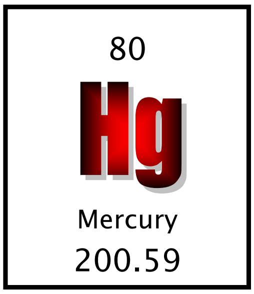
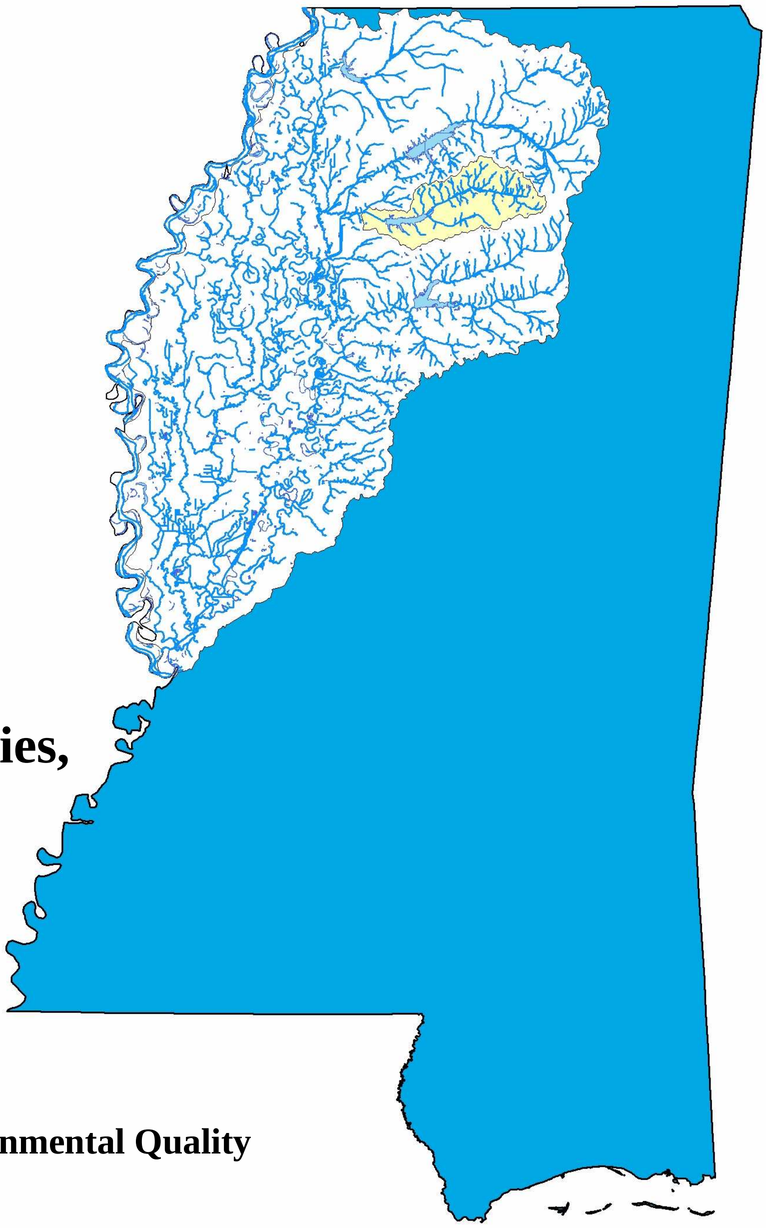
FINAL REPORT
January 2003
ID: 903013001

Yocona River and Enid Reservoir Phase One Total Maximum Daily Load for Mercury





Yazoo Basin

Yalobusha, Panola, and Tallahatchie Counties, Mississippi

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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	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
Cubic meters	Liters	1000	µg/l * MGD	Gm/day	3.79

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TMDL INFORMATION PAGE

Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Enid Reservoir	MS288ELM	Yalobusha	08030203	Mercury	Monitored
Location – Near Enid					
Yocona River	MSYOCRM	Yalobusha Panola Tallahatchie	08030203	Mercury	Monitored
Location – Near Enid: From Enid Dam to the confluence with Long Creek					

Water Quality Standard

Parameter	Beneficial use	Water Quality Criteria
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

NPDES Facilities

NPDES ID	Facility Name	County	Receiving Water	Flow (MGD)
MS0022837	Brittany Woods Subdivision	Lafayette	Four Mile Branch	0.0700
MS0051837	Forest Ridge Estates	Lafayette	Yellow Leaf Creek	0.0152
MS0029831	Lafayette County High School	Lafayette	Burney Branch	0.0225
MS0043079	Lafayette County Industrial Park	Lafayette	Barry Branch	0.3000
MS0021873	University of Mississippi	Lafayette	Burney Branch	0.9500
MS0029017	Oxford POTW	Lafayette	Yocona River	3.5000
MS0031585	Rolling Woods Subdivision	Lafayette	Four Mile Branch	0.0400
MS0054283	Sparrow's Nest Daycare	Lafayette	Fox Creek	0.0006
MS0048186	Timber Lake Estates Subdivision	Lafayette	Yellow Leaf Creek	0.0400
MS0044890	Carter's Grocery and Laundromat	Lafayette	Tributary of Jones Creek	0.0005
MS0055450	Taylor Grocery	Lafayette	Tributary of Taylor Creek	0.0010
MS0040703	U.S. Army Corps of Engineers Chickasaw Hill Recreation Area	Panola	Enid Reservoir	0.0070
MS0029050	George P. Cossar State Park	Yalobusha	Enid Reservoir	0.0200
MS0045641	Holley Automotive	Yalobusha	Otoucalofa Creek	0.2880
MS0041751	Persimmon Hill Campground	Yalobusha	Yocona River	0.0200
MS0021059	U.S. Army Corps of Engineers Riverview Recreation Area	Yalobusha	Yocona River	0.0120
MS0040690	U.S. Army Corps of Engineers Wallace Creek Recreation Area	Yalobusha	Enid Reservoir	0.0200
MS0022331	Water Valley POTW	Yalobusha	Otoucalofa Creek	1.4000
MS0042021	U.S. Army Corps of Engineers Water Valley Recreation Area	Yalobusha	Enid Reservoir	0.0008

Total Maximum Daily Load

Type	Number	Unit	MOS Type
WLA	0.305	gm/day	
LA	0.430	gm/day	
MOS	0.735	gm/day	Explicit and Implicit
TMDL	1.470	gm/day	

EXECUTIVE SUMMARY

A portion of the Yocona River including Enid Reservoir is impaired by mercury. Largemouth bass, spotted bass, and flathead catfish caught in these waterbodies 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 for human consumption.

Based on these data, the State of Mississippi issued a fish consumption advisory (see Appendix B) for Enid Reservoir and the Yocona River. These advisories were issued to help protect the people who regularly consume fish caught in the waterbodies. The bioaccumulation of methylmercury in fish flesh is the basis for the impairment in the waterbodies.

This Phase One Mercury TMDL for the Yocona River and Enid Reservoir has been developed prior to a complete understanding of the linkage between mercury in the water and mercury in the fish. 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 will 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 yet been adopted by the Mississippi Commission on Environmental Quality. MDEQ is therefore proposing the most protective of the currently adopted criteria, 12 ng/l.

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 50%.

The implementation plan in this Phase One TMDL calls for a moratorium on any mercury discharge in the Yocona River Watershed. It also calls for increased monitoring in the Yocona River Watershed. This TMDL also recommends pollution prevention alternatives and activities.

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 Yocona River and Enid Reservoir.

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 Yocona River and Enid Reservoir. 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 these waterbodies 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 waterbody that will better characterize aquatic mercury cycling.

1.3 WATERBODY SEGMENT LOCATION

Enid Reservoir and its major tributary, the Yocona River, are located in the northern non-industrialized part of the state. Enid Reservoir, completed in 1952, is one of four similar man-made reservoirs built in the 1940's and 1950's by the Army Corps of Engineers (COE) for flood control in North Mississippi. Enid Reservoir and the Yocona River from the Enid Dam to its confluence with Long Creek are listed as impaired due to mercury on Mississippi's 1998 Section 303(d) List of Waterbodies.

In an attempt to protect human health, Mississippi issued a Fish Consumption Advisory for Enid Reservoir and the Yocona River from the Enid Dam to its confluence with the Tallahatchie River. This advisory was issued due to elevated levels of mercury found in fish flesh collected in these segments. See Appendix B.

Figure 1. Area Location Map

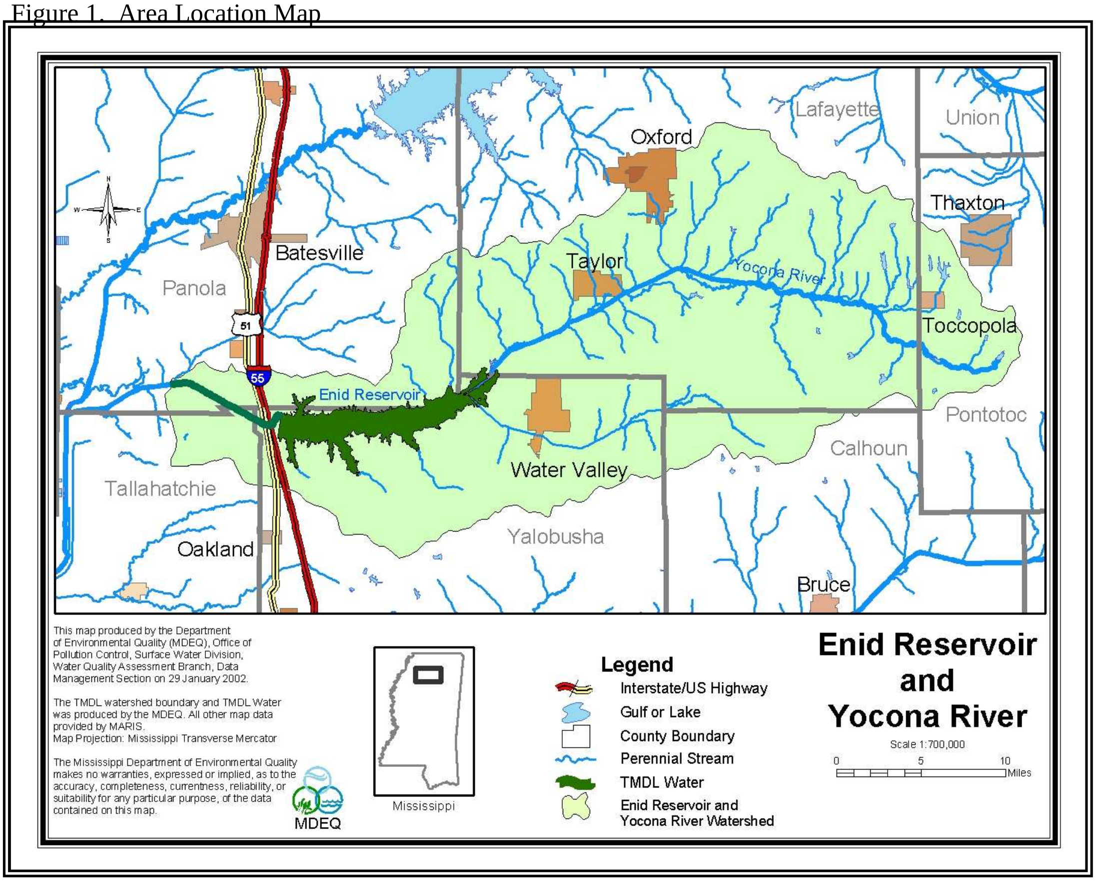


Table 1. Waterbody Identification for the Yocona River and Enid Reservoir TMDL

Waterbody Name	Waterbody ID	Assessment Type	Size	County	Listed Advisory	Advisory Cause
Enid Reservoir	MS288ELM	Monitored	28,000 acres	Yalobusha	Fish Consumption Advisory	Mercury
Location – Near Enid						
Yocona River	MSYOCRM	Monitored	8 miles	Yalobusha Panola Tallahatchie	Fish Consumption Advisory	Mercury
Location – Near Enid: From Enid Dam to the confluence with Long Creek						

Figure 2. The Yocona River Watershed – 303(d) Segment Locations

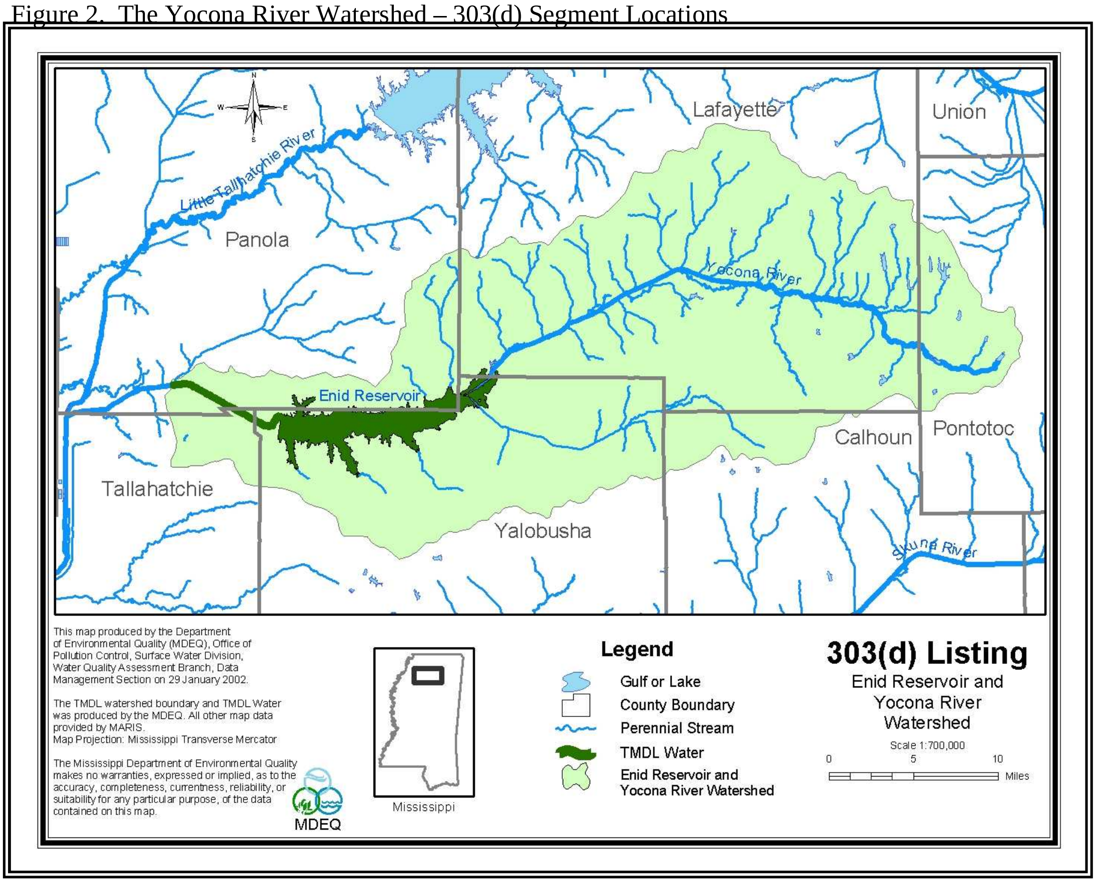


Figure 3. Landuse Distribution within the Yocona River Watershed

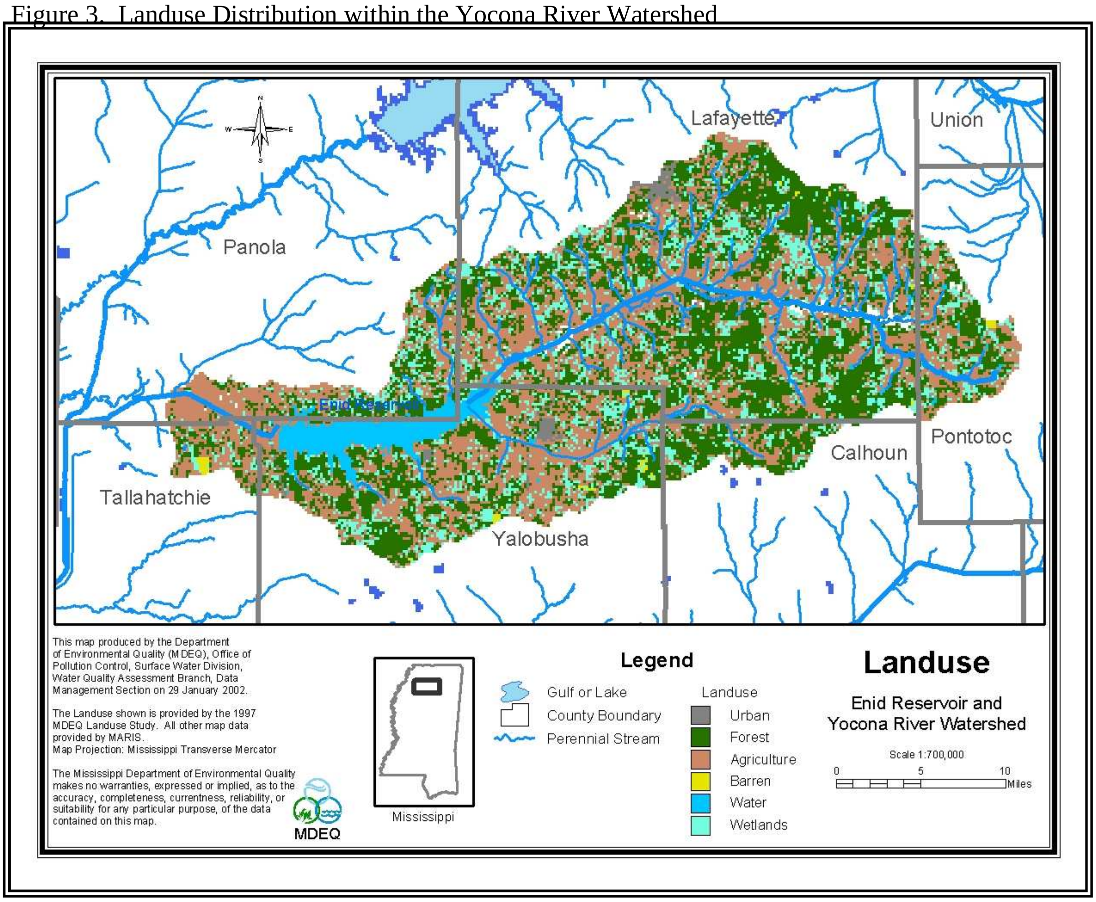


Table 2. Landuse Distribution in the Yocona River Watershed (acres)

Forest	Agriculture	Urban	Wetland	Water	Total
154471	162540	6405	69988	17664	411068
38%	**39%**	**2%**	**17%**	**4%**	**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 Enid Reservoir have been established based on a designated use of Recreation. The standards for the Yocona River have been established based on the 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 3 as defined by the current *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* regulations.

Table 3. 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

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. 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 3 applicable to Enid Reservoir and the Yocona 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 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 <u>edible</u> <u>fish</u>. 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 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 the Yocona River Watershed. This is to ensure the overall mercury load from point source contributors to the system does not increase. In addition, the TMDL includes an explicit MOS set at 50% for this TMDL.

2.1.4 Mississippi Regulations on Flow Determination

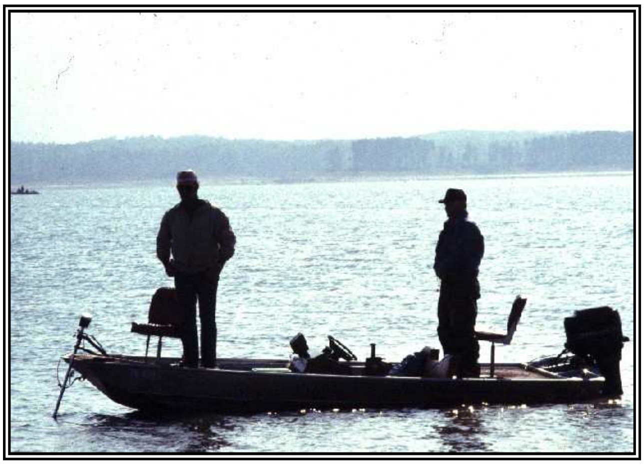
In addition to the endpoint, the flow rate must be determined in order to calculate the TMDL. According to Section II.9.D(2) of the *State of Mississippi Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulations, the 7Q10 flow shall be used when applying Chronic toxicity criteria concentrations to calculations determining the load to a stream.[8] According to USGS gage station #07275000, the mean annual flow for the Yocona River is estimated at 826 cfs. The 7Q10 flow is estimated to be 35 cfs. However, these values were based on data between 1930 and 1951. Enid Reservoir has regulated this basin since its completion in 1951. According to the U.S. Army Corps of Engineers, the minimum discharge at any time from Enid Dam into the Yocona River is 50 cfs. This minimum flow of 50 cfs was used for the development of this TMDL.

2.2 DISCUSSION OF INSTREAM WATER QUALITY

According to the State's 1998 Section 305(b) Water Quality Assessment Report, Enid Reservoir and a segment of the Yocona River are partially supporting the use of Fish Consumption. They are listed because a fishing advisory has been in effect for Enid Reservoir since May 1995 and Yocona River since September 1996. These advisory decisions were based on fish tissue data collected from Enid Reservoir and the Yocona River below the reservoir. Data collected at these sites are summarized and analyzed in the following sections.

2.2.1 Inventory of Water Quality Monitoring Data

Fish tissue samples were collected by MDEQ from both Enid Reservoir and the Yocona River below the reservoir. Samples were collected from Enid Reservoir between 1994 and 1999. Samples were collected from the Yocona River between 1995 and 1997. These data are provided in Appendix A.



2.2.2 Analysis of Fish Tissue Data

Fish tissue data have been analyzed to identify violations requiring fish consumption advisories. Statistical summaries of methylmercury levels in fish tissue (wet weight filets) from Enid Reservoir and the Yocona River are presented in Table 4. These summaries are based on available data from 1994 to 1999, which is listed in Appendix A.

A single sampling event could have more than one fish, 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 average methylmercury levels found for all of the samples collected at the site.

Advisories were posted for Enid Reservoir and the Yocona River because fish tissue concentrations exceeded 1.0 ppm at all sampling stations. The fish tissue data collected from Enid Reservoir and the Yocona River is listed in Appendix A. The Fish Advisories for these waterbodies are attached in Appendix B.

Table 4. Water Quality Station Data Analysis

Station	Sample Events	Number of Fish	Percent Exceedance*	Min ppm	Max ppm	Average ppm
Enid Reservoir	40	83	48%	0.28	2.26	1.01
Yocona River below Enid Reservoir	24	32	42%	0.37	2.05	0.96

* Percent exceedance is based on sampling events not individual fish.

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 further study contributions from nonpoint sources and background levels in the analysis.

3.1 POTENTIAL SOURCES OF MERCURY

Mercury emissions can occur from both natural and man-made sources. The man-made sources are estimated to account for the majority of all emissions. Appendix C contains a thorough outline of mercury sources. The following are examples of mercury sources in the environment that can be controlled.[7]

- Cement and Lime Kilns
- Coal and Oil Burning
- Copper Smelting
- Crematories
- Dental Amalgam Preparation/Disposal
- Dwelling Demolition (thermostats and switches)
- Electrical Product Manufacturing and Disposal (switches, fluorescent lights, some headlights and batteries)
- Evaporation of Mercury from Landfills
- Garbage Incinerators
- Hazardous Waste Incinerators
- Industrial Waste Discharge
- Laboratories Use and Waste
- Medical Waste Incinerators
- Petroleum Refining
- Residential Boilers
- Wastewater Treatment Plants and Sewage
- Wood Burning

Many items that we are in contact with everyday contain mercury. When these items are no longer useful, care should be taken to ensure that they are kept out of the trash or drain. When products containing mercury are placed in the trash, the mercury doesn’t disappear. It finds its way into the environment from waste incinerators, landfills, or wastewater treatment facilities.

Items that may contain mercury include:

- Fluorescent Lamps
- Mercury Switches
- Mercury Vapor Lamps
- Thermostat Probes
- Metal Halide Lamps
- Relays
- High Pressure Sodium Lamps
- Thermometers
- Neon Lamps
- Thermostats
- Dental Amalgam
- Manometers
- Gauges
- Laboratory Solutions

3.1.1 Fluorescent and High-Intensity Discharge Lamps

Fluorescent and high-intensity discharge (HID) lamps are used because they can use up to 50% less electricity than incandescent lighting. However, these lamps must be managed and disposed of properly because they contain mercury.[8]

3.1.2 Mercury Switches and Relays

Mercury switches are found in a variety of items ranging from chest freezers to sump pumps. Mercury containing tilt switches are found under the lids of clothes washers and chest freezers. They stop the spin cycle or turn on a light. They are also found in motion-sensitive and position-sensitive safety switches in clothes irons and space heaters. Float switches are commonly used in sump pumps and bilge pumps to turn the equipment on and off when the water is at a certain level. Automobile trunk and hood light switches often contain mercury. A variety of manufacturing processes use relays to control power to heaters or pumps. Relays that contain mercury switches activate airbags, anti-lock brakes, some seat belt systems, and some automatically adjusting suspension systems. Some agricultural equipment, military vehicles, mass transit vehicles, and fire hook and ladder equipment also contain mercury switches.[8]

3.1.3 Mercury-Containing Thermostats and Thermostat Probes

Mercury-containing tilt switches have been used in thermostats for more than 40 years. They provide accurate and reliable temperature control, require little or no maintenance, and do not require a power source. However, each switch contains approximately 3 grams of mercury. Mercury-free thermostats are available. Electronic thermostats now provide many of the same features as mercury thermostats.[8]

Mercury-containing thermostat probes may be found in several types of gas-fired appliances that have pilot lights, such as ranges, ovens, clothes dryers, water heaters, furnaces, or space heaters.

3.1.4 Mercury Thermometers

Some fever and laboratory thermometers contain mercury and should not be thrown in the trash. A typical fever thermometer contains about 0.5 grams of mercury. Larger laboratory thermometers can contain up to 3 grams of mercury. Many thermometers used to measure air and water temperature also contain mercury. They are used by homeowners, businesses, institutions, and recreational anglers. When the thermometers break outdoors, the mercury is difficult to capture. Mercury free thermometers such as digital thermometers are as accurate as mercury thermometers for most applications.[8]

3.1.5 Gauges, Manometers, Barometers, and Vacuum Gauges

Many barometers and vacuum gauges found in machinery contain mercury. Liquid mercury in the gauges responds to air pressure in a precise way that can be read on a calibrated scale. Several mercury-free alternatives are available. Some operate on the same principle as mercury gauges but use mercury-free liquids in the tube.[8]

Needle or bourdon gauges operate under a vacuum with a needle indicator. Electronic gauges can be used to measure pressure, but they must be calibrated with a mercury manometer. Equipment manufacturers recommend that service technicians use a needle or digital gauge to test the systems they are servicing, but that they calibrate the gauges they use in the field with a mercury manometer kept at their shop.[8]

3.2 POINT SOURCE ASSESSMENT

The point sources within the Yocona River watershed are listed in Table 5. Point sources that are possible contributors of mercury or that have flows greater than 0.05 MGD will be recommended by this TMDL to monitor their wastewater effluent for mercury. These possible contributors include wastewater treatment plants and concrete/cement facilities.

In an attempt to control mercury levels in the waterbody, this Phase One TMDL will call for a moratorium on any future increase in mercury discharges into the Yocona River Watershed.

Table 5. Permitted Facilities in Yocona River Watershed

NPDES ID	Facility Name	County	Receiving Water	Permitted Flow (MGD)
MS0022837	Brittany Woods Subdivision	Lafayette	Four Mile Branch	0.0700
MS0051837	Forest Ridge Estates	Lafayette	Yellow Leaf Creek	0.0152
MS0029831	Lafayette County High School	Lafayette	Burney Branch	0.0225
MS0043079	Lafayette County Industrial Park	Lafayette	Barry Branch	0.3000
MS0021873	University of Mississippi	Lafayette	Burney Branch	0.9500

Table 5 Continued. Permitted Facilities in Yocona River Watershed

NPDES ID	Facility Name	County	Receiving Water	Permitted Flow (MGD)
MS0029017	Oxford POTW	Lafayette	Yocona River	3.5000
MS0031585	Rolling Woods Subdivision	Lafayette	Four Mile Branch	0.0400
MS0054283	Sparrow's Nest Daycare	Lafayette	Fox Creek	0.0006
MS0048186	Timber Lake Estates Subdivision	Lafayette	Yellow Leaf Creek	0.0400
MS0044890	Carter's Grocery and Laundromat	Lafayette	Tributary of Jones Creek	0.0005
MS0055450	Taylor Grocery	Lafayette	Tributary of Taylor Creek	0.0010
MS0040703	U.S. Army Corps of Engineers Chickasaw Hill Recreation Area	Panola	Enid Reservoir	0.0070
MS0029050	George P. Cossar State Park	Yalobusha	Enid Reservoir	0.0200
MS0045641	Holley Automotive	Yalobusha	Otoucalofa Creek	0.2880
MS0041751	Persimmon Hill Campground	Yalobusha	Yocona River	0.0200
MS0021059	U.S. Army Corps of Engineers Riverview Recreation Area	Yalobusha	Yocona River	0.0120
MS0040690	U.S. Army Corps of Engineers Wallace Creek Recreation Area	Yalobusha	Enid Reservoir	0.0200
MS0022331	Water Valley POTW	Yalobusha	Otoucalofa Creek	1.4000
MS0042021	U.S. Army Corps of Engineers Water Valley Recreation Area	Yalobusha	Enid Reservoir	0.0008

4.0 MODELING PROCEDURE

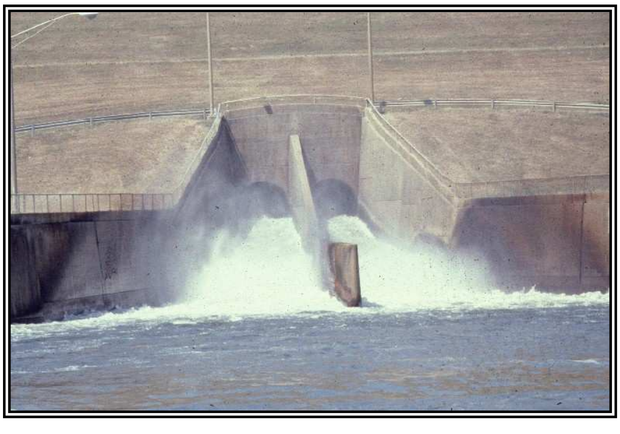
Establishing the relationship between the instream water quality target and the source loadings is a critical component of TMDL development. It allows for the evaluation of alternatives for possible wasteload reductions. The link for mercury in the water column and mercury in fish flesh has not been 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 Yocona 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 Yocona River and Enid Reservoir.

4.2 CALCULATION SETUP

The Yocona River Watershed contains most of HUC 08030203 (See Figure 2). Numerous waterbodies drain into the Enid Reservoir which discharges into the Yocona River. As discussed in Section 2.1.4, the minimum discharge at any time from the reservoir is 50 cfs. Therefore, Yocona River downstream of the reservoir should have a minimum flow of 50 cfs. As a conservative assumption, this minimum flow is the flow used to calculate this TMDL. Since the Yocona River is the most downstream impaired waterbody in this watershed, the TMDL was established for this segment. All upstream tributaries and point source loads are included in this total.



4.3 SOURCE REPRESENTATION

Only point sources are considered in this Phase One Mercury TMDL. Table 6 lists the larger facilities that are recommended for mercury monitoring in the Yocona River Watershed.

Table 6. Facilities in the Yocona River Watershed Recommended for Mercury Monitoring

Facility Name	NPDES ID
Brittany Woods Subdivision	MS0022837
Lafayette County High School	MS0029831
Lafayette County Industrial Park	MS0043079
University of Mississippi	MS0021873
Oxford POTW	MS0029017
Holley Automotive	MS0045641
Water Valley POTW	MS0022331

A significant amount of mercury water quality sampling data from the Yocona River and Enid Reservoir 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:

$$\text{Concentration} = \text{Load} / \text{Flow}$$

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

$$\text{Load} = \text{Concentration} * \text{Flow}$$

$$\text{Load gm/day} = 0.012\ \mu g/l * 50\ cfs * 2.45\ (\text{unit conversion factor}) = 1.47\ gm/day$$

The overall TMDL load for total mercury in the waterbody system is 1.47 grams per day. The total mercury II target of 0.012 μg/l is expressed as Total Recoverable Mercury.

Table 7. TMDL for Total Mercury II

Segment ID	Flow (cfs)	Total Hg(II) Target (μg/l)	TMDL (gm/day)
MSYOCRM	50	0.012	1.47

Once the total TMDL has been calculated, the components of the equation can then be allocated.

5.2 TMDL ALLOCATIONS

The allocation for this TMDL involves a wasteload allocation for point sources and a load allocation for nonpoint sources necessary for attainment of water quality standards in Enid Reservoir and the portion of Yocona River that is impaired by mercury. The Wasteload Allocation (WLA) for this TMDL was determined by multiplying the permitted flow of the dischargers within the Yocona River Watershed by the mercury criterion. Since this TMDL calls for a moratorium on any future increase in mercury discharges into the Yocona River Watershed, the WLA component should not increase. The Load Allocation (LA) accounts for atmospheric deposition and background.

5.2.1 Wasteload 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. Table 8 shows the list of permitted facilities within the Yocona River Watershed. Each facility's flow is multiplied by the mercury criterion and a conversion factor to give a daily load.

Table 8. Daily Load from Permitted Facilities in the Yocona River Watershed

NPDES ID	Facility Name	Permitted Flow (MGD)	Mercury Criterion (µg/l)	Conversion Factor	Daily Load (g/day x 10^{-3})
MS0022837	Brittany Woods Subdivision	0.0700	0.012	3.79	3.18
MS0051837	Forest Ridge Estates	0.0152	0.012	3.79	0.69
MS0029831	Lafayette County High School	0.0225	0.012	3.79	1.02
MS0043079	Lafayette County Industrial Park	0.3000	0.012	3.79	13.64
MS0021873	University of Mississippi	0.9500	0.012	3.79	43.21
MS0029017	Oxford POTW	3.5000	0.012	3.79	159.18
MS0031585	Rolling Woods Subdivision	0.0400	0.012	3.79	1.82
MS0054283	Sparrow's Nest Daycare	0.0006	0.012	3.79	0.03
MS0048186	Timber Lake Estates Subdivision	0.0400	0.012	3.79	1.82
MS0044890	Carter's Grocery and Laundromat	0.0005	0.012	3.79	0.02
MS0055450	Taylor Grocery	0.0010	0.012	3.79	0.05
MS0040703	U.S. Army Corps of Engineers Chickasaw Hill Recreation Area	0.0070	0.012	3.79	0.32
MS0029050	George P. Cossar State Park	0.0200	0.012	3.79	0.91

Table 8 Continued. Daily Load from Permitted Facilities in the Yocona River Watershed

NPDES ID	Facility Name	Permitted Flow (MGD)	Mercury Criterion (μg/l)	Conversion Factor	Daily Load (g/day x 10^{-3})
MS0045641	Holley Automotive	0.2880	0.012	3.79	13.10
MS0041751	Persimmon Hill Campground	0.0200	0.012	3.79	0.91
MS0021059	U.S. Army Corps of Engineers Riverview Recreation Area	0.0120	0.012	3.79	0.55
MS0040690	U.S. Army Corps of Engineers Wallace Creek Recreation Area	0.0200	0.012	3.79	0.91
MS0022331	Water Valley POTW	1.4000	0.012	3.79	63.67
MS0042021	U.S. Army Corps of Engineers Water Valley Recreation Area	0.0008	0.012	3.79	0.04
				ΣWLAs	**305.07**

This TMDL recommends that possible contributors of mercury or flows greater than 0.05 MGD monitor wastewater effluent for mercury.

Table 9. Facilities Recommended to Perform Mercury Effluent Monitoring

Facility Name	NPDES ID	Max Allowable Concentration (μg/l)	Max Allowable Load (g/day x 10^{-3})
Brittany Woods Subdivision	MS0022837	0.012	3.18
Lafayette County High School	MS0029831	0.012	1.02
Lafayette County Industrial Park	MS0043079	0.012	13.64
University of Mississippi	MS0021873	0.012	43.21
Oxford POTW	MS0029017	0.012	159.18
Holley Automotive	MS0045641	0.012	13.10
Water Valley POTW	MS0022331	0.012	63.67

5.2.2 Load Allocations

The Load Allocations (LA) for this TMDL account for mercury due to atmospheric deposition and background. Since atmospheric deposition is believed to be the primary source of mercury, a large portion of the TMDL has been set aside for this component. Phase Two of this TMDL project will explore atmospheric deposition along with local and national air-emission reduction goals.

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 50%.

As discussed in Section 2.1, we believe the mercury aquatic life fresh water criterion of 0.012 µg/l is protective 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 conservative assumption.

Additional conservative assumptions for TMDL calculation are 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 Enid Reservoir and the Yocona River show elevated mercury levels in largemouth bass, spotted bass, and flathead catfish. 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 conservative assumption 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 conservative assumption 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 50%.

TMDL = WLA + LA + MOS

1.47 gm/day = 0.305 gm/day WLA + 0.430 gm/day LA + 0.735 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]

MDEQ also supports and encourages Pollution Prevention activities (P2 activities) as part of this implementation plan. P2 activities help alleviate costs and resources associated with controlling, removing, and managing mercury contamination in the environment. These activities include: (1) separating mercury-containing waste from the trash and save it for local household hazardous waste collection days, (2) taking mercury-containing items such as thermometers to a household hazardous waste collection facility, (3) removing mercury-containing items from households and schools (including student laboratories), and (4) conserving electricity (burning less coal and oil, which naturally contains mercury, for electricity will emit less mercury into the environment). Table 11 gives some examples of possible P2 alternatives for products containing mercury.

Table 10. Pollution Prevention (P2) Alternatives for Products Containing Mercury

Discards Known to Contain Mercury	P2 Alternatives
Thermometers	Red Bulb (Alcohol) Thermometers Digital Thermometers
Thermostats (non-electric models)	Electric Models
Batteries (old alkaline type prior to 1996)	Recharge Alkaline Batteries Mercury Free Batteries
Button Batteries	Mercury Free Button Batteries (Zinc air type)
Silver Amalgam Waste	Ask Your Dentist
Quicksilver Maze Toy	Mercury-Free Toys
Old Latex Paints (since 1990, mercury has been banned in latex paints)	New Latex Paint
Some Shoes that Light Up (L.A. Gear's My Lil' Lights if bought before June 1994)	Mercury-Free Shoes
Switches (some light and appliance switches)	Mechanical or Electrical Switches
Contact Lens Solution Containing Thimerosol	Mercury-Free Solution
Lights (fluorescent, high intensity discharge, and mercury vapor lamps)	Energy Efficient Fluorescent Lights (These lights still contain mercury. However, energy will be conserved thereby reducing mercury emissions from coal and oil combustion)

6.0 CONCLUSION

MDEQ will not approve any NPDES Permit application for the Enid Reservoir and Yocona River drainage area that does not comply with the moratorium for additional mercury discharges into these segments. In addition, this TMDL recommends all dischargers that are possible contributors of mercury or that have flows greater than 0.05 MGD to monitor for mercury using clean techniques and accurate testing methods. This TMDL also recommends and encourages Pollution Prevention Alternatives/Activities that address possible sources of mercury within the Yocona River Watershed.

Phase Two of this TMDL will include nonpoint sources of mercury, atmospheric deposition, and will consider the effects of mercury cycling in the waterbody. 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 Yazoo Basin, Enid Reservoir and the Yocona 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 both a statewide and local newspaper. The public will be given an opportunity to review the TMDL and submit comments. MDEQ also distributes all TMDLs at the beginning of the public notice to those members of the public who have requested to be included on a TMDL mailing list. TMDL mailing list members may request to receive the TMDL reports through either, email or the postal service. Anyone wishing to become a member of the TMDL mailing list should contact Linda Burrell at (601) 961-5062 or Linda_Burrell@deq.state.ms.us.

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.

Pollution Prevention (P2) Activities: Any action that avoids, eliminates, or greatly reduces the generation, amount, and toxicity of waste at the source.

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 (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:

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

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
P2	Pollution Prevention
PCS	Permit Compliance System
PPB	Part per Billion (1×10^{-9}) (μg/l)
PPM	Part per Million (1×10^{-6}) (mg/l)
PPT	Part per Trillion (1×10^{-12}) (ng/l)
RF3	Reach File Three
USGS	United States Geological Survey
WLA	Waste Load Allocation

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APPENDIX A

Fish Flesh Mercury Data in Enid Reservoir and Yocona River (below Enid Reservoir)

County	Site	Hg (ppm)		Species	# Fish	Min. Wt.	Max. Wt.	Mean Wt.
Yalobusha	Enid Reservoir	0.28		Channel Catfish	4	1.3	2.7	1.7
Yalobusha	Enid Reservoir	1.00	**	Largemouth Bass	5	2.5	5.4	3.3
Yalobusha	Enid Reservoir	0.41		Largemouth Bass	5	1.3	1.9	1.6
Yalobusha	Enid Reservoir	0.37		Channel Catfish	4	1.5	2.4	1.9
Yalobusha	Enid Reservoir	1.29	**	Largemouth Bass	3	4.5	4.8	4.7
Yalobusha	Enid Reservoir	1.09	**	Largemouth Bass	5	3.9	4.3	4.1
Yalobusha	Enid Reservoir	0.97		Largemouth Bass	3	2.6	3.3	3.0
Yalobusha	Enid Reservoir	1.26	**	Largemouth Bass	1	4.4	4.4	4.4
Yalobusha	Enid Reservoir	1.18	**	Largemouth Bass	1	3.9	3.9	3.9
Yalobusha	Enid Reservoir	1.25	**	Largemouth Bass	1	4.6	4.6	4.6
Yalobusha	Enid Reservoir	1.34	**	Largemouth Bass	1	4.2	4.2	4.2
Yalobusha	Enid Reservoir	0.74		Largemouth Bass	1	3.4	3.4	3.4
Yalobusha	Enid Reservoir	1.08	**	Largemouth Bass	1	3.7	3.7	3.7
Yalobusha	Enid Reservoir	1.26	**	Largemouth Bass	1	3.3	3.3	3.3
Yalobusha	Enid Reservoir	0.80		Largemouth Bass	1	2.8	2.8	2.8
Yalobusha	Enid Reservoir	2.26	**	Largemouth Bass	1	2.2	2.2	2.2
Yalobusha	Enid Reservoir	0.88		Largemouth Bass	1	2.6	2.6	2.6
Yalobusha	Enid Reservoir	1.43	**	Largemouth Bass	1	2.1	2.1	2.1
Yalobusha	Enid Reservoir	0.79		Largemouth Bass	1	2.2	2.2	2.2
Yalobusha	Enid Reservoir	1.40	**	Largemouth Bass	1	1.8	1.8	1.8
Yalobusha	Enid Reservoir	0.75		Largemouth Bass	1	1.5	1.5	1.5
Yalobusha	Enid Reservoir	0.54		Largemouth Bass	1	1.7	1.7	1.7
Yalobusha	Enid Reservoir	0.66		Largemouth Bass	1	1.7	1.7	1.7
Yalobusha	Enid Reservoir	0.96		Largemouth Bass	5	1.1	1.2	1.2
Yalobusha	Enid Reservoir	0.52		White Crappie	4	1.0	1.4	1.2
Yalobusha	Enid Reservoir	1.55	**	Largemouth Bass	1	4.5	4.5	4.5
Yalobusha	Enid Reservoir	1.72	**	Largemouth Bass	1	4.0	4.0	4.0
Yalobusha	Enid Reservoir	1.31	**	Largemouth Bass	1	4.2	4.2	4.2
Yalobusha	Enid Reservoir	1.50	**	Largemouth Bass	1	3.2	3.2	3.2
Yalobusha	Enid Reservoir	1.05	**	Largemouth Bass	1	3.2	3.2	3.2
Yalobusha	Enid Reservoir	0.93		Largemouth Bass	1	2.9	2.9	2.9
Yalobusha	Enid Reservoir	0.85		Largemouth Bass	1	2.6	2.6	2.6
Yalobusha	Enid Reservoir	0.62		Largemouth Bass	1	1.9	1.9	1.9
Yalobusha	Enid Reservoir	0.75		Largemouth Bass	1	1.6	1.6	1.6
Yalobusha	Enid Reservoir	0.39		Largemouth Bass	1	1.0	1.0	1.0
Yalobusha	Enid Reservoir	0.80		White Crappie	5	1.9	2.2	2.1
Yalobusha	Enid Reservoir	1.60	**	Largemouth Bass	2	5.2	5.7	5.4
Yalobusha	Enid Reservoir	1.20	**	Largemouth Bass	4	3.2	3.9	3.6
Yalobusha	Enid Reservoir	0.94		Largemouth Bass	4	1.9	2.7	2.3
Yalobusha	Enid Reservoir	0.73		Largemouth Bass	4	1.1	1.5	1.2
*** Above 1.0 (ppm)*								

County	Site	Hg (ppm)		Species	# Fish	Min. Wt.	Max. Wt.	Mean Wt.
Yalobusha	Yocona River	1.26	**	Largemouth Bass	2	3.7	4.5	4.1
Yalobusha	Yocona River	1.10	**	Largemouth Bass	4	2.3	2.9	2.6
Yalobusha	Yocona River	0.70		Crappie sp.	3	1.0	1.3	1.2
Yalobusha	Yocona River	2.05	**	Flathead Catfish	1	17.7	17.7	17.7
Yalobusha	Yocona River	0.85		Flathead Catfish	3	4.5	5.7	4.9
Yalobusha	Yocona River	1.13	**	Largemouth Bass	1	5.7	5.7	5.7
Yalobusha	Yocona River	2.04	**	Largemouth Bass	1	4.6	4.6	4.6
Yalobusha	Yocona River	0.94		Largemouth Bass	1	4.9	4.9	4.9
Yalobusha	Yocona River	1.49	**	Largemouth Bass	1	3.9	3.9	3.9
Yalobusha	Yocona River	0.98		Largemouth Bass	1	3.8	3.8	3.8
Yalobusha	Yocona River	1.08	**	Largemouth Bass	1	2.8	2.8	2.8
Yalobusha	Yocona River	0.51		Largemouth Bass	1	2.3	2.3	2.3
Yalobusha	Yocona River	1.00	**	Largemouth Bass	1	2.2	2.2	2.2
Yalobusha	Yocona River	0.49		Largemouth Bass	1	1.8	1.8	1.8
Yalobusha	Yocona River	0.52		Spotted Bass	1	0.7	0.7	0.7
Yalobusha	Yocona River	0.97		Spotted Bass	1	1.2	1.2	1.2
Yalobusha	Yocona River	0.88		Spotted Bass	1	1.3	1.3	1.3
Yalobusha	Yocona River	1.32	**	Spotted Bass	1	1.5	1.5	1.5
Yalobusha	Yocona River	0.66		Spotted Bass	1	0.6	0.6	0.6
Yalobusha	Yocona River	1.06	**	Largemouth Bass	1	3.6	3.6	3.6
Yalobusha	Yocona River	0.37		Spotted Bass	1	1.0	1.0	1.0
Yalobusha	Yocona River	0.58		Spotted Bass	1	0.9	0.9	0.9
Yalobusha	Yocona River	0.65		Spotted Bass	1	1.1	1.1	1.1
Yalobusha	Yocona River	0.46		Spotted Bass	1	0.8	0.8	0.8
*** Above 1.0 (ppm)*								

APPENDIX B

Fish Advisories for Enid Reservoir and the Yocona River

MISSISSIPPI
STATE DEPARTMENT OF
HEALTH
Health Communications
and Public Relations
2423 North State Street
Post Office Box 1700
Jackson, Mississippi
39215-1700
601/960-7667
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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 Miss...ppi 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.

-30-

mab:5/25/95

1- 8-02; 2:59PM; ;6643938 # 2

MISSISSIPPI STATE DEPARTMENT OF HEALTH

Health Communications and Public Relations

Post Office Box 1700
2423 North State Street
Jackson, Mississippi
39215-1700

601/960-7667
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—Immediate Release—

NEWS NEWS NEWS

Mississippi today added three bodies of water to the state's list of lakes and streams with mercury levels the Food and Drug Administration considers too high for certain people.

The Mississippi State Department of Health recommends that pregnant women, breast-feeding mothers, and children under seven cut down on the amount of certain fish they eat from:

- Archusa Creek Water Park in Clark County,
- the Pascagoula River from its origin near Merrill in George County to U.S. Highway 90 in Jackson County, and
- the Yocona River from Enid Reservoir to the Tallahatchie River.

In May of 1995, Mississippi found elevated levels of mercury in bass and large catfish in the Bogue Chitto River, Yockanookany River, Enid Reservoir, and Escatawpa River from the Alabama state line to the I-10 bridge. Advisories in those areas remain in effect.

-more-

Equal Opportunity In Employment/Services

1- 8-02; 2:59PM; ;6643938 # 3

Mercury -- add 2

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 ...r when we dig for or process natural resources, and in time that mercury falls or washes back into our lakes and streams."

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

Broiled, baked, and grilled fish are a good source of protein, and 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.

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.

-30-

mab:9/30/96

APPENDIX C: Mercury Use Outline

Sources of Mercury

I. Deliberate Use of Mercury

A. Use of Mercury for its Physical and Electrical Properties

1. Instruments
   a. *Barometers*
   b. *Hydrometers*
   c. *Manometers*
   d. *Pyrometers*
   e. *Sphymonometers*
   f. *Thermometers*
2. Lamps
   a. *Fluorescent*
   b. *High Pressure Sodium*
   c. *Mercury Arc*
   d. *Metal Halide*
   e. *Neon*
   f. *UV disinfectant*
3. Pivots
   a. *WWTP Trickling Filter System*
   b. *Lighthouses*
4. Switches
   a. *Household Switches*
   b. *Industrial Switches*
   c. *Mercury Thermocouple*
   d. *Tilt (Motion) Switches*
5. Electrical Equipment
   a. *Rectifiers*
   b. *Batteries {Including alkaline, button (Hg – Zn) and (Hg – Cd)}*
6. Toys and Games

B. Medical, Dental, and Veterinary Use

1. Pharmaceuticals
   a. *Anesthetic*
   b. *Antiseptic*
   c. *Antineoplastic Agent*
   d. *Antisyphilitic*
   e. *Cathartic*
   f. *Diuretic*
   g. *Purgative*
2. Dental Amalgam
3. Disinfectant
   a. *Phenyl Mercuric Acetate (PMA)*
   b. *Thimerisol*
4. Diagnostic Reagents (see laboratory use)

C. Spiritist Use
1. Ingested, Dusted, Added to Bathing Solutions and Candles
    a. *Asogue (Hg)*
    b. *Precipitado Rojo (HgO)*
    c. *Precipitado Amarillo (HgO)*
    d. *Precipitado Blanco* (Hg_2Cl_2)

D. Laboratory Use
1. Slide Preparation
    a. *Stain*
2. Electroanalysis
    a. *Cathode*
3. Algae Sample Preservative
4. Reagents (used to analyze other chemicals)
    a. *Acetic Acid*
    b. *Acetone*
    c. *Aldehyde*
    d. *Ammonia*
    e. *Arsenic*
    f. *Barbital*
    g. *Chloride*
    h. *Chlorine*
    i. *Citric Acid*
    j. *CO in gas*
    k. *Cystine*
    l. *Glucose*
    m. *HCN*
    n. *Iron*
    o. *Kjeldahl Nitrogen*
    p. *Manganese*
    q. *Mercury*
    r. *Triophene*
    s. *Vanadium*
    t. *Wine Coloring*
    u. *Zinc*

E. Mining/Metals Industry
1. Electrolysis
    a. *Cathode*
2. Extracting Au and Ag from Ore
3. Extracting Au from Pb
4. Electroplating Al
5. Other Processes
    a. *Etching Steel/Iron*
    b. *Fire Gilding*
    c. *Blackening Brass*

F. Chlor-Alkali Industry
1. Mercury Cell Process
    a. *Production of Chlorine, Caustic Soda, Sodium Hydroxide and Products Manufactured with These Raw Materials*

G. Fungicide/Pesticide
   1. Seed Protectant
   2. Golf Courses
      a. *Snow Mold Control*
   3. Root Maggot Control
   4. Imported Gray Goods (undyed textiles)
   5. Paint and Glues
      a. *Latex Paint**
      b. *Marine Paint**
      c. *Gold Porcelain Paint*
      d. *Corrugated Cardboard Glue*

H. Preservative
   1. Kyanizing Wood*
   2. Anatomical Specimens
   3. Embalming*
   4. Tanning

I. Coloring
   1. Pigment
      a. *Colored Papers*
      b. *Horn*
      c. *Inks*
      d. *Linen*
      e. *Plastics*
      f. *Rubber*
      g. *Sealing Wax*
   2. Stain for Wood*
   3. Mordant for Dye
      a. *Beaver and Rabbit Pelts*

J. Other Deliberate Uses
   1. Plastics
      a. *Catalyst for Curing*
   2. Fireworks
      a. *Pharoah's Serpents and Bengal Green Lights*
   3. Photography*
      a. *Intensifier*
      b. *Magic Photograms*

II. Production/Storage

A. Mining
   1. Mines with Mercury as the Primary Product
   2. Mines with Secondary Production of Mercury

B. U.S. Federal Supply

C. Recycling
   1. Facilities Include Fluorescent Lamp Recycling and Thermostat Recycling

III. By-Product/Contaminant

A. Combustion
   1. Incineration
      a. *Municipal Solid Waste*
      b. *Medical Waste*
      c. *Sewage Sludge*
      d. *Cremation*
   2. Fuel Combustion
      a. *Coal*
      b. *Oil*
      c. *Natural Gas*
      d. *Wood*

B. Vaporization
   1. Landfill Gas
   2. Petroleum Refining
   3. Wastewater Treatment Plants
   4. Mining
      a. *Smelting*
      b. *Roasting*

C. Product Contaminant
   1. Chloralkali Products

IV. Natural

A. Volcanoes
B. Mineralized Bedrock
   1. Cinnabar

Source: Michigan Mercury Pollution Prevention Task Force. April 1996. *Mercury Pollution Prevention in Michigan: Summary of Current Efforts and Recommendations for Future Activities.*