**Final**

# BAYOU DU LARGE WATERSHED TMDL FOR BIOCHEMICAL OXYGEN-DEMANDING SUBSTANCES AND NUTRIENTS

**Subsegment 120505**

**SURVEYED 6/2 - 7/2004**

**TMDL REPORT**


**Water Quality Modeling Section**
**Water Quality Assessment Division**
**Office of Environmental Assessment**
**Louisiana Department of Environmental Quality**



**May 11, 2007**

Bayou Du Large Watershed TMDL
Subsegment 120505
Orginated: June 2, 2006
Revised: May 11, 2007

## EXECUTIVE SUMMARY

This report presents the results of a watershed based, calibrated modeling analysis of Bayou Du Large. The modeling was conducted to establish a TMDL for biochemical oxygen-demanding pollutants and nutrients for the Bayou Du Large watershed (subsegment 120505). The model extends from the headwaters near Houma, LA to the confluence of Bayou Du Large with Marmande Canal. Bayou Du Large is located in southeast Louisiana and its watershed includes Old Bayou Du Large, Duplantis Canal, Marmande Canal, and several unnamed tributaries. Bayou Du Large is in the Terrebonne River Basin and includes Water Quality Subsegment 120505. The area is sparsely populated and land use is dominated by agriculture. Only one facility was addressed in the TMDL effort.

Input data for the calibration model was developed from data collected during the June 2004 intensive survey; data collected by LDEQ monitoring stations in the watershed; USGS drainage area and low flow publications; and data garnered from several previous LDEQ studies on nonpoint source loadings. The nonpoint source loads included nonpoint loading not associated with flow. A satisfactory calibration was achieved for the main stem. For the projection models, data was taken from ambient records. The Louisiana Total Maximum Daily Load Technical Procedures, Revision 9, have been followed in this study.

The various spreadsheets that were used in conjunction with the modeling program may be found in the appendices. Water quality calibration was also based on measurements taken during the survey. Projections were adjusted to meet the dissolved oxygen criteria by reducing total nonpoint source loads.

Modeling was limited to low flow scenarios for both the calibration and the projection since the constituent of concern was dissolved oxygen and the available data was limited to low flow conditions. The model used was LAQUAL, a modified version of QUAL-TX, which has been adapted to address specific needs of Louisiana waters.

Bayou Du Large, Subsegment 120505, was on the 303(d) list starting with the 1999 list. The Subsegment was found to be “not supporting” its designated use of Fish and Wildlife Propagation. It is "fully supporting" Primary and Secondary Contact Recreation. Bayou Du Large was subsequently scheduled for TMDL development with other listed waters in the Terrebonne River Basin. The suspected causes of impairment were nutrients and low dissolved oxygen. The suspected sources were small flow discharges and lagoons. This TMDL addresses the organic enrichment/ low DO impairment.

The designated use of Bayou Du Large for anything other than a drainage canal is questionable. Yet, designated uses in this subsegment are primary and secondary contact recreation and fish and wildlife propagation. These uses carry with them the most stringent water quality criteria short of drinking water sources. Though this stream at one time may have been a more substantial and constantly flowing stream, it currently serves mainly as a drainage stream. The lower sections also maintain water based on the tidal elevation of Marmande Canal. This section is simply a tidal backwater when not serving as a drainage canal for storm water or irrigation runoff.

This TMDL establishes load limitations for oxygen-demanding substances and goals for reduction of those pollutants. LDEQ's position, as supported by the declaratory ruling issued by Secretary Givens in response to the lawsuit regarding water quality criteria for nutrients (Sierra Club v. Givens, 710 So.2d 249 (La. App. 1st Cir. 1997), writ denied, 705 So.2d 1106 (La. 1998), is that when oxygen-demanding substances are controlled and limited in order to ensure that the dissolved oxygen criterion is supported, nutrients are also controlled and limited. The implementation of this TMDL through wastewater discharge permits and implementation of best management practices to control and reduce runoff of soil and oxygen-demanding pollutants from nonpoint sources in the watershed will also control and reduce the nutrient loading from those sources.

The results of the projection modeling show that the water quality standard for dissolved oxygen of 5.0 mg/l can be maintained during the summer critical season with 85% reduction of man-made pollution. The minimum DO is 5.00 mg/l. There were no appropriate reference streams to calculate background conditions.

The results of the winter projection model show that the water quality criterion for dissolved oxygen of 5.0 mg/l can also be maintained during the winter critical season with 85% reduction in man-made nonpoint source pollution. The minimum dissolved oxygen is 5.00 mg/l.

There is a project in place called the Morganza to the Gulf Hurricane Protection Project. This project proposes a floodgate on Bayou Du Large southeast of Lake DeCade and a water control structure on Marmande Canal near the confluence with Bayou Du Large. With the addition of these control structures, this TMDL can be rendered obsolete.

Hurricanes Katrina and Rita created massive devastation to various watersheds. These natural disasters occurred after the survey data had been collected. It is feasible to consider that the water quality and hydrologic conditions may be somewhat different now. Therefore, this TMDL would only be considered viable for pre-hurricane conditions.

Based on the amount of reduction required, it is recommended that a use-attainability analysis (UAA) be completed to determine if a change in the DO standard for the waterbody is necessary.

The Terrrebonne Parish Library is the only permitted discharger located in this subsegment. This discharger is small and need not be included in a model of this scale because it is unlikely that it is having an impact on the targeted waterbody due to the small load and/or the distance from the waterbody named in the 303(d) lists. This discharger is accounted for as nonpoint loading through the process of calibration. It falls within one of several state or regional policies that govern permit limitations. Current permit information was reviewed for this facility. A discharger inventory list is presented at the end of this summary in Table 2.

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

**Table 1. Total Maximum Daily Load (Sum of UBOD and SOD)**

| ALLOCATION | SUMMER | | WINTER | |
|---|---|---|---|---|
| | % Reduction Required | (MAY-OCT) (lbs/day) | % Reduction Required | (NOV-APR) lbs/day) |
| Point Source WLA | 0 | 0 | 0 | 0 |
| Point Source Reserve MOS (20%) | 0 | 0 | 0 | 0 |
| Manmade Nonpoint Source LA | 85 | 611 | 85 | 481 |
| Manmade Nonpoint Source Reserve MOS(20%) | 0 | 152 | 0 | 119 |
| TMDL | | 763 | | 600 |

In accordance with Section 106 of the federal Clean Water Act and under the authority of the Louisiana Environmental Quality Act, the 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.

The LDEQ is continuing to implement a watershed approach to the surface water quality monitoring. In 2004 a four year sampling cycle replaces the previous five year cycle. Approximately one quarter of the states watersheds will be sampled in each year so that all of the states watersheds will be sampled within the four year cycle. This will allow the 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.

**Table 2. Discharger Inventory for 120505**

| | | | | | | | MONTHLY AVERAGE CONCENTRATION LIMITS | | MONTHLY AVERAGE MASS LIMITS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FACILITY | FILE No. | Out-fall No. | OUTFALL DESCRIP-TION | FACILITY TYPE | RECEIVING WATER | EXPECTED FLOW GPD | BOD5/ CBOD5, mg/L | $NH_3$-N, mg/L | BOD, lbs./day | $NH_3$-N, lbs./day | MODELING COMMENTS |
| Terrebonne Parish Library | 91032 | 001 | Treated sanitary wastewater | Library | Unnamed ditch; thence into Bayou Du Large | 190 | 30 | 15 | 0.0476 | 0.0238 | Due to insignificant impact, this discharger was not included in the model. |

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## Introduction

Bayou Du Large, subsegment 120505, of the Terrebonne Basin is listed on the court-ordered 303(d) list beginning with the 1999 305(b) report. The subsegment is listed as "not supporting" Fish and Wildlife Propagation. It is fully supporting of the Primary and Secondary Contact Recreation uses. The suspected causes of impairments are low DO and nutrients. The suspected sources are small flow discharges and lagoons. Because of the impairment, this subsegment requires the development of a total maximum daily load (TMDL) for oxygen demand substances. A calibrated water quality model for Bayou Du Large, subsegment 120505, was developed and projections for current dissolved oxygen standards were run to quantify the wasteload required to meet established dissolved oxygen criteria. This report presents the model development and results.

## 2. Study Area Description

### *2.1 General Information*

Terrebonne Basin

The Terrebonne Basin covers an area extending approximately 120 miles from the Mississippi River on the north to the Gulf of Mexico on the south. It varies in width from 18 miles to 70 miles. This basin is bounded on the west by the Atchafalaya River Basin and on the east by the Mississippi River and Bayou LaFourche. The topography of the entire basin is lowland, and all the land is subject to flooding except the natural levees along major waterways. The coastal portion of the basin is prone to tidal flooding and consists of marshes ranging from fresh to saline. (LA DEQ, 1996) Subsegment 120505 includes Bayou Du Large from Houma to its confluence with Marmande Canal. This subsegment is tidally influenced. Water flows in either direction depending upon tides and wind conditions. This area is typical of the basin and is primarily comprised of agriculture and vegetated urban as documented in Table 3. A detailed land cover map of Subsegment 120505 is also included in Appendix H. Average annual precipitation in the segment, based on the nearest Louisiana Climatic Station, is 64 inches based on a 30-year period of record (LSU, 1999). There is a Louisiana average annual precipitation map located in Appendix H.

**Table 3.  Land Uses in Segment 120505**

| Land Type | Acres | Percent Land |
|---|---|---|
| Agriculture/Cropland/Grassland | 763.93 | 61.96 |
| Vegetated Urban | 239.74 | 19.44 |
| Wetland Forest Deciduous | 88.07 | 7.14 |
| Wetland S/S Deciduous | 45.37 | 3.68 |
| Fresh Marsh | 40.92 | 3.32 |
| Water | 24.69 | 2.00 |
| Upland S/S Mixed | 23.57 | 1.91 |
| Upland Forest Deciduous | 4.67 | 0.38 |
| Upland Forest Mixed | 2.00 | 0.16 |

**Figure 1. Vector Diagram**

# Bayou DuLarge Model Layout Subsegment 120505 - Headwaters to Vernon Lake

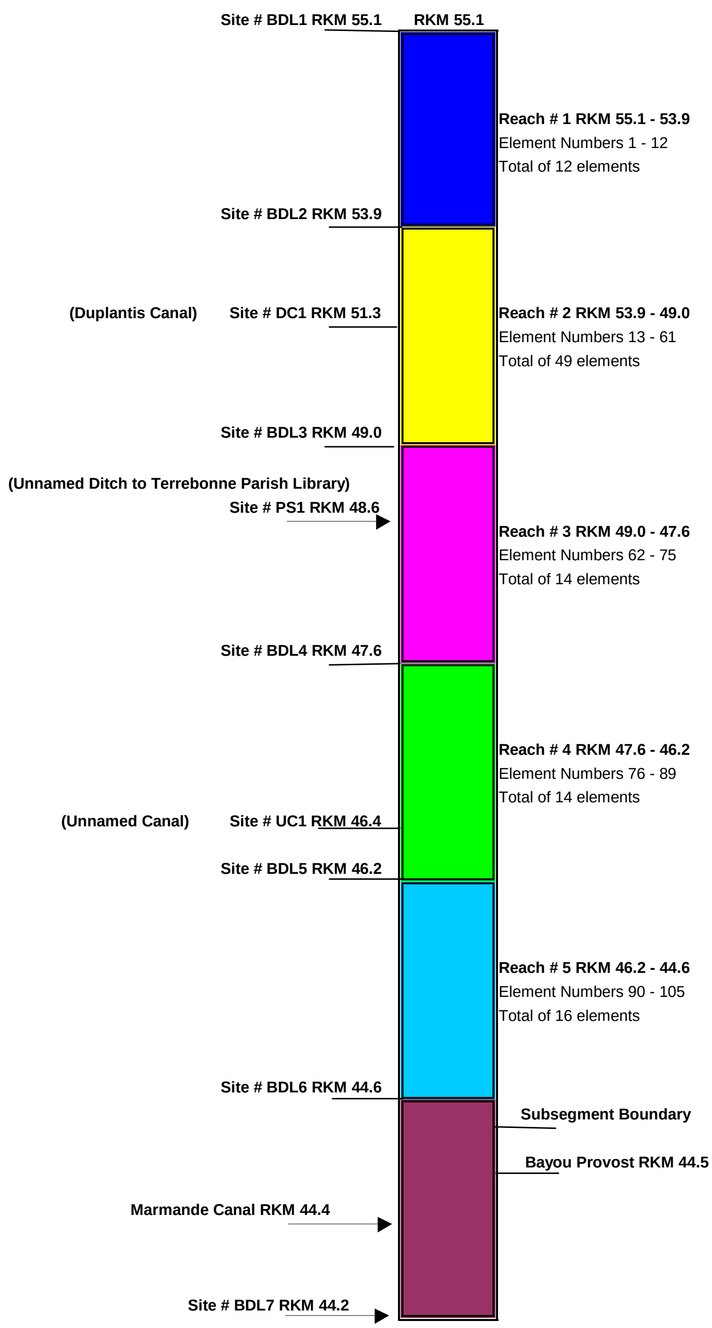
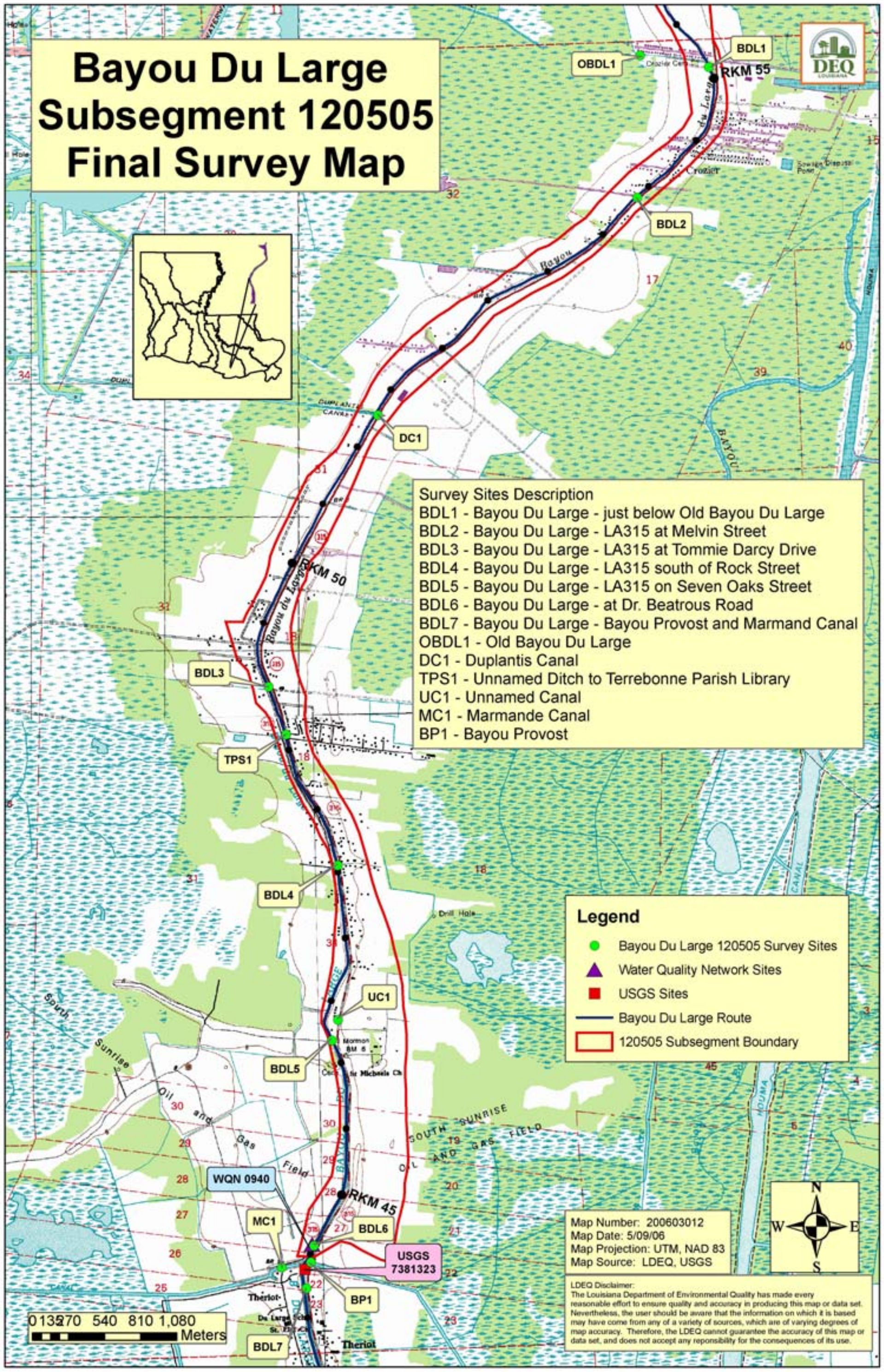


**Figure 2. Map of Study Area**



## *2.2 Water Quality Standards*

The Water Quality criteria and designated uses for Bayou Du Large watershed are shown in table 4. The designated use of Bayou Du Large for anything other than a drainage ditch is questionable. Yet, designated uses in this subsegment are primary and secondary contact recreation and fish and wildlife propagation. These uses carry with them the most stringent water quality criteria short of drinking water sources. Though this stream at one time may have been a more substantial and constantly flowing stream, it currently serves mainly as a drainage stream. The lower sections also maintain water based on the tidal elevation of Marmande Canal. This section is simply a tidal backwater when not serving as a drainage ditch for storm water or irrigation runoff.

**Table 4. Water Quality Numerical Criteria and Designated Uses for Subsegment 120505**

| Parameter | Value |
|---|---|
| Designated Uses | A B C |
| DO, mg/L | 5.0 |
| Cl, mg/L | 500 |
| $SO_4$, mg/L | 150 |
| pH | 6.5 – 9.0 |
| BAC | 1 |
| Temperature, deg Celsius | 32 |
| TDS, mg/L | 1000 |

USES: A – primary contact recreation; B - secondary contact recreation; C – propagation of fish and wildlife; D – drinking water supply; E – oyster propagation; F – agriculture; G – outstanding natural resource water; L – limited aquatic life and wildlife use.

Note 1 – 200 colonies/100mL maximum log mean and no more than 25% of samples exceeding 400 colonies/100mL for the period May through October; 1,000 colonies/100mL maximum log mean and no more than 25% of samples exceeding 2,000 colonies/100mL for the period November through April.

## *2.3 Wastewater Discharges*

The Terrrebonne Parish Library is the only permitted discharger located in this subsegment. This discharger is small and need not be included in a model of this scale because it is unlikely that it is having an impact on the targeted waterbody due to the small load and/or the distance from the waterbody named in the 303(d) lists. This discharger is accounted for as nonpoint loading through the process of calibration. It falls within one of several state or regional policies that govern permit limitations. Therefore, the Terrebonne Parish Library should be allowed to discharge at the current permit limits.

**Table 5. Discharger Inventory for Subsegment 120505**

| | | | | | | | MONTHLY AVERAGE CONCENTRATION LIMITS | | MONTHLY AVERAGE MASS LIMITS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FACILITY | FILE No. | Out-fall No. | OUTFALL DESCRIP-TION | FACILITY TYPE | RECEIVING WATER | EXPECTED FLOW GPD | BOD5/ CBOD5, mg/L | $NH_3$-N, mg/L | BOD, lbs./day | $NH_3$-N, lbs./day | MODELING COMMENTS |
| Terrebonne Parish Library | 91032 | 001 | Treated sanitary wastewater | Library | Unnamed ditch; thence into Bayou Du Large | 190 | 30 | 15 | 0.0476 | 0.0238 | Due to insignificant impact, this discharger was not included in the model. |

### *2.4 Water Quality Conditions/Assessment*

Bayou Du Large, Subsegment 120505, was on the 303(d) list beginning with the 1999 305 (b) report. The Subsegment was found to be “not supporting” its designated use of Fish and Wildlife Propagation. It was found to be fully supporting its designated use of Primary and Secondary Contact Recreation. Bayou Du Large was subsequently scheduled for TMDL development with other listed waters in the Terrebonne River Basin. The suspected causes of impairment were nutrients and low dissolved oxygen. The suspected sources were small flow dischargers and lagoons. Because of the impairment, this subsegment requires the development of a total maximum daily load (TMDL) for oxygen demanding substances.

### *2.5 Prior Studies*

There are no prior studies associated with Bayou Du Large. Preceding this study, the only locations for which LDEQ data was available were the Ambient WQN stations at Fisherman’s Retreat Bridge (0941), Dr. Beautrous Bridge (0940), and a site south of Houma, LA (0350) near Lake Mechant and Mud Lake. The data at site 0940 was used to assess subsegment 120505 and develop projection conditions.

## 3. Documentation Calibration Model

### *3.1 Program Description*

“Simulation models are used extensively in water quality planning and pollution control. Models are applied to answer a variety of questions, support watershed planning and analysis and develop total maximum daily loads (TMDLs). . . . Receiving water models simulate the movement and transformation of pollutants through lakes, streams, rivers, estuaries, or near shore ocean areas. . . . Receiving water models are used to examine the interactions between loadings and response, evaluate loading capacities (LCs), and test various loading scenarios. . . . A fundamental concept for the analysis of receiving waterbody response to point and nonpoint source inputs is the principle of mass balance (or continuity). Receiving water models typically develop a mass balance for one or more constituents, taking into account three factors: transport through the system, reactions within the system, and inputs into the system.” (EPA841-b-97-006, pp. 1-30)

The model used for this TMDL was LA-QUAL, a steady-state one-dimensional water quality model. LA-QUAL history dates back to the QUAL-I model developed by the Texas Water Development Board with Frank D. Masch & Associates in 1970 and 1971. William A. White wrote the original code.

In June, 1972, the United States Environmental Protection Agency awarded Water Resources Engineers, Inc. (now Camp Dresser & McKee) a contract to modify QUAL-I for application to the Chattahoochee-Flint River, the Upper Mississippi River, the Iowa-Cedar River, and the Santee River. The modified version of QUAL-I was known as QUAL-II.

Over the next three years, several versions of the model evolved in response to specific client needs. In March, 1976, the Southeast Michigan Council of Governments (SEMCOG) contracted with Water Resources Engineers, Inc. to make further modifications and to combine the best features of the existing versions of QUAL-II into a single model. That became known as the QUAL-II/ SEMCOG version.

Between 1978 and 1984, Bruce L. Wiland with the Texas Department of Water Resources modified QUAL-II for application to the Houston Ship Channel estuarine system. Numerous modifications were made to enable modeling this very large and complex system including the addition of tidal dispersion, lower boundary conditions, nitrification inhibition, sensitivity analysis capability, branching tributaries, and various input/output changes. This model became known as QUAL-TX and was subsequently applied to streams throughout the State of Texas.

In 1999, the Louisiana Department of Environmental Quality and Wiland Consulting, Inc. developed LA-QUAL based on QUAL-TX Version 3.4. The program was converted from a DOS-based program to a Windows-based program with a graphical interface and enhanced graphic output. Other program modifications specific to the needs of Louisiana and the Louisiana DEQ were also made. LA-QUAL is a user-oriented model and is intended to provide the basis for evaluating total maximum daily loads in the State of Louisiana.

The development of a TMDL for dissolved oxygen generally occurs in 3 stages. Stage 1 encompasses the data collection activities. These activities may include gathering such information as stream cross-sections, stream flow, stream water chemistry, stream temperature and dissolved oxygen and various locations on the stream, location of the stream centerline and the boundaries of the watershed which drains into the stream, and other physical and chemical factors which are associated with the stream. Additional data gathering activities include gathering all available information on each facility which discharges pollutants in to the stream, gathering all available stream water quality chemistry and flow data from other agencies and groups, gathering population statistics for the watershed to assist in developing projections of future loadings to the water body, land use and crop rotation data where available, and any other information which may have some bearing on the quality of the waters within the watershed. During Stage 1, any data available from reference or least impacated streams which can be used to gauge the relative health of the watershed is also collected.

Stage 2 involves organizing all of this data into one or more useable forms from which the input data required by the model can be obtained or derived. Water quality samples, field measurements, and historical data must be analyzed and statistically evaluated in order to determine a set of conditions which have actually been measured in the watershed. The findings are then input to the model. Best professional judgment is used to determine initial estimates for parameters which were not or could not be measured in the field. These estimated variables are adjusted in sequential runs of the model until the model reproduces the field conditions which were measured. In other words, the model produces a value of dissolved oxygen, temperature, or other parameter which matches the measured value within an acceptable margin of error at the locations along the stream where the measurements were actually made. When this happens, the model is said to be calibrated to the actual stream conditions. At this point, the model should confirm that there is an impairment and give some indications of the causes of the impairment. If a second set of measurements is available for slightly different conditions, the calibrated model is run with these conditions to see of the calibration holds for both sets of data. When this happens, the model is said to be verified.

Stage 3 covers the projection modeling which results in the TMDL. The critical conditions of flow and temperature are determined for the waterbody and the maximum pollutant discharge conditions from the point sources are determined. These conditions are then substituted into the model along with any related condition changes which are required to perform worst case scenario predictions. At this point, the loadings from the point and nonpoint sources (increased by an acceptable margin of safety) are run at various levels and distributions until the model output shows that dissolved oxygen criteria are achieved. It is critical that a balanced distribution of the point and nonpoint source loads be made in order to predict any success in future achievement of water quality standards. At the end of Stage 3, a TMDL is produced which shows the point source permit limits and the amount of reduction in man-made nonpoint source pollution which must be achieved to attain water quality standards. The man- made portion of the NPS pollution is estimated from the difference between the calibration loads and the loads observed on reference or least impacted streams.

### 3.2 Input Data Documentation

Data collected during an intensive survey conducted from June 2 - 7, 2004, was used to establish the input for the model calibration and is presented in Appendix F. The flows for each reach were calibrated to the critical tidal flow calculations. The incremental inflows were the difference in critical tidal flows between reaches with the exception of Reach 3. In reach 3 the incremental inflow also subtracted out the Terrebonne Parish Library Tributary.

Field and laboratory water quality data were entered in a spreadsheet for ease of analysis. The Louisiana GSBOD program was applied to the BOD data in a separate spreadsheet and values were computed for each sample taken of ultimate BOD, BOD decay rate, BOD Lag. This data was the primary source for the model input data for initial conditions, decay rates, and wasteload data. The input and output data sets are located in Appendix B1. The input justifications are in Appendix B**2**.

#### 3.2.1 Model Schematics and Maps

A vector diagram of the modeled area is presented in Appendix C1. The vector diagram shows the locations of survey stations, the reach/element design, and tributaries. An ARCVIEW map of the stream and subsegment showing river kilometers, survey stations, and other points of interest are also included in Appendix H1.

### 3.2.2 Model Options, Data Type 2

Five constituents were modeled during the calibration process. These were chlorides, conductivity, dissolved oxygen, carbonaceous biochemical oxygen demand and nitrogenous biochemical oxygen demand. The algae cycle was not modeled; however, the measured chlorophyll A values were included. This allowed the model to simulate the oxygen production associated with algae without modeling the entire algal cycle.

### 3.2.3 Temperature Correction of Kinetics, Data Type 4

The temperature values computed are used to correct the rate coefficients in the source/sink terms for the other water quality variables. These coefficients are input at 20 °C and are then corrected to temperature using the following equation:

$$X_T = X_{20} * \text{Theta}^{(T-20)}$$

Where:

$X_T$ = the value of the coefficient at the local temperature T in degrees Celsius

$X_{20}$ = the value of the coefficient at the standard temperature at 20 degrees Celsius

Theta = an empirical constant for each reaction coefficient

In the absence of specified values for data type 4, the model uses default values. A complete listing of these values can be found in the LA-QUAL for Windows User's Manual (LDEQ, 2003).

### 3.2.4 Reach Identification Data, Data Type 8

A diagram of the modeled area is presented in Appendix C1. The vector diagram shows the reach/element design established for Bayou Du Large. The modeled area is characterized by 11 sample sites. The model starts with Bayou Du Large at Old Bayou Du Large and extends with the confluence with Marmande Canal. This calibrated model includes 5 reaches, 105 elements, one headwater, and one unnamed ditch modeled as a wasteload. Duplantis Canal (DC1) and Unnamed Canal (UC1) were not modeled because there was no measurable flow during the survey. Additionally, Marmande Canal and Bayou Provost were not modeled because they were below the subsegment boundary. They are included on the vector diagram for informational purposes only. A digitized map of the stream showing river kilometers and the June 2004 survey sampling sites are included in Figure 1 and Appendix H.

### 3.2.5 Advective Hydraulic Coefficients, Data Type 9

The Leopold equations are used to scale the velocity (U), width (W), and depth (H) of a free flowing stream from a lower value of flow to a higher value or from a higher value of flow to a lower value. Note that the exponents add to one and the coefficients multiply to 1. This is known as the rule of ones. This method is not appropriate for streams which are not dependent entirely on flow such as waterbodies where flow approaches zero, but contain some depth.

$U = aQ^b \qquad H = cQ^d \qquad W = eQ^f$

$b + d + f = 1 \qquad (a)(c)(e) = 1$

The Leopold equations presume that the water surface width and average depth of a stream are zero at zero flow. Most Louisiana streams, such as Bayou Du Large, retain a significant width and depth at zero flow. The equations have therefore been modified to allow for a zero flow width and depth. The rule of ones does not apply to the modified equations. The modified Leopold equations are:

$W = aQ^b + c \qquad H = dQ^f + f \qquad U = gQ^h$

The water levels on Bayou Du Large are controlled by tides, therefore width and depths were assumed to be independent of flow. Consequently, the modified Leopold coefficients and exponents were not calculated for this model.

A dispersion coefficient was calculated for this model because Bayou Du Large is tidally influenced. This calculated coefficient was derived from a dye study conducted during the survey. This documentation is located in Appendix F6.

### 3.2.6 Initial Conditions, Data Type 11

The initial conditions are used to reduce the number of interations required by the model. The values required for this model were temperature and DO by reach. The input values came from the survey station continuous monitoring data located closest to the reach or from an average of samples taken within the reach. The input data and sources are shown in Appendix F4.

### 3.2.7 Reaeration Rates, Data Type 12

The applicability of the various equations was examined. The review showed that the Texas Equation was most applicable to Bayou Du Large.

### 3.2.8 Sediment Oxygen Demand, Data Type 12

The SOD values were achieved through calibration. The SOD value for each reach is shown in Appendix C3. The values were considered to be reasonable for this type of stream. The conversion ratio of settled CBOD and settled NBOD to SOD was considered to be zero for all reaches.

### 3.2.9 CBOD Decay and Settling Rates, Data Type 12

The decay rates used were based on the bottle rates from the survey. Review of the measured CBOD daily values revealed one distinct CBOD component, which had varying decay rates and lag times. This component had decay rates ranging from 0.053 to 0.080 per day. The total CBOD curves presented in Appendix F are based on the measured daily CBOD values. The decay and settling rates used for each reach are shown in Appendix F5.

### 3.2.10 Nitrogenous BOD Decay and Settling Rates, Data Type 13

These rates are labeled NBOD Decay and Settling in the model. The decay rates used were based on the bottle rates from the survey. NBOD decay rates ranged from 0.05 to 0.17. The decay and settling rates used for each reach are shown in Appendix F5.

### 3.2.11 Incremental Conditions, Data Types 16, 17, and 18

Bayou Du Large and Marmande Canal are tidally influenced. Bayou Provost is gated just below the confluence with Bayou Du Large and Marmande Canal and therefore, does not receive or contribute to flow. At their confluence, the water ebbs and flows in both directions of Bayou Du Large and Marmande Canal.

However, for the most part Bayou Du Large is not tidally impacted from the headwaters (BDL 1) just below Old Bayou Du Large to (BDL 6) at Beatrice Road, which is the area required for modeling. The upper sites are too far from the tidal surge and too shallow for any significant impact. Additionally, this waterbody from BDL1 to BDL 6 is primarily stagnant. At the time of the survey, Bayou Du Large both upstream and downstream of Marmande Canal were flowing into Marmande Canal. It was assumed that the total flow contribution from sites BDL 1 and BDL 6 were the difference between the flow measurements at MC 1 and BLD 7.

There were incremental conditions associated with the calibration for Bayou Du Large. The inflow was based upon minimal flow calculations. At each reach there is an assumption that some of the flow is immeasurable by the current instrumentation. The instrumentation cannot calculate velocities lower than 0.01 ft/sec. Therefore, a maximum immeasurable flow at each reach was computed to be the cross sectional area ($ft^2$) * 0.01(ft/sec). The data and sources are presented in Appendix F2.

### 3.2.12 Nonpoint Sources, Data Type 19

Nonpoint source loads which are not associated with a flow are input into this part of the model. These can be most easily understood as resuspended load from the bottom sediments and are modeled SOD and UBOD loads. The data and sources are presented in Appendix B2.

### 3.2.13 Headwaters, Data Types 20, 21, and 22

No headwater flow measurements could be obtained with the current instrumentation. At the headwaters there is an assumption that some of the flow is immeasurable by the current instrumentation. The instrumentation cannot calculate velocities lower than 0.01 ft/sec. Therefore, a maximum immeasurable flow at the headwaters was computed to be the cross sectional area ($ft^2$) for BDL1 * 0.01(ft/sec). The data and sources are presented in Appendix F2.

Thus, the headwater flow was determined by using the maximum immeasurable flow at BDL1 which is 0.1870 cfs or 0.0053 cms. The data and sources are presented in Appendix F2.

#### 3.2.14 Wasteloads, Data Types 23, 24, and 25

A facility review was performed on the subsegment and only one permitted discharger was found for subsegment 120505. This facility was not flowing during the water quality survey and therefore was not added to the calibration.

However, the unnamed ditch which contains the only permitted discharger in this subsegment was modeled as a wasteload. It was assumed that the flow from the unnamed ditch into Bayou Du Large was:

(MC1 – BDL7) – (Sum of incremental flows for BDL 1 through BDL 6)

#### 3.2.15 Boundary Conditions, Data Type 27

Dispersion was included in the model. Therefore lower boundary conditions were included as well. The lower boundary conditions were assumed to be equivalent to the measurements taken at survey station BDL6 (Bayou Du Large at Marmande Canal).

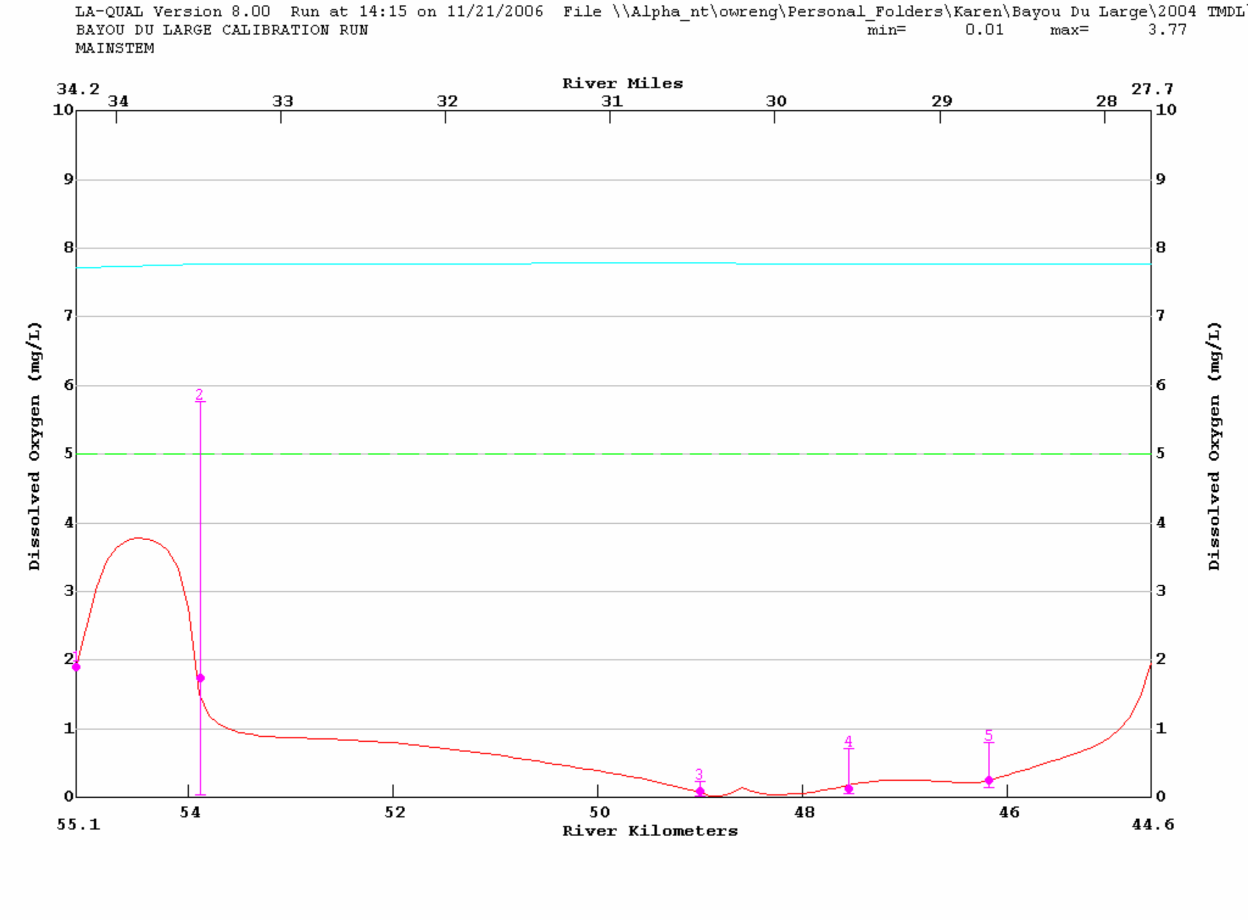
### 3.3 Model Discussion and Results

The calibration model input and output is presented in Appendix B1. The overlay plotting option was used to determine if calibration had been achieved. A plot of the dissolved oxygen concentration versus river kilometer is presented in Figure 3. The calibration points for UBOD were the measured values from the water quality samples.

An adequate calibration was achieved for DO and UBOD on the main stem. The calibration model shows that during June 2004 survey period, the DO standard of 5.0 mg/l was not being met in subsegment 120505 in any of the modeled reaches. The calibration model minimum DO on the main stem was 0.01 mg/l. This is a primarily stagnant waterbody, thus yielding low DO levels. There is an intitial peak in DO and BOD in the first reach due to the smaller load compared to the other three reaches.

Hurricanes Katrina and Rita created massive devastation to various watersheds. These natural disasters occurred after the survey data had been collected. It is feasible to consider that the water quality and hydrologic conditions may be somewhat different now. Therefore, this TMDL would only be considered viable for pre-hurricane conditions.

**Figure 3. Calibration Model Dissolved Oxygen versus River Kilometer**



## 4. Water Quality Projections

The traditional summer critical projection loading scenario was performed at the current annual DO standard. This scenario was based on reduced total nonpoint loads at summer season critical conditions (ie. 90$^{th}$ percentile seasonal temperatures and 7Q10 flows) in accordance with the LTP. A winter projection was run based on the percent reduction of total nonpoint loads used for summer critical projections.

### *4.1 Critical Conditions, Seasonality and Margin of Safety*

The Clean Water Act requires the consideration of seasonal variation of conditions affecting the constituent of concern, and the inclusion of a margin of safety (MOS) in the development of a TMDL. For the Bayou Du Large, subsegment 120505 TMDL, an analysis of LDEQ ambient data has been employed to determine critical seasonal conditions and an appropriate margin of safety.

Critical conditions for dissolved oxygen were determined for Bayou Du Large using short term water quality data from Bayou Du Large water quality site number 940 on the LDEQ Ambient Monitoring Network. The 90$^{th}$ percentile temperature for each season was used for projections. Ambient temperature data, critical temperature and DO saturation determinations are shown in Appendix E3. Graphical and regression analysis techniques have been used by LDEQ historically to evaluate the temperature and dissolved oxygen data from the Ambient Monitoring Network and run-off determinations from the Louisiana Office of Climatology water budget. Since nonpoint loading is conveyed by run-off, this was a reasonable correlation to use. Temperature is strongly inversely proportional to dissolved oxygen and moderately inversely proportional to run-off. Dissolved oxygen and run-off are also moderately directly proportional. The analysis concluded that the critical conditions for stream dissolved oxygen concentrations were those of negligible nonpoint run-off and low stream flow combined with high stream temperature.

When the rainfall run-off (and non-point loading) and stream flow are high, turbulence is higher due to the higher flow and the temperature is lowered by the run-off. In addition, run-off coefficients are higher in cooler weather due to reduced evaporation and evapotranspiration, so that the high flow periods of the year tend to be the cooler periods. Reaeration rates and DO saturation are, of course, much higher when water temperatures are cooler, but BOD decay rates are much lower. For these reasons, periods of high loading are periods of higher reaeration and dissolved oxygen but not necessarily periods of high BOD decay.

This phenomenon is interpreted in TMDL modeling by assuming that nonpoint loading associated with flows into the stream are responsible for the benthic blanket which accumulates on the stream bottom and that the accumulated benthic blanket of the stream, expressed as SOD and/or resuspended BOD in the calibration model, has reached steady state or normal conditions over the long term and that short term additions to the blanket are off set by short term losses. This accumulated loading has its greatest impact on the stream during periods of higher temperature and lower flow. The manmade portion of the NPS loading is the difference between the calibration load and the reference stream load where the calibration load is higher. The only mechanism for changing this normal benthic blanket condition is to implement best management practices and reduce the amount of nonpoint source loading entering the stream and feeding the benthic blanket.

Critical season conditions were simulated in the Bayou Du Large, subsegment 120505, dissolved oxygen TMDL projection modeling by using critical tidal flows, and the $90^{th}$ percentile temperature. Incremental flow was calculated based upon critical tidal flows; model loading was from sediment oxygen demand and resuspension of sediments.

In reality, the highest temperatures occur in July-August, the lowest stream flows occur in October-November, and the maximum point source discharge occurs following a significant rainfall, i.e., high-flow conditions. The projection model is established as if all these conditions happened at the same time. Other conservative assumptions regarding rates and loadings are also made during the modeling process. In addition to the conservative measures, an explicit MOS of 20% was used for all loads to account for future growth, safety, model uncertainty and data inadequacies.

## 4.2 Input Data Documentation

The flow in the headwater was set for summer and winter critical conditions by taking the total area of Bayou Dularge and computing a volume by using the average depth calculated for the waterbody. Using the volume and the tidal rise cycle, an average flow was calculated. Taking the average flow and dividing by 3 gives a critical tidal flow of 1.65 cfs. This was a tidal situation and the same flows were used for the the summer and winter projections. This data can be found in Appendix F2. The flows used for projections were significantly less than the flows found during the survey. Critical tidal flows can run much less than average conditions for this waterbody.

### 4.2.1 Model Options, Data Type 2

Three constituents were modeled during the calibration process. These were dissolved oxygen carbonaceous biochemical oxygen demand and nitrogenous biological oxygen demand.

### 4.2.2 Temperature Correction of Kinetics, Data Type 4

The default temperature correction values specified in the LAQUAL manual were used in the model.

### 4.2.3 Reach Identification Data, Data Type 8

The reach-element design from the calibration was used in the projection modeling.

#### 4.2.4 Advective Hydraulic Coefficients, Data Type 9

The hydraulic coefficients, exponents, and constants determined for the calibration were used in the projection model.

#### 4.2.5 Initial Conditions, Data Type 11

The initial conditions were set to the $90^{th}$ percentile critical season temperature in accordance with the LTP. The dissolved oxygen values for the initial conditions were set to the DO Standard for Subsegment 120505 which was 5.0 mg/L. The headwater flow was set to the critical tidal flow for BDL1. Using best professional judgement, the chlorophyll a value for each reach was set to 10. This is a reasonable assumption for chlorophyll a based upon the reduction of nonpoint sources.

#### 4.2.6 Reaeration Rates, Carbonaceous BOD Decay and Settling Rates, Nitrogenous BOD Decay and Settling Rates, Data Type 12 and 13

The reaeration rate equations, CBOD decay and settling rates, NBOD decay and settling rates, and the fractions converting settled CBOD and settled NBOD to SOD were not changed from the calibration.

#### 4.2.7 Incremental Conditions, Data Types 16, 17, and 18

The incremental conditions were calculated based upon the critical tidal flow calculations for each site. More detailed information can be found in Appendix F2.

#### 4.2.8 Sediment Oxygen Demand, Nonpoint Sources, Headwaters, Wasteloads, Data Type 12, 19, 20, 21, 22, 24, 25, and 26

The NPS values were calculated for each projection scenario using a load equivalent spreadsheet. An analysis was made of the calibration NPS and SOD loads in terms of total loading in units of gm-$O_2$/$m^2$/day. The same spreadsheet also calculated load reductions for the headwaters and wasteloads. The values and sources of the input data and the load analyses are presented in Appendix E for each of the projection runs.

LDEQ has collected and measured the CBOD and NBOD oxygen demand loading components for a number of years. These loads have been found in all streams including the non-impacted reference streams. It is LDEQ's opinion that much of this loading is attributable to run-off loads which are flushed into the stream during run-off events, and subsequently settle to the bottom in our slow moving streams. These benthic loads decay and breakdown during the year, becoming easily resuspended into the water column during the low flow/high temperature season. This season has historically been identified as the critical dissolved oxygen season.

LDEQ simulates part of the non-point source oxygen demand loading as resuspended benthic load and SOD. The calibrated non-point loads, UCBOD, UNBOD and SOD, are summed to produce the total calibrated benthic load. The total calibrated benthic load is then reduced by the total background benthic load (determined from LDEQ's reference stream research) to determine the total manmade benthic loading. The manmade portion is then reduced incrementally on a percentage basis to determine the necessary percentage reduction of manmade loading required to meet the water body's dissolved oxygen criteria. These reductions are applied uniformly to all reaches sharing similar hydrology and land uses.

Following the same protocol as the point source discharges, the total reduced manmade benthic load is adjusted for the margin of safety by dividing the value by one minus the margin of safety. This adjusted load is added back to the total background benthic value to obtain the total projection model benthic load. This total projection benthic load is then broken out into its components of SOD, resuspended CBOD and resuspended NBOD by multiplying the total projection benthic load by the ratio of each calibrated component to the total calibrated benthic load.

LDEQ has found variations in the breakdown of the individual CBOD and NBOD components. While the total BOD is reliable, the carbonaceous and nitrogenous component allocation is subject to the type of test method. In the past, LDEQ used a method which suppressed the nitrogenous component to obtain the carbonaceous component value, which was then subtracted from the total measured BOD to determine the nitrogenous value. The suppressant in this method was only reliable for twenty days thus leading to the assumption that the majority of the carbonaceous loading was depleted within that period of time. The test results supported this assumption. A new method was found in Standard Methods for testing long term BODs and was implemented in 2000. This new method was necessary because the nitrogen suppressant started failing around day seven and the manufacturer of the suppressant will only guarantee it's potency for a five day period. LDEQ felt a five day test would not adequately depict the water quality of streams.

This proposed method is a sixty day test which measures the incremental total BOD of the sample while at the same time measuring the increase in nitrite/nitrate in the sample. This increase in nitrite/nitrate allows LDEQ to calculate the incremental nitrogenous portion by multiplying the increase by 4.57 to determine the NBOD daily readings. These NBOD daily readings are then subtracted from the daily reading for total BOD to determine the CBOD daily values. A curve fit algorithm is then applied to the daily component readings to obtain the estimated ultimate values of each component as well as the decay rate and lag times of the first order equations.

LDEQ has implemented the new test method over the last several survey seasons. The results obtained using the new method showed that a portion of the CBOD first order equation does begin to level off prior to the twentieth day, however a secondary CBOD component begins to use dissolved oxygen sometime between day ten and day twenty-five. This secondary CBOD component was not being assessed as CBOD using the previous method but was being included in the NBOD load. Thus the CBOD and NBOD component loading used in the reference stream studies is not consistent with the results using the new proposed 60 day method and the individual values should not be used to determine background values for samples processed using the new test methods. However, the sum of CBOD and NBOD should be about the same for both new and old test methods. For this reason LDEQ decided to use the sum of reference stream benthic loads as background values. In the case of Bayou du Large, a suitable reference stream could not be determined. Therefore, this TMDL calculates an overall reduction in nonpoint sources. Without a suitable reference stream, the man-made portion cannot be determined.

### 4.2.9 Boundary Conditions, Data Type 27

The lower boundary conditions were set at the 90$^{th}$ percentile critical season temperature, the 5.0 mg/L DO standard for subsegment 120505, and the measured stream CBOD and NBOD loads for all projections and scenarios.

## 4.3 Model Discussion and Results

The projection model input and output data sets are presented in Appendix D.

### 4.3.2 Summer Projection

Summer critical season projections were run for the current standard of 5.0 mg/L May – November. In order to meet the standard, an 85% reduction of total nonpoint sources is necessary. With these percentage reductions in the benthic oxygen loads, Bayou Du Large meets the dissolved oxygen criterion. The minimum DO on the main stem is 5.00 mg/L. A graph of the dissolved oxygen concentration versus river kilometer for the summer projection is presented in Figure 4.

### 4.3.3 Winter Projection

The results of the model show that the water quality criterion for dissolved oxygen of Bayou Du Large of 5.0 mg/l can be maintained during the winter critical season. The minimum dissolved oxygen is 5.00 mg/l. This is acceptable. To achieve the criterion, the model assumed a 85% reduction in the total nonpoint loading. A graph of the dissolved oxygen concentration versus river kilometer for the winter projection is presented in Figure 5.

**Figure 4. Summer Projection at 85% Removal of Man-Made NPS Loads**

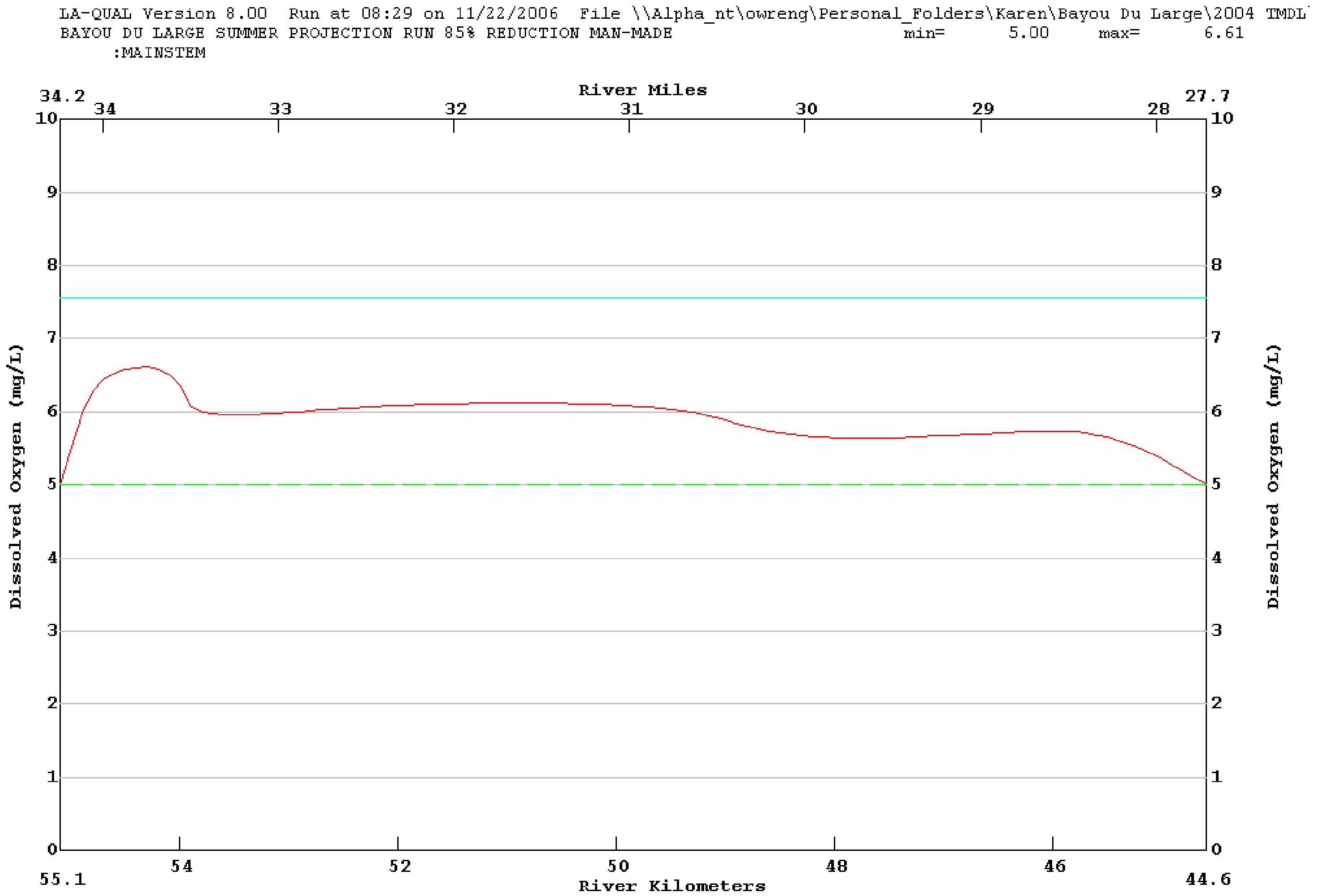
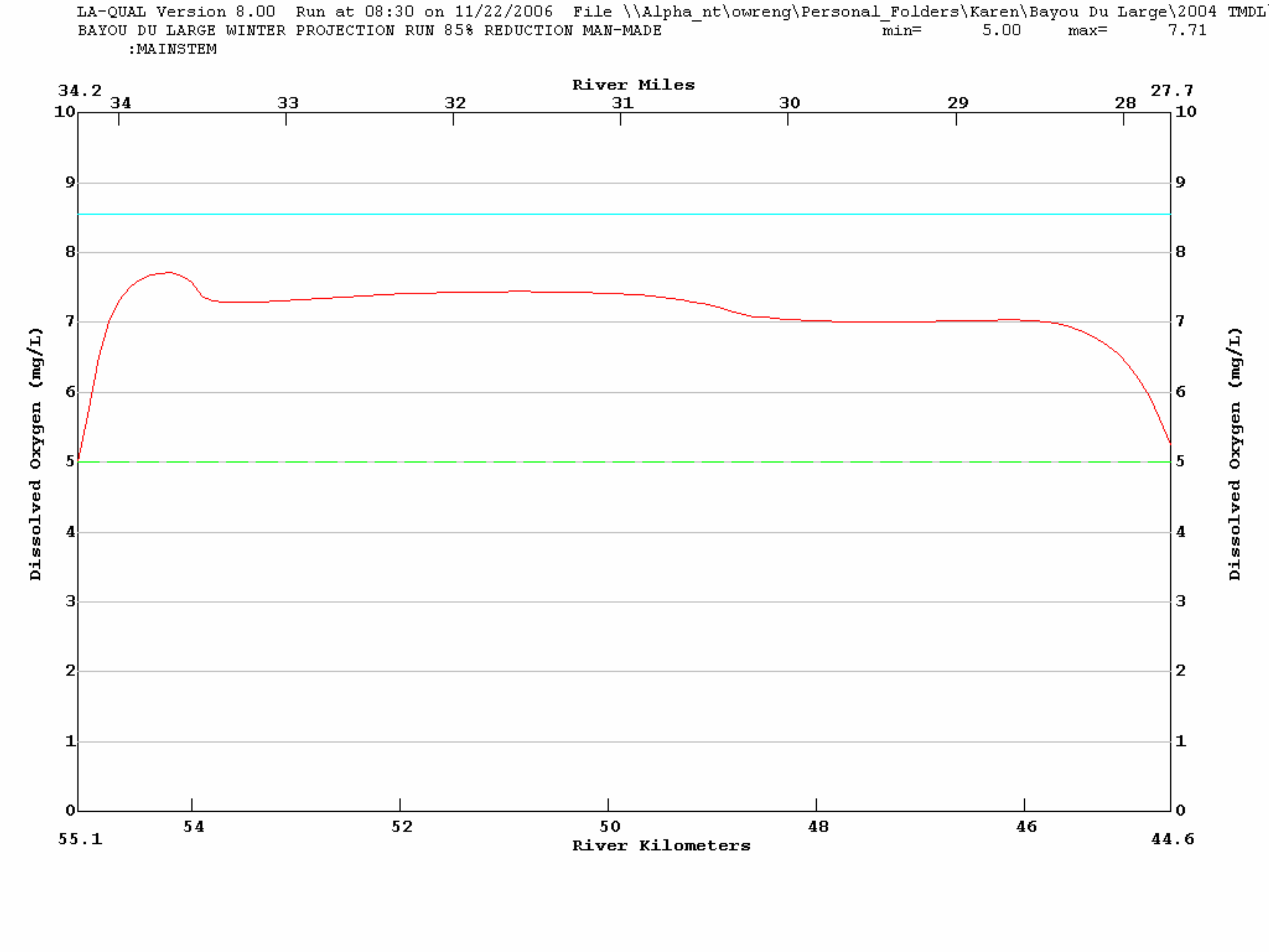


**Figure 5. Winter Projection at 85% Removal of Man-Made NPS Loads**



### *4.4 Calculated TMDL, WLAs and Las*

### 4.4.1 Outline of TMDL Calculations

An outline of the TMDL calculations is provided to assist in understanding the calculations in the Appendices. Slight variances may occur based on individual cases.

4.4.1.1 The natural backgrounds benthic loading was estimated from reference stream resuspension (nonpoint CBOD and NBOD), and SOD load data.

4.4.1.2 The calibration man-made benthic loading was determined as follows:

- Calibration resuspension and SOD loads were summed for each reach as gm $O_2/m^2$-day to get the calibration benthic loading.
- The natural background benthic loading was subtracted from the calibration benthic loading to obtain the man-made calibration benthic loading.

4.4.1.3 Projection benthic loads are determined by trial and error during the modeling process using a uniform percent reduction for resuspension and SOD. Point sources are reduced as necessary to subsequently more stringent levels of treatment consistent with the size of the treatment facility as much as possible. Point source design flows are increased to obtain an explicit MOS of 20%. Headwater and tributary concentrations of CBOD, NBOD and DO range from reference stream levels to calibration levels based on the character of the headwater. Where headwaters and tributaries exhibit man-made pollutant loads in excess of reference stream values, the loadings are reduced by the same uniform percent reduction as the benthic loads.

- The projection benthic loading at 20 °C is calculated as the sum of the projection resuspension and SOD components expressed as gm $O_2/m^2$-day.

- The natural background benthic load is subtracted from the projection benthic load to obtain the man-made projection benthic load for each reach.

- The percent reduction of man-made loads for each reach is determined from the difference between the projected man-made non-point load and the man-made non-point load found during calibration.

- The projection loads are also computed in units of lb/d and kg/d for each kind.

4.4.1.4 The total stream loading capacity at critical water temperature is calculated as the sum of:

- Headwater and tributary CBOD and NBOD loading in lb/d and kg/d.

- The natural and man-made projection benthic loading for all reaches of the stream is converted to the loading at critical temperature and summed in lb/d and kg/d.

- Point source CBOD and NBOD loading in lb/d and kg/d.

- The margin of safety in lb/d and kg/d.

### 4.4.2 Bayou Du Large TMDL

The TMDLs for the biochemical oxygen demanding constituents (UBOD and SOD), have been calculated for the summer and winter critical seasons. The TMDLs for the Bayou Du Large watershed were set equal to the total stream loading capacity. They are presented in Appendix A by point source and reach. A summary of the loads is presented in Table 6.

**Table 6. Total Maximum Daily Load (Sum of UCBOD, (UNBOD)NH3-N, and SOD)**

| ALLOCATION | SUMMER | | WINTER | |
|---|---|---|---|---|
| | % Reduction Required | (MAY-OCT) (lbs/day) | % Reduction Required | (NOV-APR) lbs/day) |
| Point Source WLA | 0 | 0 | 0 | 0 |
| Point Source Reserve MOS (20%) | 0 | 0 | 0 | 0 |
| Manmade Nonpoint Source LA | 85 | 611 | 85 | 481 |
| Manmade Nonpoint Source Reserve MOS(20%) | 0 | 152 | 0 | 119 |
| TMDL | | 763 | | 600 |

***Note1: UCBOD as stated in this allocation is Ultimate CBOD.
UCBOD to $CBOD_5$ ratio = 2.3 for all treatment levels
Permit allocations are generally based on $CBOD_5$***

**Table 7. Point Source TMDL Summary 120505**

| | | | CURRENT EXPECTED FLOW | CURRENT MONTHLY AVERAGE CONCENTRATION LIMITS | | TMDL FLOW | MOS FLOW | TMDL MONTHLY AVERAGE CONCENTRATION LIMITS | | TMDL MONTHLY AVERAGE MASS LIMITS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FACILITY | FILE No. | Out-fall No. | GPD | BOD5/ CBOD5, mg/L | $NH_3$-N, mg/L | GPD | GPD | BOD5/ CBOD5, mg/L | $NH_3$-N, mg/L | CBOD5, lbs./day | $NH_3$-N, lbs./day | MODELING COMMENTS |
| Terrebonne Parish Library | 91032 | 001 | 190 | 30 | 15 | | | 30 | 15 | 0.0476 | 0.0238 | Due to insignificant impact, was not included in the model. |

## 5. Sensitivity Analysis

All modeling studies necessarily involve uncertainty and some degree of approximation. It is therefore 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 LAQUAL model allows multiple parameters to be varied with a single run. The model adjusts each parameter up or down by the percentage given in the input set. The rest of the parameters listed in the sensitivity section are held at their original projection value. Thus the sensitivity of each parameter is reviewed separately. The sensitivity of the model's minimum DO projections to these parameters is presented in Appendix I. Parameters were varied by +/- 30%, except temperature, which was adjusted +/- 2 degrees Centigrade.

Values are sorted by percent variation of minimum DO on the main stem Bayou Du Large. As shown in Table 8, initial chlorophyll a, stream velocity, initial temperature, NBOD settling rate, benthal demand, stream reaeration, stream depth, wasteload flow, and wasteload DO are the parameters to which DO is most sensitive. The other parameters creating major variations in the minimum DO values are stream baseflow, CBOD decay rate, CBOD settling rate, and wasteload CBOD. The model is slightly to not sensitive to the remaining parameters.

**Table 8. Summary of Calibration Model Sensitivity Analysis**

SENSITIVITY ANALYSIS SUMMARY

MAINSTEM
BAYOU DU LARGE SENSITIVITY RUN

Plot 1 Base Model Minimum DO = 0.05

| Parameter | %Param Chg | Min D.O. | %D.O. Chg | %Param Chg | Min D.O. | %D.O. Chg |
|---|---|---|---|---|---|---|
| Stream Baseflow | 30. | 0.06 | 28.5 | -30. | 0.03 | -26.3 |
| Initial Chorophyll a | 30. | 0.30 | 532.3 | -30. | 0.00 | -100.0 |
| Stream Velocity | 30. | 0.07 | 53.8 | -30. | 0.00 | -93.2 |
| Initial Temperature | 2. | 0.00 | -100.0 | -2. | 0.57 | 1119.2 |
| CBOD Aerobic Decay Rate | 30. | 0.03 | -28.9 | -30. | 0.07 | 38.7 |
| CBOD Settling Rate | 30. | 0.06 | 20.1 | -30. | 0.03 | -26.1 |
| CBOD2 Settling Rate | 30. | 0.05 | 0.0 | -30. | 0.05 | 0.0 |
| NBOD Decay Rate | 30. | 0.05 | 0.1 | -30. | 0.05 | -0.1 |
| NBOD Settling Rate | 30. | 0.05 | 0.0 | -30. | 0.05 | 0.0 |
| Benthal Demand | 30. | 0.00 | -100.0 | -30. | 1.40 | 2878.1 |
| Stream Dispersion | 30. | 0.05 | 0.0 | -30. | 0.05 | 0.0 |
| Stream Reaeration | 30. | 0.99 | 2016.0 | -30. | 0.00 | -100.0 |
| Headwater Flow | 30. | 0.05 | 1.9 | -30. | 0.05 | -1.8 |
| Headwater DO | 30. | 0.05 | 0.0 | -30. | 0.05 | 0.0 |
| Headwater CBOD | 30. | 0.05 | -0.2 | -30. | 0.05 | 0.2 |
| Headwater NBOD | 30. | 0.05 | 0.0 | -30. | 0.05 | 0.0 |
| Stream Depth | 30. | 0.31 | 549.1 | -30. | 0.00 | -100.0 |
| Wasteload Flow | 30. | 0.08 | 62.6 | -30. | 0.00 | -89.9 |
| Wasteload Temperature | 2. | 0.05 | 0.0 | -2. | 0.05 | 0.0 |
| Wasteload DO | 30. | 0.08 | 77.2 | -30. | 0.00 | -97.2 |

```
Wasteload CBOD                    30.  0.04   -5.9      -30.  0.05
6.2
Wasteload NBOD                    30.  0.05    0.0      -30.  0.05
0.0
Lower Boundary Temperature         2.  0.05    0.0       -2.  0.05
0.0
Lower Boundary DO                 30.  0.05    0.0      -30.  0.05
0.0
Lower Boundary CBOD               30.  0.05    0.0      -30.  0.05
0.0
Lower Boundary NBOD               30.  0.05    0.0      -30.  0.05
0.0
```

## 6. Conclusions

This TMDL establishes load limitations for oxygen-demanding substances and goals for reduction of those pollutants. LDEQ's position, as supported by the declaratory ruling issued by Secretary Givens in response to the lawsuit regarding water quality criteria for nutrients (Sierra Club v. Givens, 710 So.2d 249 (La. App. 1st Cir. 1997), writ denied, 705 So.2d 1106 (La. 1998), is that when oxygen-demanding substances are controlled and limited in order to ensure that the dissolved oxygen criterion is supported, nutrients are also controlled and limited. The implementation of this TMDL through wastewater discharge permits and implementation of best management practices to control and reduce runoff of soil and oxygen-demanding pollutants from nonpoint sources in the watershed will also control and reduce the nutrient loading from those sources.

The modeling, which has been conducted for this TMDL, is conservative and based on limited information. The TMDL requires a watershed-wide 85% decrease in total nonpoint source loads in order to meet the DO criterion of 5.0 mg/L in the summer critical season.

There is a hurricane protection project in place called Morganza to the Gulf that proposes a floodgate on Bayou Du Large southeast of Lake DeCade and a water control structure on Marmande Canal near the confluence with Bayou Du Large. With the addition of these control structures, this TMDL can be rendered obsolete.

Hurricanes Katrina and Rita created massive devastation to various watersheds. These natural disasters occurred after the survey data had been collected. It is feasible to consider that the water quality and hydrologic data used from the survey may be somewhat different now. Therefore, this TMDL would only be considered viable pre-hurricanes.

Based on the amount of reduction required, it is recommended that a use-attainability analysis (UAA) be completed to determine if a change in the DO standard for the waterbody is necessary.

The Terrrebonne Parish Library is the only permitted discharger located in this subsegment. This discharger is small and need not be included in a model of this scale because it is unlikely that it is having an impact on the targeted waterbody due to the small load and/or the distance from the waterbody named in the 303(d) lists. This discharger is accounted for as nonpoint loading through the process of calibration. It falls within one of several state or regional policies that govern permit limitations. Therefore, the Terrebonne Parish Library should be allowed to discharge at the current permit limits.

LDEQ has developed this TMDL to be consistent with the state antidegradation policy (LAC 33:IX.1109.A).

LDEQ will work with other agencies such as local Soil Conservation Districts to implement agricultural best management practices in the watershed through the 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, the 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 art 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 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.

The LDEQ is continuing to implement a watershed approach to surface water quality monitoring. In 2004 a four year sampling cycle replaces the previous five year cycle. Approximately one quarter of the states watersheds will be sampled each year so that all of the states watersheds will be sampled within the four year cycle. 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.

## 7. References

Bowie, G.L., et. al. *Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling (Second Edition).* Env. Res. Lab., USEPA, EPA/600/3-85/040. Athens, GA: 1985.

Lee, Fred N. *Low-Flow on Streams in Louisiana*. Louisiana Department of Environmental Quality. Baton Rouge, LA: March, 2000.

Louisiana Department of Environmental Quality. *State of Louisiana Water Quality Management Plan, Volume 6, Part A, Nonpoint Source Pollution Assessment Report*. Baton Rouge, LA: 1993.

Louisiana Department of Environmental Quality. *Environmental Regulatory Code, Part IX*. Water Regulations. Baton Rouge, LA: 1998.

Shoemaker, L., et. al. *Compendium of Tools for Watershed Assessment and TMDL Development*. Office of Wetland, Oceans, and Watersheds, USEPA, EPA841-B-97-066. Washington, DC: May, 1997.

Smythe, E. deEtte. *Overview of the 1995 and 1996 Reference Streams*. Louisiana Department of Environmental Quality. Baton Rouge, LA: June 28, 1999.

Waldon M. G., R. K. Duerr, and Marian U. Aguillard. *Louisiana Total Maximum Daily Load Technical Procedures*. Louisiana Department of Environmental Quality. Baton Rouge, LA: May, 2000.

Wiland, Bruce L. *LA-QUAL for Windows User's Manual (Version 3.02C)*. Water Support Division, Engineering Section, Louisiana Department of Environmental Quality. Baton Rouge LA: March, 2000.