FINAL
TMDL for Dissolved Oxygen for Bayou Labranche (Subsegment 041201) in the Lake Pontchartrain Basin, Louisiana

Prepared for:

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Water Quality Protection Division
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Executive Summary

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (at Title 40 of the *Code of Federal Regulations* [CFR] section 130.7) require TMDLs for waterbody-pollutant pairs apply to the approved 303(d) impaired waters list, even if pollutant sources have implemented technology-based controls. A total maximum daily load (TMDL) is a calculation of the maximum amount of a pollutant that a waterbody can assimilate while still meeting the water quality standard for that pollutant. TMDLs provide the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991).

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality, and it may include a future growth (FG) component. The components of the TMDL calculation are illustrated using the following equation:

$$TMDL = \Sigma\, WLAs + \Sigma\, LAs + MOS + FG$$

The area for this TMDL includes Bayou Labranche from the headwaters to Lake Pontchartrain. Bayou Labranche is entirely within St. Charles Parish and has an area of 31.16 square miles (80.7 square kilometers). Bayou Labranche originates north of U.S. 61 (Airline Highway) and flows north for 4 miles to its confluence with Lake Pontchartrain. Bayou Labranche have been designated as a Louisiana Natural and Scenic River. The predominant land use in the impaired subsegment is wetlands (64.96 percent), followed by developed land (22.79 percent). The WLA for the municipal separate storm sewer system permit was based on the LA; therefore, it has the same reduction as the LA in Table ES-2.

The Louisiana Department of Environmental Quality (LDEQ) has included Bayou Labranche (subsegment 041201) on the state's 2010 section 303(d) list of impaired waterbodies (*Final 2010 Integrated Report*) (LDEQ 2010a) (Table ES-1). The subsegment is listed for low dissolved oxygen (DO) and turbidity impairments. The impaired designated uses for the subsegment are fish and wildlife propagation (FWP) and outstanding natural resource (ONR).

Table ES-1. Excerpt from the *Final 2010 Integrated Report*

Subsegment	Subsegment name	Designated use			
		Primary contact recreation	Secondary contact recreation	Fish and wildlife propagation	Outstanding natural resource
041201	Bayou Labranche – from headwaters to Lake Pontchartrain	Fully supporting	Fully supporting	Not supporting	Not supporting

Source: LDEQ 2010a

A water quality model (LA-QUAL) was set up to simulate DO, carbonaceous biochemical oxygen demand (CBOD), ammonia nitrogen, and nitrite+nitrate. The model was calibrated using data from fieldwork conducted in August 2009. The projection simulation was conducted at critical flows and temperatures to address seasonality, as the Clean Water Act requires. No reductions of existing point source loads were required for the projection simulation to meet the DO standard of 4 milligrams per liter (mg/L). In general, the modeling for this TMDL was consistent with guidance in the Louisiana TMDL technical procedures manual (LDEQ 2010b).

TMDLs for CBOD, ammonia, organic nitrogen, and sediment oxygen demand (SOD) were calculated using the projection simulation. In developing the TMDL, allowable loads from all pollutant sources that cumulatively amount to no more than the TMDL must be established, thereby providing the basis for establishing water quality-based controls. WLAs were assigned to permitted point source discharges, including regulated stormwater. The LAs include background loadings and human-induced nonpoint sources. An MOS of 10 percent and an FG component of 10 percent were also included.

This TMDL establishes load limitations for oxygen-demanding substances. The numeric DO water quality criterion for subsegment 041201 (4 mg/L) was used to calculate the total allowable loads in summer and winter scenarios. Table ES-2 presents a summary of the TMDLs for subsegment 041201.

Table ES-2. Summary of TMDLs, WLAs, LAs, MOSs, and FGs

Season	Loadings (lb/d)							
Summer	SOD		$CBOD_u$		Ammonia as N		Organic N as N	
	Baseline	TMDL	Baseline	TMDL	Baseline	TMDL	Baseline	TMDL
WLA	200.9	100.4	240.23	60.46	4.267	1.297	38.359	11.532
LA	681.3	340.6	814.22	204.54	14.394	4.323	130.058	39.074
MOS	110.3	55.1	131.81	33.13	2.333	0.702	21.052	6.326
FG	110.3	55.1	131.81	33.13	2.333	0.702	21.052	6.326
TMDL	1,102.7	551.3	1,318.06	331.26	23.326	7.025	210.521	63.258
Percent reduction	50.0%		74.9%		69.9%		70.0%	
Season	Loadings (lb/d)							
Winter	SOD		$CBOD_u$		Ammonia as N		Organic N as N	
	Baseline	TMDL	Baseline	TMDL	Baseline	TMDL	Baseline	TMDL
WLA	86.1	75.0	240.23	181.86	4.27	3.23	38.36	34.27
LA	292.1	254.5	814.22	616.25	14.39	10.88	130.06	116.18
MOS	47.3	41.2	131.81	99.76	2.33	1.76	21.05	18.81
FG	47.3	41.2	131.81	99.76	2.33	1.76	21.05	18.81
TMDL	472.7	411.9	1,318.06	997.64	23.33	17.64	210.52	188.07
Percent reduction	12.9%		24.3%		24.4%		24.9%	

Implementing the DO TMDL through future wastewater discharge permits, if required, along with implementing best management practices to control and reduce runoff of soil and oxygen-demanding pollutants from nonpoint sources within the watershed, should reduce nutrient loading from those sources.

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1. Introduction

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (at Title 40 of the *Code of Federal Regulations* [CFR] section 130.7) require TMDLs for waterbody-pollutant pairs apply to the approved 303(d) impaired waters list even if pollutant sources have implemented technology-based controls. A total maximum daily load (TMDL) is a calculation of the maximum allowable load (in mass per unit time) of a pollutant that a waterbody is able to assimilate while still supporting its designated uses. The maximum allowable load is determined on the basis of the relationship between pollutant sources and in-stream water quality. A TMDL provides the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991).

The text of 40 CFR 130.7 has been affected by several Federal District Court suits, appeals rulings, and a Supreme Court ruling mandating that a TMDL must be described in terms of mass per day. According to 40 CFR 130.7, if EPA does not approve a TMDL submitted by a state, EPA is responsible for developing a TMDL. In a District Court case regarding the TMDL program in Louisiana (*Sierra Club and Louisiana Environmental Action Network, Inc. v. EPA*, Civil Action Number: 96-0527), EPA was listed as the sole defendant. That case resulted in the April 1, 2002, consent decree approved by the judge. A consent decree is a negotiated set of actions to satisfy the plaintiff. In many situations, the actions are more stringent than the established regulation. For example, most consent decrees require an annual report to the plaintiff summarizing the work done in the year; that is not required by any regulation and will cease when the consent decree is closed.

The 2002 consent decree between EPA and the plaintiffs establishes a fixed set of waterbody-pollutant pairs for which TMDLs are to be established or approved, and it establishes a timeline for each set of TMDLs. Each set is determined to be complete when every waterbody-pollutant pair either has a TMDL established or approved, or a subsequent approved 303(d) list has removed the waterbody-pollutant pair. The TMDLs in this report are part of that consent decree. Because the original court suit was initiated because of a lack of progress in establishing TMDLs, the date when a TMDL is established or approved is not easy to extend, and an extension would require another agreement with the plaintiffs.

In most circumstances, a variety of scientifically acceptable methods can be used for developing a TMDL, wasteload allocation (WLA), and load allocation (LA). For these TMDLs, the LA-QUAL model was used. It should be noted that because some acceptable TMDL calculation methods appear simple, that does not imply that its results are not valid. Models vary in the amount of necessary resources (e.g. training, setup/computational time, personnel, expense), required input and background data, questions answered, and output capability (e.g., charts, tables, data files). The final result of these TMDLs (and any TMDL) is a plan adopted into the Water Quality Management Plan (WQMP) to achieve the TMDL. Stakeholder involvement and additional information, such as monitoring data, might lead to an update of the WQMP and in turn a proposal for a different plan to meet water quality objectives. Such a WQMP update receives the same public participation as the original TMDL and WQMP review and approval.

For the TMDL discussed in this report, monitoring data collected by the Louisiana Department of Environmental Quality (LDEQ) indicate that observed dissolved oxygen (DO) and levels sometimes do not meet the state's water quality criteria for Bayou Labranche (subsegment 041201) within the Lake Pontchartrain Basin. The impaired designated uses for the subsegment are fish and wildlife propagation and outstanding natural resource. The subsegment is listed as not supporting the designated uses in Louisiana's 2010 section 303(d) list (as included in the *Final 2010 Integrated Report*) for the subsegment. Subsegment 041201 has suspected causes of *forced drainage pumping* and *natural sources*.

Oxygen concentrations in bodies of water fluctuate naturally; however, depletion of DO can be caused by human activities or natural sources. Temperature and salinity also have an effect on DO. For example, during extended hot weather, the subsequent warmer water can result in fish kills from lower DO in the water column because of decreased gas solubility compared to cooler water (Scorecard 2005). Chemical reactions can generate a chemical oxygen demand on receiving waters and further lower DO. Human activities, such as lawn mowing and fertilizing, can contribute large amounts of biodegradable organic matter or nutrients through stormwater and, over time, lead to eutrophication (Scorecard 2005). Natural sources can also add organic material to a waterbody. Forests add leaves and woody debris, whereas wetlands have large algal masses that can be carried over into the waterbody. In streams with significant amounts of organic matter, bacterial degradation can result in a net reduction of oxygen in the water column.

Other factors that affect DO concentrations include the following (Murphy 2005):

- Volume and velocity of water flowing in the waterbody
- Climate and season
- The type and number of organisms in the waterbody
- Altitude
- Dissolved or suspended solids
- Amount of nutrients in the water
- Organic waste
- Riparian vegetation
- Groundwater inflow

2. Background Information

2.1 General Description

The Lake Pontchartrain Basin in southeastern Louisiana is primarily comprised of the rivers and bayous that drain into Lake Pontchartrain. The basin is bordered by the Pearl River Basin to the east, by Breton and Chandeleur Sound to the southeast, and by the Mississippi River Levee on the west and south. The northern portion of the Lake Pontchartrain Basin consists of forests, pines and hardwoods, pastures, and dairies. The southern portion consists of cypress-tupelo swamps and lowlands, and brackish and saline marshes. Elevations within the basin range from minus 5 feet at New Orleans to greater than 200 feet near the Mississippi River (LDEQ 2010c). Subsegment 041201 (Bayou Labranche) is entirely within St Charles Parish, and encompasses an area of 31.16 square miles (80.7 square kilometers) (Figure 2-1). Portions of the city of New Orleans urban area (St. Rose) and the census-designated place Destrehan are in the southern portion of the subsegment. Bayou Labranche originates north of U.S. 61 (Airline Highway) and flows north for 4 miles to its confluence with Lake Pontchartrain. Bayou Labranche has been designated as a Louisiana Natural and Scenic River (USACE 2008).

2.2 Land Use

Land use data were obtained from the 2006 U.S. Geological Survey (USGS) National Land Cover Dataset (NLCD) (Table 2-1 and Figure 2-2). The predominant land use within subsegment 041201 is wetlands (64.96 percent), followed by urban development (22.79 percent) and open water (10.49 percent). Subsegment 041201 includes very little cultivated crops, grassland/shrub, pasture/hay, barren land, or forest.

Table 2-1. Land use percentages for subsegment 041201

Land use	Percent of total area
Water	10.49%
Developed	22.79%
Barren	0.06%
Forest	0.06%
Grassland/shrub	0.51%
Pasture/hay	0.39%
Cultivated crops	0.74%
Wetlands	64.96%
TOTAL	100.00%

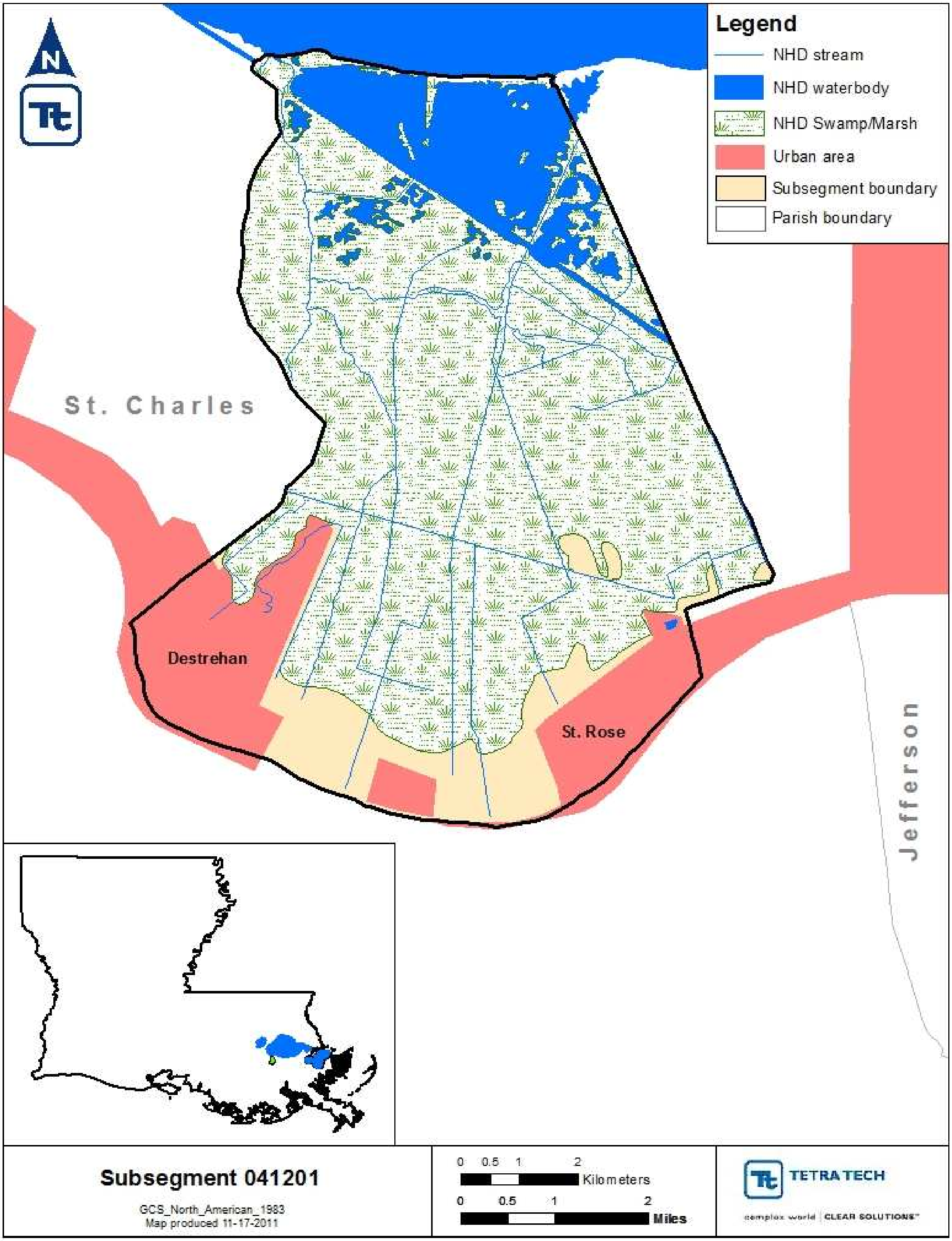

Figure 2-1. Location of subsegment 041201.

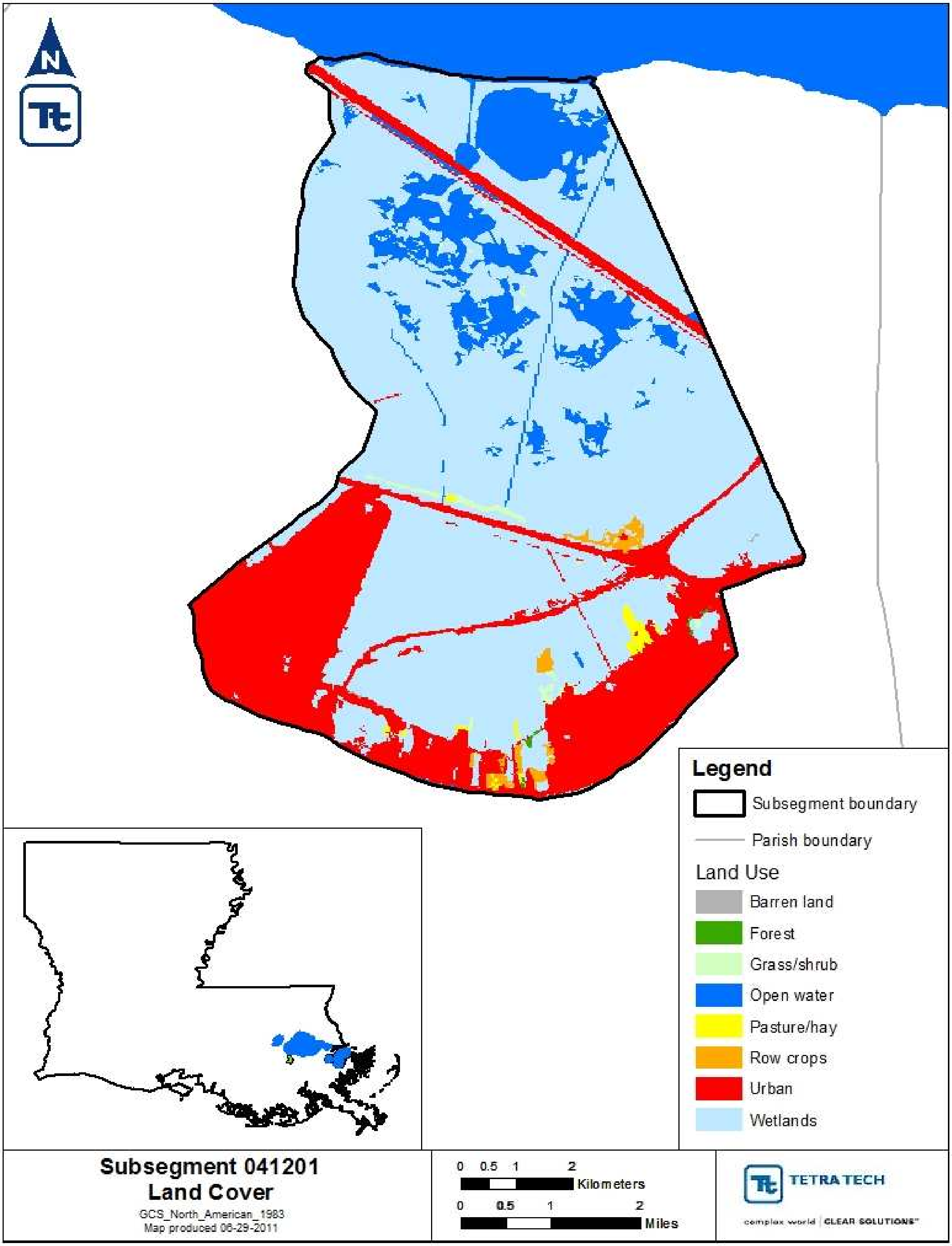

Figure 2-2. Land use in subsegment 041201.

2.3 Hydrologic Setting

The USGS online hydrology database (NWISWeb) does not include any stations within subsegment 041201 that have furnished flow data. The subsegment is tidally influenced.

2.4 Designated Uses and Water Quality Criteria

Louisiana's 2010 section 303(d) list (as included in the *Final 2010 Integrated Report*) indicates that designated uses of the subsegment are primary and secondary contact recreation, fish and wildlife propagation, and outstanding natural resource waters. Primary contact recreation includes any recreational or other water contact involving full-body exposure to water and a considerable probability of ingesting water. Examples of this use are swimming and water skiing. Secondary contact recreation involves activities like fishing, wading, or boating, whereby water contact is accidental or incidental, and the chance of ingesting appreciable amounts of water is minimal. Fish and wildlife propagation includes use of water for aquatic habitat, food, resting, reproduction, cover, or travel corridors by any indigenous wildlife and aquatic life species associated with the aquatic environment. Outstanding natural resource waters include waterbodies designated for preservation, protection, reclamation, or enhancement of wilderness, aesthetic qualities, and ecological regimes, such as those designated under the Louisiana Natural and Scenic Rivers System or those designated by LDEQ as waters of ecological significance. Characteristics of outstanding natural resource waters include, but are not limited to, highly diverse or unique in-stream and/or riparian habitat, high species diversity, balanced trophic structure, unique species, or similar qualities.

The assessment methodology presented in LDEQ's 305(b) report (LDEQ 2010a) specifies full support for primary contact recreation, secondary contact recreation, fish and wildlife propagation, and outstanding natural resource uses. Subsegment 041201 is an estuarine system. The DO criterion for this subsegment is 4 milligrams per liter (mg/L) year-round.

The Louisiana water quality standards also include an antidegradation policy (*Louisiana Administrative Code* [LAC] Title 33, Part IX, Section 1109.A), which specifies that state waters exhibiting high water quality should be maintained at that high level of water quality. If that is not possible, water quality at a level that supports the designated uses of the waterbody should be maintained. The designated uses of a waterbody may be changed to allow a lower level of water quality only through a use attainability study.

2.5 Identification of Sources

2.5.1 Point Sources

LDEQ stores permit information using internal databases. LDEQ generated a list of point source discharges within the subsegment by using the TEMPO database. Information on point source discharges to the listed subsegments was obtained from the Integrated Compliance Information System - National Pollutant Discharge Elimination System (ICIS-NPDES) and Louisiana's Electronic Document Management System (EDMS). Data were pulled from ICIS for the list of permits generated by LDEQ, and those data were confirmed through EDMS. Subsegment 041201 contains 25 identified point sources (Figure 2-3). Because of the large number of permits, these are listed in Appendix A. Each facility was evaluated on the basis of its discharges and permit limits to determine whether the facility should be used in developing the TMDLs (Section 4.9).

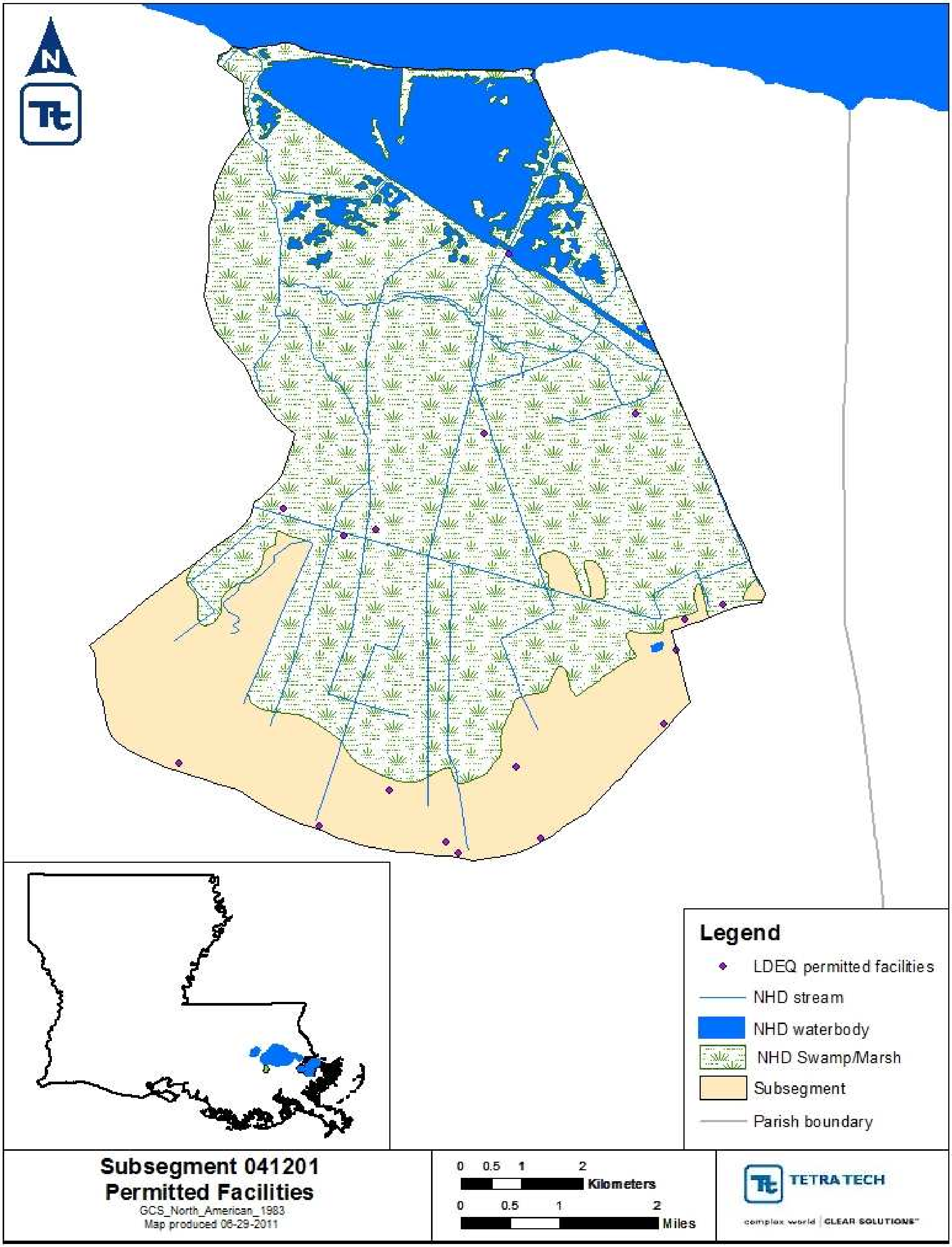

Figure 2-3. Permitted facilities within subsegment 041201 of the Lake Pontchartrain Basin.

Phase I and II stormwater systems are additional possible point source contributors within the Lake Pontchartrain Basin. Stormwater discharges are generated by runoff from urban land and impervious areas such as paved streets, parking lots, and rooftops during precipitation events. These discharges often contain high concentrations of pollutants that can eventually enter nearby waterbodies. Most stormwater discharges are considered point sources and require coverage by a National Pollutant Discharge Elimination System (NPDES) permit.

Under the NPDES stormwater program, operators of large, medium, and regulated small municipal separate storm sewer systems (MS4s) must obtain authorization to discharge pollutants. The Stormwater Phase I Rule (55 *Federal Register* 47990, November 16, 1990) requires all operators of medium and large MS4s to obtain a NPDES permit and develop a stormwater management program. Medium and large MS4s are defined by the size of the population within the MS4 area, not including the population served by combined sewer systems. A medium MS4 has a population between 100,000 and 249,999; a large MS4 has a population of 250,000 or more.

Phase II requires a select subset of small MS4s to obtain an NPDES stormwater permit. A small MS4 is any MS4 not already covered by the Phase I program as a medium or large MS4. The Phase II rule automatically covers all small MS4s in urbanized areas (UAs), as defined by the Bureau of the Census, and also includes small MS4s outside an UA that are so designated by NPDES permitting authorities, case by case (USEPA 2000).

In Louisiana, an MS4 can be identified as a regulated, small MS4 in two ways. This category includes all cities within UAs and any small MS4 area outside UAs with a population of at least 10,000 and a population density of at least 1,000 people per square mile (LDEQ 2002). Within subsegment 041201 are three regulated Phase II (small) MS4s. Table 2-2 includes MS4 discharge information for this impaired subsegment within the Lake Pontchartrain Basin.

Table 2-2. MS4 information for subsegment 041201

Agency interest (AI) #	NPDES permit number	Authority	Expiration date	Discharge subsegments	Waterbody names
115009	LAR041032	St Charles Parish Government - Municipal Separate Storm Sewer System	12/04/12	041201, 041202	Lake Pontchartrain, Lake Pontchartrain Drainage Canals, Bayou St. John, Inner Harbor Navigational Canal
108424	LAR043001	LADOTD - Statewide MS4 coverage	12/04/12	various	Including: Lake Pontchartrain, Lake Pontchartrain Drainage Canals, Bayou St. John, Inner Harbor Navigational Canal

2.5.2 Nonpoint Sources

Louisiana's section 303(d) list identifies suspected causes of the DO impairment in subsegment 041201 of the Lake Pontchartrain Basin as *forced drainage pumping and natural sources*.

3. Characterization of Existing Water Quality

3.1 Water Quality Data

Water quality data were obtained from LDEQ's routine ambient water quality monitoring program. Additional environmental data were obtained from a monitoring conducted by FTN Associates (FTN) on August 4-6, 2009. Figure 3-1 shows the locations of the LDEQ and FTN sampling sites. Data collected during the 2009 field study included in situ measurements of temperature, DO, pH, specific conductivity, and Secchi depth, in addition to sampling data for total phosphorus (TP), ortho-phosphorus (OP), chlorophyll *a*, total suspended solids (TSS), ammonia nitrogen, total Kjeldahl nitrogen (TKN), nitrate plus nitrite nitrogen (NO_3+NO_2), total organic carbon (TOC), and carbonaceous biochemical oxygen demand (CBOD) time series, which used a nitrogen suppressant. The CBOD time-series data were collected on days 2, 5, 9, 14, 20, and 27 of the analysis. Tables B-1 through B-4 in Appendix B summarize the water quality data for the section 303(d)-listed constituents, along with additional constituents used in the TMDL development process. Appendix B contains summaries of the DO and nutrient data. Appendix C presents the Field Survey Notes.

3.2 Comparison of Observed Data to Criteria

Table B-4 in Appendix B lists 76 DO observations at station 304 (Bayou Labranche north of Norco, Louisiana). Twenty-three (30 percent) of the DO levels were below the 4 mg/L water quality criterion. Figures 3-2 and 3-3 show the DO data collected at station 304 plotted over time and season. As expected, DO levels were lower in the hotter summer months.

Table B-1 in Appendix B summarizes the August 2009 DO data at 13 stations in subsegment 041201—one datum at each station. At five of the 13 stations (38.5 percent), DO levels were below the water quality criterion of 4 mg/L. Three of these stations are one on Cross Bayou Canal and two directly on Bayou Labranche. Figures B-1 through B-4 in Appendix B show the LDEQ DO and other continuous monitoring data obtained at station LABR2 (Bayou Labranche 0.57 mile downstream of LABR-1) over time.

Louisiana does not have numeric nutrient criteria. The original nutrient impairment for this waterbody was not based on a quantitative assessment of historical nutrient data. The impairment was based on an evaluative assessment that might have included DO. LDEQ and EPA plan to reevaluate the previous nutrient impairments for this waterbody. As a result, both EPA and LDEQ expect the nutrient impairment to change from category 5 (impairment exists; TMDL required) to category 3 (insufficient data) for the 2010 Integrated Report. A TMDL for DO should adequately address any potential nutrient impairment, in the absence of numeric nutrient criteria and a quantitative assessment.

LDEQ is developing numeric nutrient criteria for waterbody types by ecoregions in accordance with LDEQ's plan *Developing Nutrient Criteria for Louisiana 2006.*[1] Waterbody types for nutrient criteria development in Louisiana are (1) inland rivers and streams; (2) freshwater wetlands; (3) freshwater lakes and reservoirs; (4) big rivers and floodplains/boundary rivers and associated water bodies; and (5) estuarine and coastal waters, including up to Louisiana's 3-mile boundary in the Gulf of Mexico. LDEQ and EPA are reviewing proposed approaches for nutrient criteria development. Nutrient criteria can be implemented upon state promulgation and EPA approval per 40 CFR 131.21.

After nutrient criteria are developed, a subsequent quantitative assessment of the waterbodies, and the development of full nutrient models, nutrient limits can be established for all facilities discharging to impaired waterbodies in the Lake Pontchartrain Basin. LDEQ recommends that all facilities discharging this subsegment take a proactive approach and prepare to receive nutrient limitations in the near future. Such a proactive approach

[1] http://www.deq.louisiana.gov/portal/Portals/0/planning/LA%20Nutrient%20Strategy%20Plan%20Final%20FOR%20WEB.pdf. Accessed March 13, 2012.

should include nutrient monitoring and documentation through facility Discharge Monitoring Reports (DMRs) to assess their nutrient loads and the need to modify their treatment processes for nutrient removal.

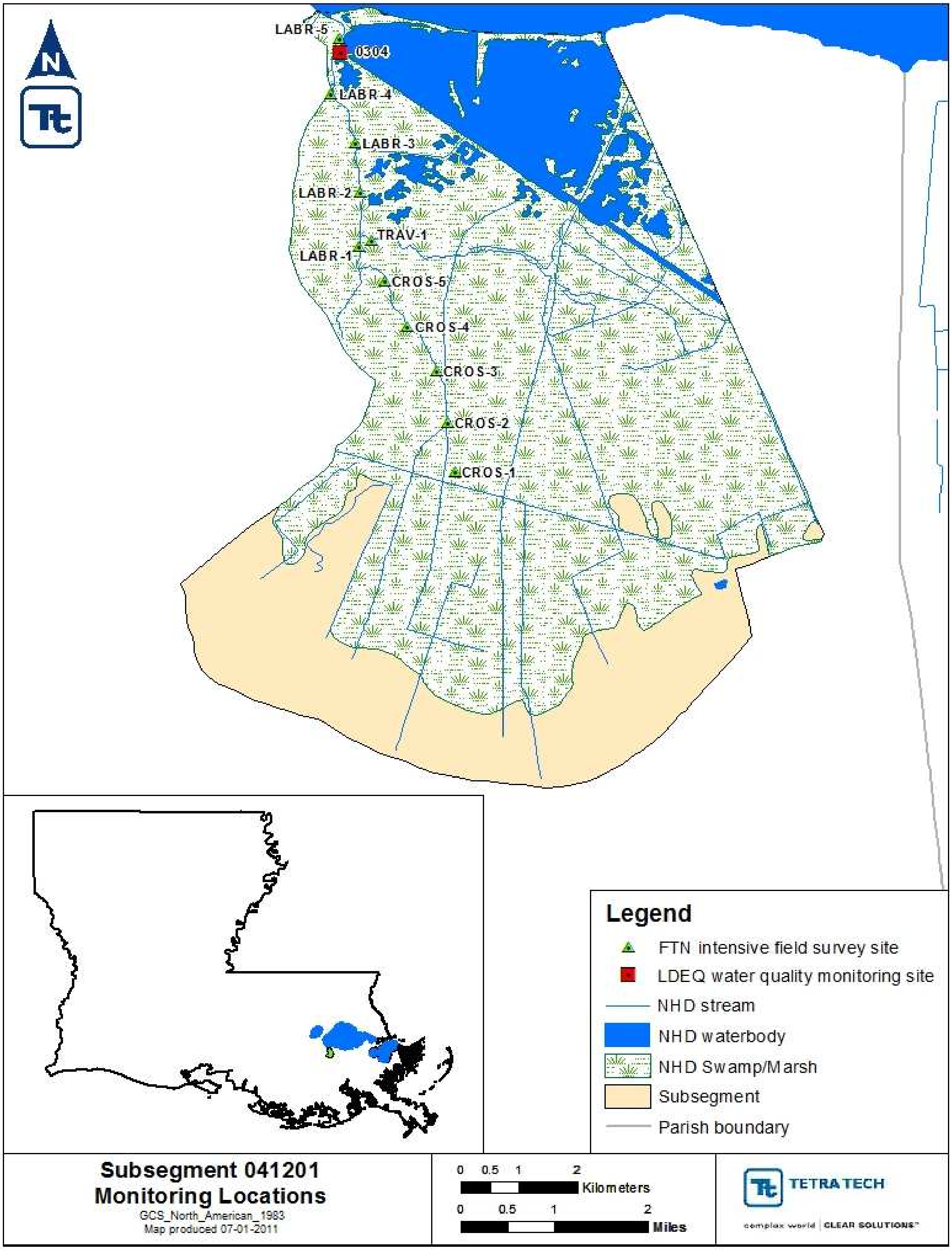

Figure 3-1. Monitoring locations within subsegment 041201 of the Lake Pontchartrain Basin.

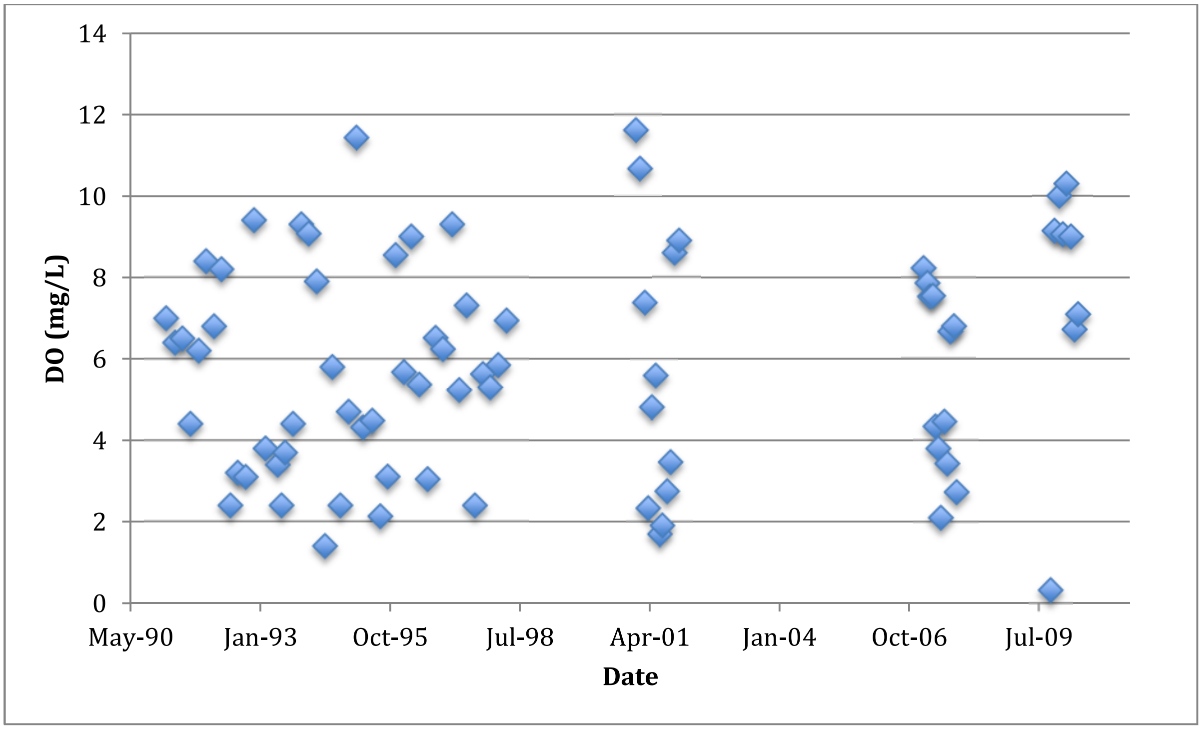

Figure 3-2. DO concentrations over time at station 304.

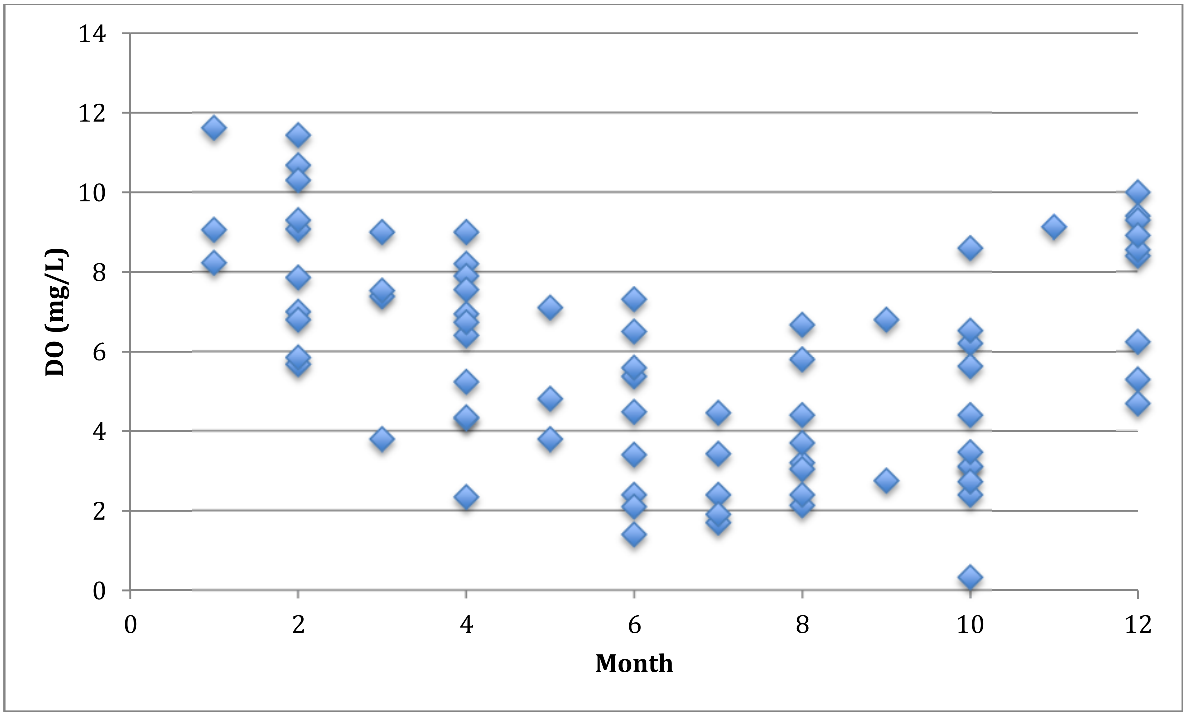

Figure 3-3. Seasonal DO concentrations at station 304.

4. Model Setup and Calibration

4.1 Model Setup

LA-QUAL (Version 9.05) was chosen to simulate DO in the TMDL for subsegment 041201. LA-QUAL is a steady-state model that LDEQ developed based on the QUAL-TX (Version 3.4) model. Several modifications were made to the QUAL-TX model, including the addition of new aeration equations that better represent conditions in Louisiana. LA-QUAL evaluates the relationships between pollutant sources and water quality. Model configuration involved setting up the model segments and setting initial conditions, boundary conditions, and hydraulic and kinetic parameters. This section describes the configuration and key components of the model.

Only the main stems of the systems were explicitly simulated and thus segmented for modeling purposes. Segmentation refers to separating a waterbody into smaller computational units. Segmentation occurred around major hydrological features such as tributaries. Tributaries were represented through boundary condition designation. Appendix D contains a diagram of the model segmentations and stream kilometers.

During modeling, it is important to consider which factors contribute most to DO depletion in Bayou Labranche. In general, CBOD, ammonia, and sediment oxygen demand (SOD) will reduce water column DO, and algae can cause a strong DO swing, as occurred during the July 2009 sampling period when a strong swing to DO was observed, indicating that minimum DO during that period could be caused directly by algae. Algae, SOD, and CBOD are the major causes of DO dynamics in Bayou Labranche.

LA-QUAL does not model the diurnal DO caused by algae. It calculates only the daily averaged concentration of DO caused by algae. However, DO criteria are written so DO is not to drop below 4 mg/L at any time. Within waterbodies with a large amount of algae, the daily averaged DO might meet criteria, but instantaneous DO might not meet criteria. To consider the diurnal DO swing, LA-QUAL is used to first model algae and the daily averaged DO under the influence of algae. The diurnal DO swing is then calculated outside of LA-QUAL using the delta method originally presented by Di Toro (1975, cited in Lung 2001). The basic idea behind the delta method is that the DO swing within a stream depends on the algae level and the re-aeration rate. With the delta method, the actual fluctuation of DO can be computed and the results are reliable.

4.2 Model Options (Data Type 2)

Data type 2 is used to identify the parameters modeled to achieve calibration for this TMDL that include temperature, DO, CBOD, nitrogen series (ammonia nitrogen and nitrate+nitrite), conductivity, phosphorus, and chlorophyll a.

4.3 Program Constants (Data Type 3)

LA-QUAL is programmed with certain default program parameters, including those for tidal variability. Data type 3 is used to override the default parameters and is optional; that is, values must be entered only if values other than the default values are desired. Default values were used for all program parameters except those listed in Table 4-1. For descriptions of the parameters and their default values, see the LA-QUAL user manual (Wiland Consulting, Inc. 2010).

Table 4-1. Water quality kinetics rates

Program constant	Value range
Hydraulic calculation method	2
Inhibition control value	3
CBOD oxygen uptake rate	1
Dispersion equation	1
Ocean exchange ratio	0.5
Tidal height	0.06
Tidal period	12
Period of tidal rise	6

4.4 Temperature Correction of Kinetics (Data Type 4)

Data type 4 includes factors used for temperature correction in rate equations. The temperature correction factors used in the model were consistent with the *Standard Operating Procedure for Louisiana TMDL Technical Procedures* (LTP) when these factors were available (LDEQ 2010b). Default values were used for all factors. For descriptions of the factors and their default values, see the LA-QUAL user manual (Wiland Consulting, Inc. 2010).

4.5 Hydraulics and Dispersion (Data Types 9 and 10)

Data types 9 and 10 describe the hydraulic and dispersion characteristics of the model reaches. The stream hydraulics were specified in the input file for the model using the following power functions:

$$width = a \times Q^b + c$$
$$depth = d \times Q^e + f$$

where

a =	width coefficient	=	0.0
b =	width exponent	=	0.0
c =	width constant	=	average width of segment
d =	depth coefficient	=	0.0
e =	depth exponent	=	0.0
f =	depth constant	=	average depth of segment

The average width and depth data for each segment were based on measurements obtained in August 2009; measurements are summarized in Table 4-2. Slight adjustments were made in some reaches to better simulate observed hydrology and water quality. Because the subsegment is tidally influenced it was assumed that the average depth and width over a tidal cycle remain fairly constant unless sustainable high level of flow enters the system, which is not considered the case for this subsegment.

Table 4-2. Average channel widths and depths for each model segment

Model reach	Width (m)	Depth (m)	Tidal range	Dispersion coefficient *a*
1	15.54	0.823	1.0	1.5
2	18.59	0.488	1.0	1.5
3	18.29	0.732	1.0	1.5
4	20.76	0.732	1.0	1.5
5	24.08	1.994	1.0	1.5
6	34.08	1.994	1.0	1.5

The dispersive hydraulic characteristics were specified in the input file for the model using the following power functions:

$$\text{tidal dispersion} = aD^b \times Q^c \times V_T{}^d$$

where

a =	dispersion coefficient	=	1.5
b =	dispersion exponent	=	0.0
c =	dispersion exponent	=	0.0
d =	dispersion exponent	=	0.0

4.6 Initial Conditions (Data Type 11)

Initial conditions were set for temperature, DO, nitrate+nitrite, phosphorus, and chlorophyll *a* using obtained water quality data, while ammonia and organic nitrogen data were set to a constant. Because LA-QUAL is a steady-state model, the initial conditions affect only the number of iterations needed to reach steady-state conditions. Setting initial conditions on the basis of observed data reduces the number of iterations the model must perform to reach a steady state.

Salinity, phosphorus, phytoplankton, and macrophytes were the parameters not simulated in the model. Their initial conditions were set to zero so that the model would not assume a fixed concentration and include their effects.

4.7 Water Quality Kinetics (Data Types 12, 13, and 14)

Several kinetic rates, including re-aeration, SOD, CBOD decay, nitrification, and mineralization (organic nitrogen decay) rates were used in the model. Data types 12, 13, and 14 focus on different rates used by the model. Data type 12 is needed only if CBOD or DO is being simulated; data type 13 is needed only if nitrogen or phosphorus is being simulated. For this TMDL, both data types were included.

The model calculates the re-aeration rate by using one of a standard set of equations. For this TMDL, the Louisiana and Thackston-Krenkel equations were used. The Louisiana equation was used in regard to the headwater area and is applicable to moderately deep to deep channels (0.3 to 3 feet [ft]), with flow between 0.02 and 0.8 feet per second [ft/s]). The equation is

$$K_2 = \frac{0.664 \times (1 + 21.52V)}{D}$$

where

V = stream velocity (meters per second)
D = stream depth (meters)

The Thackston-Krenkel equation is applicable to shallow channels (0.05 to 0.23 feet). The Thackston-Krenkel equation is

$$K_2 = \frac{3.932 \times (1 + F^{0.5}) \times U}{D}$$

where

$$F = \frac{0.319 \times V}{D^{0.5}} \quad \text{and} \quad U = \frac{4.654 \times V \times n}{D^{0.167}}$$

V = stream velocity (meters per second)
D = stream depth (meters)
n = Manning's n

These values are provided in Appendix E as part of the output file results. Table 4-3 summarizes the water quality kinetics rates. The CBOD decay rate varied per subsegment and was based on the measured $CBOD_3$, $CBOD_5$, $CBOD_{12}$, $CBOD_{20}$, and $CBOD_{25}$ data. Slight adjustments were made in some reaches to better simulate observed water quality. The SOD was calibrated in the model and varied per subsegment reach. SOD was calibrated after the CBOD levels were finalized. The SOD rates changed iteratively until modeled DO concentrations agreed well with measured water column DO concentrations.

Table 4-3. Water quality kinetics rates

Program constant—data types 12&13	Value range	Program constant—data type 14	Value range
Background SOD (g/m^2/d)	0.5–3.0	Secchi disc depth (m)	0.2
CBOD #1 decay rate (aerobic) (1/d)	0.1	Chlorophyll a to phytoplankton ratio	0.01
CBOD #1 settling rate (m/d)	0.2	Phytoplankton settling rate (1/d)	0.02
Organic nitrogen decay rate (1/d)	0.1	Phytoplankton death rate (1/d)	0.02
Organic nitrogen settling rate (1/d)	0.5	Phytoplankton max. growth rate (1/d)	2.0
Ammonia nitrogen decay rate (1/d)	0.12	Phytoplankton respiration rate (1/d)	0.04
Denitrification rate (1/d)	0.02		
Organic phosphorus hydrolysis rate (1/d)	0.05		
Organic phosphorus settling rate (1/d)	1.0		

4.8 Headwater Flow, Water Quality, and Junction Data (Data Types 20, 21, 22, and 23)

Data types 20, 21, 22, and 23 account for flow and water quality from upstream of the modeled subsegment. Headwater flow and water quality data were derived from monitoring data. In general, the flow measured at the most upstream station was taken as the headwater flow. However, Bayou Labranche is influenced by Lake Pontchartrain, and the flow direction changes due to water surface elevation change in Lake Pontchartrain. Therefore, monitored flows at different locations at different times do not represent the net flow in the channel (Figure 4-1). Flow measurements were obtained at different locations at different times. The positive flows are from Bayou Labranche to Lake Pontchartrain and the negative flows are from Lake Pontchartrain to Bayou Labranche. The net flow (0.88 cubic meters per second [cms]) is roughly estimated using the average positive flow minus the average negative flow. The net flow includes inflows from tributaries. Only one positive measurement of flow was obtained at station TRAV-1 (0.17 cms) in Bayou Travers. Because no other information was available, it was assumed that the other two tributaries have the same inflow. The headwater inflow is then calculated as the net flow minus the tributary inflows, and equals 0.37 cms. Water quality data (mainly $CBOD_u$ and DO) were estimated from the monitoring data collected from the most upstream stations.

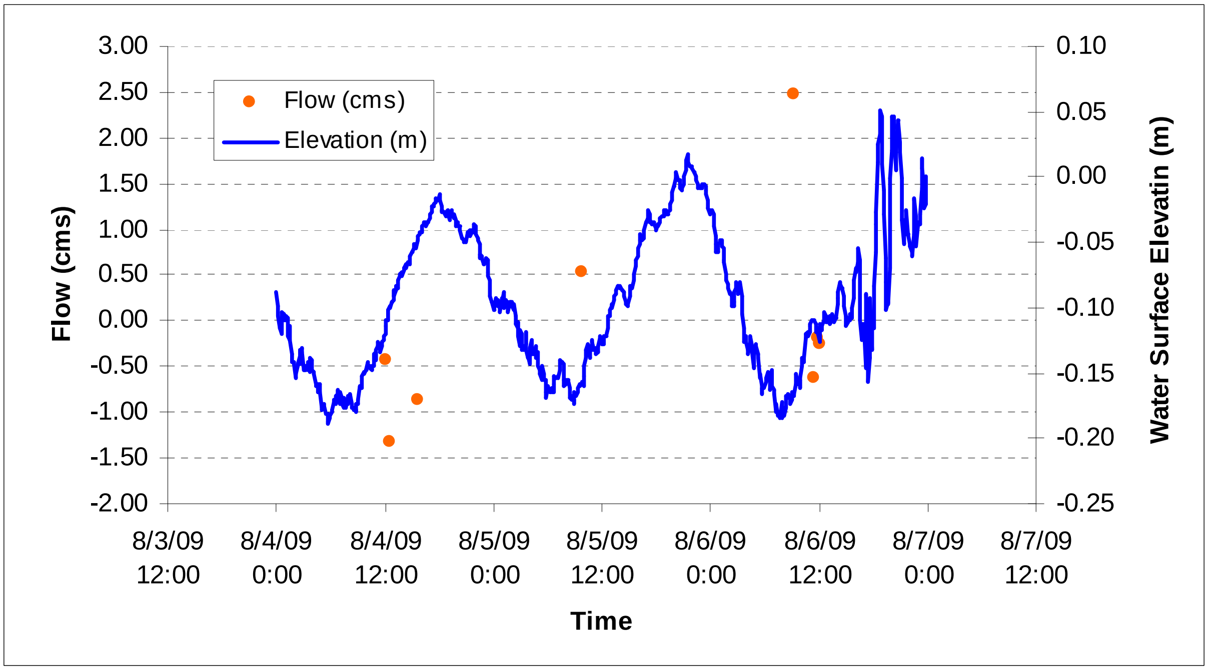

Figure 4-1. Measured flows and observed water surface elevation at NOAA Station 8762372 (East Bank 1, Norco, B. Labranche, LA near Lake Pontchartrain).

4.9 Wasteload Flow and Water Quality Data (Data Types 24, 25, and 26)

Data types 24, 25, and 26 account for flow and water quality from point sources discharging into the listed waterbodies. The permitted dischargers identified in Section 2.5.1 and listed in Appendix A were evaluated for inclusion in the model. The model included one permitted outflow. Note that stormwater permits are classified as point sources; however, for the purposes of this TMDL modeling, stormwater permits are treated as a nonpoint source. The inputs and their associated flows and concentrations are listed in Table 4-4. Average expected flow was used as the flows from permits. DO was set to 2.0 for point sources. Permitted BOD_5 discharge limits were converted to $CBOD_u$ by assuming that BOD_5 was approximately equal to $CBOD_5$ and then using a conversion factor of 2.3 to convert to $CBOD_u$.. Organic nitrogen and nitrate+nitrite were estimated on the basis of the BOD_5 discharge limit.

Table 4-4. Summary of calibration point sources data used in LA-QUAL

Point source/ tributary name	Flow (mgd)	DO (mg/L)	$CBOD_u$ (mg/L)	Org N (mg/L)	Ammonia (mg/L)	NO_3+NO_2 (mg/L)	Inorg P (mg/L)	Chloro a (µg/L)	Org P (mg/L)	Comment
LAG533466	0.000183	2.0	103.5	7.5	15	2	0.34	10	0.09	Point source
Bayou Traverse	3.88	4.4	19	7.5	0.86	0.04	0.51	75	0.37	Tributary
Bayou Trepagnier	3.88	5.6	9	7.5	0.17	0.04	0.34	23	0.09	Tributary
LGLD4	3.88	5.9	9	1.1	0.9	0.04	0.20	23	0.20	Tributary

4.10 Calibration and Sensitivity Analysis

4.10.1 Calibration

Model calibration is a critical step for model development. Calibration data must be obtained for all the parameters of the model at the same time, or as close to concurrently as practicable. Only data taken in that manner can be used for the calibration because many of the parameters and rates depend on each other. Analysis of the data for calibration indicated some conditions that formed assumptions in the model. The process of calibration confirms assumptions or requires revised assumptions. In certain instances, calibrated models are not required to produce valid TMDLs.

Model calibration also depends on the available data and should not be considered data matching. For this model, the magnitude and spatial trends are all captured with reasonable assignment of kinetic rates. Rates were not purposely changed in each reach to exactly match data. The calibration period was selected to coincide with the intensive field monitoring that occurred in August 2009. The data used for calibration are the averages of sampling results during the measurement period from August 4-6, 2009. These dates were selected for calibration because they were the only dates for which data were available. This period is considered the critical condition period because high temperatures decrease DO saturation values and increase rates of oxygen-demanding processes, such as CBOD decay, nitrification, and SOD.

Model calibration was a multi-step process using algae, ammonia, $CBOD_u$, and SOD concentrations for each reach, starting with the most upstream reach and working down to the outflow reach. The ammonia and nitrate loads were adjusted so that the predicted nitrogen concentrations would match the observed concentrations. After ammonia was calibrated, the $CBOD_u$ loads were adjusted until the predicted $CBOD_u$ concentrations were similar to the observed concentrations. SOD and algae (chlorophyll *a*) then were adjusted until the predicted DO concentrations were similar to the observed concentrations. Once algae levels were determined, DO swing was calculated using the delta method as shown in Equation 1 (Lung 2001). The daily maximum and minimum DO were computed using the averaged DO from LA-QUAL and the DO swing range from the delta method.

$$\Delta = P_{av}\frac{\left(1-e^{-K_a fT}\right)\left(1-e^{-K_a T(1-f)}\right)}{fK_a\left(1-e^{-K_a fT}\right)}$$

where

Δ = range of diurnal DO (mg/L)
K_a = re-aeration coefficient (1/day)
f = photoperiod (0–1.0). For Bayou Labranche, 0.56 was used based on the location and date.
T = 1 day
$P_{av} = a \times Chl\ a$, daily average photosynthetic DO production (mg/L/day)
$Chl\ a$ = chlorophyll *a* concentration (µg/L)
a = coefficient to convert chlorophyll *a* concentration to daily DO production.

The parameter *a* has to be determined in order to use the equation to calculate the DO swing. In Bayou Labranche, diurnal DO was measured at monitoring station LB2, and the range from minimum to maximum was 7.12 mg/L. Although not measured directly at LB2, chlorophyll *a* was monitored at CR5 (75 µg/L). The re-aeration rate was determined through LA-QUAL calibration for the average DO. Using these data, *a* was determined to be 0.2236—very similar to the literature value 0.25 (Lung 2001). The calculation values for the equation are show in Table 4-5. Once the parameter *a* (0.2236) was determined, the equation was used to examine the DO range at each model element in Bayou Labranche using the LA-QUAL computed re-aeration rate and chlorophyll *a* level for the baseline and TMDL conditions. The lowest DO at each model element then was calculated as the LA-QUAL simulated daily average DO minus half of the DO fluctuation range.

Table 4-5. Delta method calculation values

Parameter	Value-Initial	Notes
K_a (1/d)	1.180	Re-aeration coefficient.
Latitude	30.04228	
Longitude	-90.36624	
Year	2009	
Month	8	
Day	3	
Time zone	-6	time zone in hours relative to GMT/UTC
Day light savings	1	daylight savings time (0=no, 1=yes)
Sunrise	6:21 AM	Calculated from latitude, longitude, & date
Sunset	7:53 PM	Calculated from latitude, longitude, & date

Parameter	Value-Initial	Notes
Photo period (hours)	13.5	f = photoperiod
Daily average photosynthetic DO production (mg/L/day)	16.77	P_{av} = daily average photosynthetic DO production
Time (day)	1	T
Delta	**7.12**	Range of diurnal DO

Table 4-6 lists the loadings for calibration conditions, which were based on existing conditions. Overall, the model did well in predicting the observed values for temperature, ammonia, $CBOD_u$, algae, and DO, and was considered adequately calibrated on the basis of the data available. Plots of observed and calibration water quality are presented in Appendix F. Figure 4-2 is an example calibration plot.

Table 4-6. Calibration (existing) model loadings

Subsegment	Loadings (lb/d)			
	SOD	$CBOD_u$	Ammonia as N	Organic N as N
041201	1,029	3,947	70	628

4.10.2 Processes Identified through Calibration

The conclusion based on calibration of the model is that the low DO problem within Bayou Labranche is mainly caused by algae and SOD on the bottom of the Bayou. CBOD and ammonia discharges to the lake also contribute to DO depletion.

4.10.3 Sensitivity Analysis

Because a mathematical model is a simplified representation of the real world, its prediction is often subject to considerable uncertainty from a variety of sources. These sources include over-simplification of modeling assumptions and formulations, noise-distorted data, and model parameter values. It is important to gain a better understanding of a model's reliability by analyzing the uncertainty associated with a model. Sensitivity analysis is a prime method of measuring a model's uncertainty and reliability. Sensitivity is related to the actual waterbody or water system. For example, re-aeration in a narrow mountain stream is highly related to velocity, while re-aeration for a wide river in a flat area is related to both wind and water velocities. Sensitivity runs will provide useful information for understanding the physical, chemical, and biological processes within a specific waterbody. In this model, the sensitivity of the DO concentration to various parameters was examined. The analysis was performed by assessing the effects of the following:

- Velocity
- Dispersion
- Re-aeration
- CBOD aerobic decay rate
- Background SOD
- Algae growth rate

SOD results from deposition of dead phytoplankton and other organic matters from the watershed, and directly influences DO levels in the water column. CBOD loading from the watershed contributes to the oxygen demand and can be the source of SOD. Therefore, SOD is included in the sensitivity analysis.

A sensitivity analysis was performed on the model parameters using the sensitivity function built into LA-QUAL. LA-QUAL automatically changed the requested parameters by a set amount while keeping all other parameters constant. The calibration scenario was used as the baseline for the sensitivity analysis. For the analysis, all parameters were varied by ±30 percent. The results for CBOD and DO are shown in Table 4-7. Result plots are included in Appendix G.

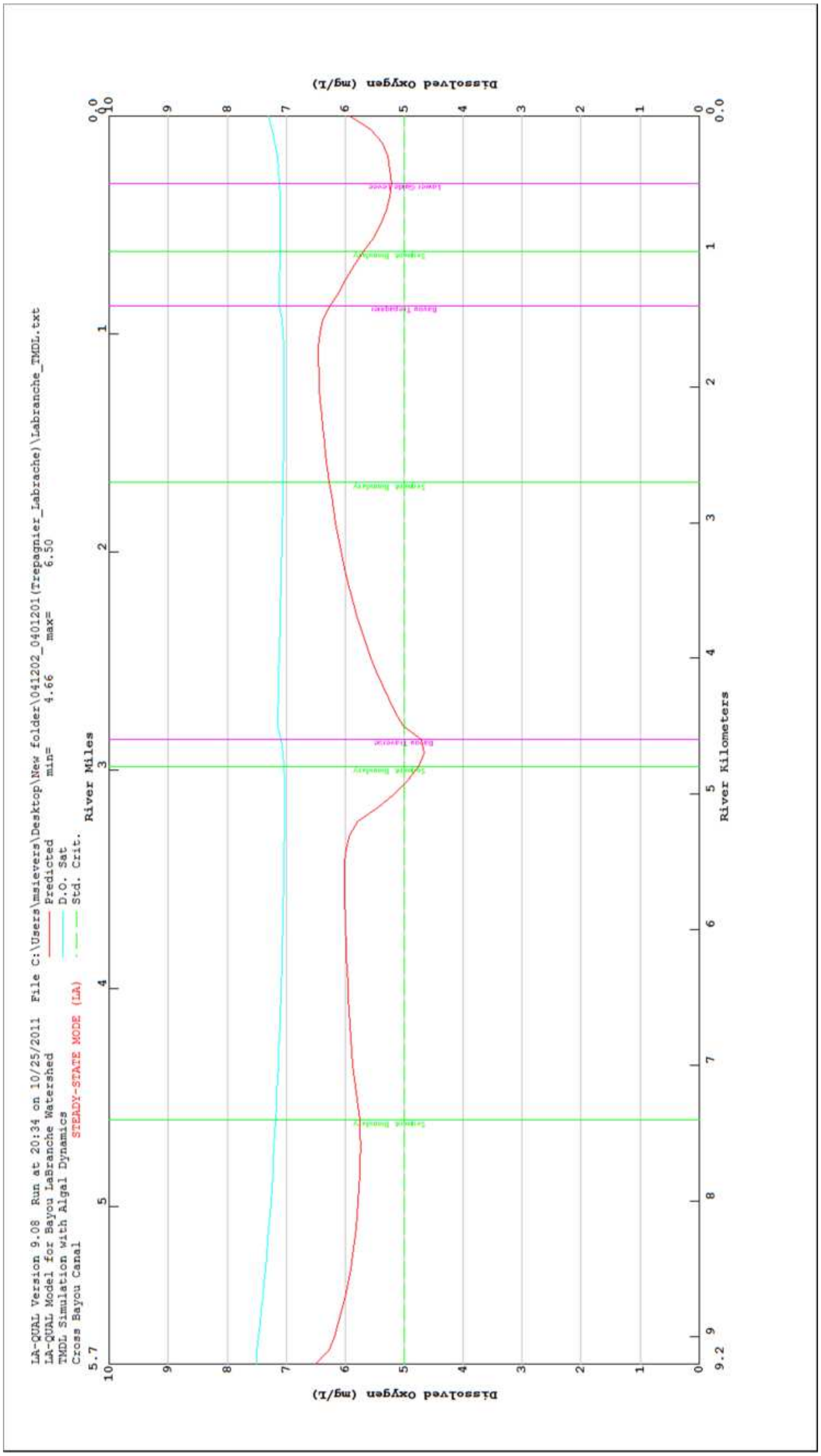

Figure 4-2. Calibration plot for DO in subsegment 041201.

Table 4-7. Results of sensitivity analysis

	DO min/max (mg/L)						CBOD$_U$ min/max (mg/L)					
	CBOD aerobic decay rate	Dispersion	Reaeration	Background SOD	Velocity	Phyto growth	CBOD aerobic decay rate	Dispersion	Reaeration	Background SOD	Velocity	Phyto growth
base	2.00/5.63	2.00/5.63	2.00/5.63	2.00/5.63	2.00/5.28	2.00/5.63	6.26/34.41	6.26/34.41	6.26/34.41	6.26/34.41	6.26/34.41	6.26/34.41
30%	2.00/5.34	2.00/5.63	2.00/6.09	2.00/5.20	2.00/5.28	2.00/6.40	5.93/34.41	6.26/34.41	6.26/34.41	6.26/34.41	7.24/34.41	6.28/34.41
-30%	2.00/5.96	2.00/5.63	1.95/4.90	2.00/6.07	2.00/6.27	2.00/4.90	6.65/34.41	6.26/34.41	6.26/34.41	6.26/34.41	5.24/34.41	6.24/34.41

Discussion of each sensitivity variable is as follows:

- When the stream velocity is increased or decreased, DO, re-aeration rate, and transport can change. While an increase of re-aeration rate can increase DO concentration, faster transport can move low DO water from upstream to downstream quicker. Therefore, DO can increase or decrease, depending on the site-specific environment.
- Stream dispersion mixes and spreads material longitudinally. The sensitivity results show no change of DO with increased or decreased dispersion.
- Stream re-aeration rate governs how fast oxygen transfers through the air-water interface. High re-aeration rate brings the amount of DO in water closer to the saturation level of DO. In Bayou Labranche, DO increases with higher re-aeration rate and decreases with lower re-aeration rate,
- BOD is one cause of DO depletion. When CBOD decays, oxygen is used. The sensitivity results show that DO can change significantly when decay rates change: a high level of CBOD and 30 percent change of BOD decay rate can change DO consumption significantly.
- DO is sensitive to background SOD rates. When SOD rate increases, DO decreases. When SOD rate decreases, DO increases.
- DO is also sensitive to algae growth rate. When algae growth rate increases, more DO is generated by photosynthesis, and the daily average DO increases. On the other hand, when algae growth rate decreases, less DO is generated and the daily average DO decreases.

5. Dissolved Oxygen Model Projection

EPA's regulations at 40 CFR 130.7 require that parties determining TMDLs take into account critical conditions for stream flow, loading, and water quality parameters. The calibrated model was used to project water quality for summer and winter critical conditions. Two scenarios were run for each season's critical conditions: baseline and TMDL. The model run for baseline conditions used the same water quality and model parameters as the calibration model; however, the flow and temperature were changed to critical conditions, and effluent water qualities from permitted dischargers were changed to permit limits. The TMDL model run was the same as the baseline run except for reductions of pollutant loadings to have DO meet criteria at all locations. This section describes identification of critical conditions, temperature inputs, headwater and tributary (wasteload) inputs, point source inputs, baseline model results, and TMDL reduction model rates. Appendix H contains the baseline output files, and Appendix I contains the TMDL output files. The output files include the input parameters.

5.1 Identification of Critical Conditions

The LDEQ LTP defines critical conditions in terms of flow and temperature. For tidal creeks, one-third of flow under calibration condition was considered as the background flow for baseline summer and winter conditions. Flow measurements were conducted at different times and locations along the bayou. EPA used elevation data to identify the relationship between flow and water elevation. Even though the flows were observed at different locations, the timing was more important for the flow direction and magnitudes. These flows were lumped together, and an assumption was made that the measurements covered the tidal periods. EPA used these measurement data to calculate the average flow.

5.2 Temperature Inputs

The critical temperatures for the headwaters were based on the 90th percentile temperature of LDEQ ambient monitoring in the representative subsegment. For summer conditions, a critical temperature of 30 degrees Celsius (°C) was used for wasteload inputs, unless the temperature was already greater than 30 °C, in which case the temperature was kept the same as calibration. For winter conditions, a critical temperature of 20 °C was used for incremental and wasteload inputs. The most critical time of year for meeting a constant DO standard is the period of high temperatures and low flows.

5.3 Headwater and Tributary (Wasteload) Inputs

The inputs for the headwater and tributaries for the summer and winter projections simulation were based on guidance in the LTP. The tributaries are also under the influence of tide. Therefore, one-third of the flow under calibration condition was used for tributaries.

DO from headwaters and tributaries was set to 90 percent of saturation level of DO. CBOD levels from headwaters and tributaries were reduced until modeled DO met the criteria. Ammonia levels were low from both the headwaters and tributaries; therefore, the ammonia inputs were not changed from the calibration values.

5.4 Point Source Inputs

Input point sources were kept the same as the calibration inputs. The tributary flows were reduced to simulate critical conditions.

5.5 Baseline Model Results

The calibrated model was run for a baseline condition. Baseline conditions are run under critical temperature and water flow conditions for both summer and winter using calibrated parameters and water quality values. The baseline condition is essentially the starting point for TMDL analysis from which loading reductions are made, because the baseline condition represents critical conditions and the calibrated model. Plots of baseline water quality are presented in Appendix J. Table 5-1 presents the baseline loadings for subsegment 041201.

Table 5-1. Baseline model loadings

Season	Loadings (lb/d)			
	SOD	$CBOD_u$	Ammonia as N	Organic N as N
Summer	1,103	1,318.1	23.33	210.52
Winter	473	1,318.1	23.33	210.52

5.6 TMDL Reduction Model Results

The model demonstrates that with loading reductions, the canal will meet DO criteria. For projection runs, the flow and weather conditions were kept identical to the baseline conditions. Only load inputs such as SOD, CBOD, and nutrients from the drainage basin were changed in order to determine loadings for the TMDL.

Several steps were used to develop the reduction percentages for oxygen demand. The TMDL was calculated by first iteratively reducing SOD. After meeting the DO criterion by reducing SOD, the CBOD reduction rate was calculated by the SOD/CBOD relationship ($SOD = a \times \sqrt{CBOD}$). This equation assumes that the settled $CBOD_u$ is linearly related to the $CBOD_u$ load. The loading of CBOD is in mg/L of O_2 and the settled CBOD is in $m/m^2/d$ of O_2. Slight adjustments were made to the SOD reduction rate, and an updated CBOD reduction rate was calculated. Then nutrients were reduced to reduce algae level at the same reduction rate as for CBOD. This process was repeated until the optimal reduction rates were determined.

Plots of TMDL water quality are presented in Appendix K.

6. Dissolved Oxygen TMDL Development

A TMDL is the total amount of a pollutant that a receiving waterbody can assimilate while still achieving water quality standards. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established, thereby providing the basis for establishing water quality-based controls.

A TMDL for a given pollutant and waterbody is calculated using the sum of individual WLAs for point sources and LAs for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality, and it may include a future growth (FG) component. The components of the TMDL are illustrated using the following equation:

$$TMDL = \Sigma\, WLAs + \Sigma\, LAs + MOS + FG$$

This TMDL establishes LAs for oxygen-demanding substances and goals for reduction of those pollutants. LDEQ’s position is that when oxygen-demanding loads are reduced in order to ensure that the DO criterion is supported, nutrients are also reduced. Implementation of this TMDL through discharge permits, along with application of best management practices (BMPs) to control and reduce runoff of oxygen-demanding pollutants will also reduce nutrient loading from those sources.

6.1 TMDLs, WLAs, and LAs

The DO TMDLs are presented as oxygen demand from $CBOD_u$, ammonia nitrogen, and SOD, and they were derived using the LA-QUAL model. A summary of the TMDLs is presented in Table 6-1. The TMDLs were calculated from SOD, $CBOD_u$, ammonia, and organic nitrogen from nonpoint source model inputs, tributary flows, incremental flows, and background data.

Table 6-1. Summary of DO TMDLs, WLAs, LAs, MOSs, and FGs

Season	Loadings (lb/d)							
Summer	SOD		$CBOD_u$		Ammonia as N		Organic N as N	
	Baseline	TMDL	Baseline	TMDL	Baseline	TMDL	Baseline	TMDL
WLA	200.9	100.4	240.23	60.46	4.267	1.297	38.359	11.532
LA	681.3	340.6	814.22	204.54	14.394	4.323	130.058	39.074
MOS	110.3	55.1	131.81	33.13	2.333	0.702	21.052	6.326
FG	110.3	55.1	131.81	33.13	2.333	0.702	21.052	6.326
TMDL	1,102.7	551.3	1,318.06	331.26	23.326	7.025	210.521	63.258
Percent reduction	50.0%		74.9%		69.9%		70.0%	
Season	Loadings (lb/d)							
Winter	SOD		$CBOD_u$		Ammonia as N		Organic N as N	
	Baseline	TMDL	Baseline	TMDL	Baseline	TMDL	Baseline	TMDL
WLA	86.1	75.0	240.23	181.86	4.27	3.23	38.36	34.27
LA	292.1	254.5	814.22	616.25	14.39	10.88	130.06	116.18
MOS	47.3	41.2	131.81	99.76	2.33	1.76	21.05	18.81
FG	47.3	41.2	131.81	99.76	2.33	1.76	21.05	18.81
TMDL	472.7	411.9	1,318.06	997.64	23.33	17.64	210.52	188.07
Percent reduction	12.9%		24.3%		24.4%		24.9%	

6.1.1 Wasteload Allocation

The WLA portion of the TMDL equation is the total loading of a pollutant that is assigned to point sources. Permitted or average (expected or observed) flows were used to calculate the WLAs.

EPA's stormwater permitting regulations require municipalities to obtain permit coverage for all stormwater discharges from MS4s. For each MS4 in the basin, a gross MS4 load was computed by multiplying the LA by the ratio of the MS4 area in each subsegment (4,541 acres) to the subsegment area (19,942 acres). Note that these values are estimates that can be refined in the future as more information about the MS4s and land-use-specific loadings becomes available. Note also that the MS4 loads presented reflect only that portion of the MS4 in the subsegment. The computed MS4 load was subtracted from the LA and included as a WLA component of the TMDL because MS4s are permitted dischargers but function similarly to nonpoint sources (through storm-driven processes). In addition, the TMDL was developed for critical low flow conditions, when stormwater is not expected to play a role in loadings.

The WLAs are presented in Table 6-2. The point source discharge did not need to be reduced. Table 6-3 lists the individual WLAs for the MS4s identified in Section 2.5. Although 25 permitted point sources dischargers were in subsegment 041201, only one facility was provided a WLA. LPDES permitted discharges without DO or nutrient effluent limitations have been determined not to be sources of these. For those dischargers, EPA is not providing allocations or permit limits. If at some time in the future, LDEQ determines that any of the discharges may contain these parameters, WLAs may be specified along with the appropriate permit conditions. MS4 WLAs should not be used as permit limits. Permit limits will not be applied to MS4 permittees. EPA expects that the MS4 WLAs will be achieved through BMPs and adaptive management.

Table 6-2. WLAs for subsegment 041201 in the Lake Pontchartrain Basin

Agency interest (AI) #	NPDES permit #	Outfall	Facility name	Flow type	Flow (gpd)	Units	BOD_5	$CBOD_u$	Amm	Org N
170587	LAG533466	001	Metro Investment LLC - WWTP	Average	180	Concentration (mg/L)	45	103.5	15	7.5
						Loading (lb/d)	0.068	0.155	0.023	0.011

Note: The official WLA is $CBOD_u$. BOD_5 is presented as a comparison to a commonly measured parameter. BOD_5 is converted to $CBOD_u$ by assuming that BOD_5 was approximately equal to $CBOD_5$ and then using a conversion factor of 2.3 to convert to $CBOD_u$.

Table 6-3. Summary of WLAs for MS4s subsegment 041201 in the Lake Pontchartrain Basin

NPDES permit #	Agency interest (AI) #	Urban area (UA)	MS4 area (acres)	Season	Pollutant	MS4 (lb/d)
LAR041032	115009	St Charles Parish Government - Municipal Separate Storm Sewer System	4,541.00	Summer	$CBOD_u$	60.31
					Organic nitrogen as N	11.52
					Ammonia as N	1.275
					SOD	100.44
				Winter	$CBOD_u$	181.70
					Organic nitrogen as N	28.79
					Ammonia as N	3.209
					SOD	75.04

The estimated annual runoff from the MS4 can be calculated with the following equation.

$$R = P \times Pj \times Rv$$

where

R = Annual runoff (inches)

P = Annual rainfall (inches)

Pj = Fraction of annual rainfall events that produce runoff (usually 0.9)
Rv = Runoff coefficient

Because watershed imperviousness is a reasonable predictor of the runoff coefficient, the runoff coefficient was substituted using the following equation.

$$Rv = 0.05 + 0.9Ia$$

where
Ia = Impervious fraction

The estimated annual runoff from the MS4 was calculated to be 12.0 inches per year. For that calculation, the average annual rainfall (58 inches) was calculated using the past 14 years of complete data collected by the National Climatic Data Center at New Orleans International Airport. The impervious fraction of the MS4 was estimated to be 20 percent using USGS impervious cover information. Once the runoff in inches was calculated, it was multiplied by the area to obtain the runoff is 1,480 million gallons per year (4.06 million gallons per day [mgd]).

6.1.2 Load Allocation

The LA is the portion of the TMDL assigned to nonpoint sources such as natural background loadings or upstream loading, however there is no upstream loading for this waterbody. For this TMDL, the LA was calculated by subtracting the WLA, MOS, and FG from the total TMDL allocation. LAs were not allocated to separate nonpoint sources because source characterization data were unavailable. The LA covers the 24 square miles area not covered in the MS4 WLA (Table 6-3).

6.2 Seasonality and Critical Condition

The federal regulations at 40 CFR 130.7 require that TMDLs include seasonal variations and take into account critical conditions for stream flow, loading, and water quality parameters. The sampling results for all pollutants were plotted over time and reviewed for any seasonal patterns (see Section 3). The water quality criteria for DO apply all year, accounting for seasonal variations. This TMDL was developed under critical conditions, providing a conservative year-round TMDL.

Critical conditions for DO have been determined as negligible nonpoint runoff and low-stream flow combined with high water temperatures. Oxygen-demanding substances can enter a water system during higher flows and settle to the bottom, where they exert a large oxygen demand during the high-temperature/low-flow seasons. Water temperature is one of the leading factors affecting DO in the segment. High water temperatures lower the DO saturation concentration, decreasing the amount of DO that the stream can contain. Moreover, high temperature increases CBOD decay and SOD. Therefore, it is most important to develop a TMDL to address the high-water-temperature conditions. Ambient water quality data from LDEQ show that low DO concentrations occur during the summer months.

6.3 Margin of Safety

Section 303(d) of the Clean Water Act and the regulations at 40 CFR 130.7 require that TMDLs include an MOS to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. The MOS may be expressed explicitly as unallocated assimilative capacity or implicitly using conservative assumptions in establishing the TMDL. In addition to the MOS, an FG component may be added to account specifically for FG in the TMDL area.

The MOS can be incorporated in two ways (USEPA 1991). One way is to implicitly incorporate it by using conservative model assumptions to develop allocations, including using the DO water quality criteria for model inflows. DO from headwaters and tributaries was set to the water quality criterion, which is lower than the 90 percent saturation level of DO at 30 ºC.

The other way to incorporate the MOS is to explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For this analysis, the MOS is explicit: 10 percent of each targeted TMDL was reserved as the MOS. Using 10 percent of the TMDL load provides an additional level of protection to the designated uses of the subsegments of concern.

6.4 Future Growth

The FG is an allocation for growth. Ten percent of the load was allocated for FG within the area covered by the TMDL. This growth includes future urban development, including point sources, MS4 areas, agriculture, and other nonpoint sources. The FG could also be used for unaccounted or unknown sources not included in the TMDL.

7. Future Activities

This section discusses TMDL implementation strategies, environmental monitoring activities, and stormwater permitting requirements and presumptive BMPs for the TMDL conducted for the Bayou Labranche.

7.1 TMDL Implementation Strategies

Current TMDL requirements do not require inclusion of implementation plans in TMDL reports. Louisiana is responsible for developing and implementing the TMDL implementation plans. Section 303(d) of the Clean Water Act and the implementing regulations at 40 CFR 130.7 state that EPA has no authority to approve or disapprove TMDL implementation plans.

WLAs will be implemented through LPDES permit procedures. LDEQ was delegated to manage the NPDES program in August 1996, and LDEQ is responsible for all permits covered by the delegation package. As part of that designation, a Memorandum of Agreement (MOA) was established between LDEQ and EPA. The designation and memorandum were revised in April 2004. In accordance with Section 1.C of the NPDES MOA between LDEQ and EPA (Revision 1, April 28, 2004), EPA has the responsibility of providing continued technical and other assistance, including interpreting and implementing federal regulations, policies, and guidelines on permitting and enforcement matters. The MOA further states that LDEQ has primary responsibilities for implementing the LPDES program in Louisiana, including applicable sections of the federal Clean Water Act, applicable state legal authority, the applicable requirements of 40 CFR Parts 122–125, and any other applicable federal regulations establishing LPDES program priorities with consideration of EPA Region 6 and national NPDES goals and objectives. For details on the designation and agreement, see the EPA Region 6 website http://www.epa.gov/region6/water/npdes/docs/louisiana-moa.pdf.[2] LDEQ's position is that, if any unresolved LDEQ comments regarding these TMDLs become the basis for an EPA Region 6 objection to an LDEQ-drafted permit or permittee objection/appeal of an LDEQ drafted permit, LDEQ may relinquish permitting authority to EPA Region 6.

7.2 Environmental Monitoring Activities

LDEQ uses funds provided under section 106 of the Clean Water Act and under the authority of the Louisiana Environmental Quality Act to run a program for monitoring the quality of Louisiana's surface waters. The LDEQ Surveillance Section collects surface water samples at various locations using appropriate sampling methods and procedures to ensure the quality of the data obtained. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term database for water quality trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program are used to develop the state's biennial section 305(b) report (*Water Quality Inventory*) and section 303(d) list of impaired waters (*Final 2010 Integrated Report*).

LDEQ has implemented a rotating approach to surface water quality monitoring. Through the rotating approach, the entire state is sampled on a 4-year cycle. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the 4-year cycle. Sampling is conducted monthly during a water year (October through September) to yield approximately 12 samples per site during each year the site is monitored. Sampling locations are selected to be representative of the waterbody. Under the current monitoring schedule, approximately one-half of the state's waters are newly assessed for section 305(b) and section 303(d) listing purposes for each biennial cycle. Monitoring allows LDEQ to determine whether any improvement in water quality occurs after implementation of the TMDLs. LDEQ evaluates the monitoring results to generate the Integrated Report submitted by April 1 in even-numbered years. More information can be found in *Louisiana's Water Quality Assessment Method and Integrated Report Rationale: 2010 Water Quality Integrated Report* (LDEQ 2010a). Monitoring will allow LDEQ to determine whether water quality improves following TMDL

[2] Accessed March 13, 2012.

implementation. As the monitoring results are evaluated at the end of each year, waterbodies might be added to or removed from the section 303(d) list of impaired waterbodies.

Two watershed coordinators have been hired to work with the Lake Pontchartrain Basin Foundation (LPBF) on stakeholder involvement in watershed plans. LDEQ's nonpoint source staff is also cooperating with the LPBF to implement these plans, and will be assigned work on additional watersheds through the planning and implementation process. In order to address some of the known problems within this basin, LDEQ has been implementing programs that address fecal coliform, DO, and mercury—the primary water quality problems identified within these waterbodies. The LPBF has implemented many programs to restore water quality, and will be an important partner for LDEQ as TMDLs are implemented within the basin. Because much of the basin is included within the Coastal Zone Boundary, Louisiana Department of Natural Resources – Coastal Management Division will be working with LDEQ and LPBF on implementation of management measures required through the Coastal Nonpoint Source Pollution Control Program (LDEQ 2010c).

7.3 Stormwater Permitting Requirements and Presumptive Best Management Practices Approach

7.3.1 Background

The NPDES permitting program for stormwater discharges was established under the Clean Water Act as the result of a 1987 amendment. The Act specifies the level of control to be incorporated into the NPDES stormwater permitting program depending on the source (industrial versus municipal stormwater). These programs specify requirements for the regulated communities/facilities to establish a comprehensive stormwater management program (SWMP) or stormwater pollution prevention plan (SWPPP) to implement any requirements of the TMDL allocation (see 40 CFR Part130).

Stormwater discharges vary significantly in flow and pollutant concentration, and the relationships between discharges and water quality can be complex. For municipal stormwater discharges in particular, the use of system-wide permits and a variety of jurisdiction-wide BMPs, including educational and programmatic BMPs, does not easily accommodate to the existing methodologies for deriving numeric water quality-based effluent limitations. These methodologies were designed primarily for process wastewater discharges, which occur at predictable rates with predictable pollutant loadings under low-flow conditions in receiving waters. EPA has recognized such problems and developed permitting guidance for stormwater permits (USEPA 1996).

Because of the nature of stormwater discharges, and typical lack of information on which to base numeric water quality-based effluent limitations (expressed as concentration and mass), EPA recommends basing an interim permitting approach for NPDES stormwater permits on BMPs. EPA permitting guidance states that, "[t]he interim permitting approach uses BMPs in first-round storm water permits, and expanded or better-tailored BMPs in subsequent permits, where necessary, to provide for the attainment of water quality standards" (USEPA 1996).

A monitoring component is also included in the recommended BMP approach. According to EPA permitting guidance, "each storm water permit should include a coordinated and cost-effective monitoring program to gather necessary information to determine the extent to which the permit provides for attainment of applicable water quality standards and to determine the appropriate conditions or limitations for subsequent permits" (USEPA 1996). This approach was further elaborated in a guidance memo issued in 2002: "The policy outlined in this memorandum affirms the appropriateness of an iterative, adaptive management BMP approach, whereby permits include effluent limits (e.g., a combination of structural and nonstructural BMPs) that address stormwater discharges, implement mechanisms to evaluate the performance of such controls, and make adjustments (i.e., more stringent controls or specific BMPs) as necessary to protect water quality. … If it is determined that a BMP approach (including an iterative BMP approach) is appropriate to meet the stormwater component of the TMDL, EPA recommends that the TMDL reflect this" (Wayland and Hanlon 2002). This BMP-based approach to stormwater sources in TMDLs is also recognized and described in the most recent EPA guidance (USEPA 2008).

This TMDL adopts the EPA-recommended approach and relies on appropriate BMPs for implementation. No numeric effluent limitations are required or anticipated for municipal stormwater discharge permits.

7.3.2 Specific SWMP/SWPPP Requirements

As discussed in the Louisiana Small MS4 NPDES permit, if a TMDL assigns an individual WLA specifically to an MS4's stormwater discharge, LDEQ's permit specifies that the WLA must be included as a measurable goal for the SWMP.

Examples of activities that the MS4 may conduct to be consistent with the WLA include the following:

- Monitoring to evaluate program compliance, the appropriateness of identified BMPs, and progress toward achieving identified measurable goals
- Development of a schedule for implementation of additional controls and/or BMPs, if necessary, on the basis of monitoring results, to ensure compliance with applicable TMDLs.

8. Public Participation

Federal regulations require EPA to notify the public and seek comments concerning the TMDLs EPA prepares. These TMDLs were developed under contract to EPA, and EPA held a public review period seeking comments, information, and data from the public and any other interested parties. The notice for the public review period was published in the *Federal Register* on December 6, 2011. The review period closed on January 20, 2012.

Comments were received from LDEQ. EPA reviewed the comments and referred to them while revising and finalizing this TMDL document, as necessary. Full comment text is included in Appendix L. Responses to the comments are included in Appendix M.

EPA will submit the final TMDL to LDEQ for implementation and incorporation into LDEQ's water quality management plan.

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