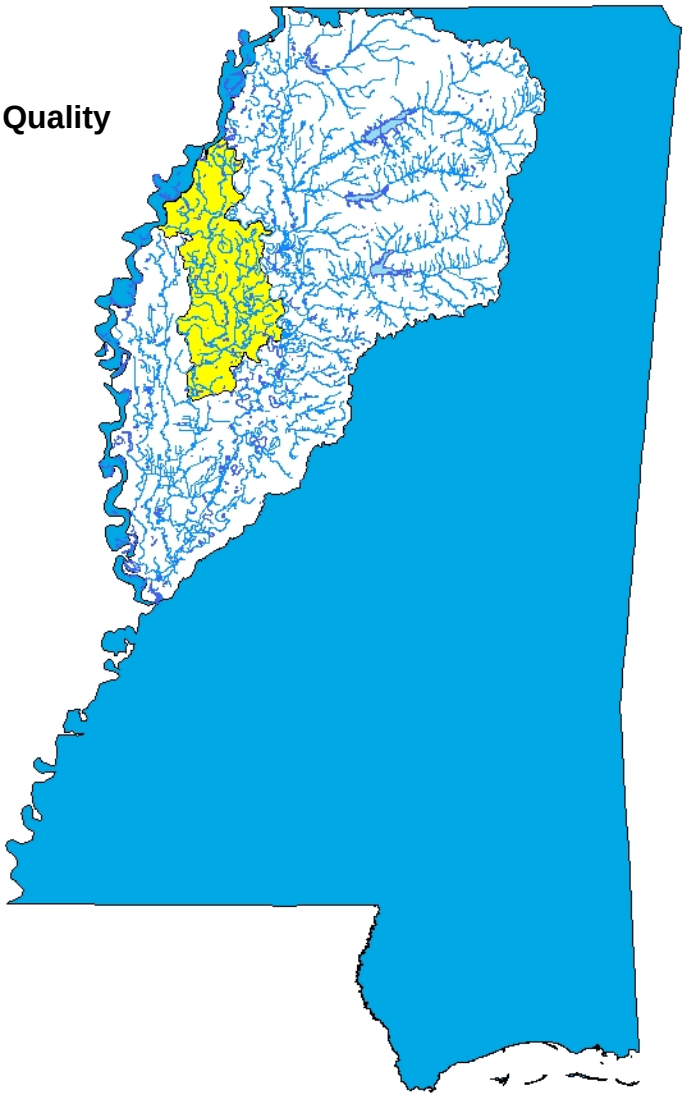

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MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY

FOREWORD

This report has been prepared in accordance with the schedule contained within the federal consent decree dated December 22, 1998. The report contains one or more Total Maximum Daily Loads (TMDLs) for waterbody 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.

Prefixes for fractions and multiples of SI units

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	μ	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

Conversion Factors

To convert from	To	Multiply by	To Convert from	To	Multiply by
Acres	Sq. miles	0.0015625	Days	Seconds	86400
Cubic feet	Cu. Meter	0.028316847	Feet	Meters	0.3048
Cubic feet	Gallons	7.4805195	Gallons	Cu feet	0.133680555
Cubic feet	Liters	28.316847	Hectares	Acres	2.4710538
cfs	Gal/min	448.83117	Miles	Meters	1609.344
cfs	MGD	.6463168	Mg/l	ppm	1
Cubic meters	Gallons	264.17205	μg/l * cfs	Gm/day	2.45

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TMDL INFORMATION PAGE

Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Big Sunflower River seg 2	MSBIGSUNRM2	Sunflower	08030207	Pathogens	Monitored
At Sunflower: From confluence with Jones Bayou to confluence with Porter Bayou					
Big Sunflower River seg 5	MSBIGSUNRM5	Coahoma	08030207	Pathogens	Monitored
At Clarksdale: From confluence with Little Sunflower River to low head dam above Clarksdale POTW					
Big Sunflower River	MSBIGSUNRM	Coahoma	08030207	Pathogens	Evaluated
At Clarksdale: From Lyons POTW (MS0020591) to Hopson Bridge					
Big Sunflower River	MSBIGSUNRM3	Sunflower Washington Humphreys	08030207	Pathogens	Evaluated
At Indianola: From confluence with Porter Bayou to confluence with Bogue Phalia					

Water Quality Standard

Parameter	Beneficial use	Water Quality Criteria
Fecal Coliform	Secondary Contact	**May - October**: Fecal coliform colony counts not to exceed a geometric mean of 200 per 100ml, nor shall more than 10 percent of samples examined during any month exceed a colony count of 400 per 100ml. **November – April**: Fecal coliform colony counts shall not exceed a geometric mean of 2000 per 100 ml, nor shall more than 10 percent of the samples examined during any month exceed a colony count of 4000 per 100 ml.

NPDES Facilities

NPDES ID	Facility Name	Subwatershed	Receiving Water
MS0036722	Inverness Compression Station	08030207007	Lake Dawson
MS0020320	Inverness POTW	08030207008	Big Sunflower River
MS0026417	Drew POTW	08030207008	Dougherty Bayou
MS0044032	America's Catch Incorporated	08030207009	Turkey Bayou
MS0024937	MS/Valley State University	08030207009	Gin Bayou
MS0036005	Schlater POTW	08030207009	McNutt Lake
MS0039667	Southern Farm Fish Processors	08030207009	Roundaway Bayou to Quiver River
MS0044458	Doddsville POTW	08030207009	Big Sunflower River
MS0029262	Goose Pond Subdivision	08030207009	Stalen Brake
MS0035726	Sumner POTW	08030207009	Stalen Brake
MS0000833	Baxter Healthcare Corporation	08030207010	Tributary of Lead Bayou
MS0025127	Merigold POTW	08030207010	Jones Bayou
MS0020842	Mound Bayou POTW	08030207010	Little Mound Bayou
MS0026450	Winstonville POTW	08030207010	Mound Bayou
MS0042234	Duncan POTW	08030207010	Hushpuckena River
MS0038814	Delta Pride Catfish	08030207010	Big Sunflower River
MS0042196	Alligator POTW	08030207010	Alligator Lake
MS0025089	Shelby POTW	08030207010	Mound Bayou
MS0020567	Cleveland POTW	08030207010	Lead Bayou
MS0024961	Moorhead POTW	08030207010	Moorhead Bayou
MS0029009	MS State Pen POTW	08030207011	Black Bayou

NPDES Facilities, continued

NPDES ID	Facility Name	Subwatershed	Receiving Water
MS0032166	Lane Acres Subdivision	08030207012	Lake Bayou
MS0021075	Jonestown POTW	08030207012	Swan Lake
MS0020311	Clarksdale POTW	08030207012	Big Sunflower River
MS0045080	Lurand POTW	08030207012	Hopson Bayou
MS0020591	Lyon POTW	08030207012	Big Sunflower River
MS0044237	Coahoma POTW	08030207012	Mill Creek
MS0044148	Berryhill Mobile Home Park	08030207012	Big Sunflower River
MS0022225	Mascot Housing Development	08030207012	Harris Bayou
MS0025054	Tutwiler POTW	08030207012	Hopson Bayou

Total Maximum Daily Load, MSBIGSUNRM, MSBIGSUNRM5, MSBIGSUNRM2, and MSBIGSUNRM3

Segment	WLA (counts per day)	LA (counts per day)	MOS	TMDL Percent Reduction
MSBIGSUNRM	4.82E+10	Varies with Flow	Explicit	86
MSBIGSUNRM5	4.82E+10	Varies with Flow	Explicit	86
MSBIGSUNRM2	1.10E+11	Varies with Flow	Explicit	68
MSBIGSUNRM3	1.26E+11	Varies with Flow	Explicit	54

EXECUTIVE SUMMARY

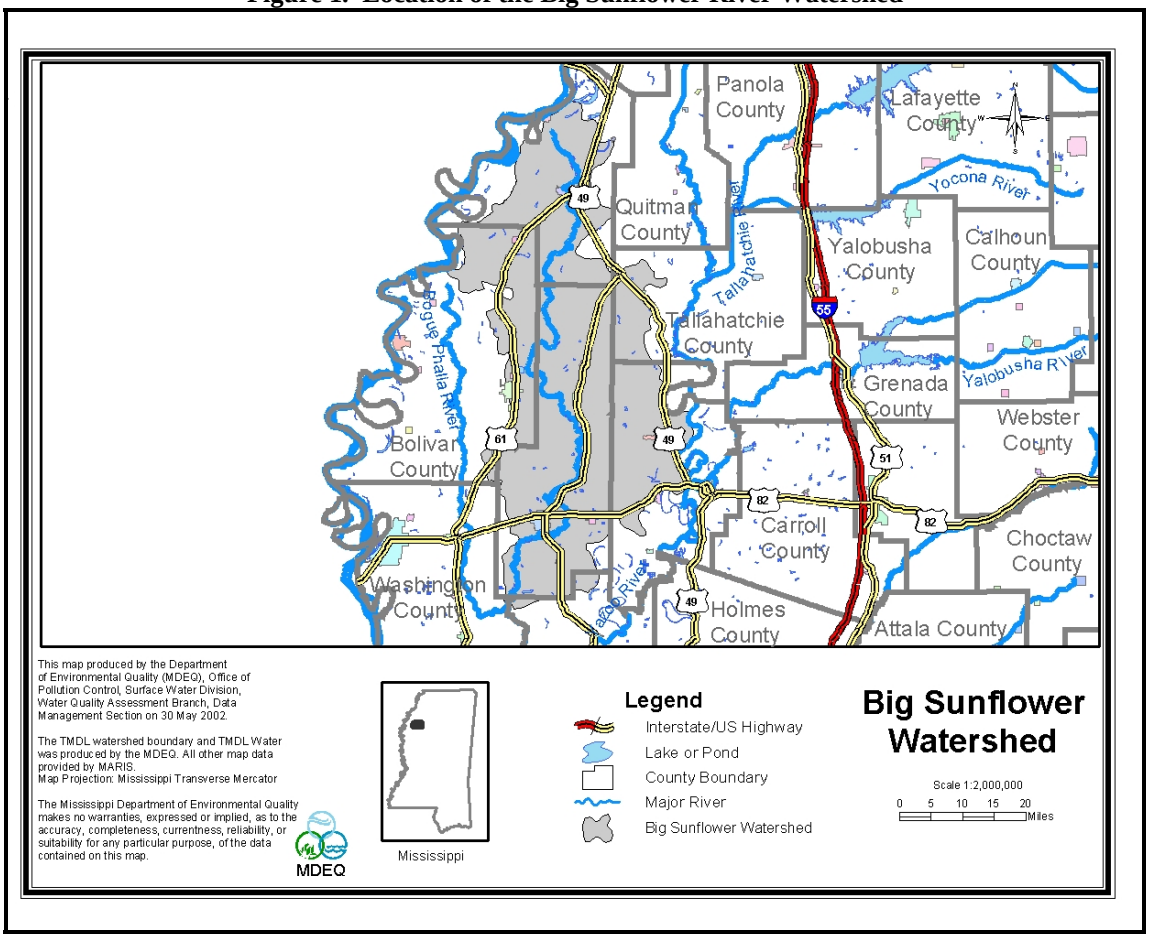
Several segments of the Big Sunflower River are on the Mississippi 1998 Section 303(d) List of Waterbodies as monitored and evaluated waterbody segments, due to fecal coliform bacteria. The applicable state standard specifies that for the summer months, the maximum allowable level of fecal coliform shall not exceed a geometric mean of 200 colonies per 100 ml, nor shall more than ten percent of the samples examined during any month exceed a colony count of 400 per 100 ml. For the winter months, the maximum allowable level of fecal coliform shall not exceed a geometric mean of 2000 colonies per 100 ml, nor shall more than ten percent of the samples examined during any month exceed a colony count of 4000 per 100 ml.

Photo 1. Big Sunflower River

The Big Sunflower River, Photo 1 and Figure 1, flows in a southernly direction from its headwaters near Lyon, Mississippi to the Yazoo River. Flowing nearly 150 miles from its headwaters to its mouth, the Big Sunflower River is one of the largest streams flowing through the Mississippi Delta. This TMDL has been developed for four listed sections of the Big Sunflower River. Due to complex hydrological factors of the Big Sunflower River, the BASINS Nonpoint Source Model (NPSM) was inappropriate as the modeling framework for performing the TMDL allocations for this study. Load duration curves, which compare the water quality data against a flow-varying allowable load, were used instead.

Although fecal coliform loadings from point and nonpoint sources in the watershed were not explicitly represented with a model, a source assessment was conducted for the Big Sunflower River Watershed. Nonpoint sources considered include wildlife, livestock, and urban development. Also considered were the nonpoint sources such as failing septic systems and other direct inputs to tributaries of the Big Sunflower River. There are 30 NPDES Permitted discharges included as point sources in the waste load allocation (WLA).

Figure 1. Location of the Big Sunflower River Watershed



Almost half of the permitted facilities currently have requirements in their NPDES Permits that require disinfection to meet water quality standards for pathogens at the end of pipe. Therefore, no changes are required for those existing NPDES permits. However, this TMDL recommends that upon reissuance the other NPDES Permits be modified to require disinfection. Monitoring of the permitted facilities in the Big Sunflower River Watershed should continue to ensure that compliance with permit limits is consistently attained.

The seasonal variations in hydrology, climatic conditions, and watershed activities are represented through the use of a continuous gage to develop the acceptable load curve and the use of water quality data collected throughout the year. The critical period was determined to be the summer season of May through October. An explicit 50 percent margin of safety (MOS) was used to account for uncertainty in the load duration curve method.

Water quality data indicate high violations of the fecal coliform standard in the waterbody. The load duration curves provide a data-based method to estimate the reductions required to meet water quality standards in the Big Sunflower River. Load duration curves and TMDLs were computed at three locations along the Big Sunflower River according to the location of monitoring stations and corresponding segment location. The estimated reductions of fecal coliform bacteria required from upstream to downstream are 86 percent, 68 percent, and 54 percent, respectively.

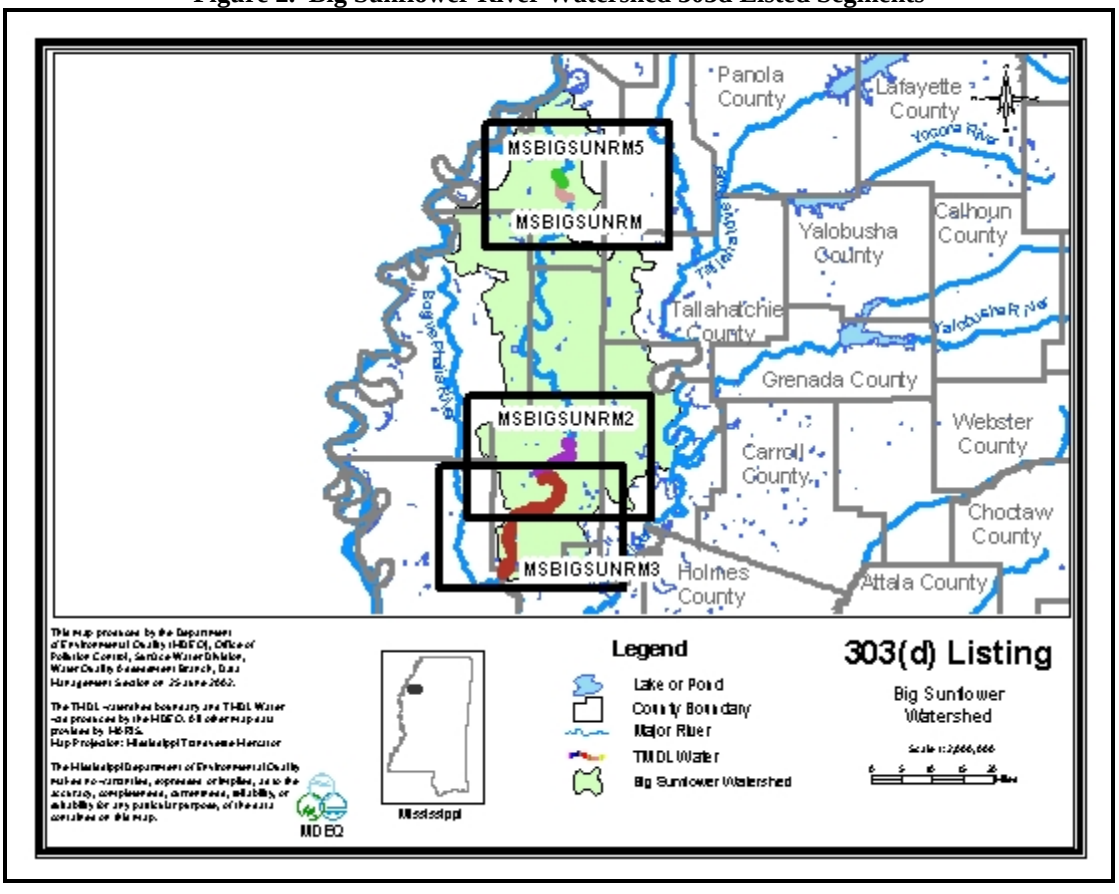
INTRODUCTION

1.1 Background

The identification of waterbodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those waterbodies 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 waterbodies through the establishment of pollutant specific allowable loads. The pollutant of concern for this TMDL is fecal coliform. Fecal coliform bacteria are used as indicator organisms. They are readily identifiable and indicate the possible presence of other pathogenic organisms in the waterbody. The TMDL process can be used to establish water quality based controls to reduce pollution from nonpoint sources, maintain permit requirements for point sources, and restore and maintain the quality of water resources.

Two segments of the Big Sunflower River are on the monitored section of the Mississippi 1998 Section 303(d) List of Waterbodies for pathogen impairment. Two segments are on the evaluated section of the Mississippi 1998 Section 303(d) List of Waterbodies for pathogen impairment. These segments were listed based on current and historical data. The listed segments, MSBIGSUNRM2, MSBIGSUNRM5, MSBIGSUNRM, and MSBIGSUNRM3, are near Sunflower, Clarksdale, Clarksdale, and Indianola, respectively. The 303d listed segments are shown in Figure 2.

Figure 2. Big Sunflower River Watershed 303d Listed Segments



The water quality and monitoring stations in each segment are shown in Figures 3, 4, and 5. Load duration curves are developed using water quality monitoring data along with long-term flow monitoring data, typically from the station where the sampling data were collected. However, when flow data are not available at the monitoring station, a nearby station can be used. The TMDL for segments MSBIGSUNRM and MSBIGSUNRM5, which overlap, was developed with one load duration curve based water quality data from station 07288000 and stage/discharge data from station 144 as shown in Figure 3. The TMDL for segment MSBIGSUNRM2 was developed with a load duration curve based water quality data from station 07288500 and stage/discharge data from station 145, which are in the same location, as shown in Figure 4. The TMDL for segment MSBIGSUNRM3 was developed with a load duration curve based water quality data from station 07288621 and stage/discharge data from station 144-f, which are in the same location, as shown in Figure 5.

Figure 3. Big Sunflower River Watershed 303d Listed Segments near Clarksdale with Stations

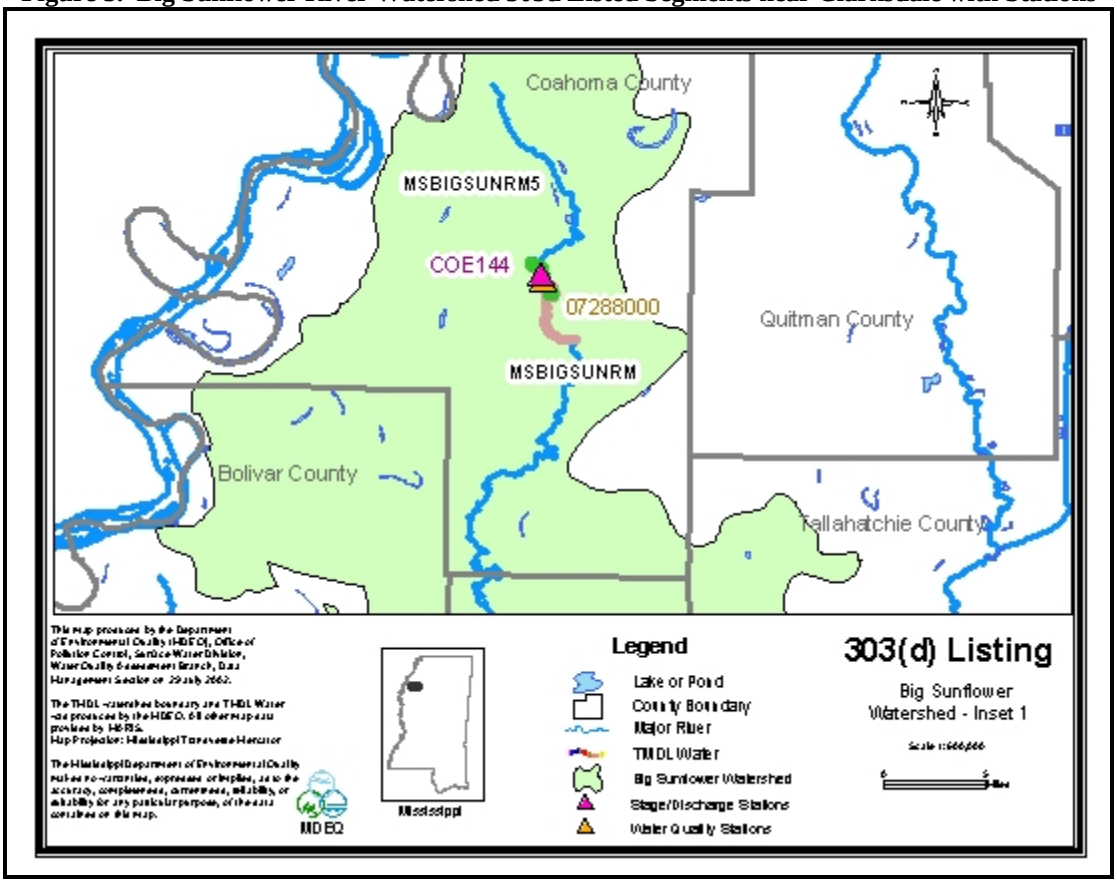


Figure 4. Big Sunflower River Watershed 303d Listed Segments near Sunflower with Stations

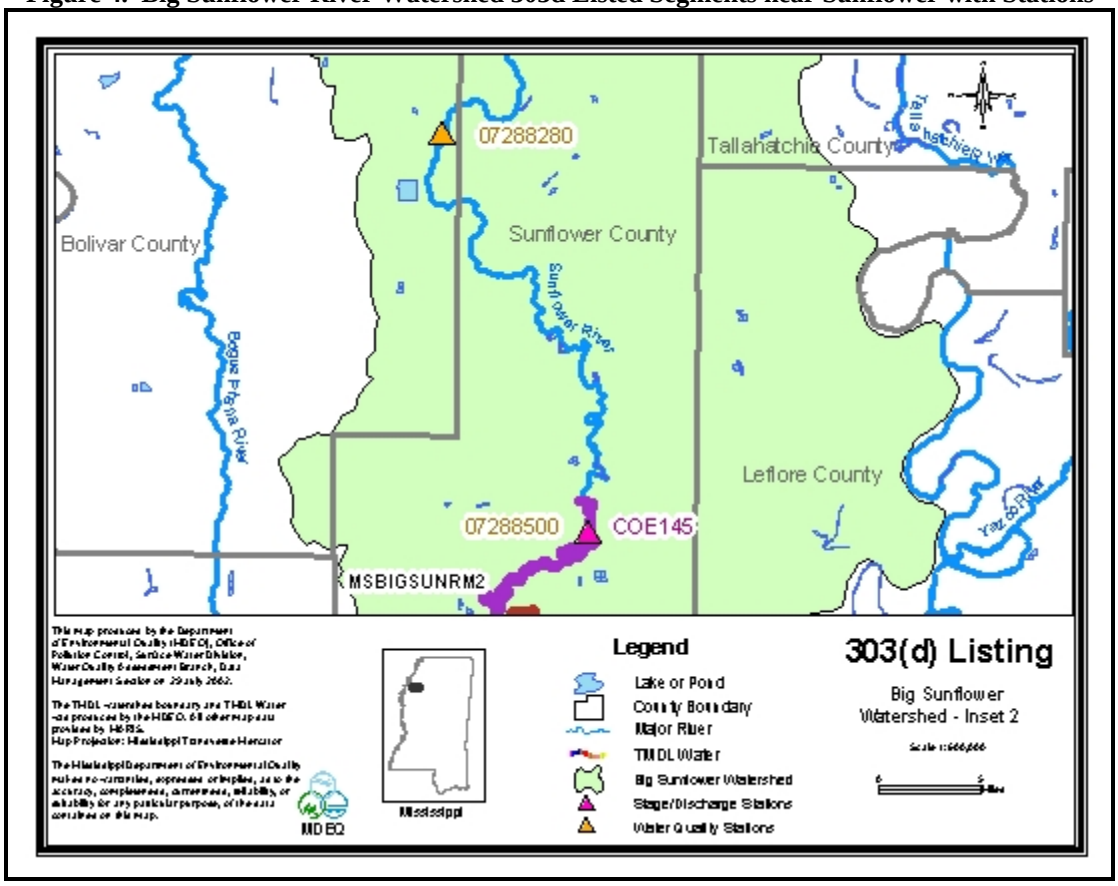
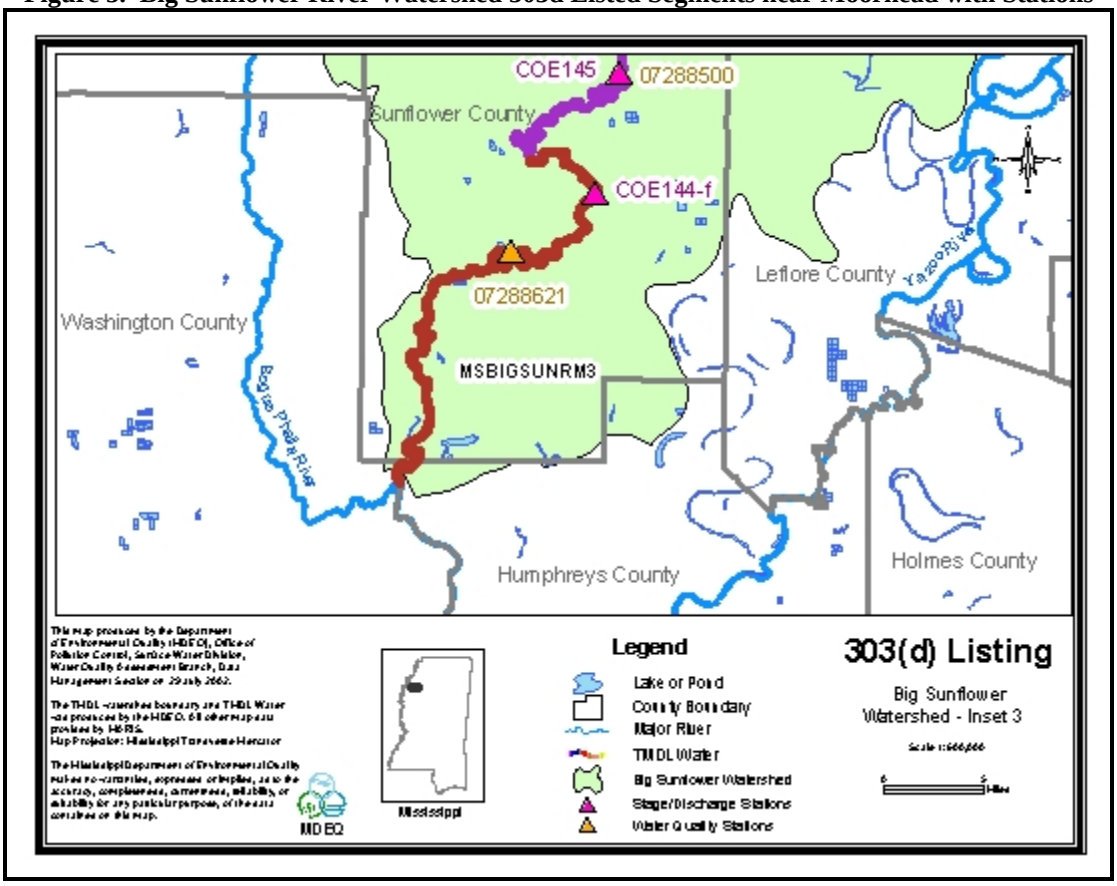


Figure 5. Big Sunflower River Watershed 303d Listed Segments near Moorhead with Stations



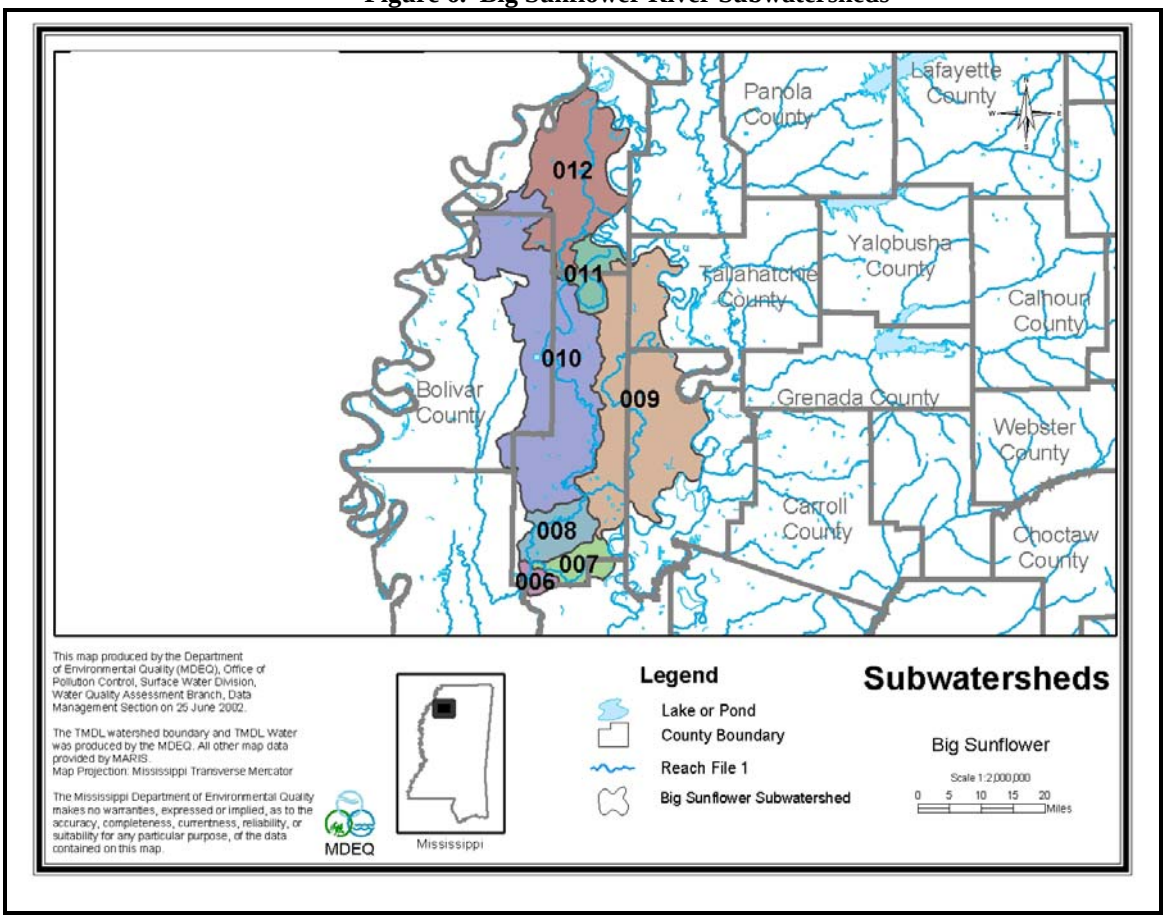
The Big Sunflower River segments are in the Yazoo River Basin Hydrologic Unit Code (HUC) 08030207 in northwest Mississippi. The watershed is approximately 1,023,721 acres; and lies within portions of Bolivar, Coahoma, Humphreys, Leflore, Sunflower, Tallahatchie, and Washington Counties. The watershed is primarily rural, but includes many small municipalities. Cropland is the dominant landuse within the watershed as shown by the land distribution summary in Table 1.

Table 1. Landuse Distribution for the Big Sunflower River Watershed

	Urban	Forest	Cropland	Pasture	Barren	Wetland	Aquaculture	Water	Total
Area (acres)	11,558	0	792,743	84,059	0	83,661	44,078	7,622	1,023,721
% Area	1%	0%	77%	8%	0%	8%	4%	1%	100%

The watershed has been divided into seven subwatersheds based on the major tributaries and topography. Figure 6 shows the subwatersheds with a three-digit Reach File 1 segment identification number. Each subwatershed is assigned a corresponding identification number, which is a combination of the eight-digit HUC and the three-digit Reach File 1 segment identification number. The identification number of the most downstream reach of the watershed is 08030207006.

Figure 6. Big Sunflower River Subwatersheds



1.2 Applicable Waterbody Segment Use

The water use classification for the listed segments of the Big Sunflower 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. The designated beneficial uses for the Big Sunflower River are Secondary Contact and Aquatic Life Support.

1.3 Applicable Waterbody Segment Standard

The water quality standard applicable to the use of the waterbody and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. The standard states that for the summer months the fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, nor shall more than ten percent of the samples examined during any month exceed a colony count of 400 per 100 ml. For the winter months, the maximum allowable level of fecal coliform shall not exceed a geometric mean of 2000 colonies per 100 ml, nor shall more than ten percent of the samples examined during any month exceed a colony count of 4000 per 100 ml. The water quality standard was used to assess the data to determine impairment in the waterbody. The instantaneous, summer portion of the water quality standard, 400 counts per 100 ml, was used as the targeted endpoint to establish these TMDLs using the load duration curve method.

TMDL ENDPOINT AND WATER QUALITY ASSESSMENT

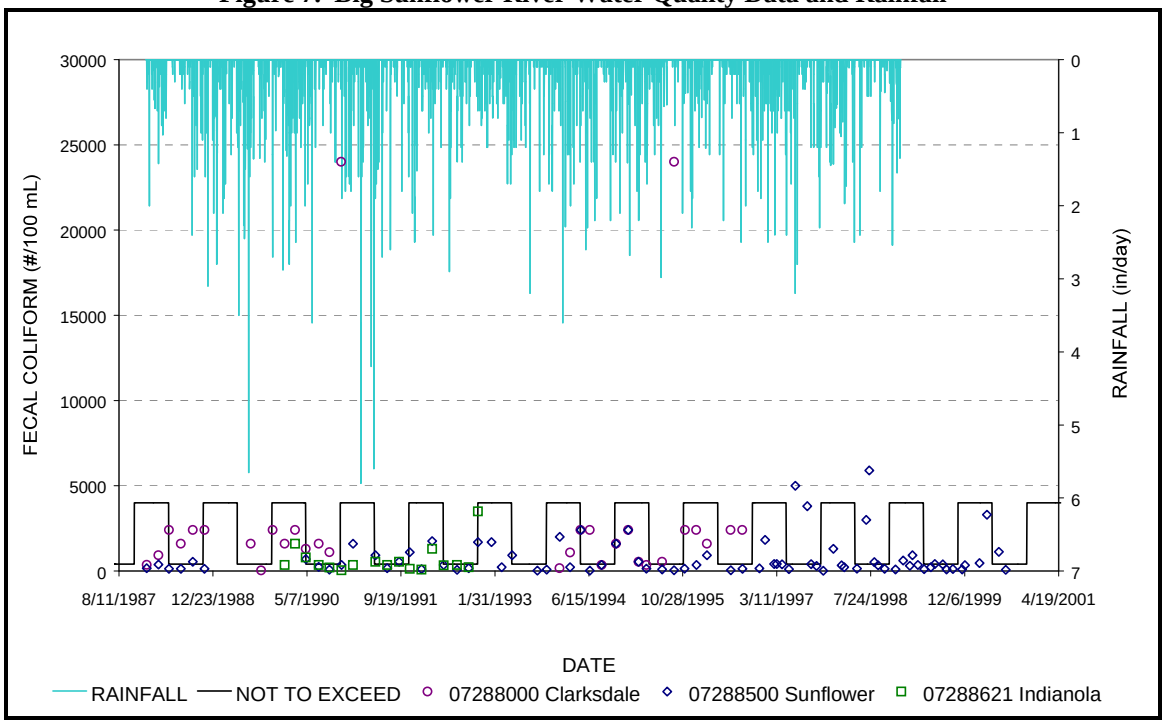
2.1 Selection of a TMDL Endpoint and Critical Condition

One of the major components of a TMDL is the establishment of instream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. Instream numeric endpoints, therefore, represent the water quality goals that are to be achieved by implementing the load and waste load reductions specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are expected to restore designated uses. The instream fecal coliform target for this TMDL is 400 colony counts per 100 ml with an explicit MOS of 50 percent, which reduces the target to 200 colony counts per 100 ml.

While the endpoint of a TMDL calculation is similar to a standard for a pollutant, the endpoint is not the standard. Currently MDEQ's standard for fecal coliform states that for the summer months the fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, nor shall more than ten percent of the samples examined during any month exceed a colony count of 400 per 100 ml. For the winter months, the maximum allowable level of fecal coliform shall not exceed a geometric mean of 2000 colonies per 100 ml, nor shall more than ten percent of the samples examined during any month exceed a colony count of 4000 per 100 ml. For these TMDLs, MDEQ considered the instantaneous portion of the standard when looking at the data for assessment of impairment, setting the target, and calculating the TMDL. The geometric mean portion of the standard is not appropriate as a target for use with load duration curves at this time because the data available at stations with the appropriate flow information are instantaneous. Data appropriate for the calculation of geometric means have been recently collected on the Big Sunflower River and are provided in Section 2.2. Additional monitoring of water quality for use in the calculation of geometric means and flow measurement at those stations is ongoing. Assessment of the geometric mean standard can be more fully evaluated upon completion of the monitoring project.

Because fecal coliform may be attributed to both nonpoint and point sources, the critical condition used for the evaluation of stream response was derived by a multi-year period. Critical conditions for waters impaired by nonpoint sources generally occur during periods of wet-weather and high surface runoff. But, critical conditions for point source dominated systems generally occur during low-flow, low-dilution conditions. The 1988-2000 period for which the water quality data exists represents both low-flow conditions as well as wet-weather conditions and encompasses a range of wet and dry seasons. Therefore, the 13-year period was used to find the critical conditions associated with all potential sources of fecal coliform bacteria within the watershed. Figure 7 shows the water quality data and the corresponding precipitation data for the majority of the period. The summer condition was chosen as the critical condition because all exceedances of the standard occurred during this period. The 400 counts per 100 ml standard was applied to all of the data in the load duration curves.

Figure 7. Big Sunflower River Water Quality Data and Rainfall



2.2 Discussion of Instream Water Quality

USGS collected data at three stations in the listed segments during the evaluation period. Monitoring for flow and fecal coliform was performed on a routine basis at station 07288000, which is located at the Second Street bridge in Clarksdale and at station 07288500, which is located l mile west of Highway 49, in Sunflower at a County Road near the Sunflower flow gage. Fecal coliform data, but no flow measurements, were also collected on the Big Sunflower River at station 07288621, which is one mile south of Indianola on Highway 49 West. Station 07288000 is in segments MSBIGSUNRM and MSBIGSUNRM5. Station 07288500 is in segment MSBIGSUNRM2. Station 07288621 is located within segment MSBIGSUNRM3. Figures 3, 4, and 5 show the impaired segments and the monitoring stations.

USGS no longer gathers routine fecal monitoring data at these stations. In order to gather fecal coliform data, MDEQ now goes to monitoring stations six times within a 30-day period. These data are used to calculate the geometric mean for the waterbody. The Big Sunflower River was recently included in this type of monitoring. These data confirm impairment in this waterbody for fecal coliform.

2.2.1 Inventory of Available Water Quality Monitoring Data

A summary of the data collected at stations shown in Figures 3, 4, and 5 on the Big Sunflower is provided in Table 2. Fecal coliform sampling data as well as flow data were available for stations 07288000 and 07288500. These data are given in Tables 3 and 4. Data collected at station 07288621 from January 1990 to October 1997 are included in Table 5. Flow data were not available for station 072788621. However, where applicable flows estimated from a nearby United States Army Corps of Engineers (USACE) continuous stage station are included. Data collected from the geometric mean study from 2001 are also shown below in Tables 6-9.

Table 2. Summary of Data Reported for the Big Sunflower River

Station Number	07288000	07288280	07288500	07288621	144	145	144-f
Agency	USGS/ MDEQ	USGS/ MDEQ	USGS/ MDEQ	USGS/ MDEQ	USACE	USACE	USACE
Location	Clarksdale	Merigold	Sunflower	Indianola	Clarksdale	Sunflower	Moorhead
Data Collected	Water Quality Data	Continuous Flow	Water Quality Data	Water Quality Data	Observed Flow and Stage	Observed Flow and Stage	Observed Flow and Stage
	Stage converted to Flow		Stage converted to Flow		Observed Continuous Stage	Observed Continuous Stage	Observed Continuous Stage
						Computed Flow	

Table 3. Fecal Coliform Data at Station 07288000

Date	Flow (cfs)	Fecal Coliform (counts/100ml)
1/5/88	-	373
3/7/88	-	920
5/2/88	58.5*	2400
7/5/88	33.1*	1600
9/6/88	27.2*	2400
11/7/88	-	2400
7/11/89	457.4*	1600
9/5/89	23.7*	33
11/6/89	191.4*	2400
1/8/90	-	1600
3/5/90	39.8*	2400
5/1/90	-	1300
7/9/90	-	1600
9/4/90	33.1*	1100
11/5/90	67.9*	24000
1/10/94	11	160
3/7/94	120	1095
5/2/94	154	2400
6/20/94	22	2400
8/22/94	12	350
11/7/94	4	1600
1/11/95	21	2400
3/6/95	892	540
4/17/95	25	350
7/10/95	220	540
9/11/95	5	24000
11/8/95	6	2400
1/8/96	8	2400
3/5/96	18	1600
7/8/96	14	2400
9/9/96	14	2400

* Flow estimated from USACE stage/discharge data at nearby station

Table 4. Fecal Coliform Data at Station 07288500

Date	Flow (cfs)	Fecal Coliform (counts/100ml)
1/5/88	4100	165
3/7/88	680	380
5/2/88	150	130
7/5/88	320	130
9/6/88	1000	540
11/7/88	280	130
5/1/90	1750	700
7/9/90	285	240
9/4/90	530	80
11/7/90	-	360
1/7/91	3700	1600
5/6/91	6800	920
7/8/91	450	160
9/9/91	315	540
11/5/91	1740	1100
1/6/92	425	110
3/3/92	735	1750
5/4/92	84	350
7/13/92	282	70
9/14/92	74	170
11/2/92	73	1700
1/13/93	1200	1700
3/8/93	330	220
5/3/93	2470	920
9/14/93	129	23
11/2/93	26	80
1/11/94	500	2000
3/7/94	3400	230
5/3/94	390	2400
6/20/94	460	27
8/22/94	350	350
11/7/94	420	1600
1/11/95	1450	2400
3/6/95	3900	540
4/17/95	310	140
7/10/95	4200	94
9/11/95	55	46
11/6/95	30	140
1/9/96	300	350
3/4/96	350	920
7/9/96	187	46
9/10/96	88	130
12/9/96	2450	150
1/8/97	1870	1820
2/25/97	1900	410
3/11/97	6480	410

Table 4. Fecal Coliform Data reported at Station 07288500, continued

Date	Flow (cfs)	Fecal Coliform (counts/100ml)
4/8/97	2230	390
5/15/97	76	110
6/18/97	2530	5000
8/20/97	327	3800
9/10/97	-	400
10/9/97	-	300
11/13/97	79	10
1/6/98	713	1300
2/19/98	3110	330
3/5/98	980	220
5/12/98	87	140
6/30/98	253	3000
7/16/98	714	5900
8/12/98	329	520
9/2/98	-	330
10/6/98	36	130
12/3/98	58	100
1/13/99	-	620
2/17/99	445	311
3/3/99	275	920
4/1/99	376	360
5/4/99	350	110
6/9/99	176	220
6/30/99	1540	420
8/11/99	400	390
9/1/99	145	100
10/4/99	-	120
11/22/99	-	100
12/8/99	-	345
2/23/00	-	460
4/3/00	-	3300
6/5/00	-	1120
7/11/00	-	76

Table 5. Fecal Coliform Data at Station 07288621

Date	Flow (cfs)	Fecal Coliform (counts/100ml)
1/8/90	6772.2*	350
3/5/90	-	1600
5/1/90	1813.6*	790
7/9/90	500.7*	350
9/4/90	455.6*	200
11/7/90	232.8*	50
1/7/91	9107.6*	350
5/6/91	18529.2*	540
7/8/91	820.1*	350
9/9/91	632.2*	540
11/5/91	2310.1*	130
1/6/92	-	80
3/3/92	1226.2*	1300
5/4/92	286.7*	335
7/13/92	532*	350
9/14/92	275.4*	230
11/2/92	275.4*	3500

* Flow estimated from USACE stage/discharge data at nearby station

Table 6. Fecal Coliform Data at Station 24, Hopson-Pixley Road

Date and Time	Fecal Coliform (counts/100ml)	Geometric Mean
9/26/2001 12:01	3800	5529
10/4/2001 12:56	6000	
10/9/2001 13:07	6000	
10/15/2001 12:17	5800	
10/17/2001 8:48	6000	
10/23/2001 11:48	6000	
11/13/2001 11:52	3000	3399
11/19/2001 14:25	6000	
11/26/2001 12:05	6000	
11/28/2001 10:35	6000	
12/5/2001 12:20	1400	
12/10/2001 13:10	1700	

Table 7. Fecal Coliform Data at Station 25, Sunflower Road

Date and Time	Fecal Coliform (counts/100ml)	Geometric Mean
9/28/2001 12:10	12	115
10/4/2001 10:52	42	
10/10/2001 11:23	92	
10/16/2001 11:30	410	
10/19/2001 10:57	1100	
10/25/2001 11:15	109	
11/16/2001 11:19	1100	534
11/21/2001 9:57	500	
11/28/2001 10:55	3800	
12/6/2001 9:51	199	
12/3/2001 11:18	560	
12/12/2001 11:17	99	

Table 8. Fecal Coliform Data at Station 26, Kinlock Road

Date and Time	Fecal Coliform (counts/100ml)	Geometric Mean
9/28/2001 13:12	16	79
10/4/2001 11:00	16	
10/10/2001 9:50	24	
10/15/2001 10:40	600	
10/18/2001 10:02	1700	
10/24/2001 10:18	40	
11/15/2001 10:38	8	228
11/21/2001 10:14	16	
11/28/2001 10:36	6000	
12/6/2001 10:32	480	
12/3/2001 10:30	2000	
12/12/2001 10:40	192	

Table 9. Fecal Coliform at Station 27, State Street in Clarksdale

Date and Time	Fecal Coliform (counts/100ml)	Geometric Mean
9/26/2001 12:50	6000	4103
10/4/2001 13:20	5700	
10/9/2001 13:32	5700	
10/15/2001 12:42	4800	
10/17/2001 8:27	5100	
10/23/2001 12:10	1000	
11/13/2001 12:16	6000	4386
11/19/2001 14:45	5800	
11/26/2001 12:25	5800	
11/28/2001 10:55	6000	
12/5/2001 12:40	2100	
12/10/2001 13:25	2800	

2.2.2 Analysis of Instream Water Quality Monitoring Data

Historically, MDEQ only had data appropriate to compare all of the samples to the instantaneous portion of the standard, which is no more than 10% greater than the instantaneous maximum standard of 400 counts per 100 ml for the summer months and 4000 counts per 100 ml for the winter months. The geometric mean portion of the current fecal coliform standard was not used in assessment due to lack of appropriate data at that time. MDEQ's new method of collecting data six times during a 30 day period must be assessed for both parts of the standard. Tables 10 and 11 show the statistical summary of the recent monitoring data, which is part of an ongoing project. The data are provisional data and clearly verify impairment indicated by previous assessments.

Table 10. Summer Statistical Summaries of Water Quality Data

Station Number	Number of Samples	Geometric Mean	Standard Violation (200 counts/100 ml)	Percent Instantaneous Exceedance	Standard Violation (400 counts/100 ml)
24	6	5529	Yes	100%	Yes
25	6	115	No	33%	Yes
26	6	79	No	33%	Yes
27	6	4103	Yes	100%	Yes

Table 11. Winter Statistical Summaries of Water Quality Data

Station Number	Number of Samples	Geometric Mean	Standard Violation (2000 counts/100 ml)	Percent Instantaneous Exceedance	Standard Violation (4000 counts/100 ml)
24	6	3399	Yes	50%	Yes
25	6	534	No	0%	No
26	6	228	No	17%	Yes
27	6	4386	Yes	67%	Yes

SOURCE ASSESSMENT

The TMDL evaluation summarized in this report examined all known potential fecal coliform sources in the Big Sunflower River Watershed. The source assessment is provided as an indication of what sources might be reduced to reach the reduction goals outlined in this report. The sources were analyzed according to the six separate subwatersheds. The subwatershed delineations were based primarily on an analysis of the Reach File 3 (RF3) stream network and the digital elevation model of the watershed. In evaluation of the sources, loads were characterized by the best available information, monitoring data, literature values, and local management activities. This section documents the available information and interpretation for the analysis.

3.1 Assessment of Point Sources

Point sources of fecal coliform bacteria have their greatest potential impact on water quality during periods of low flow. Thus, a careful evaluation of point sources that discharge fecal coliform bacteria was necessary in order to quantify the degree of impairment present during the low flow, critical condition period. There are 30 wastewater facilities discharging into the Big Sunflower River Watershed.

Once the permitted discharger was located, the effluent was characterized based on all available monitoring data including permit limits, discharge monitoring reports, and information on treatment types. Discharge monitoring reports (DMRs) were the best data source for characterizing effluent because they report measurements of flow and fecal coliform present in effluent samples. The facilities are shown in Table 12.

Table 12. Inventory of Point Source Dischargers

NPDES ID	Facility Name	Subwatershed	Receiving Water
MS0036722	Inverness Compression Station	08030207007	Lake Dawson
MS0020320	Inverness POTW	08030207008	Big Sunflower River
MS0026417	Drew POTW	08030207008	Dougherty Bayou
MS0044032	America's Catch Incorporated	08030207009	Turkey Bayou
MS0024937	MS/Valley State University	08030207009	Gin Bayou
MS0036005	Schlater POTW	08030207009	McNutt Lake
MS0039667	Southern Farm Fish Processors	08030207009	Roundaway Bayou to Quiver River
MS0044458	Doddsville POTW	08030207009	Big Sunflower River
MS0029262	Goose Pond Subdivision	08030207009	Stalen Brake
MS0035726	Sumner POTW	08030207009	Stalen Brake
MS0000833	Baxter Healthcare Corporation	08030207010	Tributary of Lead Bayou
MS0025127	Merigold POTW	08030207010	Jones Bayou
MS0020842	Mound Bayou POTW	08030207010	Little Mound Bayou
MS0026450	Winstonville POTW	08030207010	Mound Bayou
MS0042234	Duncan POTW	08030207010	Hushpuckena River
MS0038814	Delta Pride Catfish	08030207010	Big Sunflower River
MS0042196	Alligator POTW	08030207010	Alligator Lake
MS0025089	Shelby POTW	08030207010	Mound Bayou
MS0020567	Cleveland POTW	08030207010	Lead Bayou
MS0024961	Moorhead POTW	08030207010	Moorhead Bayou
MS0029009	MS State Pen POTW	08030207011	Black Bayou
MS0032166	Lane Acres Subdivision	08030207012	Lake Bayou
MS0021075	Jonestown POTW	08030207012	Swan Lake
MS0020311	Clarksdale POTW	08030207012	Big Sunflower River
MS0045080	Lurand POTW	08030207012	Hopson Bayou
MS0020591	Lyon POTW	08030207012	Big Sunflower River
MS0044237	Coahoma POTW	08030207012	Mill Creek
MS0044148	Berryhill Mobile Home Park	08030207012	Big Sunflower River
MS0022225	Mascot Housing Development	08030207012	Harris Bayou
MS0025054	Tutwiler POTW	08030207012	Hopson Bayou

3.2 Assessment of Nonpoint Sources

There are many potential nonpoint sources of fecal coliform bacteria for the Big Sunflower River, including:

- Failing septic systems
- Wildlife
- Other Direct Inputs
- Urban development

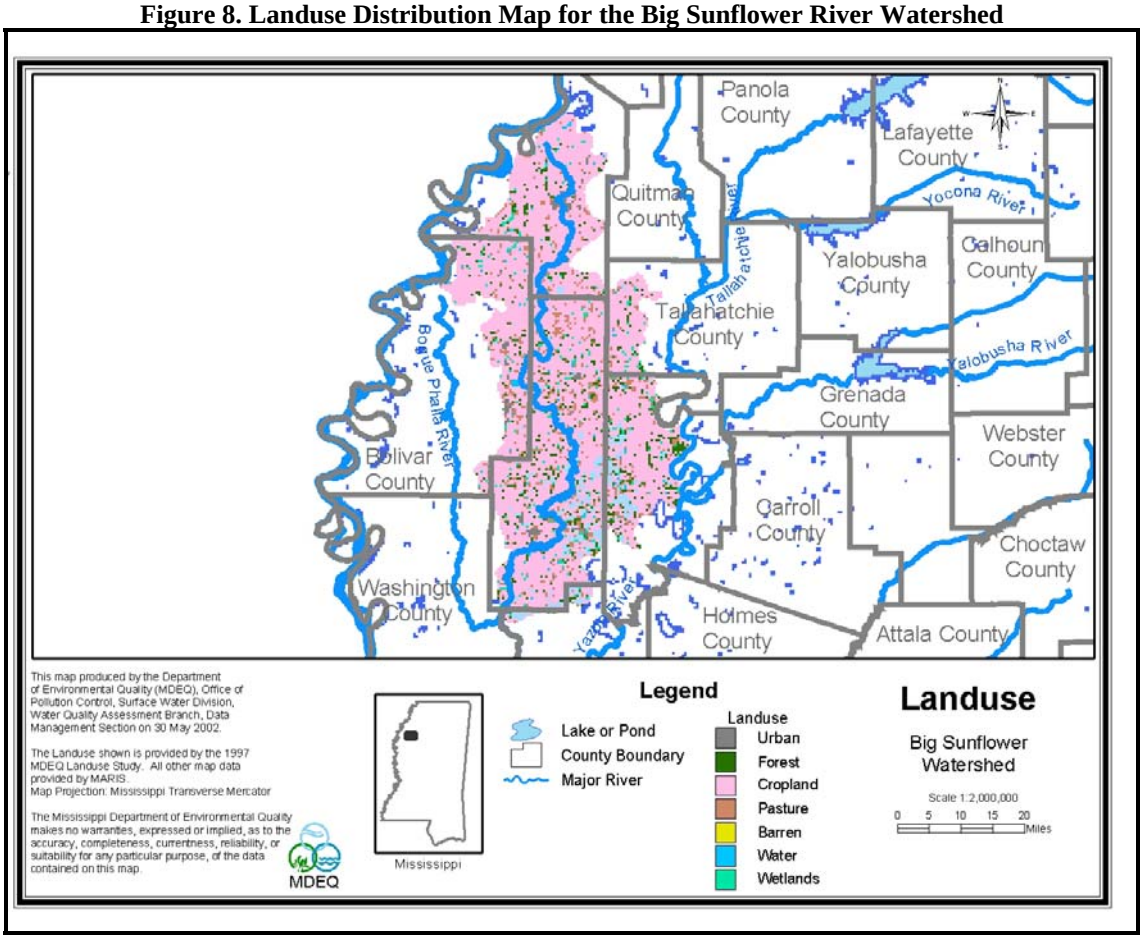
The 1,023,721-acre drainage area of the Big Sunflower River contains many different landuse types, including urban, forest, cropland, pasture, barren, and wetlands. The landuse information for the watershed is based on the State of Mississippi's Automated Resource Information System (MARIS), 1997. This data set is based 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. The landuse distribution is shown in Table 13 and Figure 8.

Table 13. Landuse Distribution for Each Subwatershed (acres)

Subwatershed	Urban	Forest	Cropland	Pasture	Barren	Wetland	Aquaculture	Water	Total
08030207006	0	0	8,719	881	0	1,114	3,012	167	13,893
08030207007	108	0	24,244	2,977	0	2,435	5,111	587	35,462
08030207008	1,049	0	42,792	3,924	0	3,944	929	1,120	53,759
08030207009	1,633	0	238,724	29,036	0	36,192	28,237	1,439	335,262
08030207010	5,244	0	289,913	31,028	0	28,306	5,861	3,288	363,640
08030207011	21	0	32,844	5,475	0	1,251	928	34	40,554
08030207012	3,503	0	155,506	10,738	0	10,419	0	985	181,151
Total	11,558	0	792,743	84,059	0	83,661	44,078	7,622	1,023,721
Percent	1%	0%	77%	8%	0%	8%	4%	1%	100%

Figure 8. Landuse Distribution Map for the Big Sunflower River Watershed



3.2.1 Failing Septic Systems

Septic systems have a potential to deliver fecal coliform bacteria loads to surface waters due to malfunctions, failures, and direct pipe discharges. Properly operating septic systems treat wastewater and dispose of the water through a series of underground field lines. The water is applied through these lines into a rock substrate, thence into underground absorption. The systems can fail when the field lines are broken, or when the underground substrate is clogged or flooded. A

failing septic system's discharge can reach the surface, where it becomes available for wash-off into the stream. Another potential problem is a direct bypass from the system to a stream. In an effort to keep the water off the land, pipes are occasionally placed from the septic tank or the field lines directly to the creek.

Another consideration is the use of individual onsite wastewater treatment plants. These treatment systems are in wide use in Mississippi. They can adequately treat wastewater when properly maintained. However, these systems may not receive the maintenance needed for proper, long-term operation. These systems require some sort of disinfection to properly operate. When this expense is ignored, the water does not receive adequate disinfection prior to release.

Septic systems have the greatest impact on nonpoint source fecal coliform impairment in the Yazoo Basin. The best management practices needed to reduce this pollutant load need to prioritize elimination of septic tank loads from failures and improper use of individual onsite treatment systems.

3.2.2 Wildlife

Wildlife present in the Big Sunflower River Watershed contributes to fecal coliform bacteria on the land surface.

3.2.3 Other Direct Inputs

Other direct inputs of fecal coliform includes all animal access to streams (domestic and wild), illicit discharges of fecal coliform bacteria, and leaking sewer collection lines.

3.2.4 Urban Development

Urban areas include land classified as urban and barren. Even though only a small percentage of the watershed is classified as urban, the contribution of the urban areas to fecal coliform loading in the Big Sunflower River was considered. Fecal coliform contributions from urban areas may come from storm water runoff, failing sewer pipes, and runoff contribution from improper disposal of materials such as litter.

LOAD DURATION CURVE PROCEDURE

The methodology outlined in a paper completed to explore the use of load duration curves for data analysis applications for streams in the Yazoo River Basin in Mississippi was followed in the development of the load duration curves (Sheely, 2002). Load duration curves were developed as a method in which TMDLs applicable to all hydrological conditions could be calculated. Prior to the introduction of this method, many TMDLs were developed to address a single flow condition such as the 7Q10 (7-day, 10-year low flow) or average flow. This new method is innovative, because it allows for the development of TMDLs that addressed more than just a single flow condition. Because these curves include the entire range of flow conditions, pollutant sources of all types can be considered in the TMDLs. The methods used to develop both the flow and load duration curves will be described.

4.1 Development of Flow Duration Curves

The first step in the development of load duration curves is to create flow duration curves using continuous flow or stage data. The only continuous USGS flow gage on the Big Sunflower River was near Merigold, station 07288280 shown in Figure 4. None of the water quality data stations corresponded with this location. Measurements of flow for three stations on the Big Sunflower River by the USACE were obtained for the period of record. The USACE stations, 144, 145, and 144-f, are shown in Figures 3, 4, and 5. The type of data obtained at each station is summarized in Table 2.

The flow and stage measurements were made at each USACE station occasionally throughout this period, with a varying number of measurements made per year. Also, daily measurements of water level, made at 8 AM each day, were available for years in the range between 1936 to 2000 for each station. The flow measurements, along with their corresponding stage, or water level, were plotted in order to create a flow-rating curve for stations 144 and 144-f. A regression analysis was done to determine the equation used to calculate a daily flow for each measurement of water level for the period of record at each station. The USACE provided computed flows for station 145, which were used instead of developing rating curves.

The flow data are used to create flow duration curves, which display the cumulative frequency distribution of the daily flow data over the period of record. The flow duration curve relates flow values measured at the monitoring station to the percent of time that those values are met or exceeded. Flows are ranked from extremely low flows, which are exceeded nearly 100 percent of the time, to extremely high flows, which are rarely exceeded.

4.2 Development of Load Duration Curves

Flow duration curves are then transformed into load duration curves by multiplying the flow values along the curve by applicable water quality criteria values for pathogens and appropriate conversion factors. The load duration curves are conceptually similar to the flow duration curves, in that the x-axis represents the flow recurrence interval. The y-axis is transformed to represent the allowable load of the water quality parameter. The curve representing the allowable load of fecal coliform was calculated using the instantaneous, summer water quality criteria of 400 counts per 100 ml and the flow associated with each flow recurrence interval. Another load duration curve showing the target

of 200 counts per 100 ml with a 50 percent MOS was also developed. The load duration curves developed for the three segments are included in Appendix A.

4.3 Comparison of Monitoring Data and Water Quality Criteria

The final step in the development of load duration curves was to add the monitoring data to the curves. Pollutant loads were estimated from the data as the product of the pollutant concentrations, instantaneous flows measured at the time of sample collection, and appropriate conversion factors. In order to identify the plotting position of each calculated load, the recurrence interval of each instantaneous flow measurement was defined. Water quality monitoring data are plotted on the same graph as the load duration curve. The load duration curves provide a graphical display of the water quality conditions in the waterbody. The monitoring data points that plot above the target line exceed the water quality target, while those that plot below meet the target.

4.4 Source Identification

The position at which the monitoring data exceed the target gives an indication of the potential sources and delivery mechanisms of the pollutants. Violations that occur on the right side of the curve, during low-flow conditions, indicate the presence of continuous pollutant sources, such as NPDES permitted discharges. Violations that occur on the left side of the curve, during higher flows, indicate intermittent sources that appear in response to rain events. Monitoring data that exceed water quality criteria in the mid-range flow indicate that pollutants are most likely due to a combination of these sources.

The load duration curves shown in Appendix A display only the water quality data points that exceed the target in each segment. The interpretation of those curves indicate that both point and nonpoint sources are present in the Big Sunflower River Watershed.

Using load duration curves for data analysis is different from the methods typically used for data analysis in that the frequency of attainment or violation of a particular water quality criteria is stressed rather than the absolute values of the monitoring data. One of the strengths of this method is that it can be used to interpret possible delivery mechanisms of pollutants. Load duration curves discussed have been shown to be influenced by the landuse distribution in their watersheds (Sheely, 2002). Because of this, load duration curves have the potential to be used as a method for targeting pollution reduction efforts in watersheds that are impaired and require TMDL development. Another strength of load duration curves is that they provide an understandable, graphical explanation of the data that are available for a monitoring station.

4.5 Stream Characteristics

The stream characteristics given below describe the most downstream reach of the listed drainage area of the Big Sunflower River. The channel geometry and lengths for the Big Sunflower River are based on data available within the BASINS modeling system. There is no accurate 7Q10 flow available for the Big Sunflower River because this waterbody is located in the Mississippi River alluvial plain. Streams in this region have exhibited a decreasing flow with time due to the lowering of water-levels in aquifers of this region. Because of this, low-flow characteristics can not be estimated with accuracy for this region. The characteristics of the section of the Big Sunflower River included in this TMDL are as follows.

- Length 141.5 miles
- Average Depth 2.34 ft
- Average Width 214.8 ft
- Mean Flow 728.5 cubic ft per second
- Mean Velocity 3.05 ft per second
- 7Q10 Flow N/A
- Slope 0.000083 ft per ft

4.6 Selection of Representative Period

The period of record for stage data ranged from 1936 to 2001. The period of record for water quality data ranged from 1988 to 2001. Seasonality and critical conditions are accounted for during the extended time frame of the data represented in the load duration curves.

The critical condition for fecal coliform impairment from nonpoint source contributors occurs after a heavy rainfall that is preceded by several days of dry weather. The dry weather allows a build up of fecal coliform bacteria, which is then washed off the ground by a heavy rainfall. By using the extended time period, many such occurrences should be captured in the data results. Critical conditions for point sources, which occur during low-flow and low-dilution conditions, are considered as well.

4.7 Existing Loading

Appendix A includes graphs of the load duration curves showing the instream fecal coliform loads for each of the three Big Sunflower River segments included in this TMDL. The graph shows a regression line through the data points that exceed the 200 counts per 100 ml target. The regression line represents the best fit of the existing loading in the Big Sunflower River.

ALLOCATION

In accordance with 40 CFR Section 130.2, which states, "TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure," this TMDL is expressed as a percent reduction of load in order to retain the benefit of utilizing various flow conditions to develop the load duration curve. The use of a single TMDL number would effectively return to the choice of just one flow condition for TMDL development. This method uses the difference between the regression line through the exceeding points and the load duration target curve to calculate the appropriate percent reduction necessary for the TMDL. The only allocation included in this TMDL is the wasteload allocation for point sources.

5.1 Wasteload Allocations

The wasteload allocation is based on the existing point sources in the Big Sunflower River Watershed. The WLA is represented on the Load Duration Curves in Appendix A as a horizontal line with a constant load appropriate for each segment. Due to the large number of point sources in the Big Sunflower Watershed and the absence of the ability to represent die-off of fecal coliform using the load duration curve method, the WLA makes up a large percentage of the TMDLs in this report. The point sources and their allocated load are shown in Table 14. The point sources that are recommended for permit modification to include fecal coliform limits and disinfection are also indicated in Table 14.

Table 14. Wasteload Allocations

NPDES ID	Facility Name	Subwatershed	Allocated Load (counts/day)	Permit Modification Necessary
MS0036722	Inverness Compression Station	08030207007	7.57E+06	No
MS0020320	Inverness POTW	08030207008	1.14E+09	Yes
MS0026417	Drew POTW	08030207008	3.26E+09	Yes
MS0044032	America's Catch Incorporated	08030207009	1.51E+09	Yes
MS0024937	MS/Valley State University	08030207009	3.41E+09	No
MS0036005	Schlater POTW	08030207009	4.92E+08	No
MS0039667	Southern Farm Fish Processors	08030207009	3.79E+09	No
MS0044458	Doddsville POTW	08030207009	3.79E+08	No
MS0029262	Goose Pond Subdivision	08030207009	3.03E+08	No
MS0035726	Sumner POTW	08030207009	2.95E+09	No
MS0000833	Baxter Healthcare Corporation	08030207010	1.40E+10	No
MS0025127	Merigold POTW	08030207010	6.82E+08	No
MS0020842	Mound Bayou POTW	08030207010	3.79E+09	No
MS0026450	Winstonville POTW	08030207010	5.68E+08	Yes
MS0042234	Duncan POTW	08030207010	5.68E+08	Yes
MS0038814	Delta Pride Catfish	08030207010	4.73E+09	No
MS0042196	Alligator POTW	08030207010	2.27E+08	Yes
MS0025089	Shelby POTW	08030207010	3.79E+09	Yes
MS0020567	Cleveland POTW	08030207010	2.27E+10	No
MS0024961	Moorhead POTW	08030207010	3.41E+09	No
MS0029009	MS State Pen POTW	08030207011	6.06E+09	Yes
MS0032166	Lane Acres Subdivision	08030207012	3.79E+08	No
MS0021075	Jonestown POTW	08030207012	1.26E+09	No
MS0020311	Clarksdale POTW	08030207012	4.54E+10	No
MS0045080	Lurand POTW	08030207012	1.51E+08	Yes
MS0020591	Lyon POTW	08030207012	6.82E+08	Yes
MS0022225	Mascot Housing Development	08030207012	3.79E+07	Yes
MS0044237	Coahoma POTW	08030207012	3.79E+08	No
MS0044148	Berryhill Mobile Home Park	08030207012	4.54E+07	Yes
MS0025054	Tutwiler POTW	08030207012	1.14E+09	No
Total			1.26E+11	

5.2 Load Allocations

The load allocation for this TMDL varies according to the flow conditions as represented graphically for each segment in Graphs A-1, A-2, and A-3.

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. For this TMDL, the MOS is an explicit 50 percent reduction of the criteria of 400 counts per 100 ml to a target of 200 counts per 100 ml.

5.4 Calculation of the TMDL

Because the TMDL is variable depending on the recurrence interval of the appropriate flow, the TMDL is expressed as an average percent reduction of the load. The percent reduction necessary for the TMDL is the average of the differences between the existing load line and the target load curve at each recurrence interval. The regression line through the exceeding points represents the existing load. The target curve represents the 200 counts per 100 ml at the various flows. Graphs A-1, A-2, and A-3 graphically represent the variable TMDL and LA, WLA and MOS for each segment. The percent reduction of fecal coliform bacteria recommended for each segment in this TMDL is shown in Table 15. The units of counts per day are appropriate for this TMDL due to the use of the instantaneous standard as opposed to units of counts/per 30 days that are used in conjunction with the use of the geometric mean standard.

Table 15. TMDL Percent Reduction

Segment	WLA (counts/day)	MOS	TMDL Percent Reduction
MSBIGSUNRM	4.82E+10	Explicit	86
MSBIGSUNRM5	4.82E+10	Explicit	86
MSBIGSUNRM2	1.10E+11	Explicit	68
MSBIGSUNRM3	1.26E+11	Explicit	54

5.5 Seasonality

For many streams in the state, fecal coliform limits vary according to the seasons. This stream is designated for the use of secondary contact. For this use, the pollutant standard is seasonal. The criteria for the most critical season, which is the summer for the Big Sunflower River as shown in Figure 7, was used as the target for this TMDL.

Because data were used throughout the year for several years at each station, seasonality was addressed. The extended period of record for the stage information allowed for representation of many different flow conditions, which is also relevant to seasonality.

5.6 Reasonable Assurance

This component of TMDL development does not apply to this TMDL Report. There are no point sources (WLA) requesting a reduction based on promised Load Allocation components and reductions. This TMDL will recommend that all point sources discharge treated and disinfected effluent that will be below the 200 colony counts per 100-ml. target at the end of the pipe.

CONCLUSION

The fecal coliform reduction scenario used in this TMDL included requiring all NPDES Permitted dischargers of fecal coliform to meet water standards for disinfection.

The TMDL will not impact existing or future NPDES Permits as long as the effluent is disinfected to meet water quality standards for pathogens. MDEQ will not approve any NPDES Permit application that does not plan to meet water quality standards for disinfection. Education projects that teach best management practices should be used as a tool for reducing nonpoint source contributions. These projects may be funded by CWA Section 319 Nonpoint Source (NPS) Grants.

6.1 Future Monitoring

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 Big Sunflower River may receive additional monitoring to identify any change in water quality. MDEQ produced guidance for future Section 319 project funding will encourage NPS restoration projects that attempt to address TMDL related issues within Section 303(d)/TMDL watersheds in Mississippi.

MDEQ assembled a team of scientists and engineers to develop a monitoring plan for the Delta ecoregion. This approach will allow MDEQ to assess the Delta based on biology that is appropriate for the Delta.

Due to the extensive interest in the Big Sunflower River and to the magnitude of the violations shown in the recent monitoring the fecal coliform monitoring being conducted in the Big Sunflower River has been extended. Additional stations were added in the upstream areas showing the greatest magnitude violations. Also, the Mississippi State Department of Health under contract with MDEQ will be conducting surveys for failing or inadequate septic systems in the Big Sunflower Watershed attempting to identify the sources of the violations.

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 be included on the TMDL mailing list should contact Linda Burrell at (601) 961-5062 or Linda_Burrell@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 written 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

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.

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 waterbody may be based upon a similar, unaltered or least impaired, waterbody or on historical pre-alteration data.

Calibrated model: a model in which reaction rates and inputs are significantly based on actual measurements using data from surveys on the receiving waterbody.

Critical Condition: hydrologic and atmospheric conditions in which the pollutants causing impairment of a waterbody have their greatest potential for adverse effects.

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 waterbody or segment regardless of actual attainment.

Discharge monitoring report: report of effluent characteristics submitted by a NPDES Permitted facility.

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.

Effluent: treated wastewater flowing out of the treatment facilities.

Fecal coliform bacteria: a group of bacteria that normally live within the intestines of mammals, including humans. Fecal coliform bacteria are used as an indicator of the presence of pathogenic organisms in natural water.

Geometric mean: the *n*th root of the product of *n* numbers. A 30-day geometric mean is the 30^{th} root of the product of 30 numbers.

Impaired Waterbody: any waterbody 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 waterbody. It also contains a portion of the contribution from septic tanks.

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

Nonpoint Source: pollution that is in runoff from the land. Rainfall, snowmelt, and other water that does not evaporate become surface runoff and either drains into surface waters or soaks into the soil and finds its way into groundwater. This surface water may contain pollutants that come from land use activities such as agriculture; construction; silviculture; surface mining; disposal of wastewater; hydrologic modifications; and urban development.

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.

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

Pollution: contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the State, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance, or leak into any waters of the State, unless in compliance with a valid permit issued by the Permit Board.

Publicly Owned Treatment Works (POTW): a waste treatment facility owned and/or operated by a public body or a privately owned treatment works which accepts discharges which would otherwise be subject to Federal Pretreatment Requirements.

Regression Coefficient: an expression of the functional relationship between two correlated variables that is often empirically determined from data, and is used to predict values of one variable when given values of the other variable.

Scientific Notation (Exponential Notation): mathematical method in which very large numbers or very small numbers are expressed in a more concise form. The notation is based on powers of ten. Numbers in scientific notation are expressed as the following: *4.16 x 10^(+b)* and *4.16 x 10^(-b) [same as 4.16E4 or4.16E-4]*. In this case, *b* is always a positive, real number. The *10^(+b)* tells us that the decimal point is *b* places to the right of where it is shown. The *10^(-b)* tells us that the decimal point is *b* places to the left of where it is shown.

For example: $2.7X10^{4} = 2.7E+4 = 27000$ and $2.7X10^{-4} = 2.7E-4 = 0.00027$.

Sigma (Σ): shorthand way to express taking the sum of a series of numbers. For example, the sum or total of three amounts 24, 123, 16, ($\mathbf{d}_1$, $\mathbf{d}_2$, $\mathbf{d}_3$) respectively could be shown as:

$$\sum_{i=1}^{3} d_i = d_1+d_2+d_3 = 24+123+16 = 163$$

Total Maximum Daily Load or TMDL: the calculated maximum permissible pollutant loading to a waterbody at which water quality standards can be maintained.

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. It also contains a portion of the contribution from septic tanks.

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

7Q10..... Seven-Day Average Low Stream Flow with a Ten-Year Occurrence Period

BASINS .....Better Assessment Science Integrating Point and Nonpoint Sources

BMP .....Best Management Practice

CWA .....Clean Water Act

DMR .....Discharge Monitoring Report

EPA.....Environmental Protection Agency

GIS .....Geographic Information System

HUC .....Hydrologic Unit Code

LA ..... Load Allocation

MARIS..... State of Mississippi Automated Information System

MDEQ..... Mississippi Department of Environmental Quality

MOS.....Margin of Safety

NRCS ..... National Resource Conservation Service

NPDES.....National Pollution Discharge Elimination System

NPSM.....Nonpoint Source Model

RF3..... Reach File 3

USACE .....United States Army Corps of Engineers

USGS .....United States Geological Survey

WLA ..... Waste Load Allocation

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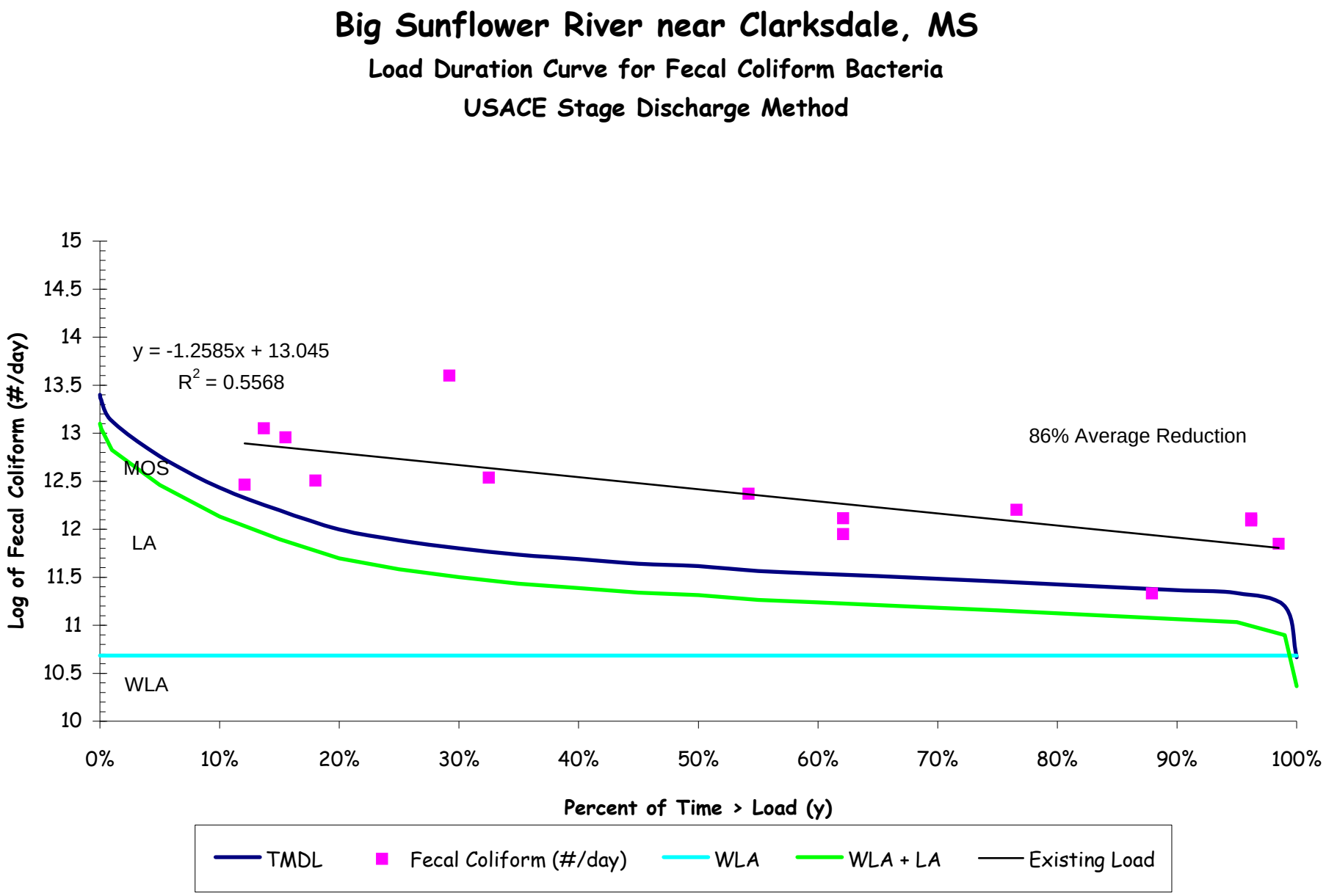
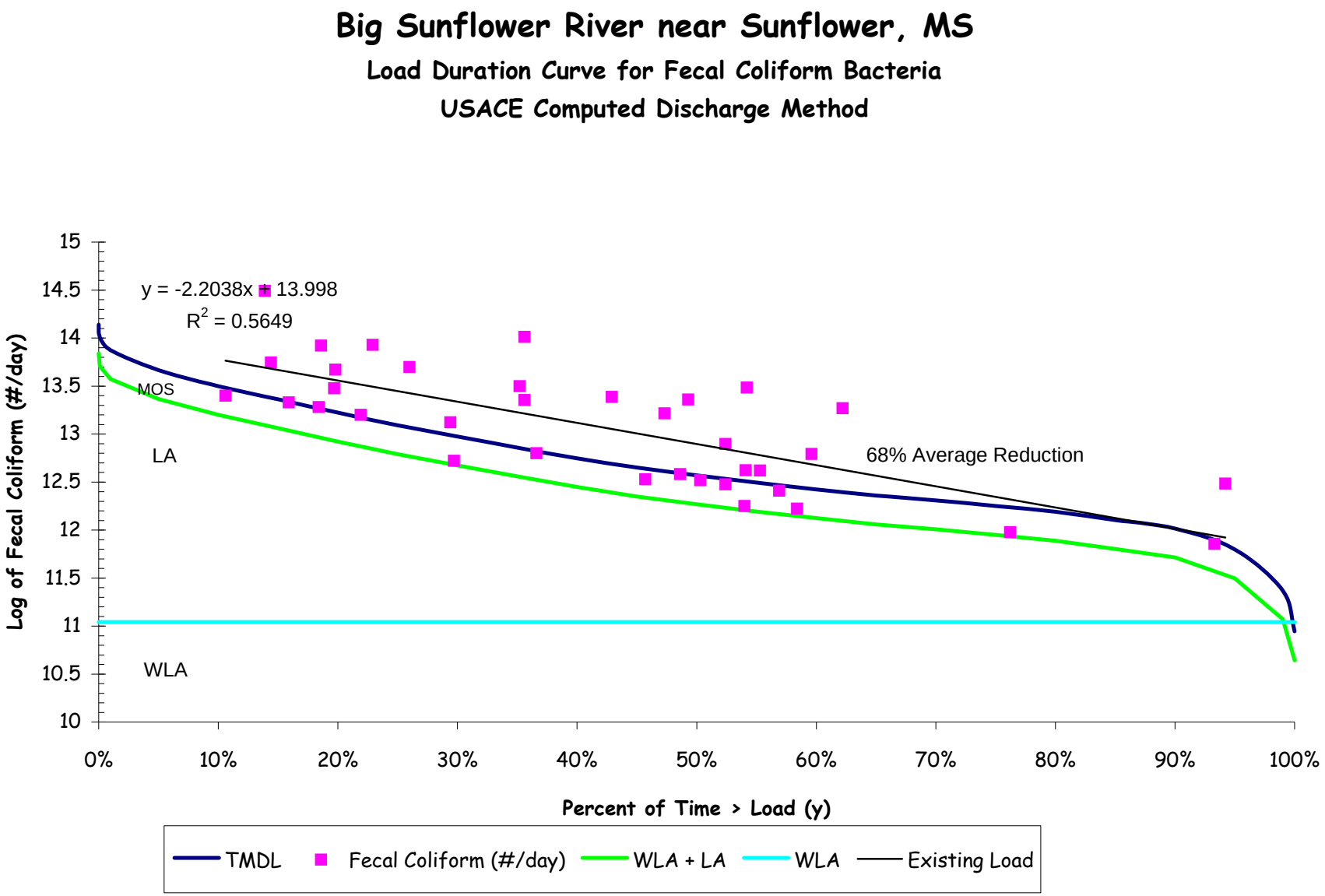
APPENDIX A

This appendix contains the load duration curves for the three areas included in this TMDL. Graph A-1 shows the load duration curve near Clarksdale for Station 07288000 and Station 144. This load duration curve is relevant to the TMDL calculation for segments MSNIGSUNRM and MSBIGSUNRM5. Graph A-2 shows the load duration curve near Sunflower for Station 07288500 and Station 145. This load duration curve is relevant to the TMDL calculation for segments MSNIGSUNRM2. Graph A-3 shows the load duration curve near Indianola and Moorhead for Station 07288621 and Station 144-f. This load duration curve is relevant to the TMDL calculation for segments MSNIGSUNRM3.

Graph A-1 MSBIGSUNRM and MSBIGSUNRM5



Graph A-2 MSBIGSUNRM2



Graph A-3 MSBIGSUNRM3