PROPOSED REPORT
January 2004

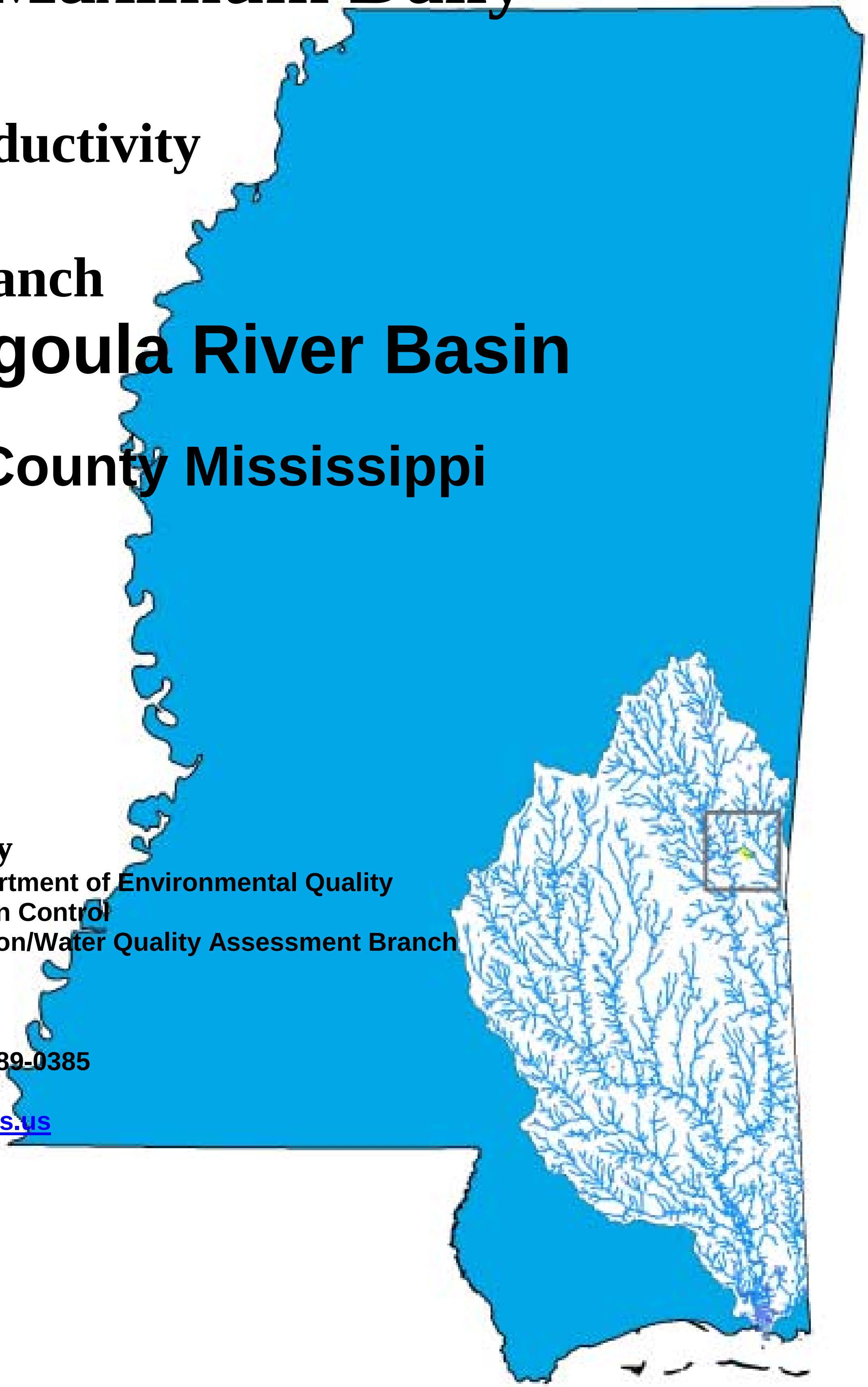
Total Maximum Daily Load

For Conductivity

Long Branch

Pascagoula River Basin

Clarke County Mississippi



Prepared By

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

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

Prefixes for fractions and multiples of SI units

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

Conversion Factors

To convert from	To	Multiply by	To Convert from	To	Multiply by
Acres	Sq. miles	0.00156	Days	Seconds	86400
Cubic feet	Cu. Meter	0.02832	Feet	Meters	0.3048
Cubic feet	Gallons	7.4805	Gallons	Cu feet	0.1337
Cubic feet	Liters	28.317	Hectares	Acres	2.4710
cfs	Gal/min	448.83	Miles	Meters	1609.3
cfs	MGD	.6463	mg/l	ppm	1
Cubic meters	Gallons	264.17	μg/l * cfs	Gm/day	2.45

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TMDL INFORMATION PAGE

i. Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Long Branch	MS068LE	Clarke	03170002	Salinity / TDS / Chlorides	Evaluated
Location: Near Linton from headwaters to confluence with Tallabogue Creek					

ii. Water Quality Standard

Parameter	Beneficial use	Water Quality Criteria
Conductivity	Fish and Wildlife	There shall be no substances added to increase the conductivity above 1000 micromhos/cm for freshwater streams

iii. NPDES Facilities

NPDES ID	Facility Name	Permitted Discharge (MGD)	Receiving Water
None			

iv. Phase 1 Total Maximum Daily Load for Conductivity Equivalents

LA (eq-lb/day)	WLA (eq-lb/day)	MOS	TMDL (eq-lb/day)
.35	**3.14**	**implicit**	**3.49**

EXECUTIVE SUMMARY

Long Branch was included in the Mississippi 1998 Section 303(d) List of Water Bodies as an evaluated water body segment, due to Salinity / Total Dissolved Solids (TDS) / Chlorides. This listing was based on survey information collected in 1988 that indicated possible impairment in the watershed. The applicable state standard specifies that there shall be no substances added to increase the conductivity above 1000 micromhos/cm for freshwater streams. The pollutant listing of Salinity / TDS / Chlorides shown in the 1998 list was generated due to the available options in EPA's old waterbody database. Conductivity impairments were shown as "Salinity / TDS / Chlorides" in the database. Multiplying the conductivity by a conversion factor and correcting for temperature derives salinity and TDS. Therefore, it is appropriate to develop this TMDL for conductivity.

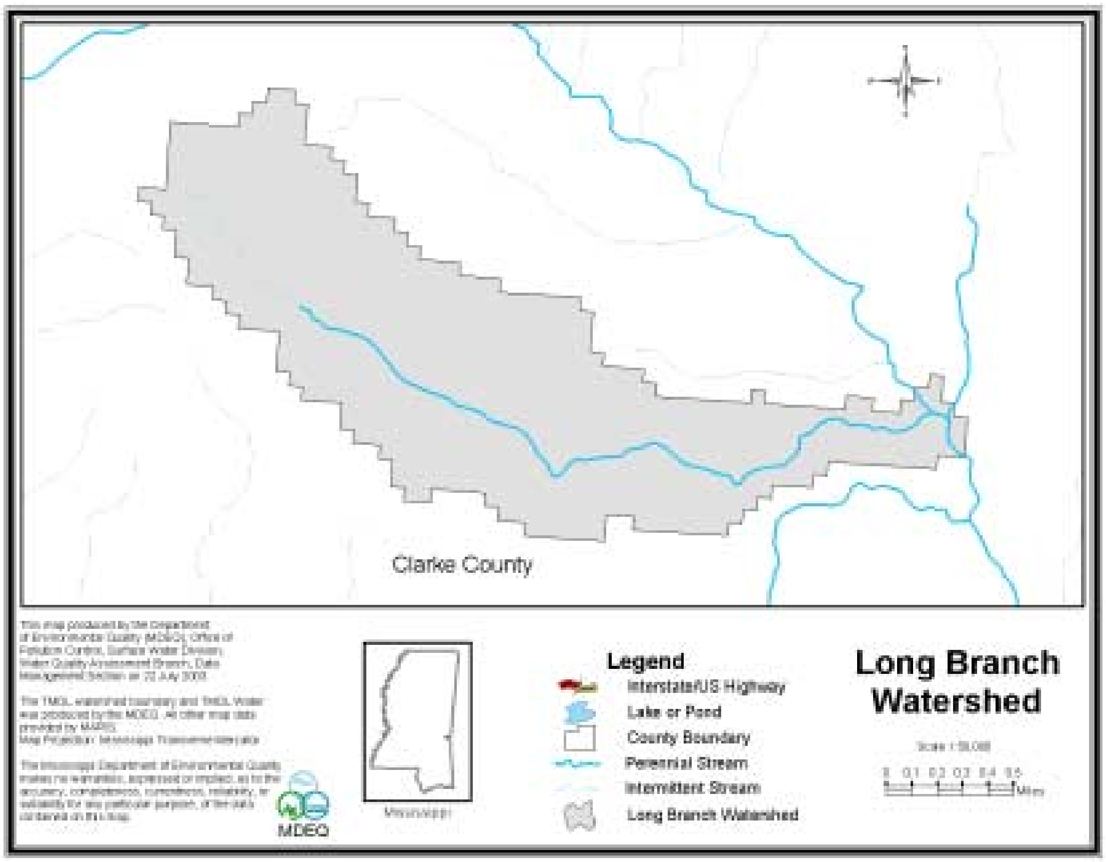


Figure 1. Long Branch Watershed

The Long Branch watershed is located in the eastern portion of the United States Geologic Survey (USGS) Hydrologic Unit Code (HUC) 03170002. The headwaters of Long Branch begin east of Quitman near Highway 511 and Linton Road and flow east to the confluence with Tallabogue Creek near Linton, Mississippi. There are no communities in the watershed. The watershed has the remnants of the early oil and gas production wells and brine pits. These old wellheads, pipes, and brine pits may produce excessive conductivity in this stream. There are no NPDES Permitted discharges located in the watershed.

A mass-balance approach was used to develop this TMDL. Measurements of flow in Long Branch are not available. Because of this, a flow coefficient was developed for this watershed based on flow data from the nearby Buckatunna Creek watershed. The flow coefficient was then applied to the Long Branch watershed to estimate the flow for this watershed.

INTRODUCTION

1.1 Background

The identification of water bodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those water bodies are required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130). The TMDL process is designed to restore and maintain the quality of those impaired water bodies through the establishment of pollutant specific allowable loads. The impairment is caused by elevated conductivity in the creek due to historic oil field development. Thus, this TMDL has been developed for conductivity for the 303(d) listed segment shown in Figure 2.

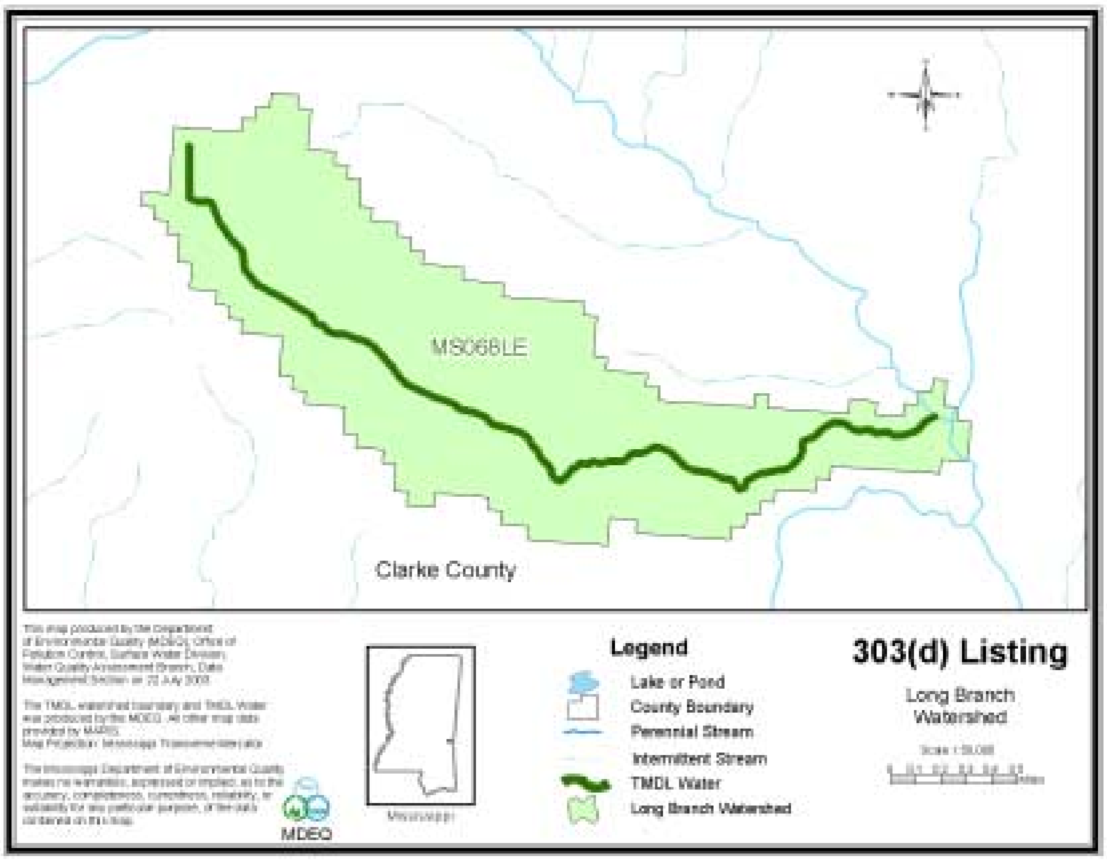


Figure 2. Long Branch Watershed 303(d) Listed Segments

1.2 Discussion of Conductivity and Salinity

Conductivity *k* is a measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions; on their total concentration, mobility, and valence; and on the temperature of measurement. Solutions of most inorganic compounds are relatively good conductors. Conversely, molecules of organic compounds that do not dissociate in aqueous solution conduct a current very poorly, if at all.

Conductance *G* is defined as the reciprocal of resistance, *R*:

$$G = 1/R$$

where the unit of *R* is ohm and *G* is ohm^{-1} (sometimes written mho). Conductance of a solution is measured between two spatially fixed and chemically inert electrodes. To avoid polarization at the electrode surfaces, the conductance measurement is made with an alternating current signal. The conductance of a solution, *G* is directly proportional to the electrode surface area, *A*, cm^2, and inversely proportional to the distance between the electrodes, *L*, cm. The constant of proportionality, *k* such that:

$$G = k\left(\frac{A}{L}\right)$$

is called "conductivity" (preferred to "specific conductance"). It is a characteristic property of the solution between the electrodes. The units of *k* are 1/ohm-cm or mho per centimeter. Conductivity is customarily reported in micromhos per centimeter (μmho/cm).

To compare conductivities, values of *k* are reported relative to electrodes with *A*=1 cm^2 and *L*=1 cm. The equivalent conductivity, Λ, of a solution is the conductivity per unit of concentration. As the concentration is decreased toward zero, Λ approaches a constant, designated as Λ°. With k in units of micromhos per centimeter it is necessary to convert concentration to units of equivalents per cubic centimeter; therefore

$$\Lambda = 0.001k / concentration$$

where the units of Λ, *k*, and concentration are mho-cm^2/equivalent, μmho/cm, and equivalent/L, respectively. (Standard Methods, 20th Edition 2-44)

Salinity is an important unitless property of industrial and natural waters. It was originally conceived as a measure of the mass of dissolved salts in a given mass of solution. The experimental determination of the salt content by drying and weighing presents some difficulties due to the loss of some components. The only reliable way to determine the true or absolute salinity of natural water is to make a complete chemical analysis. However, this method is time-consuming and cannot yield the precision necessary for accurate work. Thus, to determine salinity, one normally uses indirect methods involving the measurement of conductivity. From an empirical relationship of salinity and the physical property determined for a standard solution it is possible to calculate salinity. Because of its high sensitivity and ease of measurement, the conductivity method is most commonly used to determine salinity. (Standard Methods, 20th Edition 2-48)

1.3 Applicable Water Body Segment Use

The water use classification for the listed segments of Long Branch as established by the State of Mississippi in the *Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulation, is Fish and Wildlife Support. The designated beneficial use for Long Branch is Aquatic Life Support.

1.4 Applicable Water Body Segment Standard

The water quality standard applicable to the use of the water body and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. The applicable standard specifies that there shall be no substances added to increase the conductivity above 1000 micromhos/cm for freshwater streams. This water quality standard will be used as the targeted endpoint to evaluate impairments and establish this TMDL.

1.5 Selection of a Critical Condition

There are no point sources discharging in the watershed. Therefore, any excessive conductivity is being produced by runoff from stormwater or from leaking pipes or brine pits. Therefore with a lack of specific data, a year round look at the watershed is needed. The critical period will be selected based on the runoff flow that provides the most critical condition.

1.6 Selection of a TMDL Endpoint

One of the major components of a TMDL is the establishment of instream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. Instream numeric endpoints, therefore, represent the water quality goals that are to be achieved by meeting the load and wasteload allocations specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are expected to restore designated uses. The instream conductivity target for this TMDL is 1,000 micromhos per centimeter (μmho/cm).

Photo 2 Hard Clay Stream Bottom in Long Branch

The original listing is "Salinity / TDS / Chlorides." Each of these is empirically determined from the conductivity and temperature readings taken instream. Therefore, it is appropriate to select the conductivity standard as the endpoint or target for this TMDL.

WATER BODY ASSESSMENT

This TMDL Report includes an analysis of available water quality data and the identification of all known potential pollutant sources in the Long Branch watershed. The potential point and nonpoint pollutant sources are unknown, but have been characterized by the best available information, monitoring data, and literature values. This section documents the available information for Long Branch and the tributaries.

2.1 Discussion of Instream Water Quality Data

The State's 1998 Section 305(b) Water Quality Assessment Report was reviewed to assess water quality conditions and data available for the 303(d) listed water body in the Long Branch watershed. Conductivity data are not available for the listed segment.

2.2 Discussion of the Critical Period

The critical period could not be determined from a conductivity data review. A similar review occurred in the Perry Creek TMDL. The review of those data showed the critical condition occurred in late summer – early fall. In that stream, the data exceeded the standard for most of the year; however, the greatest exceedance was in the late summer months. This could possibly be due to high flash flows after long dry spells and warmer stream temperature. Flow records will be evaluated for August and September to determine the critical period for this TMDL.

2.3 Assessment of Point Sources

The first step in assessing pollutant sources in the watershed was locating the NPDES permitted sources. There are no NPDES facilities permitted to discharge in the watershed. There are several oil or gas wells in the watershed, but these facilities do not have a NPDES Permit. The watershed satellite photo image is shown on page 12 of this report. The small white cleared areas around the headwaters of the creek are oil or gas wells.

2.4 Assessment of Nonpoint Sources

Nonpoint loading, which gives an increased conductivity in the water body, results from the transport of the pollutants into receiving waters by overland surface runoff and groundwater infiltration. Landuse activities within the drainage basin, such as drilling and mining contribute to nonpoint source loading. Other nonpoint pollution sources include atmospheric deposition and natural weathering of rocks and soil.

Little information is available which can be used to quantify a cause and effect relationship between observed saline flows and the identified sources. After decades of oil and gas production throughout the watershed, it can be concluded that conductivity loading is the direct result of improperly plugged wells, abandoned brine pits, rainfall runoff transporting pollutants to surface waters, or an indirect result of groundwater migration through abandoned or improperly cased oil wells. Historical practices of brine discharges from active wells have elevated concentrations at the surface layer. (Parsons, 2002)

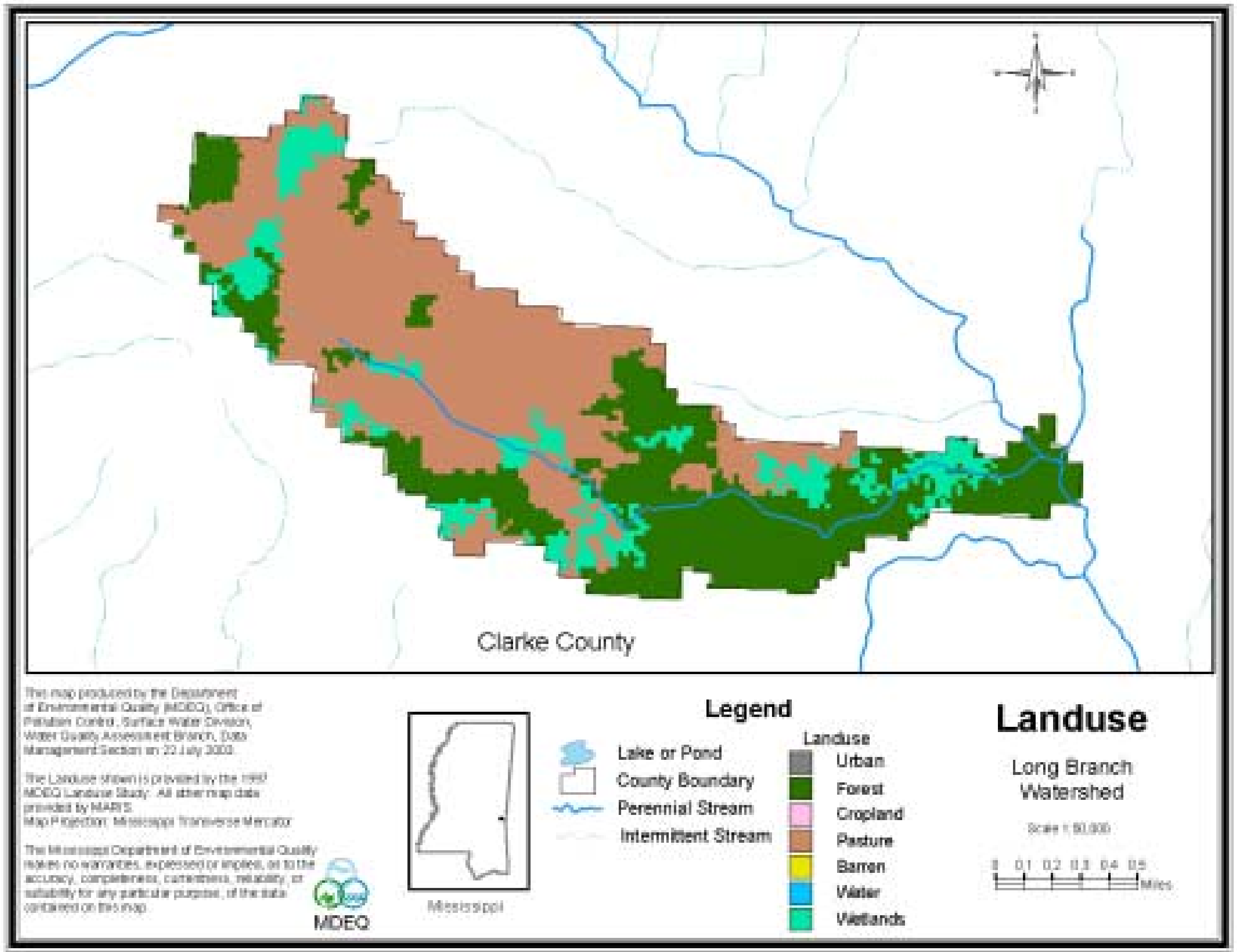
Photo 3 Long Branch Creek

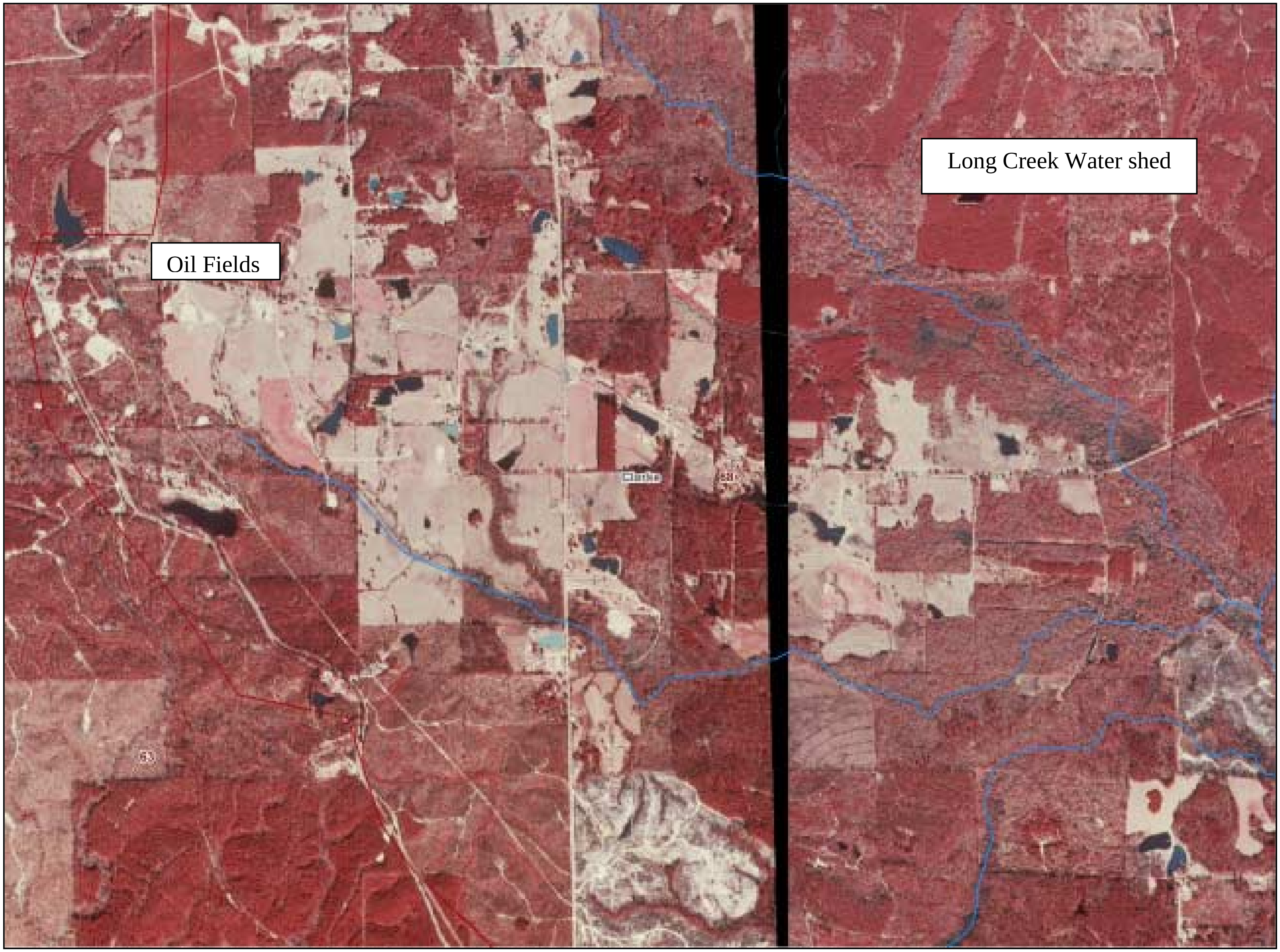
The 1341-acre drainage area contains many different landuse types, including forest, cropland, pasture, water, and wetlands. The landuse information is based on data collected by the State of Mississippi's Automated Resource Information System (MARIS) 1997. This data set is based on Landsat Thematic Mapper digital images taken between 1992 and 1993. Forestry is the dominant landuse within this watershed. The landuse distribution within the watershed is shown in Table 5 and Figure 4.

Table 5. Landuse Distribution, Long Creek Watershed

	Urban/ Transportation	**Forest**	**Agriculture and Scrub**	**Pasture**	**Total**
Area (acres)	0	492	163	686	1341
Percentage	0	37%	12%	51%	100%

Figure 3. Landuse Distribution Map for Long Branch Watershed




Long Creek Water shed
Oil Fields

TMDL CALCULATIONS

Establishing the relationship between the instream water quality target and the source loading is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired source load reductions. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain water body responses to flow and loading conditions. In this section, the selection of the TMDL estimation procedures is discussed.

3.1 Flow Estimation

There are no gages available in the watershed to determine flow accurately. Therefore, flow has been determined by finding a nearby watershed and comparing the size of both watersheds. In this case, Buckatunna Creek near Sykes, Mississippi USGS 02477900 was selected as the nearest watershed with somewhat similar features and geography. The Buckatunna Creek watershed is 480 square miles. The average annual flow in Buckatunna Creek is 730 cfs.

Table 6. Average Monthly Flows in Buckatunna Creek (cfs)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1,406	1,417	1,612	1,337	645	369	255	152	221	193	392	766

Table 6 shows the monthly average flows in the Buckatunna Creek in cubic feet per second. To determine the critical condition and seasonality, the average monthly flow in August was used which is 152 cfs. This gives the most critical condition. The Long Branch watershed is 2.095 square miles. The monthly average flow can be estimated by comparing the sizes of the watersheds. The average flow of 3.1 will be used for this TMDL.

$$\frac{2.095 sqmile}{492 sqmile} * 152 cfs = .65 cfs$$

3.2 Load Evaluation

A mass balance approach was used to estimate this TMDL. Conductivity loading was calculated using the conductivity data from a similar watershed and the monthly average flow during the critical period. The following equation can be used to calculate the conductivity load:

$$Concentration(0.001k / \Lambda) * Qcfs * 5.39$$

where C equals concentration in equivalents-mg/L and Q equals average monthly flow in cfs. An expression for the loading can be developed by setting one critical or representative flow and concentration, and calculating the conductivity load using these equations. The conversion factor will change the equation from a concentration to a load in equivalent pounds per day.

The target load is calculated by substituting the standard or 1000 μmho/cm for k and determining the equivalent load.

$$0.001 * 1000 \mu mho / cm * .65 cfs * 5.39 = 3.49 eq / d$$

Therefore, the TMDL equals 3.49 equivalent pounds per day. The needed reduction cannot be calculated until data are available to comparing the target load to the critical period load. The same percent reduction is calculated from the concentrations involved in the measured conductivity and the water quality standard.

ALLOCATION

4.1 Wasteload Allocation

There are no known NPDES Permits in the watershed. However, it is conceivable that a stormwater construction activity could take place that would need stormwater discharge permitting. Therefore, MDEQ has determined that 10% of the overall TMDL load should be allocated to the WLA portion of the TMDL. This represents a preliminary estimation of the potential stormwater permitting that would include conductivity generated by stormwater runoff. The WLA equals 0.35 equivalent pounds per day.

4.2 Load Allocation

The load allocation is the remaining available TMDL load. This equals 3.14 equivalents per day. This is based on the estimated critical flow of .65 cfs.

4.3 Incorporation of a Margin of Safety

The margin of safety is a required component of a TMDL and accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving water body. The two types of MOS development are to implicitly incorporate the MOS using conservative model assumptions or to explicitly specify a portion of the total TMDL as the MOS. The MOS selected for this model is implicit. Determining the TMDL for the water body at this flow provides protection during the worst-case scenario.

4.4 Seasonality

In the Perry Creek watershed, monthly conductivity data were found to increase in August and September. This is perhaps due to higher temperatures, long dry spells followed by high flash runoff from a summer storm. MDEQ chose these months as the critical period for this TMDL. MDEQ took the complete record of runoff data for Buckatunna Creek and determined the average monthly flows for all months. August was selected over September because the flows are lower in August that provides the critical condition for this TMDL. By selecting the critical period, the TMDL addresses seasonality. Reductions calculated for the critical period are the maximum needed during the year.

CONCLUSION

This TMDL is based on a desktop approach using MDEQ's regulatory assumptions and literature values. This TMDL recommends that no NPDES permit be issued for Long Branch if the effluent would cause or contribute to a violation of the water quality standard for conductivity.

5.1 Future Monitoring

MDEQ has adopted the Basin Approach to Water Quality Management, a plan that divides Mississippi's major drainage basins into five groups. During each yearlong cycle, MDEQ's resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Pascagoula River Basin, the Long Branch watershed may receive additional monitoring to gather conductivity data for the water body. This TMDL could then be based on data gathered in the stream.

5.2 Public Participation

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

At the end of the 30-day period, MDEQ will determine the level of interest in the TMDL and make a decision on the necessity of holding a public meeting. If a public meeting is deemed appropriate, the public will be given a 30-day notice of the meeting to be held. All comments received during the public notice period and at any public meeting become a part of the record of this TMDL. All comments will be considered in the submission of this TMDL to EPA Region 4 for final approval.

REFERENCES

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DEFINITIONS

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

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

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

Biological Impairment: Condition in which at least one biological assemblages (e.g. , fish, macroinvertebrates, or algae) indicates less than full support with moderate to severe modification of biological community noted.

Chloride: (Cl^-) one of the major inorganic anions in water and wastewater. Chloride concentration is higher in wastewater than in raw water because sodium chloride (NaCl) is a common article of diet and passes unchanged through the digestive system.

Conductivity: Measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions; on their total concentration, mobility, and valence; and on the temperature of measurement.

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

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

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

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

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

Effluent: Treated wastewater flowing out of the treatment facilities.

Groundwater: Subsurface water in the zone of saturation. Groundwater infiltration describes the rate and amount of movement of water from a saturated formation.

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

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

Load Allocation (LA): The portion of a receiving water's loading capacity attributed to or assigned to nonpoint sources (NPS) or background sources of a pollutant

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

Mass Balance: An equation that accounts for the flux of mass going into a defined area and the flux of mass leaving a defined area, the flux in must equal the flux out.

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

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

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

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

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

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

Salinity: Measure of the mass of dissolved salts in a given mass of solution.

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 water bodies or is routed into a drain or sewer system.

Total Maximum Daily Load or TMDL: The calculated maximum permissible pollutant loading to a water body 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 Standards: The criteria and requirements set forth in *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. Water quality standards are standards composed of designated present and future most beneficial uses (classification of waters), the numerical and narrative criteria applied to the specific water uses or classification, and the Mississippi antidegradation policy.

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

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

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

ABBREVIATIONS

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

BMP ....Best Management Practice

CWA ....Clean Water Act

EPA ....Environmental Protection Agency

GIS ....Geographic Information System

HUC ....Hydrologic Unit Code

LA .... Load Allocation

MARIS...Mississippi Automated Resource Information System

MDEQ... Mississippi Department of Environmental Quality

MGD .... Million Gallons per Day

MOS ....Margin of Safety

NPDES... National Pollution Discharge Elimination System

TDS ....Total Dissolved Solids

USGS .... United States Geological Survey

WLA .... Waste Load Allocation

WWTP .... Wastewater Treatment Plant