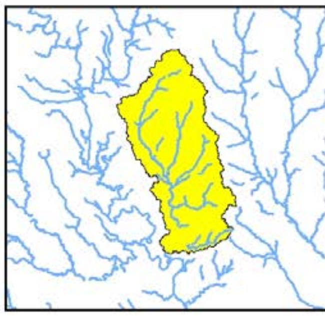
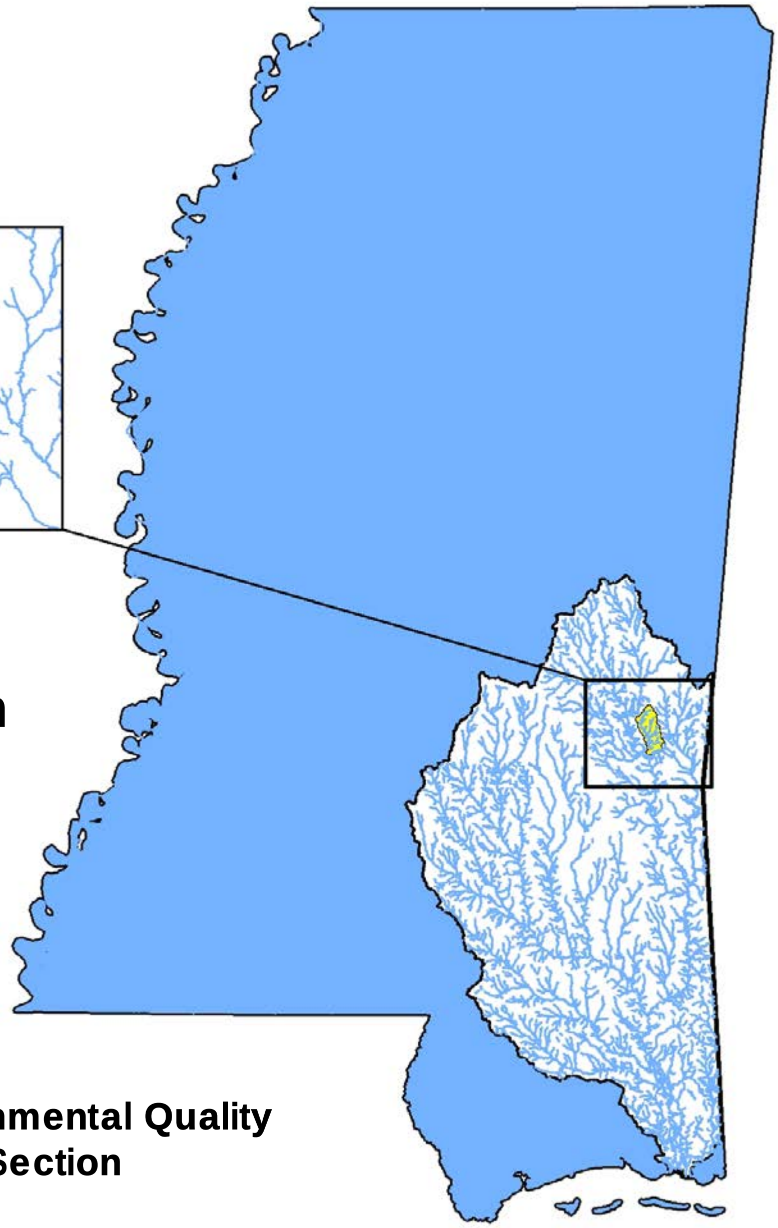
Final
December 2011

Archusa Creek Water Park Total Maximum Daily Load for Mercury

80
Hg
Mercury
200.59





Pascagoula River Basin

Clarke County, Mississippi

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FOREWORD

The report contains one or more Total Maximum Daily Loads (TMDLs) for water body segments found on Mississippi's current Section 303(d) List of Impaired Water Bodies. The implementation of the TMDLs contained herein will be prioritized within Mississippi's rotating basin approach.

As additional information becomes available, the TMDLs may be updated. Such additional information may include water quality and quantity data, changes in pollutant loadings, modifications to the water quality standards or 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

CONTENTS

TMDL INFORMATION PAGE

Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Archusa Creek Water Park	405212	Clarke	3170002	Mercury Fish Consumption	Monitored
Location: at Quitman					

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

NPDES Facilities

NPDES ID	Facility Name	County	Receiving Water	Flow (MGD)
MS0030481	Clarko State Park MSWFP	Clarke	A tributary to Morre Mill Creek	0.01

Total Maximum Daily Load in grams per day

Pollutant	WLA	LA	MOS	TMDL
Mercury	0.0705	0.1645	0.235	0.47

EXECUTIVE SUMMARY

Archusa Creek Water Park is impaired by mercury. Largemouth bass, spotted bass, and flathead catfish caught in these water bodies have been sampled and the data show an impairment due to levels of mercury in the fish flesh, which exceed the action level for human consumption.

Based on these data, the State of Mississippi issued a fish consumption advisory (see Appendix B) for Archusa Creek Water Park. This advisory was issued to help protect the people who regularly consume fish caught in the lake. The bioaccumulation of methylmercury in fish flesh is the basis for the impairment in the water bodies.

Archusa Creek Water Park Google Image

This Mercury TMDL for Archusa Creek Water Park was developed prior to a complete understanding of the linkage between mercury in the water and mercury in the fish. Additionally, this TMDL is only concerned with point source contributions to the water body. Atmospheric deposition, nonpoint source contributions, and natural background will not be considered.

The endpoints selected for this Mercury TMDL are based on MDEQ regulations. There are several mercury criteria to evaluate. The human health criterion is currently .153 μg/l of total mercury. The aquatic life support criteria are 0.012 μg/l fresh water and 0.025 μg/l salt water of total mercury II expressed as total recoverable. Recent EPA criteria guidance suggested that each of these numbers will be revised. The .153 μg/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 μg /l and .940 μg /l, respectively. However, these new numbers have not been adopted by the Mississippi Commission on Environmental Quality. MDEQ is therefore proposing the most protective of the currently adopted criterion, 0.012 μg/l.

By using the 0.012 μg/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 TMDL calls for a moratorium on any mercury discharge in the Archusa Creek Watershed. It also calls for increased monitoring in the Archusa Creek Watershed. This TMDL also recommends pollution prevention alternatives and activities.

1.0 INTRODUCTION

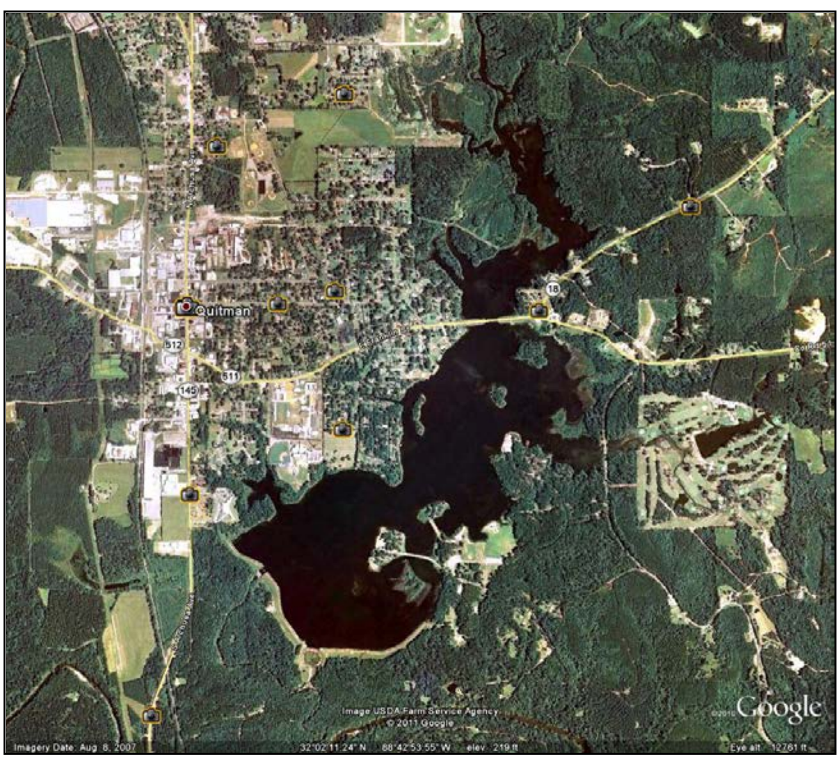
1.1 BACKGROUND

The identification of water bodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those water bodies are required by Section 303(d) of the Clean Water Act. 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 water bodies 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 Archusa Creek Water Park.

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 kidneys. 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 WATER BODY SEGMENT LOCATION

The Archusa Creek Water Park is located in Clarke County. The 450 acre lake is located off of Highway 45 in Quitman.



In an attempt to protect human health, Mississippi issued a Fish Consumption Advisory for Archusa Creek Water Park. This advisory was issued due to elevated levels of mercury found in fish flesh collected in this water body. See Appendix B.

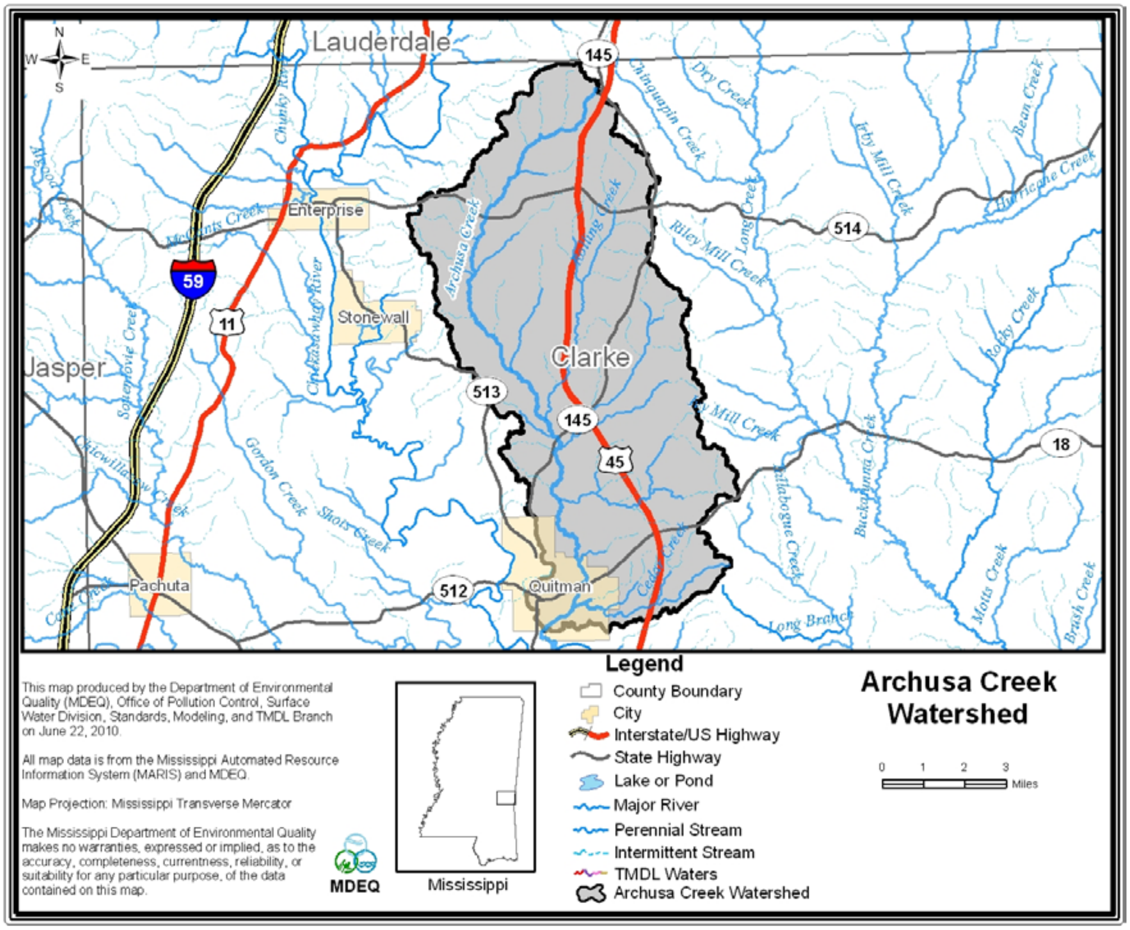


Figure 1. Area Location Map

Table 1. Water body Identification for the Archusa Creek Water Park

Water body Name	Water body ID	Assessment Type	Size	County	Listed Advisory	Advisory Cause
Archusa Creek Water Park	405212	Monitored	450 acres	Clarke	Mercury	Fish Consumption

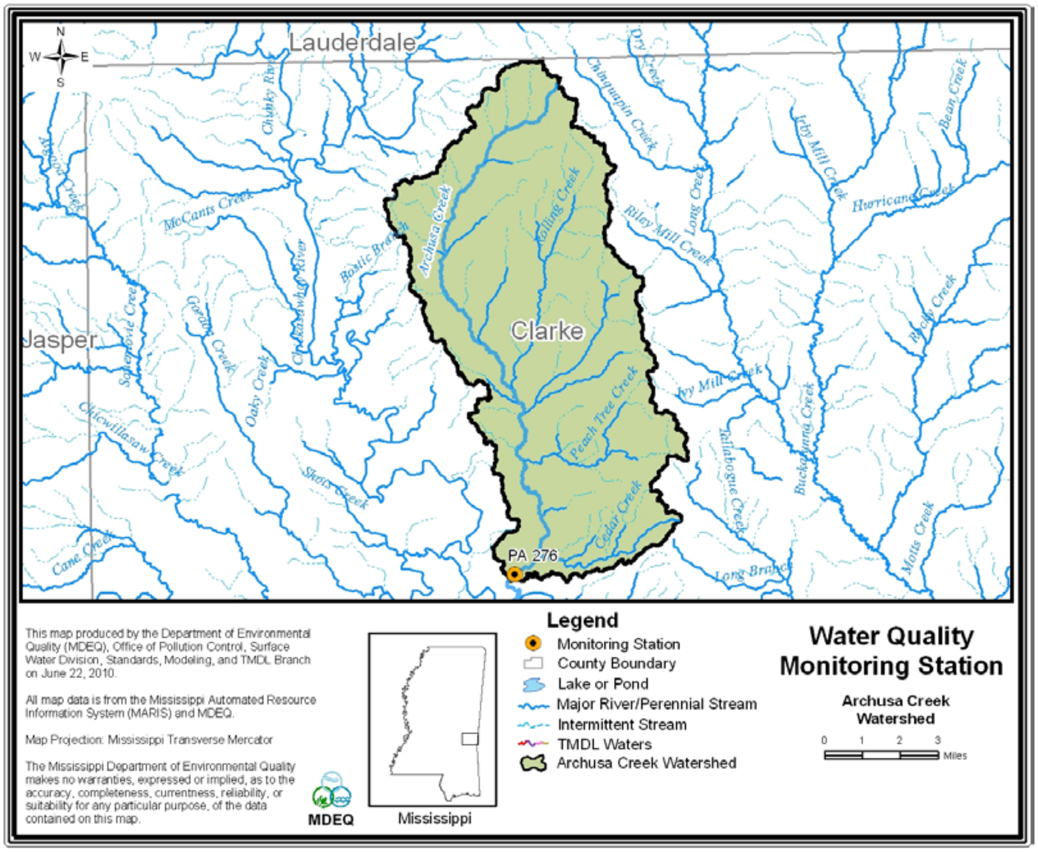


Figure 2. The Archusa Creek Watershed – Water Quality Monitoring Station

1.3 WATER BODY 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 Archusa Creek Water Park have been established based on a designated use of Recreation.

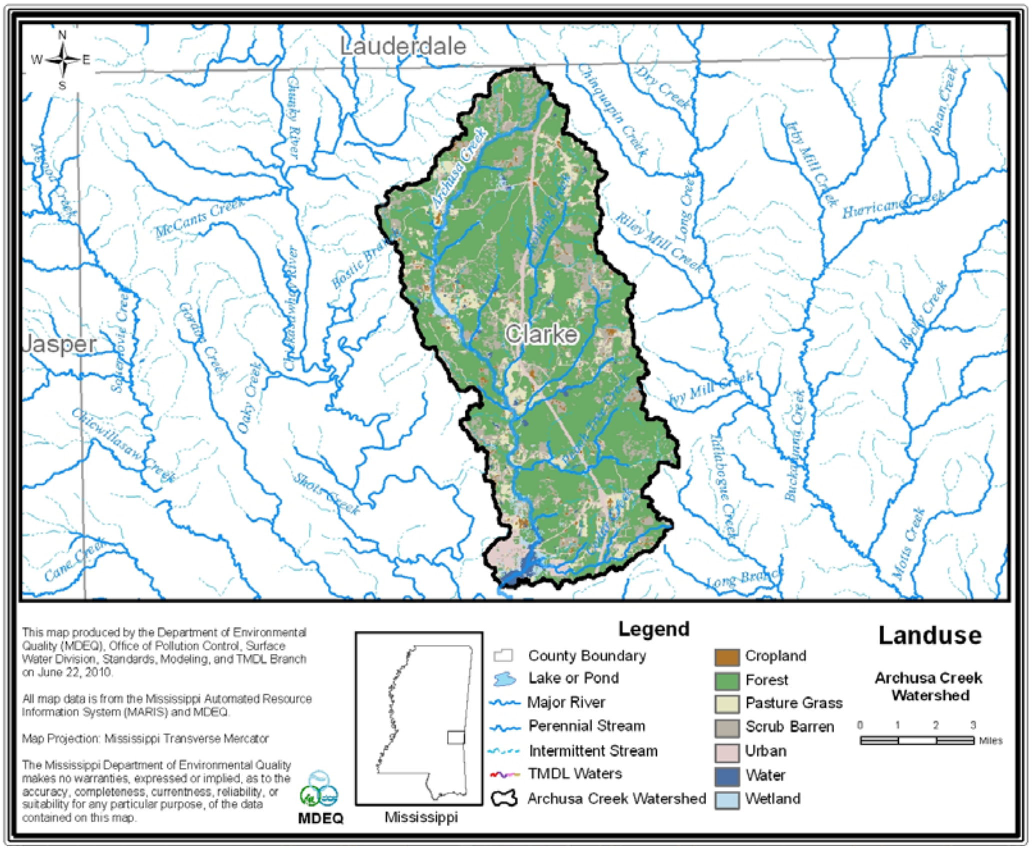


Figure 3. Landuse Distribution within the Archusa creek Watershed

1.4 APPLICABLE WATER QUALITY STANDARDS

Mercury is included within MDEQ regulations as a toxic substance. The standards specifically set the numeric criterion 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 standard. However, until the stakeholders within Mississippi are allowed to partake in the process to change Mississippi water quality 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 water body segments and the pollutant of concern are listed in Table 2 as defined by the current *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* regulations (WPC-2).

Table 2. 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

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."*

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 water bodies. Values ranging from 5 to 50 percent have been reported, and a common value of 25 percent has often been quoted. 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 water body 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 2 applicable to Archusa Creek Water Park 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 this TMDL.[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 is adopted, this TMDL may be revised to reflect those changes.

However, fish flesh sampling data indicate impairment of the water body'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 Archusa Creek 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 #02477200, the 7Q10 flow is estimated to be 16 cfs.

2.2 DISCUSSION OF INSTREAM WATER QUALITY

According to the State's 1998 Section 305(b) Water Quality Assessment Report, Archusa Creek Water Park is partially supporting the use of Fish Consumption. It is listed because a fishing advisory has been in effect since May 1995. This advisory decision was based on fish tissue data collected from Archusa Creek Water Park. Data collected are summarized in the following sections.

2.2.1 Inventory of Water Quality Monitoring Data

Fish tissue samples were collected by MDEQ from Archusa Creek Water Park. These data are provided in Appendix A.

2.2.2 Analysis of Fish Tissue Data

Fish tissue data were analyzed to identify violations requiring fish consumption advisories. Statistical summaries of methylmercury levels in fish tissue (wet weight filets) from Archusa Creek Water Park are presented in Table 4. These summaries are based on available data, which are listed in Appendix A.

A single sampling event could have more than one fish, so the number of samples is 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 Archusa Creek Water Park because fish tissue concentrations exceeded 1.0 ppm. The fish tissue data collected from the Archusa Creek Water Park is listed in Appendix A. The Fish Advisories for this water body is attached in Appendix B.

Table 4. Water Quality Station Data Analysis

Station	Year	Number of Fish	Percent Exceedance*	Min ppm	Max ppm	Average ppm
Archusa Creek Water Park	2006	9	67	0.8	2.5	1.4
Archusa Creek Water Park	2007	10	0	0.2	0.8	0.5
Archusa Creek Water Park	2008	10	20	0.3	1.3	0.7
Archusa Creek Water Park	2009	8	25	0.3	1.5	0.8
Archusa Creek Water Park	2010	10	10	0.4	2.3	0.8

* Percent exceedance is based on individual fish samples that exceeded the action level.

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 Mercury TMDL, only point source contributions are considered for evaluation.

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 source within the Archusa Creek Watershed is 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.

In an attempt to control mercury levels in the water body, this TMDL will call for a moratorium on any future increase in mercury discharges into Archusa Creek Watershed.

Table 5. Permitted Facilities in Archusa creek Watershed

NPDES ID	Facility Name	County	Receiving Water	Permitted Flow (MGD)
MS0030481	Clarko State Park MSWFP	Clarke	A tributary to Moore Mill Creek	0.01

4.0 MODELING PROCEDURE & ALLOCATION

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.

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 water body by point source discharge based on Mississippi's fresh water mercury criterion.

4.1 MODELING CALCULATIONS

Mass balance equations have been used to determine the mercury TMDLs in the Archusa Creek Watershed. A more complicated model is not warranted for 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; and (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 Archusa Creek Water Park.

4.2 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:

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

$$\text{Load gm/day} = 0.012\ \mu g/l * 16\ \text{cfs} * 2.45\ (\text{unit conversion factor}) = 0.47\ \text{gm/day}$$

The overall TMDL load for total mercury in the water body system is 0.47 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

Segment ID	7Q10 Flow (cfs)	Total Hg(II) Target (μg/l)	TMDL (gm/day)
405212	16	0.012	0.47

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

4.3 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 Archusa Creek Water Park that is impaired by mercury. The Wasteload Allocation (WLA) for this TMDL was estimating by 30% the available TMDL load minus the margin of safety. Since this TMDL calls for a moratorium on any future increase in mercury discharges into the Archusa creek Watershed, the WLA component should not increase. The Load Allocation (LA) accounts for atmospheric deposition and background.

4.3.1 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 larger portion (70%) of the available TMDL has been set aside for this component.

4.4 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 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 Archusa Creek Water Park 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.

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%.

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}$$

$$0.47 \text{ gm/day} = 0.0705 \text{ gm/day WLA} + 0.1645 \text{ gm/day LA} + 0.235 \text{ gm/day MOS}$$

4.5 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]

4.6 IMPLEMENTATION PLAN

Implementation of this 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 TMDL projects.

Long-term monitoring of wet deposition rates and fish tissue in each of the water body 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, and (3) removing mercury-containing items from households and schools (including student laboratories). Table 10 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)

5.0 CONCLUSION

MDEQ will not approve any NPDES Permit application for Archusa Creek Watershed that does not comply with the moratorium for additional mercury discharges into this water body. 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 Archusa Creek Watershed.

5.1 FOLLOW-UP MONITORING

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.

5.2 PUBLIC PARTICIPATION

This 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.

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.

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APPENDIX A

Fish Flesh Mercury Data in Archusa Creek Water Park

Date	Genus	Species	Hg (ppm)	Weight (gm)	Length (mm)
10/4/2006	*Pomoxis*	*annularis*	0.9	441	324
10/4/2006	*Micropterus*	*salmoides*	0.8	323	285
10/4/2006	*Micropterus*	*salmoides*	0.8	344	282
10/4/2006	*Micropterus*	*salmoides*	1.01	565	339
10/4/2006	*Micropterus*	*salmoides*	1.1	700	384
10/4/2006	*Micropterus*	*salmoides*	1.6	688	350
10/4/2006	*Micropterus*	*salmoides*	1.9	820	384
10/4/2006	*Micropterus*	*salmoides*	2.1	1261	468
10/4/2006	*Micropterus*	*salmoides*	2.5	2226	527
9/4/2007	*Micropterus*	*salmoides*	0.19	201	231
9/4/2007	*Micropterus*	*salmoides*	0.34	197	250
9/4/2007	*Micropterus*	*salmoides*	0.44	240	263
9/4/2007	*Micropterus*	*salmoides*	0.39	257	264
9/4/2007	*Micropterus*	*salmoides*	0.6	274	265
9/4/2007	*Micropterus*	*salmoides*	0.78	436	329
9/4/2007	*Micropterus*	*salmoides*	0.38	582	334
9/4/2007	*Micropterus*	*salmoides*	0.79	757	365
9/4/2007	*Micropterus*	*salmoides*	0.63	1136	422
9/4/2007	*Micropterus*	*salmoides*	0.7	758	410
11/19/2008	*Micropterus*	*salmoides*	1.12	1340	444
11/19/2008	*Micropterus*	*salmoides*	1.3	1511	464
11/19/2008	*Micropterus*	*salmoides*	0.76	637	342
11/19/2008	*Micropterus*	*salmoides*	0.38	485	324
11/19/2008	*Micropterus*	*salmoides*	0.85	426	307
11/19/2008	*Micropterus*	*salmoides*	0.43	311	284
11/19/2008	*Micropterus*	*salmoides*	0.54	397	286
11/19/2008	*Micropterus*	*salmoides*	0.68	336	296
11/19/2008	*Micropterus*	*salmoides*	0.56	319	287
11/19/2008	*Micropterus*	*salmoides*	0.28	233	246
4/16/2009	*Micropterus*	*salmoides*	0.78	1040	417
4/16/2009	*Micropterus*	*salmoides*	0.73	883	400
4/16/2009	*Micropterus*	*salmoides*	1.04	1121	411
4/16/2009	*Micropterus*	*salmoides*	0.69	492	328
4/16/2009	*Micropterus*	*salmoides*	0.67	353	293
4/16/2009	*Micropterus*	*salmoides*	0.73	388	318
4/16/2009	*Micropterus*	*salmoides*	0.3	228	260
4/16/2009	*Micropterus*	*salmoides*	1.46	206	251
12/10/2010	*Micropterus*	*salmoides*	2.29	2460	538
12/10/2010	*Micropterus*	*salmoides*	0.75	1420	474
12/10/2010	*Micropterus*	*salmoides*	0.67	1160	431
12/10/2010	*Micropterus*	*salmoides*	0.5	1160	404
12/10/2010	*Micropterus*	*salmoides*	0.66	1000	414

12/10/2010	*Micropterus*	*salmoides*	0.84	860	420
12/10/2010	*Micropterus*	*salmoides*	0.79	720	389
12/10/2010	*Micropterus*	*salmoides*	0.54	540	340
12/10/2010	*Micropterus*	*salmoides*	0.43	540	349
12/10/2010	*Micropterus*	*salmoides*	0.53	460	339

APPENDIX B

Mississippi's Fish Tissue Advisories And Commercial Fishing Bans August 2001			
WATERBODY	**CHEMICAL**	**DATE ISSUED**	**ACTION**
Little Conehoma Creek and Yockanookany River in Attala and Leake Counties. From Hwy 35 near Kosciusko, downstream to Hwy 429 near Thomastown	PCB's	June 1987	Consumption Advisory All Species Commercial Fishing Ban
Lake Susie, Oxbow Lake of Old Tallahatchie River in Panola County west of Batesville.	PCB's	Nov. 1989	Same as above
Escatawpa River from the Alabama state line to I-10.	Mercury	May 1995	Limit Consumption Advisory for largemouth bass and large catfish (>27 in.)*
Bogue Chitto River, entire length in Mississippi.	Mercury	May 1995	Same as above
Yockanookany River, entire length.	Mercury	May 1995	Same as above
Pearl River from Hwy 25 near Carthage, downstream to the Leake County Water Park.	Mercury	June 2001	Same as above
Enid Reservoir	Mercury	May 1995	Same as above
Yocona River from Enid Reservoir downstream to the confluence with the Tallahatchie River.	Mercury	Sept. 1996	Same as above
Pascagoula River, entire length.	Mercury	Sept. 1996	Same as above
Archusa Creek Water Park	Mercury	Sept. 1996	Same as above
Grenada Lake and Yalobusha River from the dam downstream to Holcomb.	Mercury	June 2001	Same as above
Pearl River from Hwy 25 near Carthage,	Mercury	June 2001	Same as above

downstream to the Leake County Water Park.			
Mississppi Delta - all waters from the mainline Mississippi River Levee on the West to the Bluff hills on the East.	DDT, Toxaphene	June 2001	Limit Consumption Advisory for carp, buffalo, gar, and large catfish (>22 in.)****
Roebuck Lake, LeFlore County	DDT, Toxaphene	June 2001	Limit Consumption Advisory for carp, gar, and large catfish (>22 in.)**** No Consumption of Buffalo. Commercial Fishing Ban
Yazoo National Wildlife Refuge (all waters)	DDT, Toxaphene	1975	Closed to fishing**
Gulf of Mexico	Mercury	May 1998	King Mackerel <33" - no limit. 33-39" limit consumption.*** >39" - do not eat

***** The Mississippi State Health Department recommends that people limit the amount of bass and large catfish that they eat from these areas, because of high levels of mercury in the fish. Children under seven and women of child bearing age should eat no more than one meal of these fish every two months. Other adults should eat no more than one meal of these fish every two weeks.

****** Precautionary advisory issued by U.S. Fish and Wildlife Service

******* The Mississippi State Health Department recommends that people limit the amount of 33-39" King Mackerel they eat from the Mississippi Gulf Coast. Children under seven and women of child bearing age should eat no more than one meal of these fish every two months. Other adults should eat no more than one meal of these fish every two weeks.

******** The Mississippi Department of Health recommends that people limit their consumption of these fish to no more than one meal every two weeks.

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.