TMDLS FOR DISSOLVED OXYGEN AND NUTRIENTS FOR LOST LAKE AND FOUR LEAGUE BAY, LOUISIANA (SUBSEGMENT 120708)

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Prepared for

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EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to identify waterbodies that are not meeting water quality standards and to develop total maximum daily pollutant loads for those waterbodies. A total maximum daily load (TMDL) is the amount of pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant. Through a TMDL, pollutant loads can be distributed or allocated to point sources and nonpoint sources discharging to the waterbody. This report presents TMDLs that have been developed for dissolved oxygen (DO) and nutrients for Lost Lake and Four League Bay (Subsegment 120708) in the Terrebonne basin in southern Louisiana.

Subsegment 120708 (Lost Lake and Four League Bay) is located approximately 25 to 30 miles south of Morgan City in southern Louisiana, adjacent to the Gulf of Mexico This subsegment covers 189.6 square miles and the predominant land uses are wetlands (58.7%) and open water (39.7%). There are no towns or communities in this subsegment. The only point source discharges in this subsegment are from facilities involved in oil and gas exploration, production, and/or development.

Subsegment 120708 was cited as being impaired on the final 2004 303(d) list for Louisiana as not fully supporting the designated use of propagation of fish and wildlife. It was ranked as priority #2 for TMDL development. The causes for impairment cited in the 303(d) list included low DO and nutrients. The DO criterion specified in the Louisiana water quality standards for this subsegment is 5 mg/L year-round. There are no numeric criteria for nutrients in Louisiana.

A water quality model (LA-QUAL) was set up to simulate DO, carbonaceous biochemical oxygen demand (CBOD), ammonia nitrogen, and organic nitrogen in Lost Lake and Four League Bay. The model was set up and calibrated using data from a field survey conducted by FTN Associates, Ltd. (FTN) during July 2006. The data collected during the field survey included stream flows, depths, widths, and water quality data (both in situ parameters and laboratory analyses of samples).

The summer and winter projection simulations were run at critical temperatures to address seasonality as required by the Clean Water Act. A 23% reduction of existing nonpoint source loads was required for the summer projection simulation to show the DO criterion of 5 mg/L being maintained. No nonpoint source load reductions were necessary for the winter projection. In general, the modeling in this study was consistent with guidance in the Louisiana TMDL Technical Procedures Manual.

A TMDL for oxygen-demanding substances (CBOD, ammonia nitrogen, organic nitrogen, and sediment oxygen demand) was calculated using the results of the summer and winter projection simulations. An implicit margin of safety (MOS) was established for the DO TMDL through the use of conservative assumptions in the water quality modeling. Additionally, 10% of the allowable loading was set aside as an explicit MOS and another 10% of the allowable loading was set aside for future growth (FG). Results of the DO TMDL calculations are summarized in Tables ES.1 and ES.2.

A nutrient TMDL was developed for this subsegment using allowable nitrogen loads from the DO modeling and a naturally occurring ratio of total nitrogen to total phosphorus from reference waterbodies. No reductions of existing nutrient loads are needed because average concentrations of total nitrogen and total phosphorus were lower in this subsegment than in the reference waterbodies. The nutrient TMDL included an explicit MOS equal to 10% of the TMDL and an explicit FG allowance equal to 10% of the TMDL. The nutrient TMDL is summarized in Table ES.3.

The DO TMDL establishes load limitations for oxygen-demanding substances and goals for reducing those pollutants. When oxygen-demanding substances are controlled and limited to ensure that the DO criterion is supported, nutrients are also controlled and limited. Implementing the DO TMDL through future wastewater discharge permits, if required, and implementing best management practices to control and reduce oxygen-demanding pollutants from nonpoint sources in the watershed will also control and reduce the nutrient loading from those sources.

Table ES.1. Summer DO TMDL for Subsegment 120708.

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	
Point Sources											
WLA	NA	0	0	0	0	NA	0	0	0	0	0%
MOS	NA	0	0	0	0	NA	0	0	0	0	NA
FG	NA	0	0	0	0	NA	0	0	0	0	NA
Nonpoint Sources											
LA	100566	122275	10658	1.66	233502	221748	269616	23501	3.66	514872	23%
MOS	12571	15285	1332	0.21	29188	27719	33703	2937	0.46	64360	NA
FG	12571	15285	1332	0.21	29188	27719	33703	2937	0.46	64360	NA
TMDL	125708	152845	13322	2.08	291878	277186	337022	29375	4.58	643592	NA

Table ES.2. Winter DO TMDL for Subsegment 120708.

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	
Point Sources											
WLA	NA	0	0	0	0	NA	0	0	0	0	0%
MOS	NA	0	0	0	0	NA	0	0	0	0	NA
FG	NA	0	0	0	0	NA	0	0	0	0	NA
Nonpoint Sources											
LA	67983	158800	13839	1.66	240623	149877	350154	30515	3.66	530483	0%
MOS	8498	19850	1730	0.21	30078	18735	43769	3815	0.46	66311	NA
FG	8498	19850	1730	0.21	30078	18735	43769	3815	0.46	66311	NA
TMDL	84980	198500	17297	2.08	300779	187349	437692	38145	4.58	663104	NA

Table ES.3. Nutrient TMDL for Subsegment 120708.

Season	Component	Loads in kg/day		Loads in lbs/day	
		Total Nitrogen	Total Phosphorus	Total Nitrogen	Total Phosphorus
Summer	LA	3,079.5	272.5	6,789.1	600.7
	WLA	0.0	0.0	0.0	0.0
	MOS	384.9	34.1	848.6	75.1
	FG	384.9	34.1	848.6	75.1
	TMDL	3,849.3	340.7	8,486.3	750.9
Winter	LA	3,997.5	353.7	8,813.0	779.8
	WLA	0.0	0.0	0.0	0.0
	MOS	499.7	44.2	1,101.6	97.5
	FG	499.7	44.2	1,101.6	97.5
	TMDL	4,996.9	442.1	11,016.2	974.8

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1.0 INTRODUCTION

This report presents total maximum daily loads (TMDLs) for dissolved oxygen (DO) and nutrients for Lost Lake and Four League Bay (Subsegment 120708). This subsegment was included on the final 2004 303(d) list for Louisiana (Louisiana Department of Environmental Quality (LDEQ) 2005) as not fully supporting the designated use of propagation of fish and wildlife. The priority ranking and the suspected sources and suspected causes for impairment from the 303(d) list are presented in Table 1.1. The TMDLs in this report were developed in accordance with Section 303(d) of the Federal Clean Water Act and the United States Environmental Protection Agency (USEPA) regulations at Title 40 Code of Federal Regulations (CFR) Part 130.7. The impairment for fecal coliforms in this subsegment has been addressed in a previous TMDL report (Tetra Tech 2007).

The purpose of a TMDL is to determine the pollutant loading that a waterbody can assimilate without exceeding the water quality standard for that pollutant and to establish the load reduction that is necessary to meet the standard in a waterbody. The TMDL is the sum of the wasteload allocation (WLA), the load allocation (LA), future growth (FG), and a margin of safety (MOS). The WLA is the load allocated to point sources of the pollutant of concern. The LA is the load allocated to nonpoint sources, including natural background. The FG is reserved for future increases in loads to the waterbody. The MOS is a percentage of the TMDL that accounts for any lack of knowledge concerning the relationships between pollutant loading and water quality, including uncertainty associated with model assumptions and data inadequacies.

Table 1.1. Summary of 303(d) listing for Subsegment 120708.

Subsegment Number	Waterbody Description	Suspected Causes	Suspected Sources	Priority Ranking (1 = highest)
120708	Lost Lake and Four League Bay	Low DO	Unknown source	2
		Nutrients	Unknown source	2
		Fecal Coliforms	Marina/Boating Sanitary On-vessel Discharges; Wildlife Other than Waterfowl	1

2.0 STUDY AREA DESCRIPTION

2.1 General Information

Subsegment 120708 (Lost Lake and Four League Bay) is located in the Terrebonne basin in southern Louisiana, adjacent to the Gulf of Mexico (see Figure A.1 in Appendix A). The lake and bay are located in the southern end of Terrebonne Parish approximately 25 to 30 miles south of Morgan City. Four League Bay is connected to Atchafalaya Bay on the west, connected to Lost Lake on the east by Blue Hammock Bayou, and on the south to the Gulf of Mexico via Oyster Bayou. There are no towns or communities in this subsegment. There has been significant oil and gas exploration activity southwest of Four League Bay. The subsegment area is 189.6 square miles.

The area southwest of Four League Bay has seen some wetlands restoration work as part of Louisiana's Coastal Wetlands Planning, Protection, and Restoration Act. The work has involved plugging several oil field canals and adding riprap to canal banks for bank stabilization. This will help restore the natural circulation in the bay.

2.2 Land Use

Land use characteristics for Subsegment 120708 were compiled from the United States Geological Survey (USGS) 2001 National Land Cover Database (USGS 2006). These data are the most recent land use data that are currently available for this area. The spatial distribution of these land uses is shown on Figure A.2 (located in Appendix A), and land use percentages are shown in Table 2.1. Almost all the subsegment is either water or wetlands.

Table 2.1. Land use percentages for Subsegment 120708.

Land Use Type	Percent of Total Area
Water	39.7%
Urban/Transportation	0.0%
Barren	1.6%
Forest	0.0%
Shrubland/Grassland	0.0%
Pasture/Hay	0.0%
Cultivated Crops	0.0%
Wetlands	58.7%
TOTAL	100.0%

2.3 Water Quality Standards

Water quality standards for Louisiana are listed in the Title 33 Environmental Regulatory Code (LDEQ 2007). The designated uses for Subsegment 120708 are primary contact recreation, secondary contact recreation, fish and wildlife propagation, and oyster propagation. The primary numeric criteria for the DO TMDL presented in this report are the DO criterion of 5 mg/L (year-round) and the temperature criterion of 35°C.

The Title 33 Environmental Regulatory Code does not include numeric criteria for nutrients, but it does include the following narrative criteria for nutrients (LAC 33: IX.1113.B.8):

> "The naturally occurring range of nitrogen-phosphorous ratios shall be maintained. This range shall not apply to designated intermittent streams. To establish the appropriate range of ratios and compensate for natural seasonal fluctuations, the administrative authority will use site-specific studies to establish limits for nutrients. Nutrient concentrations that produce aquatic growth to the extent that it creates a public nuisance or interferes with designated water uses shall not be added to any surface waters."

The Louisiana water quality standards also include an anti-degradation policy (LAC 33:IX.1109.A). This policy states that waters exhibiting high water quality should be maintained at that high level of water quality. If this is not possible, water quality of a level that supports designated uses of the waterbody should be maintained. Changing the designated uses of a waterbody to allow a lower level of water quality can only be achieved through a use attainability study.

2.4 Point Sources

A list of point sources in selected portions of the Terrebonne basin was developed using data from LDEQ's internal point source databases with additional information obtained from LDEQ's Electronic Document Management System. Using this information, seven point sources were identified within Subsegment 120708 (see Table 2.2). All of these point sources are facilities involved in oil and gas exploration, production, and/or development. A review of permits, applications, and discharge monitoring reports (DMRs) failed to produce evidence that these facilities are actually discharging sanitary wastewater or other oxygen-consuming effluent (even though discharges of sanitary wastewater are allowed in the general permits that start with LAG33...). Based on these findings, none of the point sources were included either in the water quality model or in the TMDLs.

Table 2.2. Point sources for Subsegment 120708.

Permit	Facility	Facility Type	Location	Receiving Waterbody
WP2472, LAG33A070 (AI = 17460)	Mobil Oil Exploration & Production SE Inc	Oil/Gas Exp Prod & Dev	Point Au Fer Field	Mosquito Bay - Ship Shoal
WP2759 (AI = 18464)	Energy XXI Gulf Coast Inc	Oil/Gas Exp Prod & Dev	Point Au Fer Field	Locust Bayou - Lake Chapeau - Burkes Bayou
WP3974 (AI = 89882)	Goodrich Oil Company	Oil/Gas Exp Prod & Dev	Mosquito Bay Field	Mosquito Bay
LAG33A037 (AI = 33011)	Mosquito Bay Field Facility	Oil/Gas Exp Prod & Dev	Mosquito Bay Field	Mosquito Bay
LAG33A453 (AI = 33017)	Four League Bay Production Facility	Oil/Gas Exp Prod & Dev	Four League Bay Field	Four League Bay
LAG33A548 (AI = 84748)	Mary A Smyth Nelson et al. #15 Production Facility	Oil/Gas Exp Prod & Dev	Point Au Fer Field	Locust Bayou
LA0120138 (AI = 124906)	State Lease 18150 Well #1	Oil/Gas Exp Prod & Dev	Four League Bay - Halter Island Field	Four League Bay

2.5 Nonpoint Sources

The 303(d) list did not cite any specific nonpoint sources as suspected sources of the DO and nutrient impairments for Subsegment 120708 (Table 1.1).

Individual nonpoint sources are not identified and quantified here because this TMDL focuses on total nonpoint source loading. Individual sources should be identified and quantified by state or local agencies if they develop an implementation plan.

2.6 Historical Data Summary

There is one LDEQ routine water quality monitoring station in this subsegment; it is Station 955 (Lost Lake west of Bayou De Cade, Louisiana). Its location is shown on Figure A.1 in Appendix A. The DO and nutrient data for this station are summarized in Tables 2.3 and 2.4, and the individual data are listed in Table B.1 in Appendix B. Using the entire period of record, the percent of DO values below the 5 mg/L criterion in the water quality standards is less than 10%, which is the allowable percentage of DO violations in USEPA's assessment guidance (USEPA 2002).

Table 2.3. Summary of LDEQ DO data for Subsegment 120708.

Monitoring Station	Period of Record	No. of Values	Min. (mg/L)	Median (mg/L)	Average (mg/L)	Max. (mg/L)	No. of Values Below 5 mg/L	Percent of Values Below 5 mg/L
Lost Lake west of Bayou De Cade	1/12/00-11/27/06	35	4.70	6.8	7.0	10.4	3	8.6%

Table 2.4. Summary of LDEQ nutrient data for Subsegment 120708.

Monitoring Station	Period of Record	Parameter	No. of Values	Min.	Median [(a)]	Average [(a)]	Max.
Lost Lake west of Bayou De Cade	1/12/00-11/27/06	NO_2+NO_3 (mg/L)	36	<0.05	<0.05	0.08	0.44
		Total Phos. (mg/L)	36	0.06	0.11	0.12	0.28
		TKN (mg/L)	36	0.56	1.02	1.06	1.98
		TOC [(b)] (mg/L)	29	6.7	9.6	9.8	13.2
		NH_3 (mg/L)	36	<0.10	<0.10	0.08	0.34

*Notes: a. Statistics were computed using half of the detection limit for values below the detection limit.
b. No TOC data were collected after April 2006.

Data from two other LDEQ stations, Station 1204 (Atchafalaya Bay south of Burns, Louisiana) and Station 957 (Caillou Bay south of Bayou Grand Caillou, Louisiana), are included

in Tables B.2 and B.3, respectively, in Appendix B. The tabular data for Station 1204 included an estimated flow for the Atchafalaya River using flow gage 07381600 (Lower Atchafalaya River at Morgan City). These data were used for boundary conditions in the water quality model.

2.7 Flow Patterns

This system is tidally influenced by the Gulf of Mexico. Stage data collected by the United States Army Corps of Engineers at Eugene Island (8 miles northwest of Four League Bay) are plotted on Figure C.1 in Appendix C. The water fluctuates by about 2.0 to 2.5 ft every day in addition to a monthly cycle as seen on the graph. This graph shows the system never reaches steady state with respect to flows.

2.8 Previous Studies

A previous study was found that investigated changes in seasonal water transport and flow patterns in Four League Bay (Denes and Caffrey 1988). Data were measured at several locations where water could enter or leave Four League Bay. The study consisted of three 50-hour sampling events in 1982 under different flow, tidal, and wind conditions to evaluate where and at what rate water enters and leaves Four League Bay. The study compared the predicted water surface elevations in the bay based on the measured data to the observed elevations. Part of the data in the first event was lost, so no conclusions were made from those data. In the last two events, the predicted and observed bay elevations were quite different. The study concluded that flows from the marsh may be more significant than flows from Oyster Bayou, Blue Hammock Bayou, and Atchafalaya Bay, but unfortunately, they had no measured flows from the marshes around the bay. The report also concluded that over the long term, changes in elevation and flow patterns are due to wind, but tides and flow from the Atchafalaya River also affect water elevation.

3.0 FTN FIELD SURVEY

FTN conducted a field survey for 18 subsegments in the Terrebonne basin July 10 through July 21, 2006. The hydrologic conditions during the field survey were typical for the Terrebonne basin during summer (high temperatures and generally low flows).

The field survey included water quality sampling and corresponding in situ measurements at various locations; measurements of flow, depth, and width at several locations; and continuous in situ monitoring at several locations. The water quality samples were analyzed for 20-day time series for carbonaceous biochemical oxygen demand (CBOD), total Kjeldahl nitrogen (TKN), ammonia nitrogen (NH_3-N), nitrate+nitrite nitrogen, total phosphorus, chlorophyll *a*, total organic carbon (TOC), and total suspended solids (TSS). A list of the survey sites and the type of data collected at each site is presented in Table D.1 (in Appendix D). The in situ measurements and water quality sampling results are summarized in Tables D.2 and D.3, respectively. The calculations of CBOD decay rates and ultimate CBOD (CBODu) concentrations from the time series data are shown in Table D.4. Tables D.5 through D.19 summarize the depth, widths, and flows measured with the acoustic Doppler current profiler instrument. Table D.20 lists the continuous monitoring data from Station 120406-B (Lake DeCade), which was the continuous monitoring station that was closest to Lost Lake and Four League Bay.

FTN collected water quality data at six locations in Subsegment 120708 (see Tables 3.1 and 3.2). All of the instantaneous DO values measured in Subsegment 120708 were above the 5 mg/L criterion in the water quality standards. The high DO values appear to be influenced by algal photosynthesis. The chlorophyll *a* concentrations were relatively high (45 to 77 µg/L).

Table 3.1. FTN field data for Stations 955, 120708-A, and 120708-B.

	955	**120708-A**	**120807-B**
Date and time of sample / measurements	7/17/06 12:05 PM	7/17/06 1:07 PM	7/17/06 1:32 PM
Depth (m) of sample / measurements	0.61	0.61	0.76
Water temperature (°C)	32.9	31.7	31.0
DO (mg/L)	9.0	8.7	7.1
Conductivity (µmhos/cm)	10,470	17,150	18,700
pH (su)	8.2	8.5	8.04
TSS (mg/L)	-	46	55
TKN (mg/L)	-	1.30	1.80
Total phosphorus (mg/L)	-	0.17	0.20
TOC (mg/L)	-	5.20	5.00
Chlorophyll *a* (µg/L)	-	52	77
NH_3-N (mg/L)	-	<0.1	<0.1
Nitrate+nitrite nitrogen (mg/L)	-	<0.04	<0.04
CBOD on day 2 of analysis (mg/L)	-	3.6	<2
CBOD on day 5 of analysis (mg/L)	-	5.4	3.4
CBOD on day 9 of analysis (mg/L)	-	5.5	6.6
CBOD on day 14 of analysis (mg/L)	-	4.8	<2
CBOD on day 20 of analysis (mg/L)	-	6.6	4.4
Ultimate CBOD (mg/L; calculated)	-	5.75	5.51
CBOD decay rate (1/day; calculated)	-	0.39	0.60

Table 3.2. FTN field data for Stations 120708-C, 120708-D, and 120708-F.

	120708-C	**120708-D**	**120807-F**
Date and time of sample / measurements	7/17/06 12:25 PM	7/17/06 1:00 PM	7/17/06 11:35 PM
Depth (m) of sample / measurements	0.68	0.61	0.76
Water temperature (°C)	31.1	31.8	32.9
DO (mg/L)	7.8	8.7	7.8
Conductivity (µmhos/cm)	12,170	14,700	8,320
pH (su)	7.98	8.6	7.9
TSS (mg/L)	23	-	24
TKN (mg/L)	1.70	-	1.50
Total phosphorus (mg/L)	0.15	-	0.15
TOC (mg/L)	7.60	-	8.20
Chlorophyll *a* (µg/L)	45	-	56
NH_3-N (mg/L)	<0.1	-	<0.1
Nitrate+nitrite nitrogen (mg/L)	<0.04	-	<0.04
CBOD on day 2 of analysis (mg/L)	3.6	-	3.1
CBOD on day 5 of analysis (mg/L)	5.1	-	4.2
CBOD on day 9 of analysis (mg/L)	7.8	-	5.4
CBOD on day 14 of analysis (mg/L)	8.1	-	4.2
CBOD on day 20 of analysis (mg/L)	8.4	-	7.2
Ultimate CBOD (mg/L; calculated)	8.04	-	5.88
CBOD decay rate (1/day; calculated)	0.38	-	0.22

4.0 CALIBRATION OF WATER QUALITY MODEL

4.1 Model Setup

In order to evaluate the linkage between pollutant sources and water quality, a computer simulation model was used. The model used for these TMDLs was version 8.11 of LA-QUAL (Wiland and LeBlanc 2007), which was selected because it includes the relevant physical, chemical, and biological processes and because it has been used successfully in the past for other TMDLs in Louisiana. The LA-QUAL model was set up to simulate organic nitrogen, ammonia nitrogen, CBODu, DO, salinity, and specific conductivity. The reason for simulating salinity and specific conductivity was to calibrate the dispersion and to allow the model to adjust DO saturation concentrations based on salinity.

Figure E.1 in Appendix E shows the model reach/element design and the location of the modeled inflows. The main stem consists of six reaches. It begins at the western end of Lost Lake, flows through Lost Lake, then through Lost Lake Pass and Blue Hammock Bayou, then southward through Four League Bay, and finally through Oyster Bayou into the Gulf of Mexico. The other branch consists of one reach to simulate Four League Bay from Atchafalaya Bay to the outlet of Blue Hammock Bayou. All these reaches were divided into smaller elements to take into account variations in water quality along their length.

4.2 Calibration Period and Calibration Targets

The two conditions that usually characterize critical periods for DO are high temperatures and low flows. High temperatures decrease DO saturation values and increase rates for oxygen-demanding processes (CBOD decay, nitrification, and sediment oxygen demand (SOD)). In most systems, low flow causes low reaeration rates. The purpose of selecting a critical period for calibration is so that the model will be calibrated as accurately as possible for making projection simulations for critical conditions.

The two data sets that were considered for model calibration were the FTN field survey (July 17, 2006) and the LDEQ routine monitoring data at Station 955 (January 2000 through November 2006). The FTN field survey was chosen for the model calibration period because the survey was conducted during hot weather with typical summertime hydrologic conditions, and field data were collected at multiple locations within the subsegment (as opposed to one location for the LDEQ routine ambient monitoring data).

The calibration targets (i.e., the concentrations to which the model was calibrated) for each parameter were set equal to the concentrations measured during the field survey with the exception of DO, which was set equal to the estimated daily minimum DO plus 1 mg/L. Continuous in situ data were not available at the six field survey sites in Subsegment 120708. Therefore, a minimum daily DO was estimated at each site by assuming that the ratio of instantaneous DO to daily minimum DO at any given time was the same at these six sites as it was at the nearest site with continuous in situ data (Station 120406-B – Lake DeCade). These calculations are shown in Table D.20 in Appendix D.

4.3 Program Constants (Data Type 3)

A value was input to replace the LA-QUAL default value for net oxygen production per unit of chlorophyll *a*. The default value (0.05 mg oxygen / µg chlorophyll *a* / day) was replaced because the chlorophyll specified in the initial conditions was contributing an unreasonably large amount of oxygen in the preliminary simulations. Calculations of oxygen production from photosynthesis and oxygen consumption from respiration were developed in a spreadsheet for a 24-hour period during the calibration period (shown in Appendix F). The calculations assumed a steady state concentration of algae; the increases in algal biomass due to growth were equal to the decreases in algal biomass due to respiration and settling over a 24-hour period. The net rate of oxygen added to the system from the combination of photosynthesis and respiration over a 24-hour period was calculated to be 0.026 mg oxygen / µg chlorophyll *a* / day. This value was input to the model in Data Type 3.

Another model parameter that was specified in Data Type 3 was the effective BOD due to algae. The default value of this parameter (zero) was overridden because preliminary model

simulations indicated that a large amount of the CBODu came from algae. The LA-QUAL User's Manual (Wiland and LeBlanc 2007) recommends a range of values from 0.10 to 0.25 mg/L of BOD per µg/L of chlorophyll *a* for this parameter. The value used in the model was 0.05 mg/L of BOD per µg/L of chlorophyll *a*. Using a value slightly below the range of values in the User's Manual was considered to be conservative.

The headwater exchange ratio was set to 1.0 in Data Type 3 to allow the model to calculate dispersive exchange at the headwater boundaries in addition to the downstream boundaries. The LA-QUAL default value (zero) was overridden because dispersive exchange is an important process that needed to be simulated for the Atchafalaya Bay headwater.

4.4 Temperature Correction of Kinetics (Data Type 4)

The temperature correction factors used in the model were consistent with the Louisiana Technical Procedures Manual (LTP; LDEQ 2006). These correction factors were:

Correction for BOD decay:	1.047 (value in LTP is same as model default)
Correction for SOD:	1.065 (value in LTP is same as model default)
Correction for ammonia N decay:	1.070 (specified in Data Group 4)
Correction for organic N decay:	1.020 (not specified in LTP; model default used)
Correction for reaeration:	automatically calculated by the model

4.5 Hydraulics (Data Type 9)

The hydraulics were specified in the input for the LA-QUAL model using the power functions (width = a * Q^b + c and depth = d * Q^e + f). The widths and depths for each reach were estimated based on digital ortho quarter quads (DOQQs), depths and widths measured in the FTN intensive survey, and spot depths from topographic maps. It was assumed that the depths and widths would be constant (independent of flow) due to backwater from the Gulf of Mexico. The values used in the model are shown in Table G.1 in Appendix G.

4.6 Dispersion and Lower Boundary Conditions (Data Types 10 and 27)

Dispersion was specified in the model because the waterbodies in Subsegment 120708 are tidally influenced and experience significant diurnal flow reversals that provide much mixing

and dispersive transport. The dispersion coefficients were calibrated by simulating salinity and specific conductivity and adjusting the dispersion coefficients within reasonable ranges to get similar values of predicted and observed concentrations at each field survey site.

Boundary conditions for the Gulf of Mexico (downstream boundary) and for Atchafalaya Bay (a headwater) were specified using LDEQ routine ambient monitoring data because there were no FTN field survey stations near those waterbodies. The closest LDEQ station in the Gulf of Mexico was Station 957, Caillou Bay south of Grand Bayou Caillou. Values for July from this station were averaged to use as inputs for the lower boundary conditions. Since LDEQ does not measure CBODu, CBODu was estimated from the TOC data. A CBODu to TOC ratio was developed from the FTN field survey by determining the ratio of CBODu to TOC for every station in the lower Terrebonne basin (excluding those stations in Lake Verret and Grassy Flat) where a water sample was taken. Then all these ratios were averaged and the resulting ratio (1.09) was multiplied by the TOC measured at Station 957 to get a CBODu value. The computation for the TOC to CBODu ratio is shown in Appendix H and the raw data for Station 957 is shown in Table B.2 in Appendix B. The values used in the model for dispersion coefficients and lower boundary conditions are shown in Table G.2 in Appendix G.

4.7 Initial Conditions (Data Type 11)

Because temperature was not simulated in the model, the temperature for each reach was specified in the initial conditions for LA-QUAL based on values measured in the FTN field survey. Chlorophyll *a* was also specified in the initial conditions to allow the model to account for algal productivity. The average of the chlorophyll *a* values measured in the FTN field survey was used for all reaches in the model.

Initial conditions for DO and ammonia nitrogen were set to the calibration targets. The initial concentrations of these two parameters do not affect the model output; the model uses them only as starting points for its iterative solution technique.

For constituents not being simulated, the initial concentrations were set to zero. Otherwise the model would have assumed a fixed concentration of those constituents and the model would have included effects of the unmodeled constituents on the modeled constituents.

4.8 Water Quality Kinetics (Data Types 12 and 13)

Kinetic rates used in LA-QUAL include CBOD decay rates, reaeration rates, nitrification rates, and mineralization rates (organic nitrogen decay).

The CBODu decay rate was based on an average of laboratory decay rates from the FTN field survey for subsegments in the lower Terrebonne basin. The measured rates were averaged to yield a rate of 0.32/day. These data are shown in Table H.1 in Appendix H.

Since most of this subsegment consisted of two very large, open, shallow waterbodies, wind-aided reaeration was specified in the model. The closest station with wind speed data on July 17, 2006 (the calibration day), was Houma, located approximately 30 to 35 miles northeast of this subsegment. All the wind speeds measured on that day were averaged and used to calculate a wind-aided surface transfer coefficient, which was entered in the model using option 20. These calculations are shown in Appendix I.

The nitrification rate was based on nitrogenous BOD (NBOD) decay rates from LDEQ field survey data collected in the Terrebonne basin. A total of 144 rates were averaged to yield a nitrification rate of 0.13/day. These data are shown in Appendix J.

The mineralization rates (organic nitrogen decay) in the model were set to 0.02/day for all reaches. This value was similar to the values shown in the “Rates, Constants, and Kinetics” publication (USEPA 1985) for dissolved organic nitrogen being transformed to ammonia nitrogen.

4.9 Nonpoint Source Loads (Data Type 19)

The nonpoint source loads that are specified in the model can be most easily understood as resuspended load from the bottom sediments and are modeled as SOD, benthic ammonia source rates, CBOD loads, and organic nitrogen loads. The SOD (specified in Data Type 12), the benthic ammonia source rates (specified in Data Type 13), and the mass loads of organic nitrogen and CBODu (specified in Data Type 19) were all treated as calibration parameters; their values were adjusted until the model output was similar to the calibration target values. The values used as model input are shown in Table G.4 in Appendix G.

4.10 Headwater Flow Rates (Data Type 20)

The headwater flow rates for both Bayou de Cade and Atchafalaya Bay were set to 1 cfs because hydraulic transport in this system was simulated primarily with dispersion rather than advection. This approach was used because 1) the net flow over one or more tidal cycles was assumed to be small in comparison with the dispersive exchange, and 2) no data were available to estimate tidally averaged flows for this subsegment. The significance of tidal dispersion is evident from the large diurnal water level fluctuations shown in Figure C.1 and is reinforced by the findings of a previous hydraulic study in Four League Bay (Denes and Caffrey 1988).

4.11 Headwater and Tributary Water Quality (Data Types 20, 24, and 25)

Concentrations of DO, CBODu, organic nitrogen, and ammonia nitrogen were specified in the model for both headwater flows. The data came from both LDEQ and the FTN field survey. The headwater data for the main branch is based on the FTN field survey. However the FTN field survey did not include a station that could be used for headwater data for Atchafalaya Bay, so data from the LDEQ Station 1204 (Atchafalaya Bay south of Burns, Louisiana) were used as headwater inputs. Because water quality at this station varies based on the flow in the Atchafalaya River, the model inputs were based on only the water quality data that were collected when the flow in the Atchafalaya River at Morgan City (USGS 07381600) was low (less than 150,000 cfs). Since LDEQ does not measure CBODu, the TOC ratio discussed in Section 4.6 was used to convert the TOC measured by LDEQ to CBODu needed for the headwater. The raw data for this station are shown in Table B.3 in Appendix B. The values used as model input are shown in Table G.5 in Appendix G.

No point sources were simulated in the model because no evidence was found to confirm that the point source facilities in this subsegment are actually discharging effluent with an oxygen demand.

4.12 Model Results for Calibration

Plots of predicted and observed water quality for the calibration and a printout of the LA-QUAL output file are presented in Appendix K. The calibration was considered to be acceptable based on the amount of data that were available.

5.0 WATER QUALITY MODEL PROJECTION

USEPA's regulations at 40 CFR 130.7 require the determination of TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Therefore, the calibrated model was used to project water quality for critical conditions. The identification of critical conditions and the model input data used for critical conditions are discussed below.

5.1 Identification of Critical Conditions

Section 303(d) of the Federal Clean Water Act and USEPA's regulations at 40 CFR 130.7 both require the consideration of seasonal variation of conditions affecting the constituent of concern and the inclusion of an MOS in the development of a TMDL. For the TMDL in this report, analyses of LDEQ long-term ambient data were used to determine critical seasonal conditions. Both an implicit MOS and an explicit MOS were used in developing the projection simulations.

Critical conditions for DO have been determined for Louisiana waterbodies in previous TMDL studies. The analyses concluded that the critical conditions for stream DO concentrations occur during periods with negligible nonpoint runoff, low stream flow, and high water temperature. For coastal waterbodies, though, critical conditions for DO tend to be correlated more closely to high water temperature than to flow rates during the critical periods. High temperatures cause DO saturation values to be lower and SOD, CBOD decay, and nitrification to be higher. High flow rates usually generate more reaeration in streams (due to increased velocity and turbulence), but changes in flow rates for coastal waters normally have little or no effect on reaeration because the advective velocities are very small. Periods of high nonpoint loading to Louisiana waterbodies tend to be cooler periods of the year because rainfall during summer usually creates less runoff due to evapotranspiration in the watershed. Therefore, periods of high nonpoint loading do not necessarily coincide with critical periods for DO.

LDEQ interprets this phenomenon in its TMDL modeling by assuming that the annual nonpoint loading, rather than loading for any particular day, is responsible for the accumulated benthic blanket of the waterbody, which is, in turn, expressed as SOD and/or re-suspended BOD

in the model. This accumulated loading has its greatest impact on the waterbody during periods of higher temperature.

The projection simulations were run with the same flows as the calibration simulation because DO is not closely correlated with flow rates in coastal waters, and the hydraulic transport in the model is being simulated primarily with dispersion rather than advection.

The impact of various conservative assumptions regarding rates and loadings yields an implicit MOS that is not quantified. Over and above this implicit MOS, an explicit MOS of 10% was incorporated into the DO TMDL in this report to account for model uncertainty.

5.2 Temperature Inputs

The LTP specifies that the critical temperature should be determined by calculating the 90th percentile seasonal temperature for the waterbody being modeled. Water temperature data were collected in Lost Lake (Station 955) for only 2 years, which is not enough data to calculate 90th percentile temperatures. Therefore, long-term data from an LDEQ monitoring station on a similar waterbody (Lake Palourde, Station 338) were used to estimate 90th percentile temperatures for Lost Lake and Four League Bay. First, 90th percentile temperatures for Lake Palourde were calculated as shown in Table L.2 in Appendix L). These 90th percentile temperatures were then adjusted based on differences between seasonal average temperatures in Lost Lake (Station 955) and Lake Palourde (Station 338) during their overlapping period of record (see Table L.1). These calculations yielded a value of 30.7°C for the adjusted 90th percentile temperature during summer. The 90th percentile winter temperature was calculated to be 22.46°C, which was used in the LA-QUAL winter projection.

5.3 Initial Conditions and Boundary Conditions

All of the model inputs for headwaters, lower boundary conditions, and initial conditions were the same in the projection simulations as in the calibration simulation, except that the temperatures in the projection simulations were set to the 90th percentile temperatures.

5.4 Nonpoint Source Loads

Because the initial projection simulation in the summer showed predicted DO values below the 5 mg/L criterion, the nonpoint source loadings for the summer projection were reduced until all of the predicted DO values were equal to or greater than 5.0 mg/L. The same percent reduction was applied to the SOD and nonpoint source mass loads of CBODu and organic nitrogen.

5.5 Other Inputs

The only model inputs that were changed from the calibration to the projection simulation were the inputs discussed above in Sections 5.2 through 5.4. Other model inputs (e.g., hydraulic coefficients, decay rates, reaeration equations, etc.) were unchanged from the calibration simulation.

5.6 Model Results for Projection

Plots of predicted water quality for the projection and printouts of the LA-QUAL output file are included as Appendix M.

Nonpoint source load reductions of 23% in the summer and 0% in the winter were required to bring the predicted DO values to at least 5.0 mg/L. These percentage reductions for nonpoint source loads represent percentages of the entire nonpoint source loading, not a percentage of the manmade nonpoint source loading. The nonpoint source loads in this report were not divided between natural and manmade because it would be difficult to estimate natural nonpoint source loads for the study area.

6.0 DO TMDL DEVELOPMENT

6.1 TMDL Calculations

A TMDL for DO was calculated for Subsegment 120708 using the results of the summer and winter projection simulations. The DO TMDL is presented as oxygen demand from CBODu, organic nitrogen, ammonia nitrogen, and SOD. Summaries of the TMDL are presented in Tables 6.1 and 6.2.

The TMDL calculations were performed using a FORTRAN program that was written by FTN personnel. This program reads two files; one is the LA-QUAL output file from the projection simulation and the other is a small input file with miscellaneous information needed for the TMDL calculations (shown in Appendix N). The output files from the program are also shown in Appendix N for the summer and winter projections. The source code for the program is shown in Appendix O. A one-page summary of the methodology for the TMDL calculations is shown at the beginning of Appendix O.

The oxygen demand from organic nitrogen and ammonia nitrogen was calculated as 4.33 times the nitrogen loads (assuming that all organic nitrogen is eventually converted to ammonia). The value of 4.33 is the same ratio of oxygen demand to nitrogen that is used by the LA-QUAL model. For the SOD loads, a temperature correction factor was included in the calculations (in order to be consistent with LDEQ procedures).

6.2 MOS and FG

The MOS accounts for any lack of knowledge or uncertainty concerning the relationship between pollutant loading and water quality. The model projections were run with the 90th percentile seasonal water temperatures (conservative values), and the calibration targets were set to 1 mg/L above the estimated daily minimum values (more conservative than instantaneous measurements). These modeling procedures yield an implicit MOS, which is not quantified. In addition to the implicit MOS, the DO TMDL in this report includes an explicit MOS equal to 10% of the TMDL and an explicit allowance for FG that is also equal to 10% of the TMDL.

Table 6.1. Summer DO TMDL for Subsegment 120708.

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	
Point Sources											
WLA	NA	0	0	0	0	NA	0	0	0	0	0%
MOS	NA	0	0	0	0	NA	0	0	0	0	NA
FG	NA	0	0	0	0	NA	0	0	0	0	NA
Nonpoint Sources											
LA	100566	122275	10658	1.66	233502	221748	269616	23501	3.66	514872	23%
MOS	12571	15285	1332	0.21	29188	27719	33703	2937	0.46	64360	NA
FG	12571	15285	1332	0.21	29188	27719	33703	2937	0.46	64360	NA
TMDL	125708	152845	13322	2.08	291878	277186	337022	29375	4.58	643592	NA

Table 6.2. Winter DO TMDL for Subsegment 120708.

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	
Point Sources											
WLA	NA	0	0	0	0	NA	0	0	0	0	0%
MOS	NA	0	0	0	0	NA	0	0	0	0	NA
FG	NA	0	0	0	0	NA	0	0	0	0	NA
Nonpoint Sources											
LA	67983	158800	13839	1.66	240623	149877	350154	30515	3.66	530483	0%
MOS	8498	19850	1730	0.21	30078	18735	43769	3815	0.46	66311	NA
FG	8498	19850	1730	0.21	30078	18735	43769	3815	0.46	66311	NA
TMDL	84980	198500	17297	2.08	300779	187349	437692	38145	4.58	663104	NA

6.3 Ammonia Toxicity Calculations

Although Subsegment 120708 is not on a 303(d) list for ammonia, the ammonia concentrations predicted in the projection simulations were checked to make sure that they did not exceed USEPA criteria for ammonia toxicity (USEPA 1999). The USEPA criteria are dependent on temperature and pH. The water temperatures used to calculate the ammonia toxicity criteria for summer and winter for Subsegment 120708 were the same as the critical temperatures used in the projection simulations. Average pH values for each season were calculated from routine monitoring data at LDEQ Station 955. The resulting criteria for ammonia nitrogen were 1.26 mg/L for summer and 3.11 mg/L for winter. The ammonia nitrogen concentrations predicted by the LA-QUAL model were well below these criteria. This indicates that the ammonia nitrogen loadings that will maintain the DO standard are low enough that the USEPA ammonia toxicity criteria will not be exceeded under critical conditions. The ammonia toxicity calculations are shown in Appendix P.

7.0 NUTRIENT TMDL DEVELOPMENT

7.1 Seasonality and Critical Conditions

USEPA's regulations at 40 CFR 130.7 require the determination of TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Also, both Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 require TMDLs to consider seasonal variations for meeting water quality standards. Aquatic life impairments typically occur as a result of long term exposure to elevated nutrient concentrations rather than short-term fluctuations in nutrient concentrations. This nutrient TMDL was developed for average annual conditions. The most obvious result of nutrients is algal blooms. When the algae die, the resultant biological oxygen demand consumes oxygen, which adversely affects aquatic life. The effect occurs in a short time but the build-up of nutrients and the conditions to start the algal bloom may occur over an extended time.

7.2 Comparison with Reference Stream Data

Since there are no numeric nutrient criteria for Louisiana, the need for nutrient reductions in subsegment 120708 was evaluated by comparing total nitrogen (TKN+NO_2+NO_3) and total phosphorus concentrations in subsegment 120708 with values from least disturbed reference sites. Five references sites in the lower Terrebonne basin were identified and sampled as part of study conducted under contract to USEPA Region 6 by the Cadmus Group, Inc. and ARCADIS U.S., Inc., along with other team members (Cadmus Group 2007). Each site was sampled four times during 2005 and 2006. These data are shown in Appendix Q. Overall average concentrations of total nitrogen (TKN plus nitrate+nitrite) and total phosphorus for the reference sites were calculated to be 0.15 mg/L total phosphorus and 1.70 mg/L total nitrogen. Using LDEQ routine monitoring data at station 955 (Lost Lake west of Bayou De Cade), the average concentrations in subsegment 120708 were calculated to be 0.11 mg/L of total phosphorus (see Table 2.3) and 1.07 mg/L of total nitrogen (1.02 mg/L TKN + 0.05 mg/L NO_2+NO_3; see Table 2.3). Because the subsegment 120708 average nutrient concentrations are lower than the reference site average concentrations, no nutrient reductions are needed for this subsegment.

7.3 Calculations for TMDL Components

The TMDL for total phosphorus and total nitrogen for Subsegment 120708 was calculated based on allowable loads of nitrogen from the DO modeling and a naturally occurring ratio of total nitrogen to total phosphorus. The naturally occurring ratio of total nitrogen to total phosphorus was used because the Louisiana Water Quality Standards require that ratio to be maintained in streams and lakes (see Section 2.3). The naturally occurring ratio of total nitrogen to total phosphorus was calculated to be 11.3 using the mean values of total nitrogen and total phosphorus from the reference streams in Appendix Q (1.70 mg/L and 0.15 mg/L). The allowable loads of total nitrogen were calculated as the simulated loads of organic nitrogen and ammonia nitrogen in the projection simulations plus assumed values of nitrate+nitrite nitrogen. The allowable loads of total phosphorus were then calculated as simply the allowable loads of total nitrogen divided by 11.3 (the naturally occurring ratio of total nitrogen to total phosphorus). The MOS and FG components for this nutrient TMDL were calculated as 10% each (or 20% combined) of the total loading after including the MOS and FG. The details of these calculations are shown in Appendix Q and the results are summarized in Table 7.1.

The WLA for point sources was set to zero because none of the point sources appear to be actually discharging sanitary wastewater or other effluent containing nutrient concentrations above background levels. Because no reductions to nutrients were required, it is assumed that the point sources may continue to discharge at their current concentration level of nutrients and not make any deleterious effect on water quality. Any increase in effluent concentrations could require additional monitoring and modeling and a revision to this TMDL.

Table 7.1. Nutrient TMDL for Subsegment 120708.

Season	Component	Loads in kg/day		Loads in lbs/day	
		Total Nitrogen	Total Phosphorus	Total Nitrogen	Total Phosphorus
Summer	LA	3,079.5	272.5	6,789.1	600.7
	WLA	0.0	0.0	0.0	0.0
	MOS	384.9	34.1	848.6	75.1
	FG	384.9	34.1	848.6	75.1
	TMDL	3,849.3	340.7	8,486.3	750.9
Winter	LA	3,997.5	353.7	8,813.0	779.8
	WLA	0.0	0.0	0.0	0.0
	MOS	499.7	44.2	1,101.6	97.5
	FG	499.7	44.2	1,101.6	97.5
	TMDL	4,996.9	442.1	11,016.2	974.8

7.4 Summary of Load Reductions

The analysis outlined in Section 7.2 above indicated that no reduction of nutrient loads is necessary.

The DO TMDL (see Section 6) establishes load limitations for oxygen-demanding substances and goals for reducing those pollutants. When oxygen-demanding substances are controlled and limited to ensure that the DO criterion is supported, nutrients are also controlled and limited. Implementing the DO TMDL through future wastewater permits, if required, and implementing best management practices to control and reduce oxygen-demanding pollutants from nonpoint sources in the watershed will also control and reduce the nutrient loading from those sources.

8.0 SENSITIVITY ANALYSES

All modeling studies necessarily involve uncertainty and some degree of approximation. Therefore it is of value to consider the sensitivity of the model output to changes in model coefficients, and in the hypothesized relationships among the parameters of the model. The sensitivity analyses were performed by allowing the LA-QUAL model to vary one input parameter at a time while holding all other parameters to their original value. The calibration simulation was used as the baseline for the sensitivity analyses. The percent change of the model's minimum DO projections to each parameter is presented in Table 8.1. Each parameter was varied by ±30%, except for temperature, which was varied ±2ºC.

Values reported in Table 8.1 are sorted by percentage variation of minimum DO from largest percentage variation to smallest. The model output was most sensitive to reaeration, SOD, wasteload DO (decrease only), and temperature. The model output was least sensitive to headwater parameters, wasteload parameters (excluding a decrease in DO), and the decay rates.

Table 8.1. Summary of results of sensitivity analyses.

Input Parameter	Change in Parameter	Predicted Minimum DO (mg/L)	Percent Change in Predicted DO (%)
Baseline	--	4.37	N/A
Reaeration	-30%	2.90	-33.6%
SOD	+30%	3.44	-21.3%
Wasteload DO	-30%	3.48	-20.4%
Temperature	+2ºC	3.82	-12.6%
Reaeration	+30%	4.73	+8.2%
SOD	-30%	4.68	+7.1%
Temperature	-2ºC	4.65	+6.4%
Stream Velocity	+30%	4.26	-2.5%
Stream Velocity	-30%	4.47	+2.3%
Wasteload DO	+30%	4.37	0%
Stream Depth	-30%	4.37	0%
Stream Depth	+30%	4.37	0%
BOD Decay Rate	-30%	4.37	0%
BOD Decay Rate	+30%	4.37	0%
Ammonia Nitrogen Decay Rate	-30%	4.37	0%
Ammonia Nitrogen Decay Rate	+30%	4.37	0%
Organic Nitrogen Decay Rate	-30%	4.37	0%
Organic Nitrogen Decay Rate	+30%	4.37	0%
Headwater Flow	-30%	4.37	0%
Headwater Flow	+30%	4.37	0%
Headwater DO	-30%	4.37	0%
Headwater DO	+30%	4.37	0%
Headwater BOD	-30%	4.37	0%
Headwater BOD	+30%	4.37	0%
Headwater Ammonia Nitrogen	-30%	4.37	0%
Headwater Ammonia Nitrogen	+30%	4.37	0%
Headwater Organic Nitrogen	-30%	4.37	0%
Headwater Organic Nitrogen	+30%	4.37	0%
Wasteload Flow	-30%	4.37	0%
Wasteload Flow	+30%	4.37	0%
Wasteload BOD	-30%	4.37	0%
Wasteload BOD	+30%	4.37	0%
Wasteload Ammonia Nitrogen	-30%	4.37	0%
Wasteload Ammonia Nitrogen	+30%	4.37	0%
Wasteload Organic Nitrogen	-30%	4.37	0%
Wasteload Organic Nitrogen	+30%	4.37	0%

9.0 OTHER RELEVANT INFORMATION

This TMDL has been developed to be consistent with the state anti-degradation policy (LAC 33:IX.1109.A).

This TMDL report does not include an implementation plan. Implementation plans are not required for TMDLs under current federal regulations. Implementation plans can be developed most effectively and efficiently on the state and local level.

LDEQ will work with other agencies such as local Soil Conservation Districts to implement nonpoint source best management practices in the watershed through the Section 319 programs. LDEQ will also continue to monitor the waters to determine whether standards are being attained.

In accordance with Section 106 of the Federal Clean Water Act, and under the authority of the Louisiana Environmental Quality Act, LDEQ has established a comprehensive program for monitoring the quality of the state's surface waters. The LDEQ Surveillance Section collects surface water samples at various locations, utilizing appropriate sampling methods and procedures for ensuring the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term data base for water quality trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program is used to develop the state's biennial 305(b) report (Water Quality Inventory) and the 303(d) list of impaired waters. This information is also utilized in establishing priorities for the LDEQ nonpoint source program.

LDEQ has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled over 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 on a monthly basis to yield approximately 12 samples per site each year the site is monitored. Sampling sites are located where they are considered to be representative of the waterbody. Under the current monitoring schedule, approximately one half of the state's waters are newly assessed for each 305(b) and 303(d)

listing biennial cycle, with sampling occurring statewide each year. The 4-year cycle follows an initial 5-year rotation that covered all basins in the state according to the TMDL priorities. This will allow LDEQ to determine whether there has been any improvement in water quality following implementation of the TMDLs. As the monitoring results are evaluated at the end of each year, waterbodies may be added to or removed from the 303(d) list.

USEPA Region 6 has funded a use attainability assessment (UAA) study for the development of site-specific DO criteria for Terrebonne basin, Louisiana. On January 31, 2008, the contractor (Tetra Tech, Inc.) submitted a draft report for USEPA's review. In addition, the state is involved in analyzing available data for the Barataria and Terrebonne basin waters to evaluate and possibly revise the existing dissolved oxygen criterion.

Once LDEQ adopts and USEPA approves the revised DO criteria, LDEQ will reassess the 303(d) listed subsegments for DO and nutrients in the Terrebonne basin. If the reassessment of a subsegment indicates a subsegment is not impaired on the basis of revised criteria, if appropriate, the DO and nutrients TMDLs may be withdrawn, and USEPA will publish a public notice. If the reassessment of a subsegment indicates that the subsegment is impaired on the basis of the revised criteria, if appropriate, the DO and nutrients TMDLs may be revised, and USEPA will publish a public notice.

Hurricane Katrina made landfall on Monday, August 29, 2005, as a Category 4 hurricane. The storm brought heavy winds and rain to southeast Louisiana, breaching several levees and flooding up to 80% of New Orleans and large areas of coastal Louisiana. Both Hurricanes Katrina and Rita have caused a significant amount of change in sedimentation and water quality in southern Louisiana. Many wastewater treatment facilities were temporarily or permanently damaged. Some wastewater treatment facilities will be rebuilt; others will be relocated. Several federal and state agencies, including USEPA and LDEQ, are engaged in collecting environmental data and assessing the recovery of the Gulf of Mexico waters.

The TMDLs in this report were developed on the basis of pre- and post-hurricane water quality conditions. Post-hurricane water quality conditions and other factors could delay the implementation of these TMDLs, render some TMDLs obsolete, or require modifications of the

TMDLs. Although hurricane effects may be valid for some TMDLs, any deviation from the TMDLs should be justified using site-specific data or information.

10.0 PUBLIC PARTICIPATION

Federal regulations require USEPA to notify the public and seek comment concerning TMDLs it prepares. The TMDLs in this report were developed under contract to USEPA, and USEPA 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 October 25, 2007, and the review period closed on November 26, 2007.

Comments were received from LDEQ. These comments were used to revise this TMDL report. The comments and responses to these TMDLs are included in a separate document that includes comments on similar TMDLs with the same public review period.

USEPA will submit the final version of these TMDLs to LDEQ for implementation and incorporation into LDEQ's current water quality management plan.

11.0 REFERENCES

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