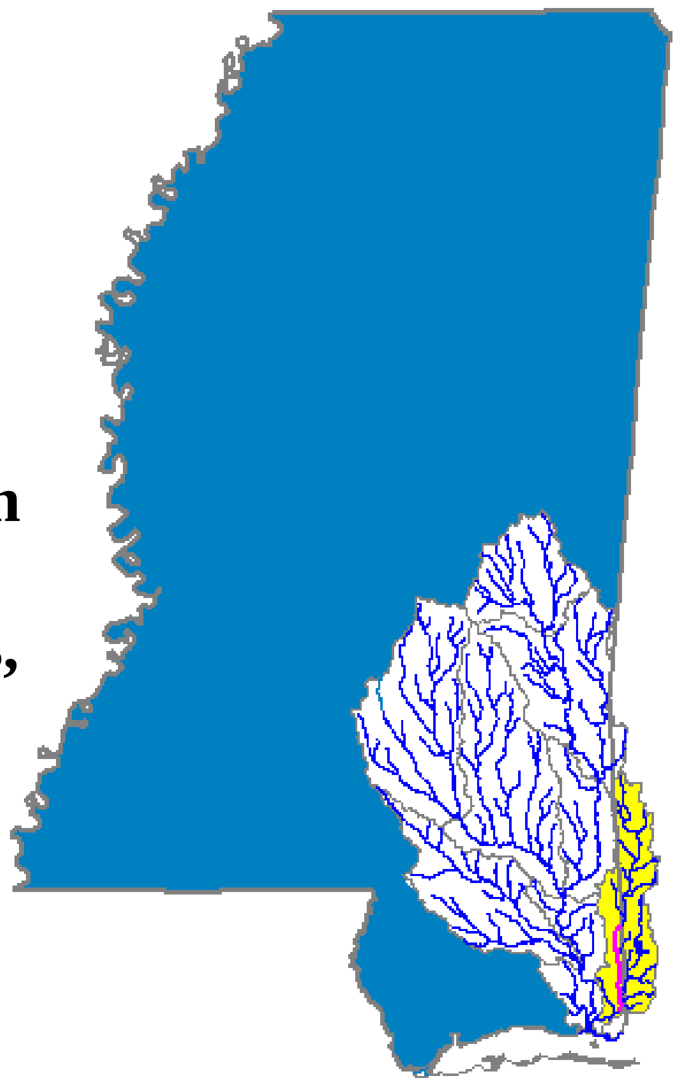
JUNE 26, 2000
APPROVED VERSION

Escatawpa River Phase One Total Maximum Daily Load

for

Mercury



Pascagoula Basin Jackson and George Counties, Mississippi

Prepared By

Mississippi Department of Environmental Quality
Office of Pollution Control
TMDL/WLA Section/
Water Quality Assessment Branch

FOREWORD

This report has been prepared in accordance with the schedule contained within the federal consent decree dated December 22, 1998. (*Sierra Club v. Hankinson, No. 97-CV-3683 (N.D. Ga.)*) 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 segments addressed are comprised of monitored segments that have data indicating impairment. 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, modification to state water quality criteria, 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	m	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	mg/l * cfs	Gm/day	2.45

CONTENTS

MONITORED SEGMENT IDENTIFICATION

Name:	Escatawpa River, Segment 1 (*Fresh Water*)
Waterbody ID:	MS107M1
Location:	Near Agricola: from Alabama state line to confluence with Spring Creek east of Hurley
Counties:	George, Jackson
USGS HUC Code:	03170008
NRCS Watershed:	080
Length:	20 miles
Use Impairment:	Fish Consumption – A fish consumption advisory is posted for this waterbody segment. See Appendix B.
Cause Noted:	Mercury
Priority Rank:	15
Standards Variance:	N/A
Pollutant Standard:	Mercury II, total chronic fresh water concentration may not exceed 0.012 µg/l expressed as total recoverable Mercury II, total chronic salt water concentration may not exceed 0.025 µg/l expressed as total recoverable

MONITORED SEGMENT IDENTIFICATION

Name:	Escatawpa River, Segment 2 (*Fresh Water*)
Waterbody ID:	MS107M2
Location:	Near Orange Grove: from confluence with Spring Creek east of Hurley to Interstate 10 Bridge
Counties:	Jackson
USGS HUC Code:	03170008
NRCS Watershed:	080
Length:	24 miles
Use Impairment:	Fish Consumption – A fish consumption advisory is currently posted for this waterbody. See Appendix B
Cause Noted:	Mercury
Priority Rank:	16
Standards Variance:	N/A
Pollutant Standard:	Mercury II, total chronic fresh water concentration may not exceed 0.012 µg/l expressed as total recoverable, Mercury II, total chronic salt water concentration may not exceed 0.025 µg/l expressed as total recoverable
TMDL:	4.73 gm/day
WLA:	0.00 gm/day
LA:	1.18 gm/day
MOS:	3.55 gm/day

NON-IMPAIRED SEGMENT IDENTIFICATION

Name:	Escatawpa River, Segment 3 (*Salt Water*)
Waterbody ID:	MS107M3
Location:	Near Moss Point: from Interstate 10 Bridge to mouth at the Pascagoula River
Counties:	Jackson
USGS HUC Code:	03170008
NRCS Watershed:	080
Length:	10 miles
Use Impairment:	A fish consumption advisory is not posted for this waterbody. Current fish flesh data show mercury levels below the FDA action level.
Cause Noted:	N/A
Standards Variance:	N/A
Pollutant Standard:	Mercury II, total chronic fresh water concentration may not exceed 0.012 µg/l expressed as total recoverable, Mercury II, total chronic salt water concentration may not exceed 0.025 µg/l expressed as total recoverable This segment is not classified as fresh water. The salt content is routinely 20 parts per thousand.

EXECUTIVE SUMMARY

The fresh water portions of the Escatawpa River, identified as Segments 1 and 2 in this report, are impaired by mercury. Largemouth bass and catfish caught in these segments have been sampled and the data show a definite impairment due to levels of mercury in the fish flesh, which exceed the FDA Action level.

Based on this data, the State of Mississippi issued a fish consumption advisory (See Appendix B) for Segment 1 and 2 of the Escatawpa River. This advisory was issued to help protect the people who regularly consume fish caught in this river. The bioaccumulation of methylmercury in fish flesh is the basis for the impairment in this stream.

This Phase One Mercury TMDL for the Escatawpa River has been developed prior to a complete understanding of the linkage between mercury in the water and mercury in the fish. There are no NPDES permitted dischargers currently in Segments 1 or 2. All of the dischargers are in Segment 3. However, Segment 3 does not have an advisory for mercury; there have been no fish sampled from Segment 3 with elevated mercury levels; and MDEQ intends to delist Segment 3 from the next Section 303(d) list. This segment is downstream of Segment 2, which is impaired for mercury. There is some process within the mercury cycle that is causing this phenomenon.

Additionally, this Phase One Mercury TMDL is only concerned with point source contributions to the waterbody. Atmospheric deposition, nonpoint source contributions, and natural background will be considered in Phase Two. It is anticipated that the mercury data generated from the point source contributors during the next few years will enhance the knowledge base on this issue.

The endpoints selected for this Phase One Mercury TMDL are based on MDEQ regulations. There are several mercury criteria to evaluate. The human health criterion is currently 153 ng/l of total mercury. The aquatic life support criteria are 12 ng/l fresh water and 25 ng/l salt water of total mercury II expressed as total recoverable. Recent EPA criteria guidance has suggested that each of these numbers be revised. The 153 ng/l criterion has been proposed to be reduced by 2/3. The aquatic life support numbers have been proposed to increase to a more representative value of 770 ng/l and 940 ng/l, respectively. However, these new numbers have not been adopted by the Mississippi Commission on Environmental Quality. MDEQ is therefore going to use the most protective of the currently available criteria.

By using the 12 ng/l criterion as the target, a large implicit margin of safety is created. However, to further account for the unknowns, an additional explicit margin of safety is included in this TMDL. This explicit margin of safety is set at 75%.

The implementation plan in this Phase One TMDL calls for a moratorium on any mercury discharge in Segments 1 and 2. It also calls for increased monitoring for dischargers in Segment 3. Although Segment 3 is downstream of the impaired segment, and, as mentioned above, no elevated levels of mercury have been found in fish, dischargers to Segment 3 should monitor their effluents for mercury.

1.0 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. This is also a requirement of 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 mercury. The purpose of this TMDL is to establish water quality objectives and best management practices to reduce the mercury levels currently found in fish flesh taken from the Escatawpa River.

Human exposure to inorganic mercury in large amounts can cause a variety of health effects. The two organ systems most likely affected are the central nervous system and the kidney. However, the most significant concerns regarding chronic exposure to low concentrations of methylmercury in fish are for neurological effects on the developing fetus and children.[1]

1.2 PHASED TMDL APPROACH

This document is Phase One of a multi-phase TMDL being developed for mercury in the Escatawpa River. This Phase One Mercury TMDL will determine the maximum load of mercury that should be introduced into the impaired segments based on Mississippi's current water quality criteria. Phase Two of this TMDL project, to be completed at a later date, will quantify the mercury load to the Escatawpa River that is directly related to atmospheric sources and other nonpoint sources. Phase Two will also attempt to include a fate and transport model for the river that will better characterize aquatic mercury cycling.

1.3 WATERBODY SEGMENT LOCATION

As summarized in Table 1, Segment 1 of the Escatawpa River begins at the Alabama - Mississippi State line and ends at the confluence with Spring Creek east of Hurley. Segment 2 starts at the confluence with Spring Creek and ends at the Interstate 10 Bridge. Segment 3 begins at the I-10 Bridge and continues to the mouth of the river into the Pascagoula River. The upstream segment located in Alabama is not included in this TMDL project.

The entire drainage area of the Escatawpa River (USGS Hydrologic Unit Code (HUC) 03170008) is approximately 1,031 square miles. The Escatawpa River Watershed has been divided into four subwatersheds for this TMDL study, representing the two impaired segments, the downstream segment, and the upstream segment located in Alabama. The watershed contains urban areas including Pascagoula and Moss Point, and a number of small suburban communities. A majority of the landuse is forest.

In an attempt to protect human health, Mississippi has issued a Fish Consumption Advisory for Segments 1 and 2 of the Escatawpa River. This advisory was issued due to elevated levels of mercury found in fish flesh collected in these segments. See Appendix B. There is no advisory for Segment 3. Data indicate there is no mercury impairment in Segment 3.

Figure 1 **Area Map**

Table 1 Waterbody Identification for the Escatawpa River TMDL

Waterbody Name	***State Waterbody ID***	***Assessment type***	***Size***	***County***	***Listed Advisory***	***Advisory Cause***
Escatawpa River, Seg 1	MS107M1	Monitored	20 mi	George, Jackson	Fish Consumption Advisory	Mercury
Location – Near Agricola: from Alabama state line to confluence with Spring Creek east of Hurley						
Escatawpa River, Seg 2	MS107M2	Monitored	24 mi	Jackson	Fish Consumption Advisory	Mercury
Location – Near Orange Grove: from confluence with Spring Creek east of Hurley to I-10						
Escatawpa River, Seg 3	MS107M3	Monitored	10 mi	Jackson	No Advisories	None
Location – Near Escatawpa: from I-10 Bridge to mouth at Pascagoula River						

Table 2 Subwatersheds in HUC 03170008

Waterbody Segment Name	*Waterbody Seg. ID*	*Subwtshd. ID Number*
Escatawpa River, Alabama Segment	n/a	031700080a
Escatawpa River, Segment 1	MS107M1	0317000801
Escatawpa River, Segment 2	MS107M2	0317000802
Escatawpa River, Segment 3	MS107M3	0317000803

Table 3 Landuse Distribution in Escatawpa River Watershed (acres)

Watershed	*Urban*	*Agricultural*	*Forest*	*Water*	*Wetland*	*Barren*	*Total*
031700080a	657	33,757	304,719	204	409	1,356	341,102
0317000801	58	19,444	38,297	45	2,812	10	60,666
0317000802	4,981	74,077	121,792	3,615	5,790	482	210,737
0317000803	4,138	6,432	28,818	780	7,186	160	47,514
Total	9,834	133,710	493,626	4,644	16,197	2,008	660,019
Percent	1%	20%	75%	1%	2%	0%	100%

1.4 WATERBODY DESIGNATED USE

Designated beneficial uses and water quality standards are established by the State of Mississippi in the *Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulations. These regulations set the criteria concentrations for pollutants and methods for calculating loads based on the standards. MDEQ regulations require the use of these standards for establishing loads for Mississippi waters. The standards for this river have been established based on a designated use of Fish and Wildlife.

1.5 APPLICABLE WATER QUALITY STANDARDS

Mercury is included within MDEQ regulations as a toxic substance. The standards specifically set the numeric criteria and calculation methods for determining the loading from sources for this pollutant.

Indications are apparent that the standard may soon be changing for each of the mercury species included in the criteria. However, until the stakeholders within Mississippi are allowed to partake in the process to change Mississippi criteria and the Mississippi Commission on Environmental Quality adopts any modification, using another concentration value for mercury or calculation method would be an arbitrary and capricious decision. The water quality standards applicable to the uses of the waterbody segments and the pollutant of concern are listed in Table 4 as defined by the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* regulations.

Table 4 State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters

Parameter	***Beneficial use***	***Water Quality Criteria***
Total Mercury	Public Water Supply	Concentration may not exceed 0.151 µg/l
Total Mercury	Fish Consumption	Concentration may not exceed 0.153 µg/l
Mercury (II) total dissolved Hg(II) expressed as total recoverable	Aquatic Life Support	*Fresh Water* Acute: instantaneous concentration may not exceed 2.1 µg/l Chronic: average concentration may not exceed 0.012 µg/l expressed as total recoverable *Salt Water* Acute: instantaneous concentration may not exceed 1.8 µg/l Chronic: average concentration may not exceed 0.025 µg/l expressed as total recoverable

Figure 2

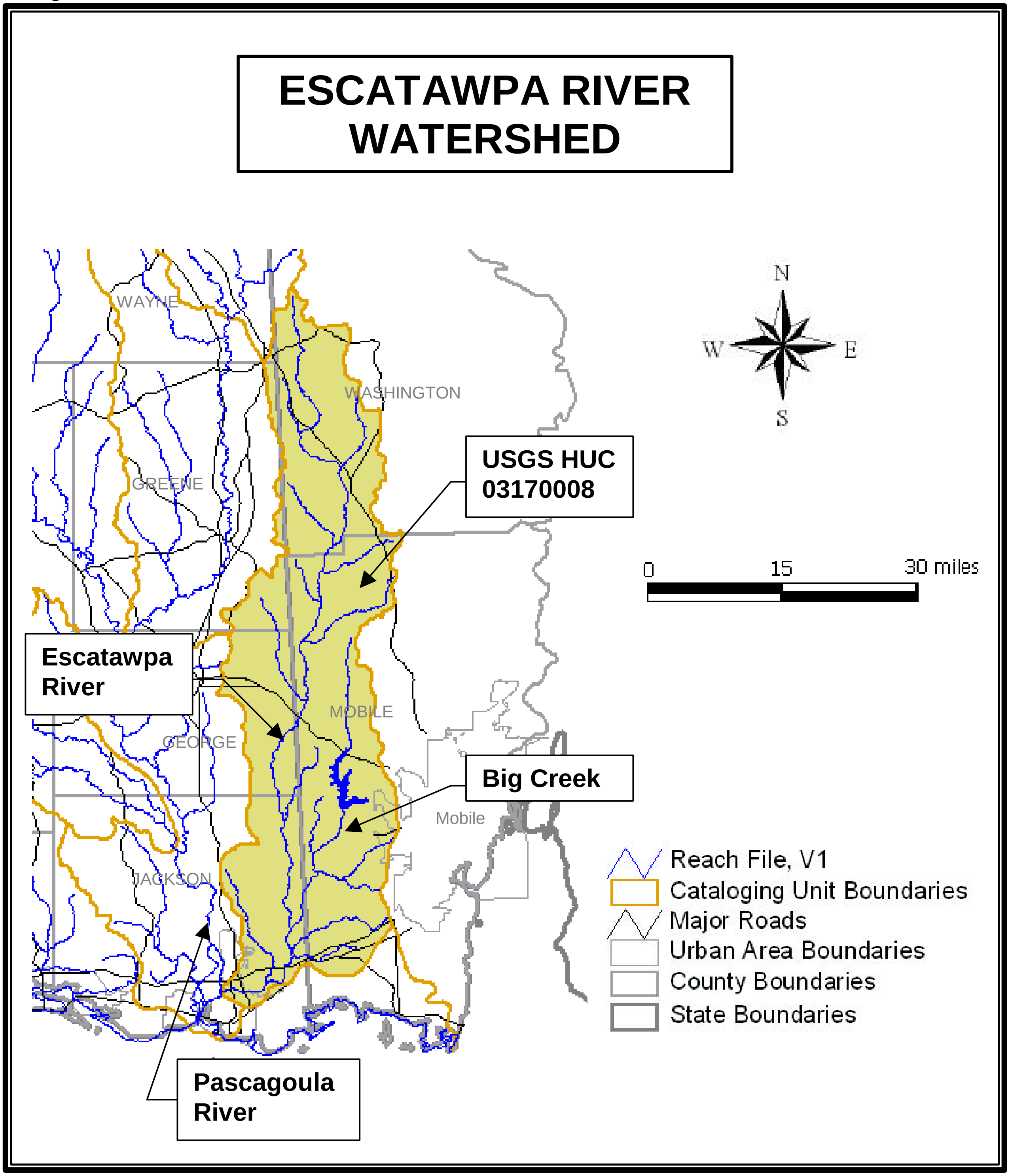
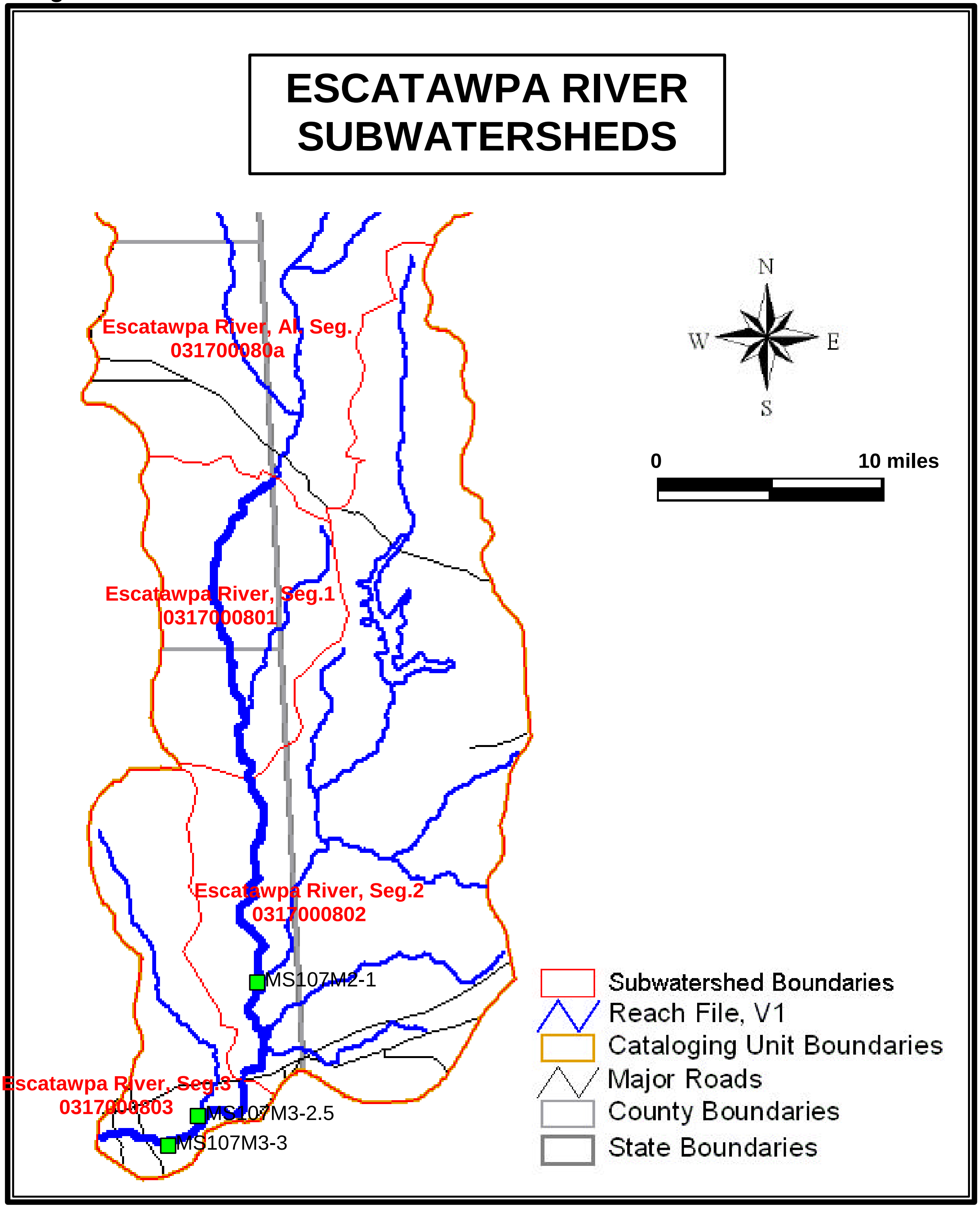

ESCATAWPA RIVER WATERSHED
WAYNE
WASHINGTON
GREENE
MOBILE
GEORGE
Mobile
JACKSON
N
W
E
S
USGS HUC 03170008
0
15
30 miles
Escatawpa River
Big Creek
Pascagoula River
Reach File, V1
Cataloging Unit Boundaries
Major Roads
Urban Area Boundaries
County Boundaries
State Boundaries

Figure 3


ESCATAWPA RIVER
SUBWATERSHEDS
Escatawpa River, Al, Seg.
031700080a
Escatawpa River, Seg.1
0317000801
Escatawpa River, Seg.2
0317000802
Escatawpa River, Seg.3
0317000803
MS107M2-1
MS107M3-2.5
MS107M3-3
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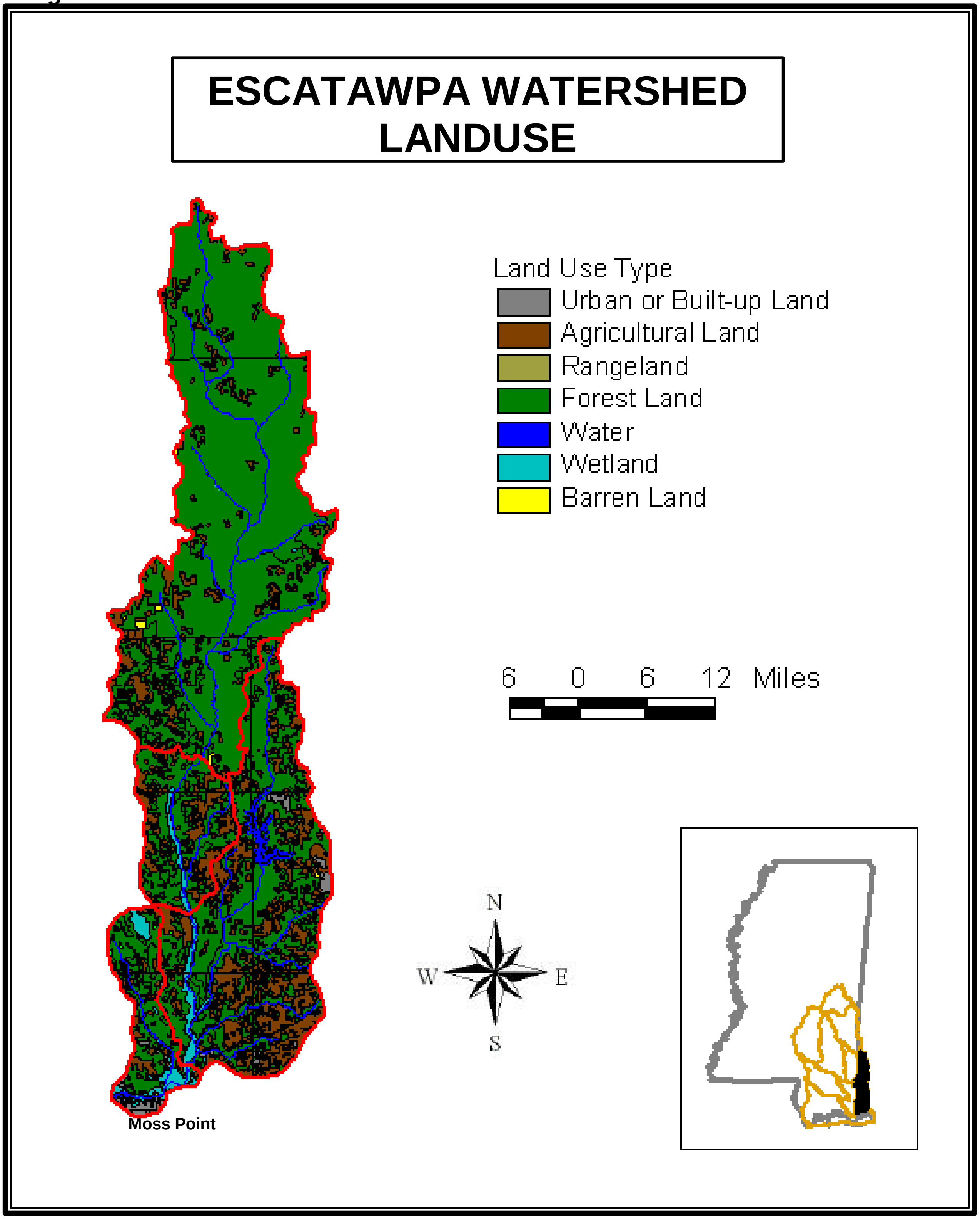
Subwatershed Boundaries
Reach File, V1
Cataloging Unit Boundaries
Major Roads
County Boundaries
State Boundaries

Figure 4


ESCATAWPA WATERSHED
LANDUSE
Land Use Type
Urban or Built-up Land
Agricultural Land
Rangeland
Forest Land
Water
Wetland
Barren Land
6 0 6 12 Miles
N
W
E
S
Moss Point

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 instream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. Instream numeric endpoints, therefore, represent the water quality goals specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are needed to restore designated uses. However, due to the many unknowns within the mercury cycle, there is no clearly defined linkage between water column mercury loading and bioaccumulation rates within the fish. Even within the Escatawpa River, Segment 2 has data showing impairment in fish flesh due to mercury, while Segment 3 is not impaired. In the Executive Summary (Vol. I, Page O-2) of its Mercury Study report to Congress, EPA states that

> *"given the current scientific understanding of the environmental fate and transport of this element, it is not possible to quantify how much of the methylmercury in fish consumed by the U.S. population is contributed by U.S. emissions relative to other sources of mercury (such as natural sources and re-emissions from the global pool). As a result, it cannot be assumed that a change in total mercury emissions will be linearly related to any resulting change in methylmercury in fish, nor over what time period these changes would occur."*[12]

2.1.1 Mercury Speciation and Chemistry

It has long been recognized that the chemical form of mercury (Hg) in air, water, and soil include elemental mercury Hg(0), inorganic ionic mercury (HgII) as soluble (HgIIs) or particulate mercury forms (HgIIp), and the organic form called monomethylmercury (MMHg or $HgCh3^{+}$). Each form has different behaviors that depend on its chemical and physical properties.[4]

The predominant source of mercury is atmospheric deposition. The atmospheric burden of mercury arises from both natural and anthropogenic sources accumulated over large periods. Both land and water environments release background mercury in the form Hg(0), except when combustion (forest and other terrestrial fires, fossil fuel combustion, waste combustion, etc.) produces the oxidized form – HgII. Hg(0) dissolves in water according to Henry's Law, and is only weakly soluble in water (about 0.006 ng/l at equilibrium with present-day air concentrations).[3] Thus, Hg(0) must oxidize to HgII, which then is the predominant form of mercury in wet or dry deposition. Hg(0) has a half-life of about 1 year in the atmosphere, while that of HgII varies between hours to months.

Only a fraction of mercury entering watersheds from deposition actually is transported into waterbodies. Values ranging from 5 to 50 percent have been reported, and a common value of 25 percent has often been quoted.[17] Most of the mercury entering the watershed remains in the soil or terrestrial biota, or is reduced to Hg(0) and transfers back to the atmosphere by evasion.

Thus, direct deposition on the waterbody frequently overshadows delivery from the watershed in many aquatic systems studied in the northern U.S.[4]

2.1.2 Mercury Transport and Transformations

Mercury that makes its way into aquatic environments is essentially all inorganic ionic HgII. Hg(0) is only weakly soluble in water, while organic forms are usually present in trace amounts with MMHg in the typical range of 0.1 to 5 percent of the total mercury. However, higher amounts of MMHg can enter from wetland drainage.[17] Measurements of MMHg in rainwater seem to be associated with marine production of dimethylmercury, which hydrolyzes to form MMHg. Dimethylmercury does not seem to occur in fresh-water environments but only in the marine environment.[5] The ionized forms of mercury (HgII, MMHg) react rapidly and strongly with particulates. Furthermore, ionized forms react strongly with sulfide ions and somewhat strongly with organic complexes.

The production of MMHg by microorganisms and its subsequent accumulation in fish is by far the greatest concern. Part of that concern arises from MMHg's long biological half-lives in fish (1-2 years) as opposed to humans and other warm-blooded creatures that have half-lives of 1-3 months. Thus fish can accumulate MMHg to high levels, and the consumed fish – especially long-lived predatory fish – provide exposure of sensitive fish-eating organisms to MMHg.

Two competing processes affect the concentrations of MMHg, methylation produces MMHg while demethylation cleaves the methyl group and then reduces HgII to Hg(0) in a two-step process. The net MMHg produced is what scientists measure and organisms accumulate.

Microorganisms perform most of the methylation and demethylation, and sulfate reducing bacteria produce almost all of the MMHg.[2] The concentration of sulfate necessary to support production has an optimum because at higher concentrations, the produced sulfide binds HgII and can make it less available for uptake by sulfate reducing bacteria. Thus, many factors control the production of MMHg: the availability of HgII controlled largely by particulate material and dissolved organic carbon compounds; sulfide and sulfate concentrations; the presence of active sulfate reducing bacteria, and zones of sulfate production. MMHg production is often associated with sediments because most of the HgII is there and anaerobic conditions associated with reductive processes like sulfate reduction also occur there. The presence of sediments along with a ready source of biodegradable organic carbon resulting from plant production, may explain why wetlands are a major locale for production of MMHg. Circulation with surface waters may make wetland MMHg available for uptake. Emerging insects may substantially increase transfer of MMHg produced in wetlands to predatory fish.[11]

The food web has an important role in distributing MMHg into fish populations where fish consumers can then become part of the food web. The wide variability in mercury concentrations in similar sized fishes arise from the variety of local conditions of mercury bio-availability, MMHg production, and MMHg transfer among food web components.[4]

2.1.3 Mississippi Mercury Criteria (Fresh Water)

The beneficial use listed in Table 4 applicable to Segments 1 and 2 of the Escatawpa River is Fish Consumption. The human health parameter for Fish Consumption is a total mercury concentration of 0.153 µg/l. The purpose of this standard is to restrict the mercury levels in fish tissue to below the 1.0 ppm FDA advisory level for human consumption. The total mercury human health standard of 0.153 µg/l in Mississippi's water quality standards was determined based on the accumulation of mercury in the types of fish that are commonly consumed in the state. Because the two impaired segments are listed for partially supporting the use of Fish Consumption, the human health standard is an appropriate endpoint for Phase One of this TMDL study.[8]

However, the aquatic life criterion in fresh water, 0.012 µg/l of total Hg(II) is currently the more restrictive criterion for mercury concentration in the water column. We believe the toxicity criteria are overprotective of toxicity to aquatic life. According to *Ambient Water Quality Criteria for Mercury – 1984*, the 0.012 µg/l criterion for aquatic life was calculated based on a FDA action level of 1.0 mg/kg. This is a concentration of mercury in fish tissue of edible fish. The criterion was also based on a bioconcentration factor (BCF) of 81,700, which was the laboratory-determined ratio of the concentration of mercury in the tissue of the fathead minnow to the concentration of dissolved HgII in the lab water. The BCF of 81,700 is based on the transfer of mercury from the water to the tissue of the fathead minnow, and not directly to any species of edible fish.

In the "unused data" section of the same criteria document, BCF's ranging from 373 to 2400 were calculated for Bluegill, although the footnotes report that each BCF was not dependent on the concentration in the water. This means that there was no direct correlation between successive samples of mercury in the water and in the Bluegill fish tissue. However, a BCF was calculated in each case anyway, and they were much lower than the fathead minnow BCF. Although the criteria document states that the high BCF of the fathead minnow "might be more representative of commonly consumed warm-water fishes"; the Bluegill (which is a freshwater fish common in Mississippi) contradicts that assumption. To infer that the BCF of mercury in fathead minnows "might" be representative in light of the stated Bluegill results is an over-protective conclusion. Therefore, the use of the 0.012 µg/l of total mercury as the endpoint target for this TMDL incorporates an implicit margin of safety.

Additionally, we believe the 0.153 µg/l human health criterion is also protective of aquatic life. In *EPA's National Recommended Water Quality Criteria-Correction*, April 1999, EPA published 0.770 µg/l as the proposed freshwater aquatic life criterion. In effect, EPA has said that 0.153 µg/l is five times more protective of aquatic life than the proposed criterion. We believe 0.153 µg/l is protective of aquatic life while 0.012 µg/l is overprotective of aquatic toxicity, (a conclusion that EPA has supported by virtue of the latest proposed aquatic life criteria publication of 0.770 µg/l.) When and if Mississippi's water quality criteria regarding mercury change, this Phase One TMDL will be revised to reflect those changes.

However, fish flesh sampling data indicate impairment of the waterbody's designated use. Therefore, to account for the uncertainty inherent with mercury fate and transport, This TMDL calls for a moratorium on future mercury discharges in Segment 1 and 2. No dischargers currently discharge into Segments 1 and 2. In addition, this TMDL includes an explicit MOS set at 75% for this TMDL. This is to ensure the overall mercury load to the system does not increase.

2.1.4 Mississippi Regulations on Flow determination

In addition to the endpoint, the flow rate must be determined in order to calculate the TMDL. According to Section II.9.D(2) of the *State of Mississippi Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulations, the 7Q10 flow shall be used when applying Chronic toxicity criteria concentrations to calculations determining the load to a stream.[8] The mean annual flow for the Escatawpa River is estimated at 1,861 cfs. The 7Q10 flow is estimated to be 161 cfs in Segment 2 using USGS guidance to determine flow rates based on the flow data from the Escatawpa River gage.

2.2 DISCUSSION OF INSTREAM WATER QUALITY

According to the State's 1998 Section 305(b) Water Quality Assessment Report, two segments of the Escatawpa River are partially supporting the use of Fish Consumption. They are listed because a fishing advisory has been in effect for the segments since 1995. These advisory decisions were based on fish tissue data collected at station MS107M2-1 (Goodes Mill). Tissue has also been analyzed from stations MS107M3-2.5 (Orange Grove) and MS107M3-3 (Moss Point). Data collected at these stations are summarized and analyzed in the following sections.

2.2.1 Inventory of Water Quality Monitoring Data

There are three MDEQ stations in the river where mercury fish tissue data have been collected.

Table 5 Fish Tissue Station Data Inventory

Station	***Agency***	***Location***	***Status***	***Sampling Dates***
MS107M2-1	MDEQ	Goodes Mill	active	1/94 – 12/99
MS107M3-2.5	MDEQ	Orange Grove	active	1/94 – 12/99
MS107M3-3	MDEQ	Moss Point	active	1/94 – 12/99

There is limited mercury water column data from the Escatawpa River currently available for analysis. On May 1, 2000, a sample taken in Segment 3 showed a mercury level of 2.94 ng/l. EPA R4 collected water-column mercury data that are commensurate with the data collected by stakeholders. The data indicate a background/LA condition between 2.0 to 3.0 ng/l currently in Segments 1 and 2.

2.2.2 Analysis of Fish Tissue Data

Fish tissue data have been analyzed to identify violations requiring fish consumption advisories. Statistical summaries of mercury levels in fish tissue from the Escatawpa River are presented in Table 6. These summaries are based on available data from January 1994 to December 1999, which is listed in Appendix A, and the recent EPA data collection effort. The EPA data were collected in May 2000 during the public notice period for this Phase One TMDL. They represent a one-time snapshot of fish-flesh mercury levels at these sampling sites.

Table 6 lists the stations identification numbers with the corresponding MDEQ Segment. A single sampling event could have more than one fish sample, so the number of samples are listed along with the number of fish collected at that site. The percent exceedance value references the number of sampling events that averaged above the 1.0 ppm FDA action level. This percentage does not represent the number of individual fish that were found to exceed the action level. The table also gives the minimum, maximum, and median mercury levels found for all of the samples collected at the site.

It should be noted that the point source facilities in the Escatawpa River discharge to Segment 3. This clouds the attempt to make a correlation between point source mercury dischargers and fish flesh mercury levels.

Advisories were posted for Segments 1 and 2 because fish tissue concentrations exceeded 1.0 ppm at station MS107M2-1. No concentrations above 1.0 ppm were reported at the two stations in Segment 3, MS107M3-2.5 and MS107M3-3. The 1995 Fish Advisory for the Escatawpa River is attached in Appendix B.

Table 6 Water Quality Station Data Analysis

Station	***MDEQ Segment***	***Sample Events***	***Number of Fish***	***Exceed 1.0 ppm***	***Min ppm***	***Max ppm***	***Median ppm***
MS107M2-1	2	30	50	60%	0.25	2.25	1.18
MS107M3-2.5	3	2	8	0%	0.45	0.52	0.49
MS107M3-3	3	7	31	0%	0.22	0.40	0.30
EPA Site 4	1	1	5	0%	0.73	1.36	0.97
EPA Site 5	2	1	5	100%	0.88	1.67	1.26
EPA Site 6	2	1	5	100%	0.85	1.68	1.14

3.0 SOURCE ASSESSMENT

A TMDL evaluation must examine all known potential sources of the pollutant in the subject watershed, including point sources, nonpoint sources, and background levels. The source assessment is used as the basis of development of the model and ultimate analysis of the TMDL allocation options. However, in this Phase One Mercury TMDL, only point source contributions are considered for evaluation. Phase Two of the TMDL will include contributions from nonpoint sources and background levels in the analysis. The point sources in the Escatawpa River watershed are listed in Table 7.

In an attempt to control mercury levels in the waterbody, this Phase One TMDL will call for a moratorium on any future mercury discharges into Segments 1 and 2 of the waterbody. In addition, this TMDL will require monitoring for mercury by all dischargers located in Segment 3.

Table 7 Permitted Facilities in Escatawpa River Watershed

Facility Name	***NPDES ID***	***Segment***	***Location***
Macland Ash Landfill	MS0044067*	3	Moss Point
Morton International	MS0001775	3	Moss Point
Escatawpa WWTP	MS0021521	3	Escatawpa
Jackson County Port Authority (Plant Daniel)	MS0021061	3	Escatawpa
Jackson County Port Authority (International Paper Company)	MS0002674	3	Moss Point
Omega Protein, Inc.	MS0002950	3	Moss Point

* *Current permit is pending modification. The leachate discharge will be sent to the Escatawpa WWTP for treatment. The leachate pretreatment permit has a requirement for mercury monitoring and reporting. The new pretreatment permit MSP09158 is waiting final approval.*

4.0 MODELING PROCEDURE

Establishing the relationship between the instream water quality target and the source loadings is a critical component of TMDL development. It allows for the evaluation of alternatives for possible wasteload reductions. The link for mercury in the water column and mercury in fish flesh has not been established. The discussion of mercury TMDL calculations is included in this section.

4.1 MODELING CALCULATIONS

Mass balance equations have been used to determine the mercury TMDLs in the Escatawpa River Watershed. A more complicated model is not warranted for Phase One of the TMDL analyzed because: (1) only contributions from point sources are considered, but none are known; (2) the mercury cycling processes will not be represented until Phase Two; (3) and water quality data for ambient mercury concentrations are not available to correspond to the levels of mercury found in the fish flesh for the Escatawpa River.

In the future, for any facilities drawing their intake water from the Escatawpa River or from the Pascagoula River within mercury impacted fish advisory areas, a TMDL will allow for the subtraction of mercury loading from fresh water intakes. In other words, facilities will only be considering the total mercury that is added to the river based on the treatment processes involved. Loading calculations will be based on net increases to the mercury load in the stream.

4.2 CALCULATION SETUP

The Escatawpa River Watershed is divided into four subwatersheds in order to isolate the two impaired stream reaches. This allows analysis to address the relative contribution of point sources within each subwatershed to the different segments of the river. The delineation of the watersheds is based primarily on an analysis of the reach file three (RF3) stream network in the basin. The four subwatersheds are listed in Table 2 and displayed in Figure 3. The dischargers that go into Segment 3 are included in the discussion of this TMDL. Although Segment 3 is downstream of the impaired segment, and, as mentioned above, no elevated levels of Hg have been found in fish, dischargers to Segment 3 should monitor for mercury in their effluents.

4.3 STREAM CHARACTERISTICS

The stream characteristics given below describe the segments MS107M1 and MS107M2. The mean flow data are computed from historical stream flow data from U.S. Geological Survey's National Water Information System (NWIS) Stations 02479560 (Agricola) and 02479600 (Hurley). The characteristics of these segments are as follows.

MS107M1

- Length 20 miles
- Average Annual Flow 1,403 cfs
- 7Q10 Flow 121 cfs
- Slope 0.04%

MS107M2

- Length 24 miles
- Average Annual Flow 1,861 cfs
- 7Q10 Flow estimate 161 cfs
- Slope 0.01%

4.4 SOURCE REPRESENTATION

Only point sources are considered in this Phase One Mercury TMDL. Table 8 lists the facilities that currently have to monitor and report for mercury in the watershed. All of these facilities are located in Segment 3 of the river, which is not currently listed as impaired for mercury. These facilities are not considered as part of this TMDL's analysis. However, they are shown here to indicate that a reduction in mercury to Segment 3 is ongoing.

Table 8 Permitted Facilities in Escatawpa River Watershed

Facility Name	***NPDES ID***	***Segment***	***Notes***
Macland Ash Landfill	MS0044067	3	Permit application under review to modify this discharge. Future leachate discharge will go to Escatawpa WWTP under pretreatment permit MSP09158 (pending approval). The remaining discharge will be from stormwater.
Morton International	MS0001775	3	The monitoring requirements have been removed from this permit.
Escatawpa WWTP	MS0021521	3	Current data indicate a mercury removal rate from 67 ng/l (influent) to 1.5 ng/l (effluent).

A significant amount of mercury water quality sampling data from the Escatawpa River is needed to adequately explain the relationship between mercury concentration in the water column with the concentration in fish tissue. As ambient mercury data and tools for analyzing mercury cycling become available, Phase Two of this TMDL project will be completed to accurately represent mercury sources, atmospheric deposition, and stream response.

5.0 ALLOCATION

TMDLs are composed of the sum of individual waste load allocations (ΣWLAs) for point sources, the sum of load allocations (ΣLAs) for nonpoint sources, and a margin of safety (MOS). This definition is mathematically expressed by the equation:

$$TMDL = \Sigma WLA + \Sigma LA + MOS$$

The TMDL is the amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. This TMDL represents the maximum load of mercury that can be introduced into the waterbody by point source discharge based on Mississippi's mercury criterion.

5.1 TMDL CALCULATION

The TMDL Calculation is based upon the conservation of mass principle, where the load can be calculated by using the following relationship:

$$Concentration = Load / Flow$$

Rearranging this equation, the load can be calculated as follows:

$$Load = Concentration * Flow$$

Load gm/day = 0.012 µg/l * 161 cfs * 2.45 (unit conversion factor) = 4.73 gm/day

Segments 1 and 2 are adjacent so the totals shown are inclusive. The overall TMDL load for total mercury in the waterbody system is 4.73 grams per day.

Table 9 TMDL for Total Mercury II

Seg.	***Segment ID***	***7Q10 Flow*** *(cfs)*	***Total Hg(II) Target*** *(µg/l)*	***TMDL*** *(gm/day)*
1	MS107M1	121	0.012	3.56
2	MS107M2	161	0.012	4.73

Once the Total TMDL has been calculated, the components of the equation can then be allocated. There are no current dischargers in Segments 1 and 2, and this TMDL calls for a moratorium on future mercury dischargers in these segments.

5.2 TMDL ALLOCATIONS

The sum of the loads allocated to the point sources, (ΣWLAs) is determined by multiplying the permitted flow from the facility by the mercury criterion. No NPDES facilities currently discharge to the impaired segments. The moratorium will set the WLA component of the TMDL equation to zero. Recent monitoring has indicated background concentrations of 2.0 to 3.0 ng/l in the river. This level will be allocated to the LA component of the equation.

Additionally, the facilities that discharge to Segment 3 of the Escatawpa River will be required to test for total Hg(II) in their effluent as part of this Phase One TMDL project. This requirement for monitoring from dischargers in Segment 3 will provide the needed data that must be gathered for Phase Two of this TMDL to determine the potential sources for this pollutant.

Table 10 Facilities Requiring Mercury Effluent Testing

Facility Name	*NPDES ID*
Macland Ash Landfill	MSP09158*
Morton International	MS0001775
Escatawpa WWTP	MS0021521
Jackson County Port Authority (Plant Daniel)	MS0021061
Jackson County Port Authority (International Paper Company)	MS0002674
Omega Protein, Inc.	MS0002950

Pending

5.3 INCORPORATION OF A MARGIN OF SAFETY

The two options for MOS development are either to implicitly incorporate the MOS using conservative assumptions or to explicitly specify a portion of the total TMDL as the MOS. A dual MOS method has been selected for this Phase One TMDL. It is implicit, based on the conservative assumptions inherent in the selection of the TMDL endpoint of 0.012 μg/l. In addition, it is explicit to account for uncertainty in the mercury linkage between fish flesh mercury levels and water-column mercury levels. The explicit MOS has been set at 75%.

As discussed in Section 2.1, we believe the mercury aquatic life fresh water criterion of 0.012 μg/l is overprotective of aquatic toxicity. The standard was not derived from actual fish toxicity studies, but was calculated to be the water column concentration that produced a fish tissue concentration of 1.0 mg/kg in the fathead minnow. This approach for establishing aquatic life criteria is flawed because the concentration of mercury in a tissue sample cannot be equated with toxic effects to the fish. Conversely, the fish consumption standard of 0.153 μg/l was determined to be the water column concentration that produced a BCF fish tissue concentration of 1.0 mg/kg in edible fish. Therefore, the use of the 0.012 μg/l as the endpoint in this TMDL incorporates a large implicit MOS.

Additional MOS is implicitly included in the TMDL by the conservative assumptions inherent in the development of the 0.153 μg/l human health standard. The criterion is based on the following equation:

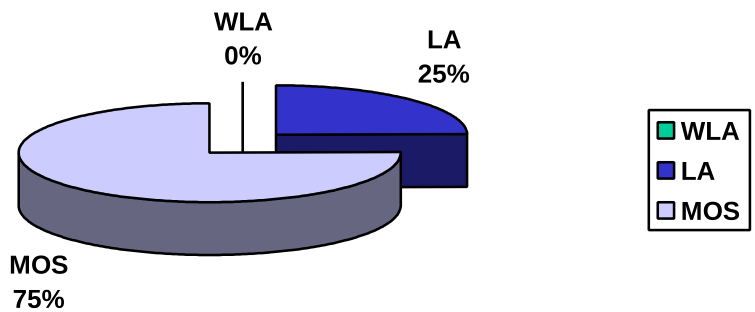
$$C = \frac{\text{reference dose} \ * \ \text{human body weight}}{\text{fish consumption rate} \ * \ \text{bio-concentration factor}}$$

The criterion was based on a combination of fish consumption rates and bio-concentration factors for fresh water fishes, coastal organisms, and salt-water fishes. If the coastal organisms and salt-water fishes are omitted from the calculation, the criterion would be 2.22 µg/l. The fish tissue data from the Escatawpa River show elevated mercury levels only in one set of catfish and several sets of largemouth bass. However, the BCF used in the criteria development considers four species of freshwater fish resulting in an average BCF of 5500, which is higher than that of either the bass or the catfish. Using the higher combined value in the denominator of the above equation, another MOS is introduced into the calculations.

Additionally, the fresh water fish consumption rate established in the *Ambient Water Quality Criteria for Mercury* is 1.72 gm/day per person. Our regulations, however, require the use of 6.5 gm/day per person. This calculation would set the criterion at 0.587 µg/l as compared to the 0.153 µg/l in Mississippi's water quality standards. The use of a fish consumption rate of almost 3.8 times that for freshwater species alone introduces yet another MOS which is already a part of the current human health standard for Mississippi.

However, there is enough uncertainty inherent to this entire process to justify the inclusion of an explicit MOS. As previously mentioned, this explicit MOS has been set at 75%. The TMDL equation is shown graphically as a pie chart in figure 5 below.

Figure 5



TMDL = WLA + LA + MOS

4.73 gm/day = 0.00 gm/day WLA + 1.18 gm/day LA + 3.55 gm/day MOS

5.4 SEASONALITY

Wet deposition is greatest in the winter and spring seasons. Mercury will be expected to fluctuate based on the amount and distribution of rainfall, and variability of localized and distant atmospheric sources. While a maximum daily load is established in this TMDL, the average annual load is of greatest significance since mercury bioaccumulation and the resulting risk to human health that results from mercury consumption is a long term phenomenon. Thus, daily or weekly inputs are less meaningful than total annual loads over many years. The use of annual load allows for integration of short-term or seasonal variability. Inputs will continue to be estimated through monitoring and modeling.

Methylation of mercury is expected to be highest during the summer. High temperatures and static conditions result in hypoxic and/or conditions that promote methylation. Based on this enhanced methylation and high predator feeding activity during the summer, mercury bioaccumulation is expected to be greatest during the summer. However, based on the refractory nature of mercury, seasonal changes in body burden would be expected to be slight. Inherent variability of mercury concentrations between individual fish of the same and/or different size categories is expected to be greater than seasonal variability.[15]

5.5 IMPLEMENTATION PLAN

Implementation of this Phase One Mercury TMDL will differ from other types of TMDLs since atmospheric deposition is believed to be the primary pollutant source. This will involve MDEQ working with stakeholders to identify the most appropriate mechanisms to implement this TMDL project. MDEQ will cooperate with EPA concerning national initiatives and strategies, which will be important to implement regulatory controls on a national and international basis. Much monitoring, research, and regulation is in progress on the national level. MDEQ will consider these ongoing activities in implementing this and future phases of this TMDL project.

The ultimate reduction of mercury in the environment will take numerous years and is in line with the Bi-national Toxics Strategy, which sets a national challenge of 50% reduction of mercury releases to the air by 2006. Phase Two of this TMDL project will explore atmospheric deposition along with local and national air-emission reduction goals. Long-term monitoring of wet deposition rates and fish tissue in each of the waterbody segments will serve as environmental indicators to evaluate the effectiveness of the TMDLs and other parallel control measures.[15]

6.0 CONCLUSION

MDEQ will not approve any NPDES Permit application for Segments 1 and 2 that does not comply with the moratorium for mercury discharges into Segments 1 and 2. In addition, this TMDL requires all NPDES Permitted dischargers in Segment 3 to monitor for mercury using clean techniques and accurate testing methods.

Phase Two of this TMDL will include nonpoint sources of mercury, atmospheric deposition, and will consider the effects of mercury cycling in the river. The TMDL calculations from Phase One may be revised in Phase Two of this TMDL since more will be known about the percentage of mercury contributions from point and nonpoint sources.

6.1 FOLLOW-UP MONITORING

Additional ambient mercury monitoring for all species of mercury will be needed for development of Phase Two. Additional information is required to facilitate the understanding of the methylmercury process and the linkage between mercury in the water column and mercury in fish flesh. Specialized monitoring approaches will also be needed to determine the atmospheric deposition contribution to mercury in the watershed.

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 are focused on one of the basin groups. During the next monitoring phase in the Pascagoula Basin, the Escatawpa River will receive additional monitoring to identify the improvements in water quality gained from the implementation of the Phase One strategy included in this TMDL.

6.2 PUBLIC PARTICIPATION

This Phase One TMDL project 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 Pascagoula. The public will be given an opportunity to review the TMDL and submit comments.

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

DEFINITIONS

Ambient stations: 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 amount of contaminant load that can be discharged to a specific stream or river without violating the provisions of the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters and Water Quality* regulations. Assimilative capacity is used to define the ability of a waterbody to naturally absorb and use waste matter and organic materials without impairing water quality or harming aquatic life.

Atmospheric Deposition: input of chemical components from the atmosphere into natural waters through the processes of wet deposition (rain, snow) and dry deposition (particle fallout, gas-water exchange). Components can include nutrients, acidity, trace elements, and anthropogenic organics.

Background: the condition of waters in the absence of 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 waterbody or on historical least impaired data.

Best management practices: 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.

Bioaccumulation: the net accumulation of a substance by an organism as a result of uptake from all environmental sources.

Bioaccumulation Factor (BAF): the ratio (in L/kg) of a substance's concentration in tissue of an aquatic organism to its concentration in the ambient water, in situations where both the organism and its food are exposed and the ratio does not change substantially over time.

Bioconcentration: the net accumulation of a substance by an aquatic organism as a result of uptake directly from the ambient water through gill membranes or other external body surfaces.

Bioconcentration Factor (BCF): the ratio (in L/kg) of a substance's concentration in tissue of an aquatic organism to its concentration in the ambient water, in situations where the organism is exposed through the water only and the ratio does not change substantially over time.

Calibration: testing and tuning of a model to a set of field data. Also includes minimization of deviations between measured field conditions and output of a model by selecting appropriate model coefficients.

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: uses specified in water quality standards for each waterbody or segment regardless of actual attainment.

Discharge monitoring report: report of effluent characteristics submitted by a facility that has been granted an NPDES Permit.

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: municipal sewage or industrial or commercial liquid waste (untreated, partially treated, or completely treated).

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.

Impairment: conditions in which the applicable state water quality standards are not met for a waterbody and the designated use is impaired.

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 cattle and land-applied mercury 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.

Margin Of Safety (MOS): a required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant load and the quality of the receiving waterbody.

Mercury (Hg): a silver-white metal, atomic weight 200.59, which is a slightly volatile liquid at room temperature. Mercury is a naturally occurring element that is found in air, water and soil. It ranks about 67th in natural abundance among the elements in crustal rocks. Most of the mercury in the atmosphere is elemental mercury vapor (which circulates in the atmosphere for up to a year, and hence can be widely dispersed and transported thousands of miles from likely sources of emission). Most of the mercury in water, soil, sediments, or plants and animals is in the form of inorganic water-soluble salts (most commonly mercuric chloride) and organic forms of mercury (commonly methylmercury). Among the commercially important compounds of mercury are mercuric sulfide, a common antiseptic also used as the pigment vermilion; mercurous chloride, or calomel, used for electrodes, and formerly used as a cathartic; mercuric chloride, or corrosive sublimate; and medicinals such as Mercurochrome.

Mercury (elemental): mercury in a zero (0) oxidation state - referred to as mercury vapor when present in the atmosphere and as metallic mercury when present in its liquid form.

Mercury II (inorganic mercury): mercury which has been naturally oxidized to a divalent oxidation state and exhibits a wide range of acute toxicity to aquatic life. Inorganic mercury occurs in numerous forms/compounds; the most common include mercuric chloride ($HgCl_2$), mercurous chloride (Hg_2Cl_2), and mercuric oxide (Hg[O]).

Methylmercury (organic mercury): Mercury II which has been methylated in surface waters by naturally occurring bacteria and which can substantially accumulate in the food chain. Nearly all of the mercury that accumulates in fish tissue is methylmercury.

Nonpoint source pollution: pollution that is 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 MDEQ Permit Board pursuant to regulations adopted by the Commission under Mississippi Code Annotated (as amended) § 49-17-17 and § 49-17-29 for discharges into State waters.

Part per million: one millionth of a measurement. This nomenclature also applies to part per billion and part per trillion. 1 mg/kg mercury in fish flesh is one part per million. 1 µg/l liquid concentration is equivalent to one part per billion. 1 nanogram liquid concentration is equivalent to one part per trillion.

Phased TMDL Project: Under the phased approach, the TMDL has load allocations and wasteload allocations calculated with margins of safety to meet water quality standards. The allocations are based on estimates that use available data and information, but monitoring for collection of new data is required. The phased approach provides for further pollution reduction without waiting for new data collection and analysis.

Point source pollution: 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): municipal wastewater treatment plant owned and operated by a public governmental entity such as a town or city.

Practical Bio-accumulation Factor (PBCF): - a practical approximation used in lieu of a BCF in the derivation of the human health criteria for mercury in Ambient Water Quality Criteria for Mercury. The PCBF's were calculated as the ratio of the average concentration of mercury in muscle in one species of fish to the average concentration of mercury in the body of water in which the species normally lives.

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

$$\overset{\mathbf{3}}{\underset{\mathbf{i=1}}{S}} d_i = d_1+d_2+d_3 = 24 + 123 + 16 = 163$$

STORET: EPA national water quality database for STORage and RETrieval (STORET). The database includes physical, chemical, and biological data measured in waterbodies throughout the United States.

Storm runoff: rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate than rainfall intensity, but instead flows into adjacent land or waterbodies or is routed into a drain or sewer system.

Total Maximum Daily Load (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.

Water quality criteria: water quality criteria comprise numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or states for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal.

Water quality standards: a law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody and an antidegradation statement.

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: a part of the land area enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a receiving water. It may also be referred to as drainage basin, river basin, or hydrologic unit.

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
DMR	Discharge Monitoring Report
EPA	Environmental Protection Agency
GIS	Geographic Information System
HCR	Hydrograph Controlled Release Facility
HUC	Hydrologic Unit Code
LA	Load Allocation
MARIS	State of Mississippi Automated Resource 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
PCS	Permit Compliance System
PPB	Part per Billion
PPM	Part per Million
PPT	Part per Trillion
RF3	Reach File Three
USGS	United States Geological Survey
WLA	Waste Load Allocation

REFERENCES

1. ATSDR. 1999. Toxicological profile for mercury (update). Agency for Toxic Substances and Disease Registry, 1999

2. Gilmour, C.C., E. A. Henry, and R. Mitchell. 1992. Sulfate Stimulation of Mercury Methylation in Freshwater Sediments. Environ. Sci. Technol. 26:2281-2287.

3. Hudson, r. J. M., S. A. Gherini, c. J. Watras, et al. 1994. Modeling the biogeochemical cycle of mercury in lakes: The mercury cycling model (MCM) and its application to the MTL study lakes. In "Mercury as a global pollutant". Watras C. J. and J. W. Juckabee (Eds.). Lewis Publishers. Pp 473-523.

4. J. David Dean, Kent Thornton, Randy Manning, & Donald Porcella, "Mercury Issues in the Southeastern United States." 2000, a report prepared for the TAPPI meeting.

5. Mason, R. P. and W. F. Fitzgerald. 1990. Alkylmercury species in the equatorial Pacific. Nature. 347:457-459.

6. Metcalf and Eddy. 1991. *Wastewater Engineering: Treatment, Disposal, Reuse*. 3rd Edition. McGraw-Hill, Inc., New York.

7. MDEQ. 1994. *Wastewater Regulations for National Pollutant Discharge Elimination System (NPDES) Permits, Underground Injection Control (UIC) Permits, State Permits, Water Quality Based Effluent Limitations and Water Quality Certification.* Office of Pollution Control.

8. MDEQ. 1995. *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Costal Waters*. Office of Pollution Control.

9. MDEQ. 1998. *Mississippi List of Waterbodies, Pursuant to Section 303(d) of the Clean Water Act*. Office of Pollution Control.

10. MDEQ. 1999. *Mississippi Water Quality Assessment, Federal Clean Water Act Section 305(b) Report*. Office of Pollution Control.

11. Tremblay, A., L. Cloutier, and M. Lucotte. 1998. Total mercury and methylmercury fluxes via emerging insects in recently flooded hydroelectric reservoirs and a natural lake. Sci. Total Environ. 219:209-221.

12. USEPA. 1997. Mercury study report to congress. EPA-452/R-97-003. Office of Air Quality, Planning and Standards. Office of Research and Development. Washington, DC.

13. USEPA. 1998. *Better Assessment Science Integrating Point and Nonpoint Sources, BASINS, Version 2.0 User's Manual*. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

14. USEPA. 1986. *Quality Criteria for Water 1986.* U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

15. USEPA. Region 6. 2000. *Mercury TMDLs for Segments within Mermentau and Vermilion-Teche River Basins*. U.S. Environmental Protection Agency, Region 6, Dallas Texas.

16. Watras, C.J., K. A. Morrison, and R. C. Back. 1996. Mass balance studies of mercury and methylmercury in small, temperate/boreal lakes of the Northern Hemisphere. In" Baeyens, E., R. Ebinghaus, O. Vasiliev. (ed.) Regional and global mercury cycles: sources, fluxes and mass balances. Kluwer Academic Publ. Netherlands. Pp. 329-358.

17. Zillioux, E.J., D. B. Porcella, J. M. Benoit. 1993. Mercury cycling and effects in freshwater wetland ecosystems. Environ. Toxicol. Chem. 12:2245-2264.

APPENDIX A: ESCATAWPA RIVER FISH TISSUE DATA

		Hg			#	Min.	Max.	Mean
COUNTY	Site	(ppm)		Species	Fish	Wt.	Wt.	Wt.
Jackson	Escatawpa River @ Site 3	**0.40**		Largemouth Bass	5	3.55	4.63	3.95
Jackson	Escatawpa River @ Site 3	**0.32**		Largemouth Bass	5	0.99	1.46	1.26
Jackson	Escatawpa River @ Site 3	**0.27**		Redfish	4	6.31	7.12	6.70
Jackson	Escatawpa River @ Site 3	**0.40**		Striped Bass	4	4.04	5.14	4.74
Jackson	Escatawpa River @ Site 3	**0.22**		Red Drum	3	5.44	6.19	5.69
Jackson	Escatawpa River @ Site 3	**0.30**		Largemouth Bass	5	1.51	1.73	1.62
Jackson	Escatawpa River @ Site 3	**0.23**		Largemouth Bass	5	0.51	0.71	0.63
Jackson	Escatawpa R. @ Goodes Mill	**2.20**	**	Largemouth Bass	2	4.47	5.40	4.93
Jackson	Escatawpa R. @ Goodes Mill	**0.93**	*	Largemouth Bass	5	1.08	2.22	1.62
Jackson	Escatawpa R. @ Goodes Mill	**1.22**	**	Bass sp.	4	1.59	2.95	2.18
Jackson	Escatawpa R. @ Goodes Mill	**0.99**	*	Bass sp.	5	1.03	1.32	1.16
Jackson	Escatawpa R. @ Goodes Mill	**1.44**	**	Largemouth Bass	3	1.74	2.45	2.00
Jackson	Escatawpa R. @ Goodes Mill	**0.71**		Bowfin	1	3.65	3.65	3.65
Jackson	Escatawpa R. @ Goodes Mill	**1.16**	**	Largemouth Bass	1	3.60	3.60	3.60
Jackson	Escatawpa R. @ Goodes Mill	**1.11**	**	Largemouth Bass	1	2.79	2.79	2.79
Jackson	Escatawpa R. @ Goodes Mill	**0.88**	*	Largemouth Bass	1	2.61	2.61	2.61
Jackson	Escatawpa R. @ Goodes Mill	**0.45**		Largemouth Bass	1	1.76	1.76	1.76
Jackson	Escatawpa R. @ Goodes Mill	**0.50**		Largemouth Bass	1	2.11	2.11	2.11
Jackson	Escatawpa R. @ Goodes Mill	**0.70**		Largemouth Bass	1	1.86	1.86	1.86
Jackson	Escatawpa R. @ Goodes Mill	**1.57**	**	Largemouth Bass	1	1.29	1.29	1.29
Jackson	Escatawpa R. @ Goodes Mill	**0.25**		Largemouth Bass	1	1.33	1.33	1.33
Jackson	Escatawpa R. @ Goodes Mill	**1.14**	**	Largemouth Bass	1	1.33	1.33	1.33
Jackson	Escatawpa R. @ Goodes Mill	**0.27**		Largemouth Bass	1	1.07	1.07	1.07
Jackson	Escatawpa R. @ Goodes Mill	**1.78**	**	Largemouth Bass	1	2.31	2.31	2.31
Jackson	Escatawpa R. @ Goodes Mill	**1.79**	**	Largemouth Bass	1	2.40	2.40	2.40
Jackson	Escatawpa R. @ Goodes Mill	**1.82**	**	Largemouth Bass	1	2.85	2.85	2.85
Jackson	Escatawpa R. @ Goodes Mill	**1.49**	**	Largemouth Bass	1	2.35	2.35	2.35
Jackson	Escatawpa R. @ Goodes Mill	**1.30**	**	Largemouth Bass	1	1.78	1.78	1.78
Jackson	Escatawpa R. @ Goodes Mill	**0.99**	*	Largemouth Bass	1	1.60	1.60	1.60
Jackson	Escatawpa R. @ Goodes Mill	**1.61**	**	Largemouth Bass	1	1.33	1.33	1.33
Jackson	Escatawpa R. @ Goodes Mill	**1.59**	**	Largemouth Bass	1	1.53	1.53	1.53
Jackson	Escatawpa R. @ Goodes Mill	**1.02**	**	Largemouth Bass	1	1.19	1.19	1.19
Jackson	Escatawpa R. @ Goodes Mill	**0.73**		Largemouth Bass	1	1.13	1.13	1.13
Jackson	Escatawpa R. @ Goodes Mill	**1.74**	**	Largemouth Bass	2	3.17	3.78	3.48
Jackson	Escatawpa R. @ Goodes Mill	**1.22**	**	Largemouth Bass	2	1.24	1.53	1.39
Jackson	Escatawpa R. @ Goodes Mill	**1.20**	**	Largemouth Bass	2	0.90	1.03	0.97
Jackson	Escatawpa R. @ Goodes Mill	**1.43**	**	Flathead Catfish	4	4.69	6.03	5.63
Jackson	Escatawpa R. @ Site 2.5	**0.45**		Largemouth Bass	3	2.55	3.78	3.22
Jackson	Escatawpa R. @ Site 2.5	**0.52**		Largemouth Bass	5	0.78	1.36	1.04
*- Above .75 (ppm)								
** Above 1.0(ppm)								

APPENDIX B
FISH ADVISORY FOR ESCATAWPA RIVER

MISSISSIPPI STATE DEPARTMENT OF HEALTH

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Immediate Release

NEWS NEWS NEWS

Mississippi today became one of almost 40 states that have found some game fish with mercury levels the Food and Drug Administration considers too high for certain people.

The Mississippi State Department of Health recommended that pregnant women, breast-feeding mothers, and children cut down on the fish they eat from four bodies of water.

Mississippi found elevated levels of mercury in bass and large catfish in the Bogue Chitto River, Yockanookany River, Enid Reservoir, and upper Escatawpa River from the Alabama state line to the I-10 bridge.

Data from these Mississippi waters indicate that large catfish more than 27 inches long and bass will have the most mercury.

Children under seven and women who might have children should eat no more than one meal of bass or large catfish every two months from these waters. Other adults should eat no more than one meal of these fish every two weeks from these waters.

-more-

Mercury - add 1

The Mississippi State Department of Health, the Department of Environmental Quality, and the State Department of Wildlife, Fisheries, and Parks worked together to find Mississippi's mercury problem. Most other states have identified mercury problems as well.

"Mercury is a heavy metal that can damage the brain and nervous system of young children," said Robert Hotchkiss, MD, chief of community health services for the State Department of Health. "Much higher levels can cause health problems in adults but are not usually associated with fish consumption."

Mercury can harm young children who eat contaminated fish or drink breast milk from a mother with high mercury levels. Pregnant women should take care to protect the developing fetus.

"We don't know if the mercury in our water is there because of natural reasons or because of human activity," Bruce Brackin, deputy state epidemiologist, said. "We do know that mercury packed tightly within the earth can get into the air when we dig for or process natural resources, and in time that mercury falls or washes back into our lakes and streams. Mississippi does not have any industries that release enough mercury to account for what we are seeing."

-more-

Mercury - add 2

After mercury is set free, it enters the food chain and collects in the larger fish that eat other fish.

"We're risking something we can't afford to give away," Hotchkiss said. "Too much mercury might take just one IQ point from a child, but if you apply that across a population in the information age, mercury can make a difference."

Because broiled, baked, and grilled fish are a good source of protein, Mississippians should keep fish in their diets, Hotchkiss said.

State agencies will continue to sample game fish, looking for other waters that might have too much mercury. Working with the Department of Wildlife, Fisheries, and Parks, the Department of Environmental Quality has already sampled 897 fish from 23 rivers and streams, 11 oxbow lakes, and 49 reservoirs, including all state-owned fishing lakes.

Because farm-raised catfish are fed a commercially prepared diet and grow quickly, they don't collect mercury and are safe to eat.

Also, the chemical make-up of the water and soil in most of the Delta helps prevent mercury build-up in farm-raised fish.

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mab:5/25/95